CAPITA SYMONDS

PROOF OF EVIDENCE OFDANIELE FIUMICELLI

PROPOSED CONCRETE BATCHING PLANT
FERME PARK DEPOT
CRANFORD WAY
LONDON
N8 9DG
18TH NOVEMBER 2005

Contents

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CAPITA SYMONDS

PROOF OF EVIDENCE ON NOISE AND VIBRATION MATTERS – DANIELE FIUMICELLI

I am employed by Capita Symonds Ltd as a principal consultant in the noise and vibration team, prior to my current employment I spent 19 years in Local Government as an Environmental Health Officer. I qualified as an Environmental Health Officer in 1986 and I am a full corporate member of the Chartered Institute of Environmental Health Officers. I was awarded an MSc degree in Environmental Acoustics from the Southbank University in 1999 and I am a full corporate member of the Institute of Acoustics. Throughout my career as an Environmental Health Officer and now as an acoustic consultant my work has included dealing with noise matters associated with applications for planning permission, including applications for batching plants.

INTRODUCTION

1.0 My proof of evidence deals with potential adverse noise impacts from the proposed development of a concrete batching plant at Ferme Park Depot, Cranford Way, London, N8 9DG, on the amenity of nearby existing residential development.

1.1 This evidence concerns the planning applications containing proposals to erect and operate a concrete batching plant at Ferme Park Depot, Cranford Way, London, N8 9DG, London Borough Haringey Ref HGY/2005/00007 which are subject to a public inquiry, Planning Inspectorate, Ref APP/5420/A/05/1189822/.

1.2 There is potential for adverse noise impacts to arise from the use of the land for the mixing, batching and dispatch of concrete, in regard to existing residential premises at Chettle Court, a large block of flats to the south of the site, and houses and flats on Uplands Road to west of the site, and to a lesser degree houses and flats on Wightman Road to the east of the site.

1.3 The government provides advice to local planning authorities on planning and noise via PPG 24 – planning and noise. The introduction to PPG 24, paragraph 1 states that it provides:

"advice on how the *planning* system can be used to minimise the adverse impact of noise without placing unreasonable restrictions on development or adding unduly to the costs and administrative burdens of business."

1.4 The general principles of the advice in PPG 24 are given in paragraph 2 as:

"The impact of noise can be a material consideration in the determination of planning applications".

And

"The planning system has the task of guiding development to the most appropriate locations".

And

"It will be hard to reconcile some land uses, such as housing, hospitals or schools, with other activities which generate high levels of noise, but the planning system should ensure that, wherever practicable, noise-sensitive developments are separated from major sources of noise (such as road, rail and air transport and certain types of industrial development)."

And

"Development plans provide the policy framework within which these issues can be weighed but careful assessment of all these factors will also be required when individual applications for development are considered."

And qualifies the above by stating,

"Where it is not possible to achieve such a separation of land uses, local planning authorities should consider whether it is practicable to control or reduce noise levels, or to mitigate the impact of noise, through the use of conditions or planning obligations."

1.5 In the context of noise generating development, as is the case considered here, Paragraph 11 of PPG24 specifically recommends:

"Noise characteristics and levels can very substantially according to their source and the type of activity involved. In the case of industrial development for example, the character of the noise should be taken into account as well as its level."......."More detailed advice on factors to consider in relation to major noise sources including roads, railways, airports, industrial noise and recreational noise is provided in Annex 3"

1.6 In regard to industrial and commercial development, as proposed in this case, paragraph 19 in Annex 3 of PPG 24 states the following:

"The likelihood of complaints about noise from industrial development can be assessed, where the Standard is appropriate, using guidance in BS 4142: 1990. Tonal or impulsive characteristics of the noise are likely to increase the scope for complaints and this is taken into account by the "rating level" defined in BS 4142. This "rating level" should be used when stipulating the level of noise that can be permitted. The likelihood of complaints is indicated by the difference between the noise from the new development (expressed in terms of the rating level) and the existing background noise. The Standard states that: "A difference of around 10 dB or higher indicates that complaints are likely. A difference of around 5 dB is of marginal significance." Since background noise levels vary throughout a 24 hour period it will usually be necessary to assess the acceptability of noise levels for separate periods (eg day and night) chosen to suit the hours of operation of the proposed development. Similar considerations apply to developments that will emit significant noise at the weekend as well as during the week. In addition, general guidance on acceptable noise levels within buildings can be found in BS 8233: 1987, and guidance on the control of noise from surface mineral workings can be found in MPG 11".

1.7 With regard to the development proposals considered here, there is a significant risk that noise emitted from and associated with the proposed concrete batching plant, may cause unacceptable noise impacts to the occupiers of the existing nearby noise sensitive premises.

1.8 As well as eroding the amenity of existing nearby noise sensitive premises, noise from the proposed concrete batching plant could lead to complaints of statutory nuisance, which the local authority has a duty to investigate and act upon under part iii of the Environmental Protection Act 1990, if nuisance or conditions prejudicial to health are established.

1.9 Additionally, because the "best practicable means" defence from section 80(7) of the Environmental Protection Act 1990 would apply to any statutory nuisance action by Haringey Council against any industrial, trade or business occupier of the site considered here, it might not be possible to retrospectively secure acceptable acoustic conditions for residents of the existing nearby dwellings using statutory nuisance powers, if measures to attenuate noise from the concrete batching site were to prove:

- not reasonably practicable, having regard among other things to local conditions and circumstances, to the current state of technical knowledge and to the financial implications;
- not compatible with any duty imposed by law;
- not compatible with safety and safe working conditions, and with the exigencies of any emergency or unforeseeable circumstances;

1.10 In respect to potential adverse and unacceptable noise impacts from the proposed development on the amenity of existing noise sensitive premises, the guidance of PPG 24 suggests that that there are reasonable grounds for the local planning authority to consider refusing planning permission for proposed noise generating development where mitigation of noise impacts to an acceptable degree is not possible.

1.11 If however, it may be possible to incorporate into the design, layout and construction of a proposed noise generating development measures to mitigate the impacts of noise on existing nearby noise sensitive premises to an acceptable degree. Consequently, the guidance of PPG 24 suggests that the local planning authority may consider granting planning permission for the proposed developments, with conditions requiring the final design, layout and construction of the proposed developments to incorporate mitigation in order to provide acceptable acoustic conditions for future occupiers.

1.12 A glossary of acoustical terminology is presented in appendix A.

1.13 After this introduction and then summary, my evidence proceeds as follows:

Section 3 provides a critical review of the acoustic reports and baseline surveys of noise submitted in support of the application and an addendum provided subsequently by the applicant. This section includes discussion of appropriate methodologies for the prediction of the propagation of noise and methodologies and criteria for the assessment of noise impacts in the context of the proposed development considered in this proof.

Section 4 provides the outcomes of a noise impact assessment I have carried out and considers the noise impacts from the operation of the proposed development on existing nearby sensitive development.

Section 5 provides conclusions.

2.0 SUMMARY

2.1 In considering the noise impacts from the proposed development, this evidence demonstrates that the application is deficient to the extent that it risks underestimating unacceptable noise impacts from the proposed development on existing nearby noise sensitive development.

2.2 In principle, there is not an objection to noise generating development at the site considered in this proof, provided the noise impacts are adequately assessed by the applicant, any significant adverse impacts are identified by their assessment and measures capable of mitigating any significantly adverse noise impacts to acceptable levels are incorporated into the proposals submitted for approval by the Local Planning Authority.

2.3 This evidence will demonstrate that the identification, assessment and planned mitigation of noise impacts from the proposed development site has not been sufficient to demonstrate that noise impacts from these sources are likely to be acceptable to occupiers of existing nearby noise sensitive premises; and that the existing and future lawful use and amenity of neighbouring land already in noise sensitive use has not been adequately protected against being prejudiced by the proposed development.

3.0 CRITICAL REVIEW OF SHARPS REDMORE PARTNERSHIP ACOUSTIC REPORTS AND BASELINE SURVEYS OF NOISE SUBMITTED IN SUPPORT OF THE APPLICATION

3.1 This section of my proof is in regard to an addendum report from the Sharps Redmore Partnership, with the title London Concrete Limited, Proposed Concrete Batching Plant at Cranford Way, Ferme Park, Hornsey, given the project No 034778 and dated 21st June 2005.

3.2 The addendum report from the Sharps Redmore Partnership builds on, and includes, a previous report they produced dated 22nd April 2003, and re-considers the noise impacts of the proposed development in the light of the changes contained in a subsequent planning application (ref HGY/2005/0007) submitted to the Local Planning Authority, which includes proposals to provide an acoustic screen to the lorry loading area.

3.3 As part of the critical review of the Sharps Redmore Partnership reports it is important to first go back to the Sharps Redmore Partnership report dated 22nd April 2003, in particular to section 2.0 – Assessment methodology and criteria, as this is a primary area of disagreement.

3.4 Section 2.1 of the 22nd April 2003 report lists several methods whereby the impact of noise can be assessed. These different methods can also be described as follows:

3.4.1 Benchmark comparisons – Absolute (fixed limits)

3.4.1.1 Benchmark comparisons are made by comparing specific sound levels against established benchmark sound level values defined in existing standards and regulations. The precise noise indices to be used when quantifying the specific sound levels for comparison with any benchmark sound levels must be as defined in the standards and regulations which have either been imposed or adopted for this purpose, and the benchmark sound levels must be appropriate to the noise source and the nature and character of the noise under consideration.

3.4.1.2 Exceedances of specific sound levels over any defined benchmarks are indicative of negative impacts of the noise under consideration.

3.4.1.3 An example of this type of assessment is BS 8233:1999 - Sound Insulation and Noise Reduction for Buildings Code of Practice or the WHO Guidelines for Community Noise (1999). These types of assessment do not usually take into account any correction factors that allow for any enhancement of impact due to aggravating aspects of the nature and character of the noise under consideration

3.4.2 Change comparisons - Relative

3.4.2.1 Change comparisons are carried out by comparing specific sound levels before and after a development to describe the difference in specific sound level between the before and after situations.

3.4.2.2 Increases or decreases in relevant specific sound levels or other features are indicative of negative or positive noise impacts of the development respectively.

3.4.2.3 An example of this type of assessment is the assessment of road traffic noise impacts as described in the Department of Transport's Design Manual for Road and Bridges Vol 11.

3.4.2.4 The simple comparison of noise levels before and after a development is an attractive concept as it is relatively straightforward an uncomplicated concept for the lay person to understand, and is presented as such in the description of the perception of noise levels in the glossary of terms attached to the Sharps Redmore report dated the 21st June 2005.

3.4.2.5 Unfortunately however, for most situations, the assessment of noise impact is not simple or uncomplicated because the subjective human response to noise isn't and therefore cannot be based solely the numerical difference in noise levels with and without the development, although establishing these differences can be an important starting point

3.4.2.6 Usually it is also necessary to qualify the simple deduction of any change in noise level by considering what might be the effect of any differences between the existing and future situations in either the type of noise source or the nature of any change in noise or other factors, on whether the numerical change in noise level can be used alone to judge the extent of any noise impact. The various factors that have been identified as influencing this process include:

- The nature of the noise impact e.g. interference with amenity, annoyance or sleep disturbance;
- The averaging time period of any noise measurements;
- The time of day that noise impact might arise;

- The characteristics of the noise source (intermittency, variability etc.);
- The duration and frequency of occurrence of the noise impact;
- The spectral characteristics of the noise;
- The absolute level of the noise;
- The influence of the noise indicator used;
- The nature and character of the locality and its existing acoustic environment;

3.4.2.6 The above qualification of the assessment of noise using comparison of noise levels before and after a development is a reflection of the important limitation of many quantitative noise level based assessment methods, which is that the nature and character of a noise may make it distinguishable and disturbing even though it does not exceed or may even be below the existing background and ambient noise levels.

3.4.3 Context comparisons - Relative

3.4.3.1 Context comparisons are carried out by comparing specific sound levels from a source, including any correction factors to allow for the nature and character of the noise under consideration making it more noticeable, against appropriate indicators of the pre-existing situation before the development takes place. Appropriate indicators of the pre-existing situation may include either or both the ambient and residual sound levels. Examples of context comparisons might include comparing specific sound levels indicated by $L_{Amax,t}$ or $L_{Aeq,t}$ (measured with the contributions made by all sound sources other than the specific sound under investigation having been suppressed) against ambient or residual sound levels indicated by existing $L_{Aeq,t}$ or $L_{A90,t}$ ambient and background noise levels respectively without the development.

3.4.3.2 Exceedances of specific sound levels corrected for characteristics which may make the noise more noticable over the pre-existing noise levels are indicative of the possibility of negative impacts of the development.

3.4.3.3 An example of this type of assessment is the BS 4142:1997 - Method for rating industrial noise affecting a mixed industrial and residential areas.

3.4.3.4 BS 4142:1997 specifically takes into account correction factors that allow for any enhancement of impact due to the nature and character of the noise under consideration making it more noticeable.

3.4.3.5 With BS 4142:1997 the measured background noise level ($L_{A90,t}$) is subtracted from the rating noise level (the $L_{Aeq,t}$ of the noise in question corrected for acoustic features which make it more noticeable) under investigation. Paragraph 9 of BS 4142:1997 advises that as the difference increases, the likelihood of complaints increases, and that:

- A difference of around 10 dB indicates that complaint are likely
- A difference of around 5 dB is of marginal significance
- If the rating level is more than 10 dB below the measured background noise level this is a positive indication that complaints are unlikely.

3.5 Section 2.3 of the Sharps Redmore partnership report dated 22nd April 2003 states that a benchmark comparison (fixed limit is the term they use) type assessment method has been used to analyse noise from the proposed concrete batching activity in the appeal site.

3.5 In particular the Sharps Redmore Partnership report dated 22nd April 2003 relies on the recommended guideline noise levels from BS 8233:1999 and the WHO guidelines for community noise (1999).

3.6 The Sharps Redmore Partnership report dated 22nd April 2003 and the addendum report both regard the WHO external guideline noise level values of $L_{Aeq,16hr}$ =50/55 dB as appropriate, as they claim it is "the most useful assessment criteria to this case".

3.7 In my view it is not appropriate to use these sources of guidance in the context of this development proposal, as the recommended guideline noise levels from BS 8233:1999 and the WHO guidelines for community noise are only appropriate for assessing the impact of particular types of noise.

3.8 For example, section 7.3 of BS 8233:1999 is explicit in stating that its recommended guideline noise levels should only be used to assess noise sources which are "steady such as road traffic, mechanical services or continually running plant". Additionally section 7.6.1.2 of BS 8233:1999 goes on to advise that residents will usually tolerate higher levels of anonymous noise, such as that from road traffic, than noise from non-anonymous sources, and that the guideline noise levels it recommends are for anonymous noise only.

3.9 Whilst the WHO guidelines for community noise does recommend sound level values for prevention of annoyance, section three of the executive summary to this document states that "to protect the majority of people from being seriously annoyed during the daytime, the outdoor sound level from steady, continuous noise should not exceed 55 dB LAeq on balconies, terraces and in outdoor living areas. To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound level should not exceed 50 dB LAeq. Where it is practical and feasible, the lower outdoor sound level should be considered the maximum desirable sound level for new development". It is important to note that the WHO qualifies its advice on external noise levels and annoyance by stating that the noise in question should be "steady, continuous noise", which is clearly not the case in regard to this development proposal where the noise emissions are likely to be variable and intermittent.

3.10 Section 2.5 of the Sharps Redmore partnership report dated 22nd April 2003 correctly states that use of the BS 4142:1997 - method for rating industrial noise affecting a mixed industrial and residential areas, which is a context comparison type noise assessment, should only be used to assess noise that is industrial in nature. In my view the dominant noises emitted by this development are likely to be industrial in nature, being emitted by stationary plant or non-moving mobile plant as part of the process of turning the raw materials of aggregate, sand, cement and water into the finished manufactured product of concrete.

3.11 To illustrate the point that BS 4142 is suited to the assessment of industrial noise or noise of an industrial nature I would draw your attention to the decision in the appeal by Tesco Stores Ltd against the decision by Herefordshire Council to refuse planning permission to extending the operating hours of a Supermarket in appeal reference APP/W1850/A/O3/1124124, shown in Appendix I. Here the inspector held that the delivery of goods and collection of waste in the service yard of a supermarket in a town centre was more than just the mere arrival and departure of the trucks, and that whilst the short term noise from movement of trucks was not noise of an industrial nature, the longer term noise of the truck being unloaded or loaded, with tail gate lifts, trolleys and pallet lifters being used was noise of an industrial nature. As such noise has been held to be noise of an industrial nature this presents an even stronger case that noise from plant directly associated with manufacture of concrete is at least noise of an industrial nature and I my view is industrial noise, and therefore clearly comes under the terms of reference of BS 4142:1997.

3.12 Further support for the view that BS 4142:199 is suited to the assessment of industrial noise is also found in the appeal by Conrad Phoenix (Canada Water) Ltd against the decision by the London Borough of Southwark to refuse planning permission for development of blocks of flats adjacent to a major newspaper printing works in appeal reference APP/A5840/A/04/1142305, shown in Appendix I. Here the inspector rejected the use of BS 8233:1999 (and by association the WHO Community noise guidelines) for assessment of noise of an industrial nature which was not steady and contained features likely to make it more noticeable and instead accepted that BS 4142:1997 was more appropriate to assessing this type of noise. The inspector also accepted that using long time averaging periods for noise measurements was likely to underestimate the impact of intermittent noise of an industrial nature which for periods much shorter than the averaging time period.

3.13 However, section 2.5 of Sharps Redmore Partnership report dated 22nd April 2003 then goes on to incorrectly state that BS 4142 is better suited to the assessment of steady noise (unlike the WHO guidelines and BS 8233 referenced by Sharps Redmore which both restrict their application to steady continual noises only). To be precise in rebutting this point, I must point out that previous versions of the BS 4142 standard prior to the current edition did refer to "steady noise", but the second paragraph of the foreward to the latest version of BS 4142 (1997) specifically refers to the term now being deleted following revision of the standard, and the text makes several references to using the standard to assess the impacts of noises that are not steady and are instead "intermittent or cyclic" – e.g. sections 6.3.1.3 and 6.3.1.4, and the note to section 6.3.8; or "fluctuates at random" – e.g. section 6.3.11.

3.14 In the light of the above I cannot agree with the last sentence in section 2.5 of the Sharps Redmore Partnership report dated 22nd April 2003, which states that "The use of BS4142 is not applicable here".

3.15 Instead, in my view the use of BS 4142:1997 to assess the noise impacts of the proposed concrete batching plant is wholly appropriate as it is specifically suited to noise of an industrial nature and is capable of taking into account elements of the nature and character of a noise which might enhance its ability to disturb. Whereas the sources of guidance that Sharps Redmore Partnership have used are limited in their scope, do not specifically relate to industrial noise and are not capable of taking into account elements of the nature and character of a noise which might enhance its ability to disturb.

3.16 Additionally it should be noted that should the development go ahead as proposed and the local authority receive complaints regarding noise, then any meaningful objective noise level based assessment of the noise would have to include and be guided by a BS 4242:1997 based assessment.

3.17 In discussing fixed noise limits (benchmark comparisons as I've described them above) the Sharps Redmore Partnership in section 2.8 of their report dated 22nd April 2003 refer to noise exposure categories (NECs) from PPG 24. This is puzzling in the context of this application, which concerns a new noisy development, as the use of the NEC methodology and criteria from

PPG 24 is reserved for the situation where the development of new noise sensitive premises is proposed near to sources of transportation noise or approximately equal mixtures of transportation noise and industrial noise. Paragraph 3 of Annex 1 of PPG 24 describes it is bad practice to use the NECs for assessment of industrial noise of new housing and paragraph 4 of Annex 1 of PPG 24 is explicit in prohibiting the use of the NEC procedure to assess the impacts of a new noise generating development on existing noise sensitive premises.

3.18 Section 3 of the Sharps Redmore Partnership report dated 22nd April 2003 and Appendix F of the Sharps Redmore Partnership report dated 21st June 2005 include the results of three noise surveys carried out in an attempt to establish the existing noise climate in the locality, and in particular at Chettle Court, a large block of flats overlooking and to the south of the development site.

3.19 The first noise survey was carried out on the 17th April 2003 and is described in the Sharps Redmore Partnership report dated 22nd April 2003. This noise survey was carried out initially at the entrance to Chettle Court, then stopped, and re-started and completed at the entrance to the development site, as access to the rear of Chettle Court was not available and it is claimed by Sharps Redmore that the noise levels at the entrance to Chettle Court and at the entrance to the development site were "the same" on this day, this may have been so but the acoustic climate at the entrance to Chettle court is different to the rear of Chettle Court, so measurements at either the entrance to Chettle court or the Development site are unlikely to be representative of typical conditions at the rear of Chettle court facing the development site. The fact that noise measurements were not taken at the rear of Chettle Court suggests that these noise measurements are not likely to be representative of the noise climate at the rear of Chettle Court. Additionally noise level measurements were only taken from 0700 hrs to 1345 hrs and were not continuous, as each hour contains a 15 minute break in the measurements. Consequently, there is significant uncertainty whether these noise measurements reflect the typical acoustic environment at the rear of Chettle Court.

3.20 The results of a second and third noise survey carried out in June 2005 are presented in Appendix F of the Sharps Redmore Partnership report dated 21st June 2005.

3.21 For these noise surveys access to the rear of Chettle court was available and the reported measurements were continual and cover virtually the whole of the proposed working day of the concrete batching plant. The results of the second Sharps Redmore noise survey are lower than those reported previously and the Sharps Redmore Partnership report dated 21st June 2005 speculates that the difference is due to lower levels of activity on the Cranford Way commercial estate now that the TNT operation has left and the wind direction. It should be noted that the reported wind direction during the second Sharps Redmore noise survey was from the south and south-west, which tends to be the prevailing wind direction in London and therefore noise measurements made under these conditions would be more representative of typical baseline noise levels under the most commonly occurring wind conditions. In my view the difference between the earlier and later noise surveys is most probably due to the noise levels at the rear of Chettle court being likely to be lower than at the entrance to the development site most normal circumstances, as Chettle court it is further away from the nearby railway and the sources of noise on the Cranford Way commercial estate than the entrance to the development site. I am therefore satisfied that the baseline noise levels measured at the rear of Chettle Court as reported in the Sharps Redmore report are reasonably indicative of the typical noise levels found at this location.

3.22 Appendix F of the Sharps Redmore Partnership report dated 21st June 2005 also presents the results of a third short-term noise survey carried out in June 2005. The Sharps Redmore addendum report states that the objective of this survey was to "check relative levels at Chettle Court versus the application site entrance". At first sight the reported noise levels suggest that the noise levels at Chettle Court and the application site entrance are similar. But the noise levels were not measured simultaneously at each location, which would have given a clear indication of the relationship between the noise levels at each location. Instead the noise levels were measured on four occasions in successive periods, at first Chettle Court and then at the application site entrance, with an approximate 10 to 15 minute break in between each measurement, presumably to allow the acoustician to travel from one location to the other. Consequently, differences in activity levels and therefore noise levels in the locality, from one measurement period to another, could also account for the apparent similarity between the measured noise levels between Chettle Court and the application site entrance, rather than their being a close relationship between the simultaneous noise levels at each location.

3.23 A key difference between the Sharps Redmore Partnership report dated 22nd April 2003 and their report dated 21st June 2005, is the inclusion within the development of an acoustic screen between the loading area and Chettle Court. The purpose of the acoustic screen is to attenuate the noise transmission from the loading of the stationery concrete mixer trucks.

3.24 Appendices E1 and E2 to the Sharps Redmore Partnership report dated 21st June 2005 purport to show how the attenuation effect of the acoustic screen has been calculated.

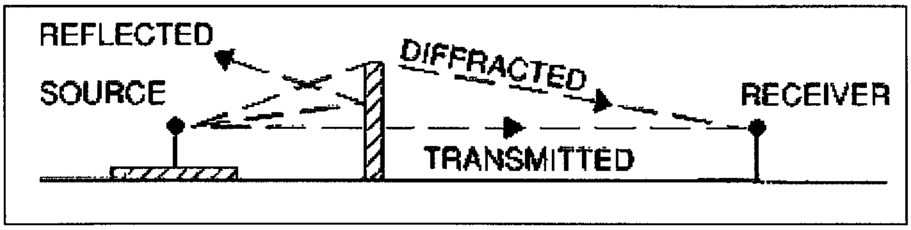
3.22 However, the calculation sheets in appendices E1 and E2 show a basic barrier attenuation calculation. The calculation appears to only predict the barrier attenuation from the pathway directly over the top of the acoustic screen and does not include lateral transmission around the eastern end of the acoustic screen (transmission around the western end is prevented by the proposed building housing the offices, mixing plant etc.). This is a critical omission when assessing the performance of an acoustic screen, because when a noise barrier is placed between the noise source and the receiver, the barrier disperses the sound along five paths, for example:

- a diffracted or bent path over the top of the barrier deflected an angle ø from a straight path on a line drawn from the source to the top of the barrier,
- two diffracted or bent paths, one around each end of the barrier,
- a reflected path away from the receiver

and

- a transmitted path through the barrier.

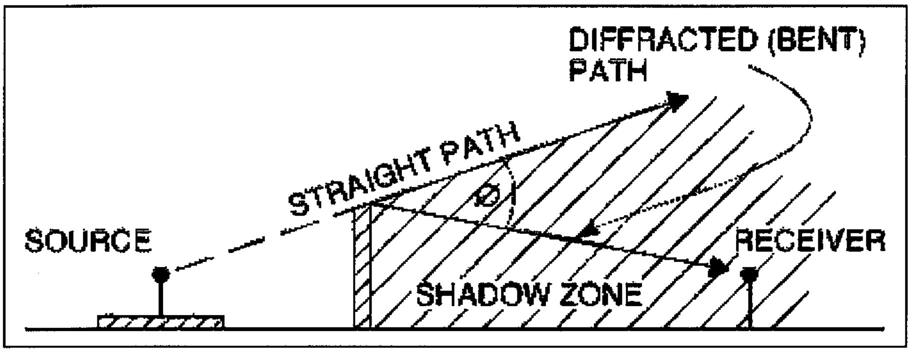
Figure 1 below shows the noise transmission pathways reflected, through and over a barrier.



NB there are also pathways around either end of the barrier not shown in fig 1

3.23 Diffraction of sound over the top of the acoustic barrier produces a shadow zone behind the barrier, with the boundary of this shadow zone outlined by a straight line drawn from the noise source over the top of the barrier wall. All receivers located within the shadow zone will experience some degree of sound attenuation. The amount of nose reduction is directly related to the diffraction angle ø between the straight path and the diffracted path over the barrier, and similarly for each end of the barrier, as shown in figure 2 below.

Figure 2: Illustration of the angle Ø between the straight path and the diffracted path over a barrier, and the acoustic shadow zone between the barrier and receiver.



NB: There is also an equivalent angle ø in relation to the lateral diffraction of noise around each end of the barrier, not shown in fig 2

3.24 The greater the angle ø the more the barrier attenuation increases. The higher either the source or the receiver relative to the top of the barrier, the smaller the angle ø and the less the attenuation. The angle ø increases as the effective height and length of the barrier relative to the noise source and the receiver grows. Thus, barrier attenuation is a function of the barrier height and the distances between the source, barrier and receiver and the height of the source and receiver. As a rule, an acoustic barrier works most effectively when placed close to either the noise source or the receiver, and the noise source and receiver are both at a lower height than the top of the barrier, and the lateral pathways around the barrier and the direct path way through the barrier attenuate the noise transmitted to the source by 10 dBA or more compared to the path over the top of the barrier.

3.25 Unfortunately, as Sharps Redmore have not included lateral transmission around the acoustic screen in their assessment of the noise reduction provided by the acoustic screen, there is considerable risk that their assumed barrier attenuation derived from their barrier calculations is an over estimate of likely performance, and therefore their prediction of noise levels from the development at Chettle court is an underestimate of the noise levels likely to occur should the development go ahead as per the application.

3.25 Another area of concern regarding the prediction of the noise attenuation provided by the acoustic screen is the apparent disparity in the receiver heights Sharps Redmore have used to represent Chettle court in the calculations in Appendices E 1 and E2 of their addendum report, and the much higher height at which Chettle court is found relative to the development site in reality. As pointed out above, the higher a receiver is relative to the source and the height of the barrier, the less the noise attenuation provided by any intervening barrier. In predicting the insertion loss of the acoustic screen Sharps Redmore have used a receiver height no greater than 13.5 metres in their Appendices E1 and E2 screening calculations, whereas visual comparison of the land heights suggests that this is an underestimate of the difference in ground levels between the development site and Chettle court.

3.26 In reality, the Ordinance Survey report that the development site is approximately 37.1 metres above sea height, and ground level at Chettle Court is approximately 58.7 metres above sea height, a difference of approximately 21.6 metres. The underestimation by Sharps Redmore of the difference in ground levels between the development site and Chettle court, and therefore the noise receiver heights relative to the noise source and acoustic barrier height, is further compounded by the fact that Chettle court is an eight storey block of flats approximately 17.2 metres high, so that the flats on the upper floors are much higher than those at ground level and approximately 38.8 metres higher than the development site, and therefore likely to benefit less from the proposed acoustic screen.

3.27 Another factor not taken into account by Sharps Redmore in the prediction of the attenuation of noise by the acoustic screen is the reflection of noise off the source side of the acoustic screen back onto the truck, and subsequent re-radiation in the direction of Chettle court. This has potential to reduce the attenuation of noise by the acoustic screen by approximately 3 dBA.

3.28 Section 3.7 of the report states that based on their calculated screening attenuation and in the judgement of Sharps Redmore Partnership a screening attenuation of "13 dB" can be ascribed to the joint noise sources of the motor revving to turn the drum as the lorry is being filled and the exhaust outlet. The lack of an A added to the dB unit indicates that the linear weighted decibel has been used to estimate the screening attenuation, which would sound significantly less a reduction in noise to the average listener than if the dBA i.e. the A –weighted decibel, were used to describe the noise reduction.

3.29 Appendix B shows the calculation of the barrier attenuation from the proposed screen using the principles of ISO 9613. For the highest noise source identified by Sharps Redmore at 3.2 metres, this produces barrier attenuation rates of 12.6 dBA for a receiver 1.5 metres above ground level at Chettle Court and 11.2 dBA for a receiver position 1.5 metres below the top of Chettle Court.

3.30 Consequently, in the light of the matters raised in points 3.23, 3.24, 3.25, 3.26 and 3.27 I am concerned that the estimation of noise reduction from the proposed acoustic screen used in the Sharps Redmore prediction of the propagation of noise from the loading of the trucks to Chettle court may be an overestimate, thereby leading to underestimation of the likely noise levels at Chettle court.

3.31 Section 3.8 of the Sharps Remore report dated the 21st June 2005 claims that by turning this proposed development through 90^0 compared to the previous application, a directivity loss of at least "5 dB" would be gained (again the use of the linear un-weighted decibel means that this would sound significantly less a reduction in noise to the average listener than if the dBA, i.e. the A –weighted, decibel, were used to describe the noise reduction). The directivity of the noise source and therefore any potential directivity loss is not substantiated in either of the Sharps Redmore reports. It is therefore not possible to ascribe such a directivity loss based on the information presented by Sharps Redmore. Additionally, acoustic reflections off the building holding the batching plant, workshops and offices etc. will tend to counter any directivity loss. Consequently, I do not share the view that the predicted noise levels at Chettle court contained in the Sharps Redmore report dated the 21st June 2005 are overstated, and I regard it is prudent to ignore any directivity loss as the direction, magnitude and significance of any such loss has not been established.

3.32 Sections 3.9 to 3.12 of the Sharps Redmore report dated the 21st June 2005 present their final predicted noise levels at Chettle court and compares them with those predicted in their report dated 22nd April 2003. As outlined above there is a significant risk that the predicted noise levels are an underestimate of the noise levels likely to occur and the assessment of the impact of the predicted noise levels from the proposed concrete batching plant using fixed benchmark comparisons (fixed limits) such as BS 8223:1999 and the WHO guidelines for community noise is inappropriate in the context of the development proposal subject to this appeal.

3.33 A potentially significant omission from both the Sharps Redmore reports is the assessment of noise impacts from sources of noise other than the movement and loading of the trucks.

3.34 Even though the delivery of aggregates by rail is likely to take place early in the morning for several hours between approximately 0600 and 1000 hrs, it was not assessed in either of the Sharps Redmore reports beyond stating it takes place further away from Chettle court than the loading of the trucks. But any increased distance attenuation could be offset by higher source noise levels from the delivery of aggregates by rail compared to loading of he trucks and by the lower background and ambient noise levels and greater noise sensitivity early in the morning. However, what the predicted noise levels and impacts are at noise sensitive receivers from aggregates by rail is not made clear by either of the Sharps Redmore reports.

3.35 Another noise source not assessed by Sharps Redmore are the motors used to drive the screw feed mechanisms which lift cement from the bottom of the storage silos to the top of the batching plant.

3.36 Additionally, experience of other concrete batching plants suggests some other noise sources that have not been assessed by Sharps Redmore. For example, at other concrete batching plants at the end of each working day the trucks are loaded with 20 mm aggregate and water, without cement or sand, and then the mixing drum is spun at high speed to scour the inside and remove excess concrete before it hardens.

3.37 Experience of other concrete batching plants suggests another potentially very noisy activity that has not been assessed by Sharps Redmore which could arise from time to time, is the use of lump hammers and/or pneumatic/electric hammer drills to dislodge encrusted concrete from the inside of the mixing drums and around the hopper mouth.

4.0 ISO 9613 PREDICTION OF PROPAGATION OF NOISE AND BS 4142 ASSESSMENT OF NOISE IMPACTS

4.1 ISO 9613: 1992 Pts 1 & 2: Acoustics - Attenuation of Sound Outdoors is an internationally recognised methodology for predicting propagation of noise outdoors.

4.2 ISO 9613 specifies 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.

4.3 The method can also be used to predict A-weighted sound pressure level as specified in IS0 1996/BS7445. These predicted A-weighted sound pressure levels can encompass a variety of meteorological conditions. However, in this case different meteorological conditions have not factored in as they are largely unknown and instead the calculations have based on neutral meteorological conditions which neither favour or discriminate against propagation from source to the receiver, as the distance from the source to receiver is relatively short and as a consequence the likely influence of ordinary metrological conditions on propagation is likely to be negligible to insignificant.

4.4 The method specified in part 2 of IS0 9613 consists specifically of octave-band algorithms (with nominal mid-band frequencies from 63 Hz to 8 kHz) for calculating the attenuation of sound that originates from a point sound source, or an assembly of point sources. The source (or sources) may be moving or stationary. Specific terms are provided in the algorithms for the following physical effects:

- geometrical divergence A_{div}; - Attenuation due to distance.

  $A_{div} = [20 \, Log(d/d_0) + 11] \, dB$

  where: d= the distance from source to receiver (m) and d_0 is the reference distance (1 m)

- atmospheric absorption A_{atm} ; - Attenuation due to the air absorbing sound energy

  $A_{atm} = \alpha d/l\,000$

  where; α = the atmospheric absorption coefficient ($dBKm^{-1}$), d = distance in kilomertres

- ground effect A_{gr}; - Attenuation or reinforcement of noise levels due to absorption or refection by the intervening ground between the noise source and receiver

  A_{gr} = A, + A, + A,

  Where A, = attenuation in the source region, A, = attenuation in the receiver region and A, = attenuation in the middle region

- screening by obstacles A_{bar}; - Attenuation by barriers interfering with the transmission of the noise from the noise source to the receiver

  Where A_{bar} is calculated using an octave band based Makaewa/Fresnel number based algorithm taking into account diffraction over the top and around the edges of any barrier

4.5 Additionally the ISO 9613 methodology includes allowances for reflection of sound off surfaces in the vertical plane (reflections of the ground and in the horizontal plane are allowed for in the calculation of the ground effect).

4.6 The ISO 9613 method is applicable in practice to a great variety of noise sources and environments. It is applicable, directly or indirectly, to most situations concerning road or rail traffic, commercial and industrial noise sources, construction activities, and many other ground-based noise sources. It does not apply to sound from aircraft in flight, or to blast waves from mining, military or similar operations.

4.7 The calculation of the equivalent continuous downwind octave-band sound pressure level at a receiver location, $L_{jr(DW)}$, is calculated for each point source, and its image sources, in the eight octave bands with nominal mid-band frequencies from 63 Hz to 8 kHz, using

$L_{ft(DW)}$ = Lw + Dc - A

Where:

L_w, is the octave-band sound power level, in decibels, produced by the point sound source relative to a reference sound power of one picowatt (lpW); The sound power level of a noise source is a means of describing its noise output independent of any influence from the environment it which it is placed

D_c is the directivity correction, in decibels, that describes the extent by which the sound level from the sound source varies with angle for a listener at constant distance from the sound source. In this case an omni-directional point sound sources radiating uniformly into free space in all directions has been assumed and no allowance for source directivity has been made as there is no quantified information regarding any source directivity effects;

A is the octave-band attenuation, in decibels, that occurs during propagation from the point sound source to the receiver.

4.8 The attenuation term *A* is given by

$A = A_{div} + A_{atm} + A_{gr} + A_{bar} + A_{mis}$

Where:

- A_{div} is the attenuation due to geometrical divergence;
- A_{atm} is the attenuation due to atmospheric absorption;
- A_{gr} is the attenuation due to the ground effect;
- A_{bar} is the attenuation due to a barrier;
- A_{mis} is the attenuation due to miscellaneous other effects (none have been used in this case)

4.9 For the loading of the concrete trucks assessed in this proof the emission sound power used have been derived from the data on noise levels from loading of the trucks in the Sharps Redmore reports, which were corroborated by measurement taken by the author of loading of mixig trucks at London Concrete.

4.10 The significance of the attenuation in order of priority, with the most attenuation first is:

- Geometrical divergence - approximately 53.5dBA
- Barrier attenuation – approximately 11.2 to 12.6 dBA depending on source/receiver geometry, upto 3 dBA less with re-radiation of sound reflected of the acoustic screen off the truck.
- Ground effect - approximately –1.5 dBA
- Atmospheric conditions – negligible

4.11 The details of the ISO 9613 calculation carried out as part of this proof are provided in Appendix B. However, table 1 below provides a summary of the ISO 9613 predicted noise levels at Chettle Court from loading of a mixer truck:

Table 1: Summary of the ISO 9613 predicted noise levels at Chettle Court from loading of a mixer truck:

Source height	**Predicted noise level 1.5 m above ground level at Chettle Court – $L_{Aeq,t}$ dB**	**Predicted noise level 1.5 m below the roof of Chettle Court – $L_{Aeq,t}$ dB**
1 m	45.1	45.0
3.2	49.5	50.7
Combined noise level - – $L_{Aeq,t}$ dB	50.8	51.7

4.12 At this point it is worth noting that the above predicted noise levels at Chettle Court from loading of a mixer truck, which include the barrier effect of the proposed acoustic screen are higher than equivalent noise levels given in the second Sharps Redmore assessment of the proposed scheme:

4.13 Having predicted the noise level at Chettle Court from loading cement trucks on the development site, the impact of these predicted noise levels needs to be assessed.

4.14 As explained earlier in this proof the appropriate assessment methodology for this proposed development is contained in BS 4142:1997 method for rating industrial noise affecting a mixed industrial and residential areas.

4.15 Fundamental to carrying out a BS 4142:1997 assessment of the noise is establishing the typical $L_{A90,t}$ background noise level at Chettle court.

4.16 As described above the baseline noise survey carried out by Sharps Redomore on 14th and 15th June 2005 and the presented in their addendum report is a suitable basis for establishing the typical $L_{A90,t}$ background noise level at Chettle court. The table in Appendix F2 of the Sharps Redmore addendum report presented their noise level as measured at the rear of Chettle court, which can be summarised as follows:

Table 2: Summary of $L_{A90,t}$ background noise levels measured by Sharps Redmore at rear of Chettle Court

Mean $L_{A90,\,1\,hour}$ dB	**Lowest $L_{A90,\,1\,hour}$ dB**	**Highest $L_{A90,\,1\,hour}$ dB**
41.9	40.0 (0700-0800 hrs)	43.5 (1200 –1400 hrs)

4.17 As part of the BS 4142:1997 assessment process the specific noise level of the source in question is corrected for a reference time, of 1 hour in this case as the noise in question is only likely to occur during the day time. The correction for the reference time is based on the ratio of time the noise occurs to the time the noise does not occur within the reference time period. During observations at London Concrete's Wembley concrete batching the loading of their concrete trucks took between 5 and 7 minutes (8 loads). Consequently, this evidence takes a typical loading period to be 6 minutes. The table below shows the reference time correction for upto five London Concrete trucks loaded in one hour.

Table 3; Reference time correction for at least one and up to five London Concrete trucks loaded in one hour.

Load time (mins)	No loads in 1 hour	Total time (mins)	Total time/ 60	Log total time/60	Reference time correction (dBA)
6	1	6	0.1	-1	-10
6	2	12	0.2	0.7	-7
6	3	18	0.3	0.5	-5.
6	4	24	0.4	0.4	-4
6	5	30	0.5	0.3	-3.

4.17 When the reference time correction is applied to the specific noise levels predicted at Chettle court this produces the following corrected specific noise levels:

Table 4: Specific noise levels at Chettle court corrected for a reference time period of 1 hour

Location at Chettle court	**Specific noise level (dBA)**	**1 truck an hour (-10dBA)**	**2 trucks an hour (-7 dBA)**	**3 trucks an hour (-5 dBA)**	**4 trucks an hour (-4 dBA)**	**5 trucks an hour (-3 dBA)**
1.5m above ground level	50.8	40.8	43.8	45.8	46.8	47.8
1.5m below roof level	51.7	41.7	44.7	46.7	47.7	48.7

4.18 Having corrected the specific noise level for the relevant reference time, in order to obtain the rating level of the noise in question the specific noise level is corrected by the addition of 5 dBA to take account of acoustic features that might increase the likelihood of complaint. In this case the noise is irregular enough to attract attention and the addition of the 5 dBA correction factor is appropriate, therefore the rating levels are as follows:

Table 5: The predicted rating level at Chettle Court of the noise from the loading of concrete trucks at the proposed development site.

Location at Chettle court	**1 truck an hour (dBA)**	**2 trucks an hour (dBA)**	**3 trucks an hour (dBA)**	**4 trucks an hour (dBA)**	**5 trucks an hour (dBA)**
1.5 m above ground level	45.8	48.8	50.8	51.8	52.8
1.5 m below roof level	46.7	49.7	51.7	52.7	53.7

4.19 Having determined the rating level at Chettle Court of the noise from the loading of concrete trucks at the proposed development site the next step is to subtract the typical $L_{A90,\ 1\ hour}$ background noise level in order to calculate the difference, as follows:

Table 6: The difference between the BS4142 rating level at Chettle Court of the noise from the loading of concrete trucks at the proposed development site and the typical $L_{A90,\ 1\ hour}$ background noise level at Chettle court (42 dBA).

Location at Chettle court	**1 truck an hour (dBA)**	**2 trucks an hour (dBA)**	**3 trucks an hour (dBA)**	**4 trucks an hour (dBA)**	**5 trucks an hour (dBA)**
1.5 m above ground level	3.8	6.8	8.8	9.8	10.8

1.5 m below roof level	4.7	7.7	9.7	10.7	11.7

4.20 Paragraph 9 of BS 4142:1997 advises that as the difference between the rating level of the noise in question and the typical background noise level increases, the likelihood of complaints increases, and that:

- A difference of around 10 dB indicates that complaint are likely
- A difference of around 5 dB is of marginal significance
- If the rating level is more than 10 dB below the measured background noise level then this is a positive indication that complaints are unlikely.

4.21 The third bullet point above indicates that complaints may be received even if the rating level of the noise in question is below the measured background noise level.

4.22 As table 6 above indicates the difference in predicted rating level and typical background noise level at Chettle court during any hour from 0700 to 1900 hrs, does not go below the typical background noise level for even a single loading of a truck in one hour and exceeds being of marginal significance once 2 an hour are loaded and approaches or exceeds the difference at which complaints are likely once 3 or more trucks an hour are loaded.

4.23 The above assessment is based on the mean $L_{A90,\ 1\ hour}$ background noise level at Chettle court of 42 dB taken from the Sharps Redmore survey of the $14^{th}/15^{th}$ June 2005. During periods when the $L_{A90,\ 1\ hour}$ background noise level at Chettle court is less than this e.g. between 0700 to 0800 hrs the $L_{A90,\ 1\ hour}$ background noise level was 40 dBA, the difference in rating level and $L_{A90,\ 1\ hour}$ background noise level at Chettle court will increase, predicting a more adverse impact at these times than later in the day when the $L_{A90,\ 1\ hour}$ background noise level at Chettle court is higher then the mean.

4.24 Additionally during the observations at the London Concrete batching plant at Wembley it was noted that all the trucks normally “resident” at the site (8) were loaded and despatched within the first hour between 0700 and 0800 hrs, plus several other private contractors. This pattern of hectic early morning operation with most trucks being loaded and dispatched in the first hour is to be expected with an industry servicing the construction business, as most construction sites in London start operations between 0700 and 0800 hrs and will want concrete from close to the start of their working day.

4.25 Conversely, during periods when the $L_{A90,\ 1\ hour}$ background noise level at Chettle court is more than the mean value of 42 dBA e.g. between 1300 to 1400 hrs the $L_{A90,\ 1\ hour}$ background noise level was 43.5 dBA, the difference in rating level and $L_{A90,\ 1\ hour}$ background noise level at Chettle court will decrease, suggesting a less adverse, though still significant, negative impact at these times compared to earlier in the day.

4.26 It is tempting to simply trade off the increase in adverse impact during the early periods of the day when the $L_{A90,\ 1\ hour}$ background noise level at Chettle court is less than the mean; against those periods later in the day when the $L_{A90,\ 1\ hour}$ background noise level at Chettle court is more than the mean. However, I would caution against this approach at it overlooks the greater noise sensitivity early in the day as persons are awakening and starting to their daily routine, compared to later in the day when most persons are likely to be more active and less readily disturbed by intrusive noise.

4.27 Factors other than noise level influence the impact of noise of an industrial nature, including what have been described as "non-acoustic factors"[1]. The degree of adverse response to noise is clearly influenced by various "non-acoustic factors" including attitudinal factors such as fear of the noise source and awareness or perception of non-noise problems associated with the noise source. These non-acoustic factors can significantly influence how persons respond to noise and can render noise that would be tolerable in a particular situation intolerable in other circumstances under investigation. As yet, and it may be never achieved, there is no combined model of all the interrelations between noise exposure, annoyance and all the non-acoustic variables that can influence noise annoyance that can be used to confidently predict community response. It may be that the most that can be done is for the non-acoustic factors to be simply be borne in mind when using noise level based guidance to assess the impact of noise, and there should be an awareness that noise level alone is only part of the mosaic of issues determining planning issues and that sensible judgment in regard to non-acoustic factors that may influence community response has to be applied.

[1] Berry BF & Porter N – Defra Report NANR 5 - Review and analysis of published research into the adverse effects of industrial noise, in support of the revision of planning guidance: Final Report, March 2004..

5.0 CONCLUSSIONS

5.1 The noise and acoustic information submitted in support of the application significantly underestimated the predicted propagation of noise from the development site to nearby existing noise sensitive premises.

5.2 The applicant's noise assessment methodology and criteria are not appropriate to the main noises emitted by the development.

5.3 Alternative assessment of the main noise identified by the applicant's noise assessment emitted by the development, using appropriate methodology and criteria indicates that unacceptable impacts on the amenity of nearby noise sensitive premises are likely should the development go ahead as per the application subject to this inquiry.

APPENDIX A
GLOSSARY OF TERMS

A1. DEFINITIONS AND UNITS

A1.1 Noise is defined as unwanted sound. The range of audible sound is from 0dB to 140dB, which is taken to be the threshold of pain. The sound pressure detected by the human ear covers an extremely wide range. The decibel (dB) is used to condense this range into a manageable scale by taking the logarithm of the ratio of the sound pressure and a reference sound pressure.

A1.2 The unit of frequency is Hz. 1 Hz is one pressure fluctuation in one second. The frequency response of the ear is usually taken to be about 16Hz (number of oscillations per second) to 18,000Hz. The ear does not respond equally to different frequencies at the same level. It is more sensitive in the mid-frequency range than at the lower and higher frequencies, and because of this, the low and high frequency component of a sound are reduced in importance by applying a weighting (filtering) circuit to the noise measuring instrument. The weighting which is most used and which correlates best with the subjective response to noise is the dB(A) weighting. This electronic filter matches the variation in the frequency sensitivity of the meter to that of the human ear. This is an internationally accepted standard for noise measurements.

A1.3 The ear can just distinguish a difference in loudness between two noise sources when there is a 3dB(A) difference between them. Also when two sound sources of the same noise level are combined the resultant level is 3dB(A) higher than the single source. When two sounds differ by 10dB(A), one is said to be twice as loud as the other.

A1.4 A few examples of noise of various levels are given below:

Sound Level, dB(A)	Environmental Condition
0 – 10	Threshold of hearing
10 - 20	Broadcasting Studio
20 – 30	Bedroom at night

30 – 40	Library
40 – 50	Living room urban area
50 – 60	Typical Business Offices
60 – 70	Conversation Speech
70 – 80	Average traffic busy street
80 – 90	Inside bus
100 – 110	Alarm Clock (1m away)
110 – 120	Loud car horn (1m away)
120 – 130	Pneumatic drill (1m away)
130 - 140	Threshold of pain

A1.5 The subjective response to a noise is dependent not only upon the sound pressure level and its frequency, but also its intermittency. Various statistical indices have been developed to try and correlate annoyances with the noise level and its fluctuations in a changing noise environment. The indices and parameters used in this report are defined below:

A1.6 L_{Aeq}: Equivalent Continuous Sound Pressure Level The A-weighted sound pressure level of a steady sound that has, over a given period, the same energy as the fluctuating sound under investigation. It is in effect the energy average level over the specified measurement period (T) and is the most widely used indicator for environmental noise.

A1.7 L_{AN}: the A-weighted sound level exceeded for N% of the measurement period. In BS7445 the L_{A90} is used to define the background noise level, i.e. the noise that would remain once all local noise sources were removed. The L_{A10} gives an indication of the upper limit of fluctuating noise and is used in the assessment of road traffic noise.

A1.8 L_{AMAX}: The maximum 'A' weighted noise level recorded during the measurement period.

A1.9 Octave band: An octave band is the interval between two discrete frequencies having a ratio of two, as a consequence the frequency range has a upper limit that is twice the frequency of the lower limit.

APPENDIX B – ISO 9613 CALCULATION SHEETS

Table 1: ISO 9613 prediction of noise levels from loading of truck, source at height of 3.2 m and receiver 1.5 m above ground level at Chettle court.

ISO9613-2:1996		Hz	63	125	250	500	1000	2000	4000	8000	Lin	A
Source sound power (L_w)		dB	91.0	95.0	102.0	106.0	109.0	109.0	104.0	94.0	113.9	113.8
Directivity index (D_I)		dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Directivity index (D_Ω)		dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Directivity correction	(D_c)	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Distance (d_p)	132.0	m										
Source height (h_s)	3.20	m										
Receiver height (h_r)	23.0	m										
Distance (d')	133.5	m										
Geometrical divergence	A_{div}	dB	53.5	53.5	53.5	53.5	53.5	53.5	53.5	53.5	53.5	53.5
Temperature / Relative humidity	10/70	C/%										
Atmospheric absorption	A_{atm}	dB	0.0	0.1	0.1	0.3	0.5	1.3	4.4	15.6	1.0	1.2
	G	d (m)										
Source region	0.0	96.0	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5		
Receiver region	0.0	132.0	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5		
Middle region	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Ground effect	A_{gr}	dB	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0
Barrier? Yes/No If Yes:	Yes	-										
Barrier to source (d_{ss})	2.1	m										
Barrier to receiver (d_{sr})	125	m										
Barrier height (h_b)	4.5	m										
D_z (Over the Top)	0.193	Shad	5.6	6.2	7.3	8.9	11.0	13.4	16.1	19.0	10.5	11.7
Lateral Pathway? Yes/No If Yes:	Yes	-										
Barrier length (LHS)	10	m										
Barrier length (RHS)	4	m										

D_z (LHS)	10.403	Shad	16.1	19.0	20.0	20.0	20.0	20.0	20.0	20.0	19.9	20.0
D_z (RHS)	1.823	Shad	9.9	12.1	14.7	17.5	20.0	20.0	20.0	20.0	18.3	19.6
D_z (Total)	-	-	3.9	5.0	6.4	8.0	10.0	11.8	13.5	14.9	9.5	10.5
Barrier effect	A_{bar}	dB	5.7	7.1	8.6	10.3	12.2	13.7	14.9	15.8	11.6	12.6
Down Wind Noise Level	L_{AT}(DW)	dB(lin)	34.7	37.3	42.7	44.9	45.8	43.5	34.2	12.1	50.8	
		dB(A)	8.5	21.2	34.1	41.7	45.8	44.7	35.2	11.0		49.5
Meteorological correction (Co)	0.0	dB										
Meteorological effect	C_{met}	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Long Term Noise Level	L_{AT}(LT)	dB(lin)	34.7	37.3	42.7	44.9	45.8	43.5	34.2	12.1	50.8	
		dB(A)	8.5	21.2	34.1	41.7	45.8	44.7	35.2	11.0		49.5

Table 2: ISO 9613 prediction of noise levels from loading of truck, source at height of 3.2 m and receiver 1.5 m below roof level of Chettle court.

ISO9613-2:1996		Hz	63	125	250	500	1000	2000	4000	8000	Lin	A
Source sound power (L_w)		dB	91.0	95.0	102.0	106.0	109.0	109.0	104.0	94.0	113.9	113.8
Directivity index (D_I)		dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Directivity index (D_Ω)		dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Directivity correction	(D_c)	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Distance (d_p)	132.0	m										
Source height (h_s)	3.20	m										
Receiver height (h_r)	37.5	m										
Distance (d')	136.4	m										
Geometrical divergence	A_{div}	dB	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7
Temperature / Relative humidity	10/70	C/%										
Atmospheric absorption	A_{atm}	dB	0.0	0.1	0.1	0.3	0.5	1.3	4.5	16.0	1.0	1.2
	G	d (m)										
Source region	0.0	10.0	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5		
Receiver region	0.0	107.0	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5		

			63	125	250	500	1000	2000	4000	8000	Lin	A
Middle region	1.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Ground effect	A_{gr}	dB	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0
Barrier? Yes/No If Yes:	Yes	-										
Barrier to source (d_{ss})	2.1	m										
Barrier to receiver (d_{sr})	125	m										
Barrier height (h_b)	4.5	m										
D_z (Over the Top)	0.103	Shad	5.2	5.6	6.2	7.3	8.9	11.0	13.4	16.1	8.8	9.6
Lateral Pathway? Yes/No If Yes:	Yes	-										
Barrier length (LHS)	100	m										
Barrier length (RHS)	4	m										
D_z (LHS)	149.133	Shad	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
D_z (RHS)	1.785	Shad	9.8	12.0	14.6	17.4	20.0	20.0	20.0	20.0	18.3	19.5
D_z (Total)	-	-	3.8	4.6	5.5	6.7	8.3	10.0	11.8	13.5	8.0	8.8
Barrier effect	A_{bar}	dB	5.7	6.7	7.8	9.2	10.7	12.2	13.7	14.9	10.4	11.2
Down Wind Noise Level	L_{AT}(DW)	dB(lin)	34.6	37.5	43.3	45.9	47.1	44.8	35.1	12.4	51.8	
		dB(A)	8.4	21.4	34.7	42.7	47.1	46.0	36.1	11.3		50.7
Meteorological correction (Co)	0.0	dB										
Meteorological effect	C_{met}	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Long Term Noise Level	L_{AT}(LT)	dB(lin)	34.6	37.5	43.3	45.9	47.1	44.8	35.1	12.4	51.8	
		dB(A)	8.4	21.4	34.7	42.7	47.1	46.0	36.1	11.3		50.7

Table 3: ISO 9613 prediction of noise levels from loading of truck, source at height of 1.0 m and receiver 1.5 m above ground level at Chettle court.

ISO9613-2:1996		Hz	63	125	250	500	1000	2000	4000	8000	Lin	A
Source sound power (L_w)		dB	91.0	95.0	102.0	106.0	109.0	109.0	104.0	94.0	113.9	113.8
Directivity index (D_I)		dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Directivity index (D_Ω)		dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Directivity correction	(D_c)	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Distance (d_p)	132.0	m										

Source height (h_s)	1.00	m										
Receiver height (h_r)	23.0	m										
Distance (d')	133.8	m										
Geometrical divergence	A_{div}	dB	53.5	53.5	53.5	53.5	53.5	53.5	53.5	53.5	53.5	53.5
Temperature / Relative humidity	10/70	C/%										
Atmospheric absorption	A_{atm}	dB	0.0	0.1	0.1	0.3	0.5	1.3	4.4	15.7	1.0	1.2
	G	d (m)										
Source region	0.0	30.0	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5		
Receiver region	1.0	132.0	-1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Middle region	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Ground effect	A_{gr}	dB	-3.0	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5
Barrier? Yes/No If Yes:	Yes	-										
Barrier to source (d_{ss})	2	m										
Barrier to receiver (d_{sr})	130	m										
Barrier height (h_b)	5	m										
D_z (Over the Top)	1.892	Shad	9.8	12.0	14.6	17.3	20.0	20.0	20.0	20.0	18.2	19.5
Lateral Pathway? Yes/No If Yes:	Yes	-										
Barrier length (LHS)	100	m										
Barrier length (RHS)	4	m										
D_z (LHS)	131.126	Shad	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
D_z (RHS)	2.500	Shad	10.8	13.3	15.9	18.8	20.0	20.0	20.0	20.0	18.8	19.8
D_z (Total)	-	-	7.0	9.2	11.5	13.8	15.2	15.2	15.2	15.2	14.2	15.0
Barrier effect	A_{bar}	dB	8.4	9.9	12.2	14.4	15.7	15.7	15.7	15.7	14.7	15.5
Down Wind Noise Level	$L_{AT}(DW)$	dB(lin)	32.1	33.0	37.6	39.3	40.8	40.0	31.9	10.6	46.2	
		dB(A)	5.9	16.9	29.0	36.1	40.8	41.2	32.9	9.5		45.1
Meteorological correction (Co)	0.0	dB										
Meteorological effect	C_{met}	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Long Term Noise Level	$L_{AT}(LT)$	dB(lin)	32.1	33.0	37.6	39.3	40.8	40.0	31.9	10.6	46.2	

		dB(A)	5.9	16.9	29.0	36.1	40.8	41.2	32.9	9.5		45.1

Table 4: ISO 9613 prediction of noise levels from loading of truck, source at height of 3.2 m and receiver 1.5 m below roof level of Chettle court.

ISO9613-2:1996		Hz	63	125	250	500	1000	2000	4000	8000	Lin	A
Source sound power (L_w)		dB	91.0	95.0	102.0	106.0	109.0	109.0	104.0	94.0	113.9	113.8
Directivity index (D_I)		dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Directivity index (D_Ω)		dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Directivity correction	(D_c)	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Distance (d_p)	132.0	m										
Source height (h_s)	1.00	m										
Receiver height (h_r)	37.5	m										
Distance (d')	137.0	m										
Geometrical divergence	A_{div}	dB	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7
Temperature / Relative humidity	10/70	C/%										
Atmospheric absorption	A_{atm}	dB	0.0	0.1	0.1	0.3	0.5	1.3	4.5	16.0	1.0	1.3
	G	d (m)										
Source region	0.0	10.0	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5		
Receiver region	1.0	107.0	-1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Middle region	0.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Mean height (h_m) - A-weight only		m										
Ground effect	A_{gr}	dB	-3.0	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5
Barrier? Yes/No If Yes:	Yes	-										
Barrier to source (d_{ss})	2	m										
Barrier to receiver (d_{sr})	130	m										
Barrier height (h_b)	5	m										
D_z (Over the Top)	1.520	Shad	9.1	11.2	13.7	16.4	19.3	20.0	20.0	20.0	17.5	19.1
Lateral Pathway? Yes/No If Yes:	Yes	-										

Barrier length (LHS)	100	m										
Barrier length (RHS)	4	m										
D_z (LHS)	129.590	Shad	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
D_z (RHS)	2.444	Shad	10.8	13.2	15.9	18.7	20.0	20.0	20.0	20.0	18.8	19.8
D_z (Total)	-	-	6.6	8.7	11.0	13.3	15.0	15.2	15.2	15.2	13.9	14.8
Barrier effect	A_{bar}	dB	8.1	9.5	11.8	14.0	15.5	15.7	15.7	15.7	14.5	15.3
Down Wind Noise Level	L_{AT}(DW)	dB(lin)	32.2	33.2	37.8	39.5	40.8	39.8	31.6	10.1	46.2	
		dB(A)	6.0	17.1	29.2	36.3	40.8	41.0	32.6	9.0		45.0
Meteorological correction (Co)	0.0	dB										
Meteorological effect	C_{met}	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Long Term Noise Level	L_{AT}(LT)	dB(lin)	32.2	33.2	37.8	39.5	40.8	39.8	31.6	10.1	46.2	
		dB(A)	6.0	17.1	29.2	36.3	40.8	41.0	32.6	9.0		45.0

APPENDIX C
PPG 24

DEPARTMENT OF THE ENVIRONMENT
WELSH OFFICE

PPG 24
JULY 1994

PLANNING POLICY GUIDANCE

PLANNING AND NOISE

Planning policy guidance notes set out the Government's policies on different aspects of planning. Local authorities must take their content into account in preparing their development plans. They may be material to decisions on individual planning applications and appeals.

This PPG gives guidance to local authorities on the use of their planning powers to minimise the adverse impact of noise and builds on the advice previously contained in DOE Circular 10/73 (Welsh Office 16/73). It:

- outlines the considerations to be taken into account in determining planning applications both for noise-sensitive developments and for those activities which will generate noise;
- introduces the concept of noise exposure categories for residential development, encourages their use and recommends appropriate levels for exposure to different sources of noise; and
- advises on the use of conditions to minimise the impact of noise.

CONTENTS

Paragraphs

INTRODUCTION

1. Noise can have a significant effect on the environment and on the quality of life enjoyed by individuals and communities. The aim of this guidance is to provide advice on how the **planning system** can be used to minimise the adverse impact of noise without placing unreasonable restrictions on development or adding unduly to the costs and administrative burdens of business. It builds upon the principles established in Circular 10/73 (Welsh Office Circular 16/73) "Planning and Noise", and takes account of the recommendations of the Noise Review Working Party which reported in October 1990 (HMSO, ref. no. ISBN 0 11 752343 7). It outlines some of the main considerations which local planning authorities should take into account in drawing up development plan policies and when determining planning applications for development which will either generate noise or be exposed to existing noise sources.

GENERAL PRINCIPLES

2. The impact of noise can be a material consideration in the determination of planning applications. The planning system has the task of guiding development to the most appropriate locations. It will be hard to reconcile some land uses, such as housing, hospitals or schools, with other activities which generate high levels of noise, but the planning system should ensure that, wherever practicable, noise-sensitive developments are separated from major sources of noise (such as road, rail and air transport and certain types of industrial development). It is equally important that new development involving noisy activities should, if possible, be sited away from noise-sensitive land uses. Development plans provide the policy framework within which these issues can be weighed but careful assessment of all these factors will also be required when individual applications for development are considered. Where it is not possible to achieve such a separation of land uses, local planning authorities should consider whether it is practicable to control or reduce noise levels, or to mitigate the impact of noise, through the use of conditions or planning obligations.

NOISE POLICIES IN DEVELOPMENT PLANS

3. Where the development plan is material to the development proposal, section 54A of the Town and Country Planning Act 1990 (inserted by section 26 of the Planning and Compensation Act 1991) requires applications and appeals to be determined in accordance with the plan, unless material considerations indicate otherwise. Development plans should give developers and local communities a degree of certainty about the areas in which particular types of development will be acceptable and those in which special measures may be required in order to mitigate the impact of noise. Policies on noise should take account of the guidance in the rest of this note and in the Annexes: it will generally be appropriate for these policies to be set out in Part II of Unitary Development Plans and in district local plans. But in some cases (when dealing with strategic issues such as development of, or near,major aerodromes, for example) it may be necessary to include some noise policies in Part I of UDPs and in structure plans.

4. Where noise policies apply to the plan area as a whole, they should be set out in the same way as other general policies. Area-specific noise policies may be useful in some circumstances and, in such cases, the relevant boundaries should be illustrated on the proposals map. However, it will generally be inappropriate for a proposals map to show detailed noise contours as noise emissions may change significantly over time (eg, in the case of an aerodrome, operational changes may lead to significant variations in the impact of the noise on those living in the area).

5. Plans should contain policies designed to ensure, as far as is practicable, that noise-sensitive developments are located away from existing sources of significant noise (or programmed development such as new roads) and that potentially noisy developments are located in areas where noise will not be such an important consideration or where its impact can be minimised. It may also

be appropriate for local planning authorities to adopt policies to avoid potentially noisy developments in areas which have remained relatively undisturbed by noise nuisance and are prized for their recreational and amenity value for this reason.

6. The Secretary of State considers that housing, hospitals and schools should generally be regarded as noise-sensitive development, but planning authorities may wish to include other developments or uses within this definition, depending on local circumstances and priorities and, if so, these should be explained in the development plan.

7. Where it is particularly difficult to separate noise- sensitive development from noisy activities, plans should contain an indication of any general policies which the local planning authority propose to apply in respect of conditions or planning obligations.

Noise exposure categories for residential development

8. This guidance introduces the concept of Noise Exposure Categories (NECs), ranging from A-D, to help local planning authorities in their consideration of applications for residential development near transport-related noise sources. Category A represents the circumstances in which noise is unlikely to be a determining factor, while Category D relates to the situation in which development should normally be refused. Categories B and C deal with situations where noise mitigation measures may make development acceptable. Annex 1 illustrates this approach in more detail. It also explains why the NEC procedure cannot be used in the reverse context for proposals which would introduce new noise sources into areas of existing residential development.

9. The table in Annex 1 contains a recommended range of noise levels for each NEC covering day and night-time periods. However, in some cases it may be appropriate for local planning authorities to determine the range of noise levels which they wish to attribute to any or each of the NECs. For example, where there is a clear need for new residential development in an already noisy area some or all NECs might be increased by up to 3 dB(A) above the recommended levels. In other cases, a reduction of up to 3 dB(A) may be justified.

DEVELOPMENT CONTROL

Noisy development

10. Much of the development which is necessary for the creation of jobs and the construction and improvement of essential infrastructure will generate noise. The planning system should not place unjustifiable obstacles in the way of such development. Nevertheless, local planning authorities must ensure that development does not cause an unacceptable degree of disturbance. They should also bear in mind that a subsequent intensification or change of use may result in greater intrusion and may wish to consider the use of appropriate conditions.

11. Noise characteristics and levels can vary substantially according to their source and the type of activity involved. In the case of industrial development for example, the character of the noise should be taken into account as well as its level. Sudden impulses, irregular noise or noise which contains a distinguishable continuous tone will require special consideration. In addition to noise from aircraft landing and taking off, noise from aerodromes is likely to include activities such as engine testing as well as ground movements. The impact of noise from sport, recreation and entertainment will depend to a large extent on frequency of use and the design of facilities. More detailed advice on factors to consider in relation to the major noise sources including roads, railway, airports, industrial and recreational noise and their measurement is given in Annex 2. Separate advice on the control of noise from mineral working sites is provided in Minerals Planning Guidance Note 11 -"The Control of Noise from Surface Mineral Workings" (MPG11).

Noise-sensitive development

12. Local planning authorities should consider carefully in each case whether proposals for new noise-sensitive development would be incompatible with existing activities. But such development should not normally be permitted in areas which are - or are expected to become - subject to unacceptably high levels of noise. When determining planning applications for development which will be exposed to an existing noise source, local planning authorities should consider both the likely level of noise exposure at the time of the application and any increase that may reasonably be expected in the foreseeable future, for example at an airport. Annex 2 gives guidance on the assessment of noise from different sources. Authorities will also wish to bear in mind that while there will be sites where noise is significantly lower at night than during the day, other sites may be subjected to night-time noise from traffic at a level which is little below the day-time level. These sites warrant particular protection: noise-sensitive development should not normally be permitted where high levels of noise will continue throughout the night, especially between the hours 23.00 to 07.00 when sleep is most likely to be disturbed.

Measures to mitigate the impact of noise

13. A number of measures can be introduced to control the source of, or limit exposure to noise. Such measures should be proportionate and reasonable and may include one or more of the following:

(i) **engineering**: reduction of noise at point of generation (eg by using quiet machines and/or quiet methods of working); containment of noise generated (eg by insulating buildings which house machinery and/or providing purpose-built barriers around the site); and protection of surrounding noise-sensitive buildings (eg by improving sound insulation in these buildings and/or screening them by purpose-built barriers);

(ii) **lay-out**: adequate distance between source and noise-sensitive building or area; screening by natural barriers, other buildings, or non-critical rooms in a building;

(iii) **administrative**: limiting operating time of source; restricting activities allowed on the site; specifying an acceptable noise-limit.

14. Early consultation with the applicant about the possible use of such measures is desirable and may enable them to be incorporated into the design of the proposal before it is formally submitted for determination. Alternatively it may be appropriate for a local planning authority to ensure that such measures are introduced by imposing conditions.

Conditions

15. The appropriate use of planning conditions can enable many development proposals to proceed where it would otherwise be necessary to refuse permission. General advice on the use of conditions is contained in DOE/WO Circular 1/85. Conditions should only be imposed where they are

* necessary

* relevant to planning

* relevant to the development to be permitted

* enforceable

* precise

* reasonable in all other respects.

16. Some examples of model conditions are given in Annex 3, but local planning authorities should give careful consideration to the individual circumstances of each application before imposing any conditions. In particular, authorities should not use the opportunity presented by an application for minor development to impose conditions on an existing development which already enjoys planning permission. In the case of aerodromes, for example, limits on hours of operation and the number and type of aircraft may be applied to new aerodromes, but in the case of existing aerodromes they should only be sought where the proposed development is likely to have a material effect on use. Conditions which set noise limits raise particular issues on which detailed guidance is given in Annex 4.

17. Where it is proposed to grant permission for noise-sensitive development in areas of high ambient noise, planning conditions should be imposed to ensure that the effects of noise are mitigated as far as possible. For example, intervening buildings or structures (such as garages) may be designed to serve as noise barriers. In some cases sound insulation measures may be considered appropriate. (Such measures will mainly apply to windows: additional guidance is given in Annex 5.) However, it should be remembered that the sound level within a residential building is not the only consideration: most residents will also expect a reasonable degree of peaceful enjoyment of their gardens and adjacent amenity areas.

18. There will also be circumstances when it is acceptable - or even desirable in order to meet other planning objectives - to allow noise-generating activities on land near or adjoining a noise-sensitive development. In such cases, local planning authorities should consider the use of planning conditions or planning obligations to safeguard local amenity. Care should be taken to keep the noisiest activities away from the boundary or to provide for measures to reduce the impact of noise. Authorities should also take into account the fact that the background noise level in some parts of suburban and rural areas is very low, and the introduction of noisy activities into such areas may be especially disruptive.

19. Where an authority's planning objectives cannot be achieved by imposing a planning condition (because, for example, they require the developer to make a financial contribution, or they relate to development, roads or buildings other than those covered by the planning application), it may be appropriate to enter into a planning obligation under section 106 of the Town and Country Planning Act 1990 (as substituted by section 12 of the Planning and Compensation Act 1991). Advice on the use of such obligations is given in DOE Circular 16/91 (WO 53/91).

Designated areas and the countryside

20. Special consideration is required where noisy development is proposed in or near Sites of Special Scientific Interest (SSSIs). Proposals likely to affect SSSIs designated as internationally important under the EC Habitats or Birds Directives or the Ramsar Convention require extra scrutiny. Further advice will be given in a forthcoming PPG on Nature Conservation. Special consideration should also be given to development which would affect the quiet enjoyment of the National Parks, the Broads, Areas of Outstanding Natural Beauty or Heritage Coasts. The effect of noise on the enjoyment of other areas of landscape, wildlife and historic value should also be taken into account.

21. In some cases, noisy development may have a serious effect on the welfare of livestock on nearby farms. The degree to which different species will be affected will vary, so, when considering applications which could affect livestock, local planning authorities may wish to consult the Ministry of Agriculture, Fisheries and Food (Land Use Planning Unit) or the Welsh Office Agriculture Department (Branch A).

ENVIRONMENTAL ASSESSMENT

22. EC Directive 85/337 requires environmental assessment (EA) for certain types of project to be carried out before planning permission is granted. It has been implemented for projects that require planning permission by the Town and Country Planning (Assessment of Environmental Effects) Regulations 1988. For a limited number of projects listed in Schedule 1 to the Regulations, such as major aerodromes, EA is required in every case; for a wider range of projects listed in Schedule 2 to the Regulations, including local roads, other new aerodromes, industrial estate development, disposal of non-toxic waste and mineral extraction, EA is required if the proposal is likely to have significant environmental effects. Where EA is required, the likely effects of noise will be one of the considerations to be dealt with in the environmental statement prepared by the developer and submitted to the local planning authority with the planning application.

OTHER STATUTORY CONTROLS

23. Additional statutory powers to control noise exist outside the planning system. The granting of planning permission does not remove the need to comply with these controls. The major legislative instruments are:

(i) Part III of the Environmental Protection Act 1990, which requires local authorities to serve abatement notices where the noise emitted from any premises constitutes a statutory nuisance; and

(ii) Part III of the Control of Pollution Act 1974, which gives local authorities powers to control noise from construction sites, and also introduced the concept of the Noise Abatement Zone (NAZ).

Implementation of this legislation usually falls to the Environmental Health Department of a local authority.

24. Other means of tackling noise include:

(i) the Noise at Work Regulations 1989, which are enforced by inspectors of the Health and Safety Executive (HSE);

(ii) the Building Regulations 1991 for England and Wales which impose standards for sound insulation between dwellings (see paragraph 25); and

(iii) the Civil Aviation Act 1982 which provides for noise mitigation measures at designated aerodromes.

Codes of Practice giving guidance on how to reduce or minimise noise from various activities have been produced, some of which have been approved as statutory codes under the Control of Pollution Act 1974. Certain noise-producing appliances are subject to product standard controls.

25. More information on other noise control regimes is given in Annex 6. The bodies and authorities responsible for offering advice or for implementing these controls will often have expertise or experience which planning authorities may find helpful in assessing proposals for development. For example, in the case of proposals for noisy indoor or outdoor sports developments, authorities should liaise with the regional office of the Sports Council and the governing body for the sport, who may be able to advise on ways of minimising the disturbance. In the case of land-fill waste-disposal sites, much of the advice contained in MPG11 "The Control of Noise at Surface Mineral Workings" will be relevant, but waste regulation authorities should in any case be consulted at an early stage to discuss the need for specific noise controls. Where

development is proposed near an aerodrome, liaison with the aerodrome management will be essential. Annexes 2 and 6 give further guidance on some of these points.

26. In some cases it will be particularly important for local planning authorities to liaise with the relevant body because some part of the activity for which planning permission has been sought may be subject to another more appropriate means of control or licensing condition. The planning permission should not seek to duplicate such controls or conditions. For example, the Government considers that the Building Regulations are the most appropriate means of control for sound insulation between dwellings and local planning authorities should not therefore use planning conditions to control sound insulation in such cases.

CANCELLATION OF ADVICE

27. The following advice is hereby cancelled:

- DOE Circular 10/73 (WO 16/73)

- model planning conditions 5 - 10 in Appendix A to DOE/Welsh Office Circular 1/85.

GLOSSARY

Below are explanations of terms as they are used in the PPG; they are not definitions.

Aerodrome: any area of land, water, or space on the roof of a building, which is commonly used to provide facilities for the landing and departure of aircraft - including types capable of descending or climbing vertically. The term is generic and embraces other terms such as airport, airfield and heliport. For a formal definition see the Civil Aviation Act 1982.

Auxiliary power unit: small jet engine used to provide power to an aircraft's primary systems (eg ventilation and electrical systems) whilst the main engines are shut down.

Decibel (dB): a unit of level derived from the logarithm of the ratio between the value of a quantity and a reference value. It is used to describe the level of many different quantities. For sound pressure level the reference quantity is 20 μPa, the threshold of normal hearing is in the region of 0 dB, and 140 dB is the threshold of pain. A change of 1 dB is only perceptible under controlled conditions.

dB(A): decibels measured on a sound level meter incorporating a frequency weighting (A weighting) which differentiates between sounds of different frequency (pitch) in a similar way to the human ear. Measurements in dB(A) broadly agree with people's assessment of loudness. A change of 3 dB(A) is the minimum perceptible under normal conditions, and a change of 10 dB(A) corresponds roughly to halving or doubling the loudness of a sound. The background noise level in a living room may be about 30 dB(A); normal conversation about 60 dB(A) at 1 metre; heavy road traffic about 80 dB(A) at 10 metres; the level near a pneumatic drill about 100 dB(A).

Hertz (Hz): unit of frequency, equal to one cycle per second. Frequency is related to the pitch of a sound.

$L_{A10,T}$: the A weighted level of noise exceeded for 10% of the specified measurement period (T). It gives an indication of the upper limit of fluctuating noise such as that from road traffic. $L_{A10,18h}$ is the arithmetic average of the 18 hourly $L_{A10,1h}$ values from 06.00 to 24.00.

$L_{A90,T}$: the A weighted noise level exceeded for 90% of the specified measurement period (T). In BS 4142 it is used to define background noise level.

$L_{Aeq,T}$: the equivalent continuous sound level - the sound level of a notionally steady sound having the same energy as a fluctuating sound over a specified measuring period T. $L_{Aeq,T}$ is used to describe many types of noise and can be measured directly with an integrating sound level meter. It is written as L_{eq} in connection with aircraft noise.

$L_{A\,max}$: the highest A weighted noise level recorded during a noise event. The time weighting used (F or S) should be stated.

NNI: Noise and Number Index: A composite measure of exposure to aircraft noise that takes into account the average peak noise level and the number of aircraft in a specific period. Now generally superseded by Leq.

Noise index: a measure of noise over a period of time which correlates well with average subjective response.

Noise-sensitive development: dwellings, hostels, health buildings, educational establishments, and other similar buildings.

Rating level: the noise level of an industrial noise source which includes an adjustment for the character of the noise. Used in BS 4142.

R_w: single number rating used to describe the sound insulation of building elements (also see Appendix 4). It is defined in BS 5821: 1984.

ANNEX 1
NOISE EXPOSURE CATEGORIES FOR DWELLINGS

1. When assessing a proposal for residential development near a source of noise, local planning authorities should determine into which of the four noise exposure categories (NECs) the proposed site falls, taking account of both day and night-time noise levels. Local planning authorities should then have regard to the advice in the appropriate NEC, as below:

NEC	
A	Noise need not be considered as a determining factor in granting planning permission, although the noise level at the high end of the category should not be regarded as a desirable level.
B	Noise should be taken into account when determining planning applications and, where appropriate, conditions imposed to ensure an adequate level of protection against noise.
C	Planning permission should not normally be granted. Where it is considered that permission should be given, for example because there are no alternative quieter sites available, conditions should be imposed to ensure a commensurate level of protection against noise.
D	Planning permission should normally be refused.

2. A recommended range of noise levels is given below for each of the NECs for dwellings exposed to noise from road, rail, air, and mixed transportation sources. Annex 2 provides a detailed explanation of how they have been derived. Paragraph 9 of the main text explains that in some cases local planning authorities may be able to justify a range of NECs of up to 3dB(A) above or below those recommended.

3. The NEC noise levels should not be used for assessing the impact of industrial noise on proposed residential development because the nature of this type of noise, and local circumstances, may necessitate individual assessment; and because there is insufficient information on people's response to industrial noise to allow detailed guidance to be given. However, at a mixed noise site where industrial noise is present but not dominant, its contribution should be included in the noise level used to establish the appropriate NEC.

4 The NEC procedure is only applicable to circumstances where consideration is being given to introducing residential development into an area with an existing noise source, rather than the reverse situation where new noise sources are to be introduced into an existing residential area. This is because the statutory planning system can be used to impose conditions to protect incoming residential development from an existing noise source but, in general, developers are under no statutory obligation to offer noise protection measures for application to existing dwellings which will be affected by a proposed new noise source. Moreover, there would be no obligation on the part of individuals having an interest in each dwelling affected to take up such an offer, and therefore no guarantee that all necessary noise protection measures would be put in place.

5. Thus, where new industrial or commercial development is proposed near a residential area the effect of the new noise source on the surrounding area will have to be assessed in accordance with existing procedures. In many cases where a new source of noise is to be introduced by a project that requires environmental assessment (EA) (see paragraph 22), the effect of noise will be

considered in this context; but it must be accepted that in these circumstances the options to control noise are likely to be more limited than where residential development is proposed in an area with an existing noise source. It must also be borne in mind that when dealing with new roads and aerodromes, schemes may exist to provide insulation in specified circumstances.

Other noise-sensitive development

6. Developments such as offices, hospitals and schools will contain buildings and activities which are noise-sensitive. But these developments are likely to occupy sizeable sites and to contain a proportion of buildings and activities which are less noise-sensitive. The NEC principle cannot therefore be sensibly applied to such developments and it will be more appropriate to refer to specific guidance on internal noise standards in respect of each activity. General information can be found in BS 8233; guidance for health and hospital buildings is published by the Department of Health; and the Department for Education publishes guidance for schools (see Annex 8).

Noise index and measurement positions

7. Traditionally, different indices have been used to describe noise from different sources, and limits have been set over different time periods. This has caused confusion, and this PPG follows the move towards consistency advocated in BS7445 by expressing all noises in terms of $L_{Aeq,T}$. The recommended time periods are 07.00-23.00 and 23.00-07.00.

8. Values in the tables below refer to noise levels measured on an open site at the position of the proposed dwellings, well away from any existing buildings, and 1.2m to 1.5m above the ground. The arithmetic average of recorded readings should be rounded up. Where that average falls on the divide between NECs B & C it will be for the local planning authority to determine which is the more appropriate NEC for the proposal.

9. Levels of noise from road and rail traffic are often specified as one metre from a facade, and these facade levels should be assumed to be 3 dB(A) higher than levels measured away from any buildings, unless a more accurate figure is available. For road traffic noise in NECs C & D, $L_{Aeq,16h}$ $L_{A10,18h}$ -2 dB.

10. For aircraft, the noise levels refer to aircraft noise exposure contour values which are specified at 1.2 m above the ground. Because most aircraft noise originates from above, contours include the effects of ground reflection. This is why some values for aircraft noise in the table appear 2 dB higher than for other sources.

RECOMMENDED NOISE EXPOSURE CATEGORIES FOR NEW DWELLINGS NEAR EXISTING NOISE SOURCES

NOISE LEVELS[0] CORRESPONDING TO THE NOISE EXPOSURE CATEGORIES FOR NEW DWELLINGS $L_{Aeq,T}$ dB				
	NOISE EXPOSURE CATEGORY			
NOISE SOURCE	A	B	C	D
road traffic				
07.00 - 23.00	<55	55 - 63	63 - 72	>72
23.00 - 07.00[1]	<45	45 - 57	57 - 66	>66
rail traffic				
07.00 - 23.00	<55	55 - 66	66 - 74	>74
23.00 - 07.00[1]	<45	45 - 59	59 - 66	>66
air traffic[2]				
07.00 - 23.00	<57	57 - 66	66 - 72	>72
23.00 - 07.00[1]	<47	47 - 59	59 - 68	>68
mixed sources[3]				
07.00 - 23.00	<55	55 - 63	63 - 72	>72
23.00 - 07.00[1]	<45	45 - 57	57 - 66	>66

Notes

[0]**Noise levels:** the noise level(s) ($L_{Aeq,T}$)used when deciding the NEC of a site should be representative of typical conditions.

[1]**Nighttime noise levels (23.00 - 07.00):** sites where individual noise events regularly exceed 82 dB L_{Amax} (S time weighting) several times in any hour should be treated as being in NEC C, regardless of the $L_{Aeq,8h}$ (except where the $L_{Aeq,8h}$ already puts the site in NEC D).

[2]**Aircraft noise:** daytime values accord with the contour values adopted by the DoT which relate to levels measured 1.2m above open ground. For the same amount of noise energy, contour values can be up to 2 dB higher than those of other sources because of ground reflection effects. The nighttime noise criteria are based on 1980 WHO guidance (for details see Annex 2).

[3]**Mixed sources:** This refers to any combination of road, rail, air and industrial noise sources. The "mixed source" values are based on the lowest numerical values of the single source limits in the table. The "mixed source" NECs should only be used where no individual noise source is dominant.

To check if any individual noise source is dominant (for the purposes of this assessment) the noise level from the individual sources should be determined and then combined by decibel addition (remembering first to subtract 2dB from any aircraft noise contour values). If the level of any one source then lies within 2dB of the calculated combined value, that source should be taken as the dominant one and the site assessed against the appropriate NEC for that source, rather than using the "mixed source" NECs. If the dominant source is industrial noise see paragraph 19 of Annex 3.

If the contribution of the individual noise sources to the overall noise level cannot be determined by measurement and/or calculation, then the overall measured level should be used and the site assessed against the NECs for "mixed sources".

ANNEX 2
NOISE EXPOSURE CATEGORIES : EXPLANATION OF NOISE LEVELS

1. The following is an explanation of how the noise levels in the NEC table in Annex 1 have been calculated or derived. Wherever possible figures have been based on research findings or figures contained in statutory regulations. However, the NEC table attempts to give guidance across a broad spectrum of situations and not all of these are covered by existing research work or regulations. In these instances assessments and interpolations have had to be made and these are also explained below.

2. The explanations under each heading make specific reference to each of the transport modes: road, rail, and air. However, separate explanations of "mixed sources" are not given. The "mixed source" values are based on the lowest numerical values of the single source limits in the table.

3. The values given in the NEC table are free-field levels, together with an addition of 2dB for ground reflection of air traffic noise. Details of correction factors to convert between facade levels and free field where appropriate are given below. For night-time levels typical insulation values for window systems that are likely to be used in each NEC have been assumed. Because the insulation performance of different window installations are likely to vary these values are nominal.

NEC A

Daytime

4. There is no recent, major, U.K.-based research from which to take figures for road or rail traffic. The level is therefore based on guidance provided by the World Health Organisation[1] that "general daytime outdoor noise levels of less than 55 dB(A) L_{eq} are desirable to prevent any significant community annoyance". The figure of 55 dB(A) has been taken to be "free field" and therefore no adjustments have been necessary for road and rail traffic noise levels before inserting them in the table. In respect of air traffic noise a considerable amount of research has been carried out.[2] 57 dB Leq (previously 35 NNI) relates to the onset of annoyance as established by noise measurements and social surveys.

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[1] Environmental Health Criteria 12 - Noise. World Health Organisation, 1980.

[2] Directorate of Operational Research and Analysis "The Noise and Number Index"
DORA Communication 7907, Second Edition, September 1981

Brooker, P et al
"United Kingdom Aircraft Noise Index Study: Final Report"
Civil Aviation Authority DR Report 8402, January 1985

Critchley, JB and Ollerhead, JB
"The Use of Leq as an Aircraft Noise Index"
Civil Aviation Authority DORA Report 9023, September 1990

Night-Time

5. As for daytime, there is no recent, major, U.K.-based research from which to take figures for road or rail traffic. There has been recent research on the effect of aircraft noise on sleep[3] which looks at noise levels at which people are awoken from sleep. The night-time noise level in this category is based on the WHO guideline previously referred to[1] which states that for night-time: "based on limited data available, a level of less than 35 dB(A) is recommended to preserve the restorative process of sleep" and this is considered more relevant when seeking to achieve the best practicable conditions for rest and sleep.

6. For a site to fall within NEC A noise should not be a determining factor when granting planning permission. It follows that residents may reasonably expect to sleep with their windows open sufficiently to provide adequate ventilation. No guidance is given in the WHO document on the allowance to be made for the sound insulation qualities of a partially open window. This is usually taken to be 10 - 15 dB(A)[4] and for the purposes of the NEC table a reduction of 13 dB(A) from the facade level has been assumed. This would give a recommended maximum figure of 48 dB(A) at the facade. However, as the NEC figures are "free field" a correction of - 3 dB(A) is necessary giving 45dB(A) in the Table for road and rail noise. For air traffic noise 2 dB(A) has been added to 45 dB(A) to allow for ground reflection.

NEC B

Daytime

7. The daytime upper limits for all three transport modes are based on the levels that trigger official grant schemes. For road traffic noise the trigger level is 68 dB $L_{A10\ 18h}$[5] at a facade. This has been converted to an $L_{Aeq\ 18h}$ level by subtracting 3 dB, and to an $L_{Aeq\ 16h}$ value by adding 1 dB, giving 66 dB $L_{Aeq\ 16h}$ at a facade. Finally, this figure has been converted to a "free-field" level by subtracting 3 dB, thus arriving at 63 dB $L_{Aeq\ 16h}$ in the table.

8. For railway noise the proposed trigger level[6] is 68 dB $L_{Aeq\ 18h}$ at a facade. This has been converted to 66 dB $L_{Aeq\ 16h}$ free-field.

9. For air traffic noise, 66 dB $L_{Aeq.16h}$, previously 50 NNI, was the daytime criterion for noise insulation schemes at Heathrow, Gatwick and Stansted.

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[3] Report of a field study of aircraft noise and sleep disturbance. Department of Transport, 1992

[4] Transportation Noise Reference Book: Edited by Paul Nelson, published by Butterworths, 1987

[5] Noise Insulation Regulations, 1973

[6] Draft Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1993, issued for consultation October 1993

Night-time

10. The night-time levels are based on the WHO figure of 35 dB(A) as explained under NEC A above. Because noise should be taken into account when determining planning applications in this NEC, it has been assumed that the minimum amelioration measure available to an occupant will be to close bedroom windows at night. Single glazed windows provide insulation of about 25 dB(A).[7] Therefore, in order to achieve 35 dB(A) inside a bedroom the facade level should not be greater than 60 dB(A). This figure has been adjusted by 3 dB(A) to provide a "free-field" level in the table of 57 dB(A) for road noise. For air traffic noise 2 dB(A) has been added to 57 dB(A) to allow for ground reflection. For rail traffic, the level proposed to trigger the official grant scheme[6] has been adopted. This level is 63 dB L_{Aeq6h} and it has been converted to 59 dBL_{Aeq6h} free-field.

NEC C

Daytime

11. The upper limit is based on a Building Research Establishment (BRE) survey[8] which has shown that the insulation package supplied under the Noise Insulation Regulations is inadequate for road traffic noise levels of 78 dB $L_{A10, 18h}$ and above at a facade. This figure is equivalent to a "free-field" level of 75 dB $L_{A10\ 18h}$; which in turn is equivalent to 73 dB $L_{Aeq\ 16h}$. The 73 dB $L_{Aeq\ 16h}$ has been reduced by 1 dB to 72 dB $L_{Aeq\ 16h}$ in the table, which is the maximum external level that the standard noise insulation package will reduce to an acceptable internal level.

12. For rail traffic noise no reliable data are available for this criterion. However, there is some evidence[9] that noise from rail traffic causes less disturbance than noise from road traffic at the same level. Therefore, the level at the top of NEC C has been set 2 dB higher than the "free-field" level for road traffic noise.

13. For air traffic noise the value put forward in Circular 10/73, which is now well established, has been used. This is 60 NNI or 72 dB $L_{eq\ 16h}$, including a 2 dB allowance for ground reflection.

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[7] Transportation Noise Reference Book: Edited by Paul Nelson, published by Butterworths, 1987 and Sound Control For Homes, published by the Building Research Establishment and CIRIA, 1993 [BRE report 238, CIRIA report 127].

[8] Utley W. et al "The effectiveness and acceptability of measures for insulating dwellings against traffic noise" (Journal of Sound and Vibration (1986) Vol 109(1), pages 1-18).

[9] "Railway Noise and the Insulation of Dwellings" Mitchell Committee Report, published February 1991.

Night-time

14. The night-time levels are based on the WHO figure of 35 dB(A) as explained under NEC A above. The standard noise insulation package provides insulation of about 35 dB(A).[8] Therefore at a facade level of 70 dB(A) or above the internal limit for a bedroom of 35 dB(A) may not be achieved. The level of 70 dB(A) has therefore been reduced by 1 dB(A) and a correction factor of 3 dB(A) applied to derive the "free-field" level of 66 dB(A) in the NEC table for road and rail noise. For air traffic noise 2 dB(A) has been added to give 68 dB(A) to allow for ground reflection.

NEC D

15. This is the category in which planning permission should normally be refused. The noise levels in this category simply repeat those derived for the upper limit of NEC C.

ANNEX 3
DETAILED GUIDANCE ON THE ASSESSMENT OF NOISE FROM DIFFERENT SOURCES

Noise from road traffic

1. For established roads it will normally be sufficient to base assessments on the current measured noise level (paragraph 8 of Annex 1 refers). When considering potential new development near major new or recently improved roads, local planning authorities should ascertain forecast noise levels (eg over the next 15 years) with the assistance of the local highway authority. In some cases highway authorities will have prepared predictions of the effects of traffic noise for the purposes of the "Noise Insulation Regulations 1975" and the "Noise Insulation Amendment Regulations 1988". Otherwise highway authorities should be consulted on the traffic flow data needed for the preparation of predictions in accordance with "Calculation of Road Traffic Noise" (DOT and Welsh Office, 1988). Use by highway authorities of traffic management schemes and powers in the Road Traffic Regulation Act 1984 may also be appropriate. Research undertaken by the T.R.L. for DoT indicates that structural damage of buildings through vibration from road traffic is unlikely to occur. Advice is available in "Design Manual for Roads and Bridges" Vol 11, Section 3, Part 7 - "Traffic Noise and Vibration". But if vibration remains a concern, advice on acceptable levels can be found in BS 6472:1992, and advice on levels that may result in damage to structures in BRE Digest 353.

Noise from railways

2. Railway noise emanates from a variety of sources. For noise from operational railway lines the noise exposure categories in Annex 1 will be appropriate; while local noise from station activities, freight distribution depots, and marshalling yards should be treated in the same way as noise from industrial and commercial sources. Local planning authorities are advised to ask the developer to provide details of the present levels of noise, and to consult the railway operator to find out if there are proposals for significant operational changes.

3. In considering the long distance traffic effects of developments which would result in the use of rail transport (for example the carrying of aggregates from extraction sites, or goods from freight terminals), it will be appropriate to take into account the railway noise aspect.

4. The likelihood of significant ground-borne vibration will depend on the nature of the ground and the types of train. The possibility of vibration and re-radiated noise caused by trains running in tunnels should also not be overlooked. Advice on acceptable levels of vibration can be found in BS 6472:1992.

5. In October 1993 the Department of Transport published draft noise insulation regulations for new railway lines, with the aim of providing equity with "The Noise Insulation Regulations 1975" (as amended) which apply to new roads. Draft technical guidance, in a form similar to "Calculation of Road Traffic Noise" (DOT and Welsh Office, 1988), was made available at the same time.

Noise from aircraft

6. For major aerodromes, NNI contours have been produced for many years to aid development control. In September 1990 the Department of Transport adopted a new index and now expresses noise exposure contours in terms of L_{eq}dB(A) over the period 07.00-23.00. This index is

equivalent to $L_{Aeq,T}$ used for other types of noise. General advice on this index can be obtained from the Department of Transport, CA4, 2 Marsham Street, London SW1P 3EB (Tel: 071 276 6269). Technical advice on the index and on production of noise contours can be obtained from the Department of Safety, Environment and Engineering, Civil Aviation Authority, 45-59 Kingsway, Holborn, London WC2B 6TE (Tel: 071 379 7311).

7. Using forecast contours, it should be possible to determine approximately which areas are likely to fall within the different noise exposure categories. For small aerodromes local planning authorities should not rely solely on L_{eq} where this is based on less than about 30 movements a day. Local planning authorities should also be aware that in some circumstances the public perceive noise from general aviation as more disturbing than similar levels around major airports.

8. Recommended noise exposure categories for new dwellings exposed to aircraft noise are given in Annex 1, but 60 L_{eq} dB(A) should be regarded as a desirable upper limit for major new noise-sensitive development. Where replacement schools, clinics, and other community facilities are needed to serve the existing population in high noise areas, expert consideration of sound insulation measures will be necessary. When determining applications to replace schools and build new ones in such areas, local planning authorities should have regard to the likely pattern of aircraft movements at the aerodrome in question which could cause noise exposure during normal school hours/days to be significantly higher or lower than shown in average noise contours.

9. Where land is, or is likely to become, subject to significant levels of aircraft noise, local planning authorities should seek the co-operation of the aerodrome management in arriving at the most appropriate longer-term forecasts of air traffic and the effect on the noise contours in order to determine approximately which areas are likely to fall within the different noise exposure categories. The objective will be to achieve a clear and stable pattern of constraints against which development control policies can be formulated and incorporated in local plans and Part II UDPs.

10. Beyond the extremities of the published contours, noise will still be audible near the arrival and departure routes. The former are generally predetermined by the orientation of the runway and safety considerations; however, departure routes can usually be designed to avoid, as far as possible, noise in built-up areas. The usage of these routes may change over time because of changes in aircraft mix and operations. The departure routes often comprise a wide corridor of tracks. Local planning authorities should consult National Air Traffic Services where appropriate.

11. Information concerning noise from Heathrow, Gatwick and Stansted airports is available from the Department of Transport (CA4, 2 Marsham Street, London SW1P 3EB, Tel: 071 276 5323) and for most other airports from the appropriate airport management. Where noise contours expressed in L_{eq}dB(A) are not available, local planning authorities should approach the aerodrome management to secure early compilation of contours.

12. If the construction or development of an aerodrome with a basic runway length of 2,100 metres or more is proposed, it will fall within Schedule 1 to the Town and Country Planning (Assessment of Environmental Effects) Regulations 1988 (see paragraph 22 of the PPG), and environmental assessment (EA) will be mandatory. If the construction of an aerodrome is proposed which does not fall within Schedule 1 to the Regulations, EA will be required if the development is likely to have significant environmental effects. Where a major aerodrome is the subject of a proposal which will effect its capacity, there will be a need to prepare or revise forecast noise contours to estimate the resulting noise climate.

Military aerodromes

13. The noise exposure categories should be used for assessing proposals for new developments near military aerodromes. Because many of these are in rural locations, however, there will often be the flexibility to ensure that new residential developments are located so as to fall within noise exposure category A, while still taking full account of other planning constraints. This option will not apply to proposals for residential development involving extension, conversion, or change of use of existing buildings. When determining such applications local planning authorities should take account of the differences between civil and military operations. Military jet aircraft can generate very high noise levels, particularly during take off, and occasionally the effectiveness of noise abatement flight procedures normally adopted may be limited by operational requirements. Changes in aircraft type and number of movements may also occur over a short period, resulting in unpredictable changes in noise levels. However, military flying is usually concentrated into weekday working hours when the public sensitivity to noise is at its lowest.

14. For aerodromes where a Ministry of Defence (MoD) noise insulation grant scheme has been introduced, authorities will already hold an MoD map showing $L_{Aeq,T}$ contours. These are based on a 12 hour period, not a 16 hour period as is used at designated civil aerodromes. Other information and advice may be obtained from the Ministry of Defence, DLS, Leatherhead Road, Chessington, Surrey, KT9 2LU (Tel: 081 397 5266 or 081 391 3459). Liaison with the aerodrome commander and the MoD Land Agent may also be helpful.

Helicopters and heliports

15. When determining a planning application for a heliport the predicted noise should not be assessed in isolation - account should be taken of local circumstances including the existing level of noise disturbance in the area surrounding the site and factors such as whether the area is already exposed to noise from fixed wing aircraft. Local planning authorities will need to consider the effect of further disturbance resulting from the proposal.

16. Helicopter noise has different characteristics from that from fixed wing aircraft, and is often regarded as more intrusive or more annoying by the general public. The Noise Exposure Categories should be applied with caution. Further research on this subject has been commissioned by the Department of Transport and should be published in 1994.

17. Helicopter routes may be established over cities and near aerodromes, although often their use will not be mandatory. Planning applications for helicopter landing/take-off facilities should be accompanied by information about the proposed take-off/landing flight paths, and air traffic routes where appropriate. Preferably, these paths should have been discussed and agreed in principal with National Air Traffic Services (NATS) beforehand. Where such information does not accompany the application, but is considered necessary, the local planning authority should request it and suggest that the applicant has discussions with NATS.

18. Increased use of helicopters has led to movements from the gardens of private houses and from commercial premises, such as factories, offices and hotels. For safety reasons, helicopters may only operate from elevated sites if given special approval by the CAA. All these movements can cause local annoyance. However, they may often be incidental or ancillary to the principal use of the land and as such do not generally require a separate planning permission. The construction of hard standing, installation of landing lights etc may be regarded as development requiring planning consent.

Noise from industrial and commercial developments

19. The likelihood of complaints about noise from industrial development can be assessed, where the standard is appropriate, using guidance in BS 4142: 1990 "Method for rating industrial noise affecting mixed residential and industrial areas". Tonal or impulsive characteristics of the noise are likely to increase the likelihood of complaints and this is taken into account by the "rating level" defined in BS 4142: 1990. This "rating level" should be used when stipulating the level of noise that can be permitted. The likelihood of complaints is indicated by the difference between the noise from the new development (expressed in terms of the rating level) and the existing background noise. The Standard states that: "A difference of around 10dB or higher indicates that complaints are likely. A difference of around 5 dB is of marginal significance." Since background noise levels vary throughout a 24 hour period it will usually be necessary to assess the acceptability of noise levels for separate periods (eg day and night) chosen to suit the hours of operation of the proposed development. Similar considerations apply to developments that will emit significant noise at the weekend as well as during the week. In addition, general guidance on acceptable noise levels within buildings can be found in BS 8233:1987, and guidance on the control of noise from surface mineral workings can be found in MPG 11/1993.

20. Commercial developments such as fast food restaurants, discos, night clubs and public houses pose particular difficulties, not least because associated activities are often at their peak in the evening and late at night. Local planning authorities will wish to bear in mind not only the noise that is generated within the premises but also the attendant problems of noise that may be made by customers in the vicinity. The disturbance that can be caused by traffic and associated car parking should not be underestimated.

Noise from construction sites

21. Detailed guidance on assessing noise from construction sites can be found in BS 5228, "Noise Control on construction and open sites", parts 1-4. In particular, Part 1: 1984, "Code of Practice for basic information and procedures for noise control" will be useful because as well as giving general advice it describes a method for predicting noise from construction sites.

Noise from recreational and sporting activities

22. For these activities (which include open air pop concerts), the local planning authority will have to take account of how frequently the noise will be generated and how disturbing it will be, and balance the enjoyment of the participants against nuisance to other people. Partially open buildings such as stadia may not be in frequent use. Depending on local circumstances and public opinion, local planning authorities may consider it reasonable to permit higher noise emission levels than they would from industrial development, subject to a limit on the hours of use, and the control of noise emissions (including public address systems) during unsocial hours. A number of sports activities are the subject of Codes of Practice, and further details on these can be found in Annex 7. Some noisy activities enjoy permitted development rights granted by Part 4 of Schedule 2 to the Town and Country Planning General Development Order 1988, and so may not require specific planning permission provided that they only occur on a temporary basis. However, this permission may be withdrawn by making a direction under Article 4 of the Order. Further details are contained in Annex 7. Additional advice on sport and noise can be found in PPG 17.

Noise from landfill waste disposal sites

23. Conditions attached to waste disposal licences generally set limits to the amount of waste, frequency of deliveries, and hours of operation; and prescribe screening requirements. These will have indirect effects on the amount of noise generated, but site licence conditions can also relate specifically to noise control in the interests of protecting local amenity. This will be particularly relevant when dealing with sites where the operator is working with the benefit of an Established Use Certificate (as defined in section 36(2) of the Environmental Protection Act 1990) or a planning permission not subject to a noise condition. Local planning authorities and waste regulation authorities should consult closely at an early stage when considering the need for specific noise controls to be imposed by appropriate conditions in any planning permission or in the subsequent site licence.

24. The main sources of noise will be from vehicular movement, tipping operations, and site plant. Appropriate planning or licensing conditions might therefore relate to hours of working; the number and/or capacity of vehicles using the site and their points of ingress and egress; and the provision of acoustic screening. Useful information on predicting the noise will be found in BS 5228: Part 1. In addition, general guidance can be found in paragraph 9 of MPG 11/1993.

ANNEX 4

EXAMPLES OF PLANNING CONDITIONS

Conditions should be used selectively and only when the local planning authority is satisfied that planning permission should be granted. By virtue of Article 25 of the Town and Country Planning General Development Order 1988, reasons must be given for the imposition of every condition. Local planning authorities must be in a position to give their full reasons for imposing any conditions. The examples below cannot cater for all situations and additions may be made. Authorities should follow the guidance given in Department of the Environment/Welsh Office Circular 1/85 "The Use of Conditions in Planning Permissions". Planning departments may need expert advice, usually from environmental health departments, when considering the imposition of, and monitoring compliance with, some of these conditions.

Comments in brackets ( ) give additional information and do not form part of the planning condition.

Conditions to minimise the effect of noise on new noise sensitive development

1. Construction work shall not begin until a scheme for protecting the proposed [noise sensitive development] from noise from the .... has been submitted to and approved by the local planning authority; all works which form part of the scheme shall be completed before [any part of] the [noise sensitive development(s)] is occupied.

> (Authorities should give applicants guidance on the maximum noise levels to be permitted within or around the noise sensitive development so as to provide precise guidelines for the scheme to be submitted).

2. The building envelope of plot number(s) .... shall be constructed so as to provide sound attenuation against external noise, not less than ...... dB(A), with windows shut and other means of ventilation provided.

> (This condition is appropriate where, for example, individual dwellings need to be protected against external noise. The term "building envelope" is intended to include the external windows, doors, walls, and roof, through which noise could enter the building. Other methods of specifying sound insulation are given in BS 5821: Part 3: 1984, but this is likely to be replaced by a European Standard.)

Conditions restricting use of an aerodrome or part of an aerodrome

3. The total number of movements shall not exceed [ ] per [period of time], except in an emergency.

4.Movements shall take place only between [hours of day] on [days of week], except in an emergency.

5. The [development] hereby permitted shall not be used by any aircraft with an authorised weight exceeding [ ], except in an emergency.

6. The total number of movements by aircraft exceeding [ ] maximum all-up weight shall not exceed [ ] in any [period of time].

(The maximum all-up weight of an aircraft is its weight when fully loaded.)

7. The runways shall not be used by [class of aircraft], except in an emergency.

(With definition of "class" if necessary.)

8. The total number of "touch and go"* movements shall not exceed [ ] per [period of time].

9. "Touch and go"* movements shall take place only between [hours of day] on [days of week].

(* "touch and go" refers to a landing immediately followed by a take off, as in testing and training flights).

10. Auxiliary power units shall not be used between [hours of day] on [days of week].

("Auxiliary power unit" refers to a small engine used to power the aircraft's primary systems when its engines are not running.)

Condition restricting the use of industrial or commercial buildings**

11. The building shall be used for .... and for no other purpose (including any other purpose in Class .... of the Schedule to the Town and Country Planning (Use Classes) Order 1987 or in any provision equivalent to that Class in any other statutory instrument revoking and re-enacting that Order).

Conditions restricting noise emitted from industrial or commercial buildings and sites**

12. Before the use commences, the [specified building(s)] shall be insulated in accordance with a scheme agreed with the local planning authority.

(Authorities using this condition should advise the applicant on the degree of sound insulation considered necessary to achieve an acceptable external noise level).

13. Before the development hereby permitted commences a scheme shall be agreed with the local planning authority which shall specify the provisions to be made for the control of noise emanating from the site.

(These provisions could include physical and/or administrative measures).

14. [Specified activities] shall not take place anywhere on the site except within [specified building(s)].

(The Condition should describe precisely the activities to be controlled as well as the particular building(s) in which they are permitted to take place).

15. The building shall be [constructed/adapted] so as to provide sound insulation against internally generated noise of not less than ..... dB(A), with windows shut and other means of ventilation provided.

(Other methods of specifying sound insulation are given in BS 5821, Part 3: 1984, but this is likely to be replaced by a European Standard.)

16. The level of noise emitted from the site shall not exceed [A] dB between [T] and [T] Monday to Friday and [A] dB at any other time, as measured on the [specified boundary/boundaries] of the site at [location(s) of monitoring point(s)].

Specify: A - noise level expressed as $L_{Aeq,T}$ over a time period X (eg 1 hour)
T - time of day

17. The rating level of the noise emitted from the site shall [not exceed] [be lower than] the existing background noise level [determined to be A dB] by [more than] [at least] B dB between [T] and [T] Monday to Friday and [B] dB at any other time. The noise levels shall be determined at [the nearest noise sensitive premises] [specified location(s)]. The measurements and assessment shall be made according to BS 4142:1990.

Specify: A - background noise level expressed as $L_{A90,T}$ over a time period T
B - noise level difference between rating level and background level)
T - time of day

18. No [specified machinery] shall be operated on the premises before [time in the morning] on weekdays and [time in the morning] on Saturdays nor after [time in the evening] on weekdays and [time in the evening] on Saturdays, nor at any time on Sundays, Bank Holidays or Public Holidays.

19. Before [any] [specified plant and/or machinery] is used on the premises, it shall be [enclosed with sound-insulating material] [and] [mounted in a way which will minimise transmission of structure borne sound] in accordance with a scheme to be agreed with the local planning authority.

(Advice should be appended to the permission indicating the sound insulation required, or the maximum permitted noise level at a specified monitoring point.)

20. Notwithstanding the provisions of Article 3 of the Town and Country Planning General Development Order 1988 no further plant or machinery shall be erected on the site under or in accordance with Part 8 of Schedule 2 to that Order without planning permission from the local planning authority.

****Note:** For industrial and commercial sites, local authorities may wish to consider imposing two types of planning condition, as detailed below. The first type (conditions 16 and 17) sets a noise limit over a given period at a specified point - such as outside the nearest noise sensitive building or at the site boundary. The second type (conditions 11-15 and 18-20) specifies the type of activity that may take place; any restrictions necessary on the hours of operation; and details of the construction and lay-out of the development.

The first type of condition allows the developer to achieve the required noise level in whatever way he considers most cost-effective - so it may be suitable for speculative developments. A further advantage is that it controls noise in the long term since any future changes within the development must be made in such a way that the limits are not exceeded. However, a disadvantage of this type of condition is that in order to ensure compliance, noise emissions must be monitored. Whilst monitoring may be costly and time-consuming this should not be regarded as sufficient reason for not using noise conditions where they are appropriate.

Compliance with the second type of condition is easier to check and it may prove more effective against certain noise problems. For example, conditions on the location of the access to the development may help to solve the problem of noise in neighbouring residential areas that arises from traffic (particularly heavy vehicles) generated by the development. But control of activity, construction and layout, may prove less effective than noise limits in controlling noise resulting from future changes within the development. In practice, therefore, a combination of both types of condition may prove advantageous. This could entail the developer being given, at an early stage, target noise limits for use in drawing up a scheme of building and operation for the development. If a local planning authority is content that the proposals would satisfy these noise limits the scheme could be incorporated into a planning condition.

ANNEX 5
SPECIFYING NOISE LIMITS

If a local planning authority wishes to impose a planning condition which will specify an acceptable noise limit from a new source, the following points should be considered.

1. Type of limit

Depending on circumstances, it may be appropriate to set either:

(a) an absolute limit based on the average level of noise which should not be exceeded in a specified time period;

(b) a relative limit based on the permitted increase in noise level with respect to the background level. This is the approach used in BS 4142:1990.

Generally, relative limits are not appropriate where the permitted increase in noise over background is substantial - eg 15 dB or more. Because background noise varies during the day, the background noise level determined should be representative of a typical quiet period during the working day.

Either type of limit may be a single value over the relevant period, or different values for, say, day and night. It may be appropriate to set an evening value as well where the noise source lends itself to fine control.

A noise limit which is close to the background level will be difficult to monitor and the advice given in BS 4142 should be followed. This is particularly important at quiet sites where the LAeq,T may be 10 dB or more above the $L_{A90,T}$ - even when the noise source is not operating.

The idea of setting an additional overriding maximum level is often attractive, but may be hard to enforce because with unattended monitoring stations it is difficult to exclude extraneous noises (which will increase the measured level). There may also be the administrative difficulty of dealing with occasional transient high noise levels from the site.

Where the noise will only be produced inside buildings and the maximum frequency spectrum levels are known, it may be appropriate to set a standard for the sound insulation of a building envelope rather than a noise limit at an external monitoring point.

2. Noise index

Because noises vary over time and have different characteristics many indices have been developed to describe noise levels. The equivalent continuous noise level over a time period T ($L_{Aeq,T}$) has emerged as the best general purpose index for environmental noise. For road traffic noise $L_{A10,18h}$ is still widely used; and to describe background noise $L_{A90,T}$ is appropriate. To describe the sound insulation of a component of a building envelope (eg a window) Rw (BS 5821) is appropriate. It is more difficult to specify the insulation of the whole building envelope because the value depends on different insulation values for the various building elements such as windows, walls and roof structure, as well as the type of noise source and its location.

These indices are explained in the Glossary. Additional information may be found in BS 7445: 1991: Description and measurement of environmental noise.

3. Monitoring point(s)

Normally the noise limit will be chosen to protect the nearest noise sensitive premises and the best position for the monitoring point(s) will often be outside the sensitive premises. However, this does not mean that the monitoring point must always be close to the premises. Normally noise limits refer only to noise from the source under consideration and not to the total measured value which may include, for example, traffic noise. In situations where extraneous noise makes monitoring difficult it may be easier to monitor a suitably adjusted level at the boundary of the site instead of outside the premises to be protected. This approach requires that the noise level at the boundary monitoring point is a reliable indicator of the level at the building to be protected and this may not be the case if the noise source is mobile. Monitoring points should be accessible to all parties concerned.

4. Meteorological conditions

The noise level measured at a monitoring point will be affected by wind speed and direction, and temperature gradients, particularly when the monitoring point is remote (>30 m) from the source. The size of these effects is hard to predict, and so measurements (or predictions) should be made under reasonably stable conditions. A suitable condition is a light wind with a vector component up to 2 m/s from source to receiver; this will increase the noise level by about 2 dB(A) compared with the no wind case.

ANNEX 6
INSULATION OF BUILDINGS AGAINST EXTERNAL NOISE

1. Noise from outside a building can enter a room through windows, ventilators, walls, roof and doors. In most cases, however, windows provide the main path and it is therefore important to ensure that their insulation is specified correctly. This Annex summarises the main issues to be considered in specifying adequate sound insulation of windows. More detailed guidance is given in BRE Information Paper IP6/94 'The sound insulation provided by windows'.

2. The sound insulation of a window increases with the thickness (or mass) of glass subject to other limiting factors, such as air gaps. Therefore to provide good insulation a window must be fitted with effective seals.

3. Double windows can provide higher levels of sound insulation than single panes, and in general the wider the spacing between the panes the higher the insulation. However, the insulation over a band of frequencies can be seriously reduced by a resonance in the cavity between the panes. The frequency of this resonance is dependent on the cavity width and mass of the panes, and is usually in the range 50 to 300 Hertz (Hz). This should be considered when specifying windows to provide protection against low frequency noise such as traffic. For example, secondary window systems have a wider cavity (and a lower resonance frequency) than thermal double glazing; the effect of this is that secondary windows provide better insulation than thermal windows against noise with energy at high frequencies, such as electric trains, but may be only marginally better against noise with low frequency energy such as that from road traffic (see Table 1). Proprietary systems can be designed to optimise the performance.

4. Because the sound insulation of a window (and other components of the building envelope) varies with the frequency (or pitch) of the sound, therefore the overall noise reduction provided by a window will depend, among other factors, on the spectrum of the external noise. Table 1 shows typical reductions in noise level from common sources which would be expected from various types of window systems fitted in brick/block walls in a dwelling. For other buildings such as offices and schools the proportion of glazing to brickwork may be greater and this will result in a lower noise reduction. In addition, the type of furniture in these buildings will absorb less sound than domestic soft furnishings. The insulation provided by any type of window when partially open will be in the region of 10-15 dB(A).

Table 1. Typical noise reduction of a dwelling facade with windows set in a brick/block wall.

Difference between dB(A) levels outside and inside

NOISE SOURCE	single glazing	thermal double glazing	secondary glazing
Road Traffic	28	33	34
Civil Aircraft	27	32	35
Military Aircraft	29	35	39
Diesel Train	28	32	35
Electric Train	30	36	41

Note: The values in the Table are the difference between dB(A) levels measured outside and inside typical dwellings; they have not been corrected for reverberation time or window area, and so cannot be compared with values obtained under other conditions. The Table is intended to give an idea of the insulation likely to be achieved in practice - not under ideal conditions. Secondary glazing systems in particular will perform better in installations where sound insulation is not limited by poor sealing or by flanking sound paths such as through doors or acoustically weak parts of window bays. The values for single glazing are representative of well sealed windows.

5. If the walls or roof are constructed from lightweight materials they may allow transmission of significant amounts of sound into the building. This could limit the overall improvement achieved by improving the performance of other elements such as the windows.

6. To provide adequate insulation against external noise it is necessary to keep closed those windows and ventilators which have not been designed to provide sound insulation (even when closed some ventilators may still not be adequately sealed). Therefore alternative methods of providing ventilation and control of summertime temperatures must be considered. Sound insulating ventilators may be "whole house" systems or individual units installed where necessary. Ventilators of the type specified in the Noise Insulation Regulations will limit the insulation against traffic noise to about 38 dB(A). Further guidance can be found in BRE Digests 338 "Insulation against external noise", and 379 "Double glazing and double windows".

7. The sound insulation of building elements such as windows is often measured in a laboratory. The insulation is expressed in terms of Rw (BS 5821:1984). This is a single number that describes the insulation over a frequency range of 100 Hz to 3150 Hz. The value allows different products to be compared, but it cannot be used directly to determine the sound insulation that will be achieved when the element is installed in a building.

8. Guidance on suitable internal noise levels can be found in BS 8233.

Note: the transmission of airborne and impact noise between new or converted dwellings is controlled under Part E of the Building Regulations (see Annex 7, paragraphs 9 and 10).

ANNEX 7
MORE INFORMATION ON OTHER NOISE CONTROL REGIMES

1. It is not the purpose of the planning system to tackle existing noise problems. Other means are available for this, and should be seen as complementing the planning system in this context. Applicants should be warned that being granted planning permission, and complying with any conditions attached, will not necessarily protect them from legal action subsequently brought by the local authority or private citizens.

The Environmental Protection Act 1990

2. Part III of the Environmental Protection Act 1990 (the 1990 Act) gives local authorities in England and Wales considerable and wide-ranging powers to tackle noise problems. Where a local authority is satisfied that the noise emitted from any premises is prejudicial to health or a nuisance, it must serve an abatement notice on the person responsible for the noise. This notice may require the abatement of the nuisance or prohibit or restrict its occurrence or recurrence, and may also require the execution of such works and the taking of such steps as are necessary for this purpose. If an abatement notice is not complied with, local authorities may bring proceedings in a magistrates' court. Fines of up to ?5000 are available where the nuisance arises on domestic premises, and up to ?20,000 where the nuisance arises on industrial, trade or business premises.

3. Section 82 of the 1990 Act also gives individuals the power to complain direct to a magistrates' court about a noise problem. Magistrates courts are able to make orders requiring the abatement of the nuisance and specifying whatever measures are necessary for this purpose, and to award costs. A person who without reasonable excuse contravenes any requirement of such an order may be guilty of an offence and can be fined.

The Noise and Statutory Nuisance Act 1993

4. This Act gives local authorities powers to tackle noise caused by vehicles, machinery or equipment in the street where they are satisfied that the noise amounts to a statutory nuisance, and allows them to adopt provisions relating to the operation of loudspeakers in streets and the control of noise from audible intruder alarms on premises. It also reinstates a power that local authorities used to have under the Public Health Act 1936 to recover expenses incurred in abating statutory nuisances by putting a charge on the premises where it is the owner of those premises that is or was responsible for the nuisance. With the exception of the audible alarm provisions, the Act came into force on 5 January 1994.

The Control of Pollution Act 1974

5. Part III of the Control of Pollution Act 1974 (the 1974 Act) was largely repealed in England and Wales by the Environmental Protection Act 1990. However, those sections that are extant give local authorities powers to control noise from construction sites, and noise from loudspeakers in streets. The Act also introduced the concept of the Noise Abatement Zone (NAZ) which provides a more sophisticated means of controlling, and, where justified, reducing noise from commercial and industrial premises, particularly in areas of mixed development. Although NAZs have been criticised for their complexity, and although few have been designated in recent years, the powers available in such zones (for example noise reduction notices) remain a potentially useful means of tackling some types of urban noise problem.

Codes of Practice

6. Under the 1974 Act the Secretary of State also has the power to prepare and approve Codes of Practice for the purpose of giving guidance on how best to minimise or reduce noise. To-date four Codes of Practice have been approved by the Secretary of State. These are:

Code of Practice on Noise from Audible Intruder Alarms HMSO 1982
Code of Practice on Noise from Ice Cream Van Chimes Etc HMSO 1982 Code of Practice on Noise from Model Aircraft HMSO 1982
Code of Practice on Noise Control on Construction and
Open Sites (BS 5228, Parts 1 and 3 HMSO 1984
Part 4) HMSO 1986

Further Codes may be issued. In addition, many of the governing bodies of sport have produced codes of conduct which are used when organising events, and these should be consulted when new sites are being selected. The Sports Council, for example, has published reports on Providing for Motorsports (1986) and Providing for Motorised Water Sport (1990). These Codes do not have the force of law, but may be of assistance to local authorities and magistrates' courts in the exercise of their powers and functions under the 1974 and 1990 Acts.

By-laws

7. Some noise sources may be controlled by by-laws made by local authorities, particularly certain kinds of noise taking place in streets or in parks and recreation grounds. There are also certain old by-laws in some areas which cover other types of noise nuisance now subject to control under the 1974 or the 1990 Act: such by-laws may still be valid, but no new by-laws of this kind are likely to be confirmed unless they can be shown not to duplicate existing legislation.

European Community Directives

8. The European Community has issued directives focused on limiting noise from products, particularly modes of transport, construction equipment and other specific products such as lawnmowers and household appliances. The major directives are as follows:

70/157 (as amended)	Council Directive relating to the permissible sound level and the exhaust systems of motor vehicles.
78/1015 (as amended)	Directive on the permissible sound level and exhaust system of motorcycles.
74/151 (as amended)	Directive relating to certain parts and characteristics of wheeled agricultural or forestry tractors.
79/113 (as amended)	Directive relating to the determination of the noise emission of construction plant and equipment.
84/532	Directive on the approximation of the laws of the Member States relating to common provisions for construction plant and equipment.
86/662	Directive on limitation of noise from hydraulic excavators, rope-operated excavators, dozers, loaders and excavator loaders.
80/51 (as amended)	Directive on the limitation of noise from subsonic aircraft.
84/538 (as amended)	Directive on the approximation of the laws of the Member States relating to the permissible sound power level of lawnmowers.

86/188	Directive on the protection of workers from the risks related to exposure to noise at work.
86/594	Directive on airborne noise emitted by household appliances.

Building Regulations

9. The Building Regulations 1991 for England and Wales impose requirements for sound insulation between dwellings. The Building Regulations 1991 Approved Document E (Resistance to the passage of sound) (ISBN 0 11 752315 1) gives practical guidance on how the required standards of sound insulation can be achieved.

10. The Building Regulations 1991 came into force on 1 June 1992, and were extended to cover sound insulation between converted flats by including provisions that are as close to new build as is practical. The Government considers that the Building Regulations are the most appropriate means of control for sound insulation in such conversions, and local planning authorities should not therefore use planning conditions to control sound insulation in such cases. However, this does not preclude the use of conditions where planning approval is required for change of use to a noisy activity of premises adjacent to dwellings (eg a conversion to a cafe, discotheque or other noisy undertaking) where dividing walls or a floor separate a dwelling from such a use.

Motor vehicles

11. The Road Vehicles (Construction & Use) Regulations 1986 (as amended) contain safety and environmental standards for the construction and use of all classes of vehicle. In terms of noise, the regulations include drive by noise limits and test procedures for new vehicles, and requirements for the design and use of vehicle horns, reversing and theft alarms. The use of a vehicle so as to cause excessive noise which could be avoided is also prohibited and any exhaust system must be maintained and not modified to cause additional noise.

Noise at work

12. The Noise at Work Regulations 1989, which are enforced by inspectors of the Health and Safety Executive (HSE), require employers to take a number of steps to protect employees from exposure to excessive noise.

Aircraft

13. The manner in which aircraft may be flown is specified in Section 76 of the Civil Aviation Act 1982 and the Rules of the Air Regulations 1991. Under Section 76 of the Civil Aviation Act aircraft are exempt from action in respect of trespass or nuisance, including noise nuisance, as long as they comply with the provisions of any Air Navigation Order. Rule 5 of the Rules of the Air Regulations states that with certain exemptions an aircraft should not fly at below 1500ft over heavily populated areas, or below 500ft elsewhere except when taking off or landing. Should these limits be broken the pilot may be reported to the Civil Aviation Authority.

Temporary use of land

14. Under Part 4 of Schedule 2 to the Town and Country Planning General Development Order 1988, certain temporary activities enjoy permitted development rights. These allow the land to be

used for up to 28 days (14 days in the case of temporary markets/car boot sales and motor sports) in any one calender year without the need to apply for planning permission. A local authority may make a direction under article 4 of this Order which withdraws the general permission and so requires anyone wishing to institute the particular use to make a specific planning application. If an article 4 direction is to remain in force for more than six months, then the approval of the Secretary of State for the Environment (Secretary of State for Wales) is necessary. Compensation may be payable if permission on a subsequent planning application is refused, or is granted subject to conditions.

ANNEX 8
STATUTORY INSTRUMENTS

The Noise Insulation Regulations 1975.	(SI 1975:NO. 1763)
The Building Regulations 1991	(SI 1991:NO. 2768)
The Town and Country Planning (Use Classes) Order 1987.	(SI 1987:NO. 764) (as amended)
The Town and Country Planning (Assessment of Environmental Effects) Regulations 1988.	(SI 1988:NO. 1199)
The Noise Insulation (Amendment) Regulations 1988.	(SI 1988:NO. 2000)
The Town and Country General Development Order 1988.	(SI 1988:NO. 1813) (as amended)
The Noise at Work Regulations 1989	(SI 1989:NO. 1790)
The Education (School Premises) Regulations 1981	(SI 1981:NO. 909)

BRITISH STANDARDS

BS 4142: 1990, Method for rating industrial noise affecting mixed residential and industrial areas.

BS 5228: 1984 (parts 1-3), 1992 (part 4), Noise control on construction and open sites.

BS 5821: 1984, Rating the sound insulation in buildings and of building elements.

BS 7445: 1991, Description and measurement of environmental noise.

BS 8233: 1987, Sound insulation and noise reduction for buildings.

GUIDANCE

Department for Education Design Note 17: Guidelines for Environmental Design in Educational Buildings.

APPENDIX D
BS 4142:1997

BRITISH STANDARD

BS 4142 : 1997

Method for

Rating industrial noise affecting mixed residential and industrial areas

ICS 17.140.20

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee EH/1, Acoustics, to Subcommittee EH/1/3, Residential and industrial noise, upon which the following bodies were represented:

Association of Consulting Engineers
Association of Consulting Scientists
Association of Metropolitan Authorities
Association of Noise Consultants
British Association for Shooting and Conservation
British Cement Association
British Coal Corporation
British Occupational Hygiene Society
British Scrap Federation
Chartered Institute of Environmental Health
Confederation of British Forgers
Department of the Environment (Building Research Establishment)
Electricity Association
Institute of Acoustics
Institute of Sound and Vibration Research
Institution of Civil Engineers
Institution of Mechanical Engineers
London Transport
Ministry of Defence
National Physical Laboratory
Open University
Royal Automobile Club
UK Steel Association
University of Bradford
University of Salford

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Contents

Foreword

This British Standard has been prepared by Subcommittee EH/1/3. It supersedes BS 4142 : 1990, which is withdrawn.

This British Standard describes a method of determining the level of a noise of an industrial nature, together with procedures for assessing whether the noise in question is likely to give rise to complaints from persons living in the vicinity. The user is reminded that this standard is not based on substantive research but rather on accumulated experience. It has been prepared under the direction of the Health and Environment Sector Board. First published in 1967, BS 4142 was amended in 1975, 1980 and 1982. It was revised in 1990 to align it with ISO 1996: Parts 1 to 3, which are implemented as BS 7445 : Parts 1 to 3. This revision clarifies aspects of the standard in the light of comments from the users. In particular, the term 'residual noise level' has been introduced and the term 'steady noise' deleted, the section dealing with measurement of specific noise level has been clarified and requirements for verification and traceability of instrumentation have been aligned with BS 7445 (ISO 1996).

Response to noise is subjective and affected by many factors (acoustic and non-acoustic). In general, the likelihood of complaint in response to a noise depends on factors including the margin by which it exceeds the background noise level, its absolute level, time of day, change in the noise environment etc., as well as local attitudes to the premises and the nature of the neighbourhood. This standard is only concerned with the rating of a noise of an industrial nature, based on the margin by which it exceeds a background noise level with an appropriate allowance for the acoustic features present in the noise. As this margin increases, so does the likelihood of complaint.

The standard is intended to be used for assessing the measured or calculated noise levels from both existing premises and new or modified premises. The standard may be helpful in certain aspects of environmental planning and may be used in conjunction with recommendations on noise levels and methods of measurement published elsewhere.

The standard is necessarily general in character and may not cover all situations. The likelihood that an individual will complain depends on individual attitudes and perceptions in addition to the noise levels and acoustic features present. This standard makes no recommendations in respect of the extent to which individual attitudes and perceptions should be taken into account in any particular case.

Although, in general, there will be a relationship between the incidence of complaints and the level of general community annoyance, quantitative assessment of the latter is beyond the scope of this standard, as is the assessment of nuisance.

It should be noted that noise assessment is a skilled operation and should be undertaken only by persons who are competent in the procedures.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

1 Scope

This British Standard describes methods for determining, at the outside of a building:

a) noise levels from factories, or industrial premises, or fixed installations, or sources of an industrial nature in commercial premises; and

b) background noise level.

The standard also describes a method for assessing whether the noise referred to in (a) is likely to give rise to complaints from people residing in the building. The method is not suitable for assessing the noise measured inside buildings or when the background and rating noise levels are both very low.

NOTE. For the purposes of this standard, background noise levels below about 30 dB and rating levels below about 35 dB are considered to be very low.

Examples of how to use the standard to obtain noise ratings and to assess the likelihood of complaints are given in annex A.

2 References

2.1 Normative references

This British Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on the inside back cover. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this British Standard only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

2.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions and symbols

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

NOTE. The convention applied to this standard is that all measured or calculated numbers are rounded to the nearest whole number with 0.5 being rounded up.

3.1 equivalent continuous A-weighted sound pressure level, $L_{\mathrm{Aeq},T}$

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

$$L_{\mathrm{Aeq},T} = 10\ \lg_{10}\left\{(1/T)\int_{t_1}^{t_2} (p_A{}^2(t)/\ p_O{}^2)\mathrm{d}t\right\} \qquad (1)$$

where:

$L_{\mathrm{Aeq},T}$ is the equivalent continuous A-weighted sound pressure level determined over a time interval $T = t_2 - t_1$;

p_O is the reference sound pressure (20µPa);

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

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

3.2 specific noise source

The noise source under investigation for assessing the likelihood of complaints.

3.3 reference time interval, T_r

The specified interval over which an equivalent continuous A-weighted sound pressure level is determined.

3.4 specific noise level, L_{Aeq,T_r}

The equivalent continuous A-weighted sound pressure level at the assessment position produced by the specific noise source over a given reference time interval.

3.5 measurement time interval, T_m

The total time over which measurements are taken.

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

3.6 rating level, L_{Ar,T_r}

The specific noise level plus any adjustment for the characteristic features of the noise.

3.7 ambient noise

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

3.8 residual noise

The ambient noise remaining at a given position in a given situation when the specific noise source is suppressed to a degree such that it does not contribute to the ambient noise.

3.9 residual noise level, $L_{\mathrm{Aeq},T}$

The equivalent continuous A-weighted sound pressure level of the residual noise.

3.10 background noise level, $L_{\mathrm{A90},T}$

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

4 Measuring equipment

4.1 Equivalent continuous noise level

Equivalent continuous noise levels shall be measured in terms of $L_{Aeq,T}$ using an integrating-averaging sound level meter or equivalent system conforming to type 2 or better of BS EN 60804.

NOTE. If the noise is steady, an approximation to $L_{Aeq,T}$ can be obtained by visually averaging the indication of a sound level meter set to frequency weighting 'A' and the use of this method should be reported.

4.2 Background noise level

For measurement of background noise level, $L_{A90,T}$, the components of the measuring system shall conform to type 2 or better of BS EN 60651.

5 Measurement practice

5.1 Operational tests

Apply an acoustic calibrator or pistonphone conforming to BS 7189 to the microphone to check the sensitivity of the measuring equipment before and after measurements. Record the results of such tests.

5.2 Verification and traceability

In addition to the tests in **5.1**, at certain time intervals, e.g. every two years, more extensive tests of the performance of the instrumentation may be prescribed by authorities responsible for the use of the results.

NOTE. In deciding on how comprehensive these tests should be, the level of accuracy involved in application of this standard in the particular case should be considered. For the highest level of verification, tests of the conformity of the calibrator or pistonphone to BS 7189 and verification of the complete measuring equipment to BS 7580 : Part 1 should be carried out either by a national metrology institute, or a competent calibration laboratory that can demonstrate that its measurements are traceable to national or international standards. In the UK, acoustical calibration laboratories are accredited by the United Kingdom Accreditation Service (UKAS); the relevant national metrology institute is the National Physical Laboratory. Where less comprehensive tests are prescribed these should also be reported under clause **10**.

5.3 Measurement positions

Choose measurement positions that are outside buildings and that will give results that are representative of the specific noise level and background noise level at the buildings where people are likely to be affected.

To minimize the influence of reflections, make the measurements at least 3.5 m from any reflecting surface other than the ground.

NOTE 1. The preferred measurement height is 1.2 m to 1.5 m above the ground.

NOTE 2. Where it is necessary to make measurements above ground floor level, choose a position which is 1 m from the facade on the relevant floor of the building.

NOTE 3. Report the measurement position, height and the distance from any reflecting structure other than the ground.

5.4 Precautions against interference

Take precautions to minimize the influence on the readings from sources of interference such as the following (and from any other sources):

- wind, passing over the diaphragm of the microphone of a sound level meter which can generate noise interference;
- heavy rain, falling on the microphone windshield or nearby surfaces which can cause noise interference;
- electrical interference, which can be caused in the sound level meter by, for example, nearby power cables or radio transmitters.

Use an effective windshield to minimize turbulence at the microphone.

NOTE. For the purposes of this standard, windshields are generally effective up to windspeeds of 5 m/s.

Measured levels shall be considered valid only if they exceed readings on the measuring instrument owing to the above influences by at least 10 dB.

5.5 Weather conditions

Record the weather conditions prevailing during all measurements.

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

NOTE 2. More than one assessment may be appropriate.

6 Specific noise level

6.1 General

Determine the specific noise level at the assessment location(s) as a discrete entity, distinct and free of influence from other noises contributing to the ambient noise, following the appropriate procedures in **6.3**. Report in detail the methods used.

Take care that all sample measurements are representative of the period of interest.

6.2 Reference time interval

Evaluate the specific noise, in all cases, over the appropriate reference time interval which is as follows:

- 1 h during the day;
- 5 min during the night.

NOTE. The shorter reference time interval at night means that short duration noises with an on time of less than 1 h lead to a greater specific noise level when determined over the reference time interval during the night rather than during the day. The choice of day and night periods will depend on normal local circumstances. It is intended that the night period should cover the times when the general adult population are preparing for sleep or are actually sleeping.

6.3 Determination of the specific noise level

6.3.1 Determine the specific noise level by applying the procedures in **6.3.2** to **6.3.14**.

6.3.2 The ambient noise is comprised of the residual noise and the specific noise when present. When taking measurements of the ambient noise to determine the specific noise level, it is important to distinguish between the specific noise and the residual noise. Distinguish between the specific noise and the residual noise. Minimize the influence of noise from other sources by measuring at times and during intervals when the residual noise level has subsided to typically low levels.

6.3.3 Compensate for the effect of the residual noise using the corrections set out in table 1. Measure the residual noise level in the absence of the specific noise.

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

Table 1. Corrections to noise level readings

Difference between noise level readings with specific noise present and absent dB	Correction to be subtracted from noise level reading with specific noise present dB
> 9	0
6 to 9	1
4 to 5	2
3	3
< 3	see **6.3.4** to **6.3.7**

NOTE. An estimate of the residual noise level during the measurement time intervals when the residual noise level has subsided to typically low levels can be made by measuring the background noise level when all other conditions are similar to those when the measurements are taken with the specific noise present.

6.3.4 Where possible, determine the specific noise level directly by measurement at the assessment location(s).

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

6.3.5 Where it is not possible to determine the specific noise level directly by measurement at the assessment location(s), for example, because of the influences of noise from other sources, determine the specific noise level by a combination of measurement and calculation. Report the method of calculation in detail and give the reason for using it.

NOTE. It may be possible to obtain a representative measurement at some other location and then use a method of calculation to estimate the specific noise level at the assessment location(s).

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

6.3.7 Determine the specific noise level as separate component parts, when:

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

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

Determine the equivalent continuous A-weighted sound pressure level of the specific noise, $L_{\mathrm{Aeq},T}$, over time interval, T, from the equivalent continuous A-weighted sound pressure levels of its components L_{Aeq,T_i} from equation (2).

$$L_{\mathrm{Aeq},T} = 10\,\lg_{10}\{(1/T)\ \Sigma T_i 10^{0.1 L_{\mathrm{Aeq},T_i}}\} \qquad (2)$$

where:

$T = \Sigma T_i$ if components are sequential;
T = maximum value of T_i if components are concurrent.

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

NOTE 1. The time interval, T, may contain intervals, T_i, during which the noise is off and the noise level is deemed to be 0 dB.

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

6.3.8 Take the measurement of the specific noise level over a time interval, T_m, which reflects all significant temporal and level variations of the specific noise.

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

6.3.9 If the measurement time interval is equal to the reference time interval use the following procedure.

Measure the equivalent continuous A-weighted sound pressure level, L_{Aeq,T_m}, correct for the influence of residual noise and assign the result to the specific noise level.

6.3.10 If the specific noise is continuous, such that measurements over the time interval, $T_m (< T_r)$, are representative of measurements over the reference time interval, T_r, use the following procedure.

Measure the equivalent continuous A-weighted sound pressure level, L_{Aeq,T_m}, correct for the influence of residual noise and assign the result to the specific noise level.

6.3.11 If the specific noise fluctuates at random, use the following procedure.

Select the measurement time interval to give a reliable estimate of the equivalent continuous A-weighted sound pressure level over the reference time interval. Measure the equivalent continuous A-weighted sound pressure level, $L_{\mathrm{Aeq},T_\mathrm{m}}$, correct for the influence of residual noise and assign the result to the specific noise level.

6.3.12 If the specific noise is continuous and cyclic with a period less than or equal to the reference time interval, use the following procedure.

Select the measurement time interval, T_m, to cover at least one complete cycle (or more). Measure the equivalent continuous A-weighted sound pressure level, $L_{\mathrm{Aeq},T_\mathrm{m}}$, correct for the influence of residual noise and assign the result to the specific noise level (see figure 1).

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

6.3.13 If the specific noise is intermittent and either steady or cyclic and the reference time interval, T_r, is at a representative time, and the on-time is less than the reference time interval, use the following procedure.

Determine the on-time, T_o, and select the measurement time interval, $T_\mathrm{m} \leq T_\mathrm{o}$, to obtain a representative value for the equivalent continuous A-weighted sound pressure level $L_{\mathrm{Aeq},T_\mathrm{m}}$, for the noise while it is on (see figure 2). Correct for the influence of residual noise.

Calculate the specific noise level as follows:

$$L_{\mathrm{Aeq},T\mathrm{r}} = L_{\mathrm{Aeq},T\mathrm{m}} + 10 \lg T_\mathrm{o}/T_\mathrm{r} \quad (3)$$

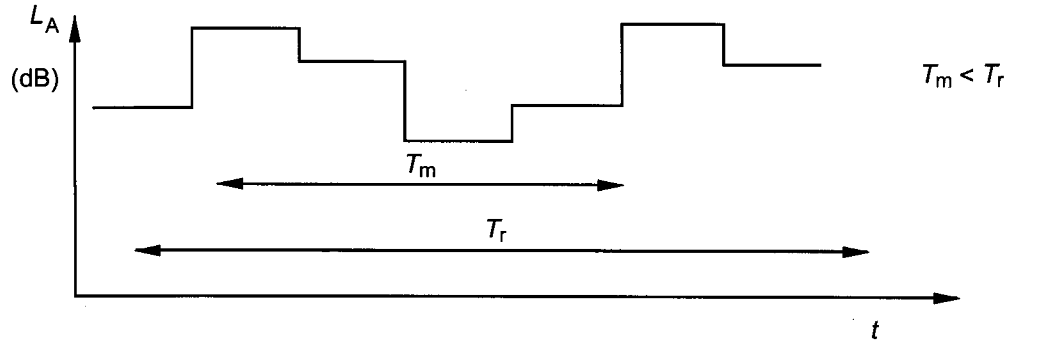


Figure 1. Selecting the measurement time interval

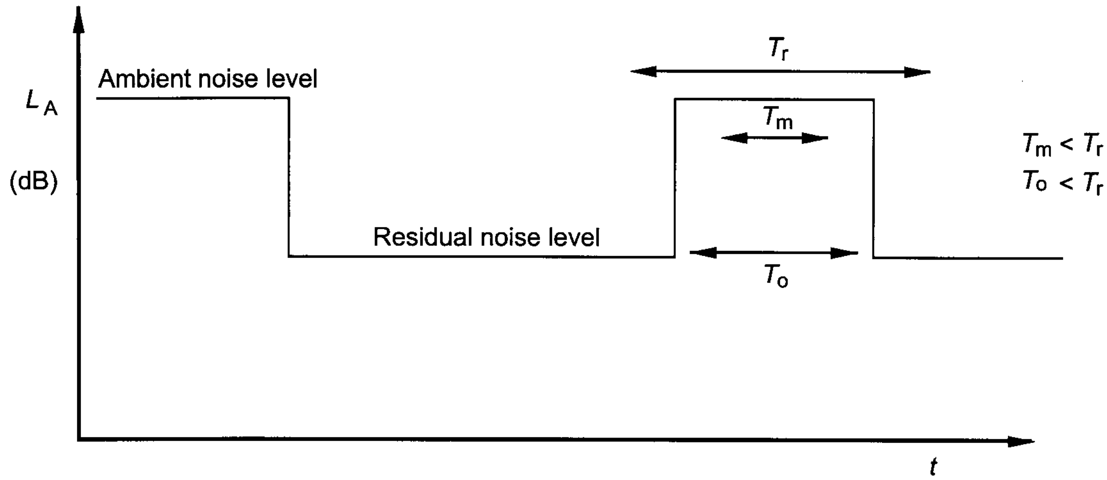


Figure 2. Selecting the measurement time interval

6.3.14 If the specific noise is intermittent or cyclic, and the reference time interval is at a representative time and the on-time is equal to or greater than the reference time interval, use the following procedure.

Select the measurement time interval, T_m, to obtain the highest representative value for the equivalent continuous A-weighted sound pressure level L_{Aeq,T_m}. Correct for the influence of residual noise and assign the result to the specific noise level (see figure 3).

7 Background noise level

NOTE. For the measurement of background noise level, this standard distinguishes three situations in which:

a) a new specific noise source is to be commissioned or a modification is to be made to an existing specific noise source (see **7.2**);

b) there is an existing specific noise source not operating continuously (see **7.3**);

c) an existing specific noise source is operating continuously (see **7.4**).

7.1 General

7.1.1 Where possible, measure the background noise level at the assessment location(s). If it is not possible to measure the background noise level at the assessment location(s) then measure the background noise level at another position where it is presumed to be equivalent and report the reasons for presuming it to be equivalent.

7.1.2 Ensure that the measurement time interval is sufficient to obtain a representative value of the background noise level.

NOTE. The background noise level can often be significantly affected by meteorological conditions, particularly where the main background noise sources are remote from the assessment location. In such cases, it may be necessary to repeat the background noise measurements on a number of occasions to obtain a representative measurement sample. More than one assessment may be appropriate.

7.1.3 Make measurements during periods when the background noise level is typical of the background noise when the specific noise source is or will be operating, but is not actually operating at the time of measurement.

7.1.4 Measure the background noise level during periods when weather conditions are appropriate to the assessment similar to those which prevail when the specific noise level is determined, or are likely to be similar to those during the operation of a new or modified specific noise source.

7.2 New or modified specific noise source

Measure the background noise on days of the week and at times of the day when the specific noise source will be operating.

7.3 Existing specific noise source not operating continuously

Measure the background noise level in the absence of the specific noise on days and at times when the specific noise source would normally be operating, either:

a) during a temporary shutdown of the specific noise source; or

b) during a period immediately before or after the specific noise source operates.

7.4 Existing specific noise source which operates continuously

Measure the background noise level at a position which is not influenced by the specific noise and where the background noise level is considered to be equivalent to that of the assessment location and report the reasons for presuming it to be equivalent.

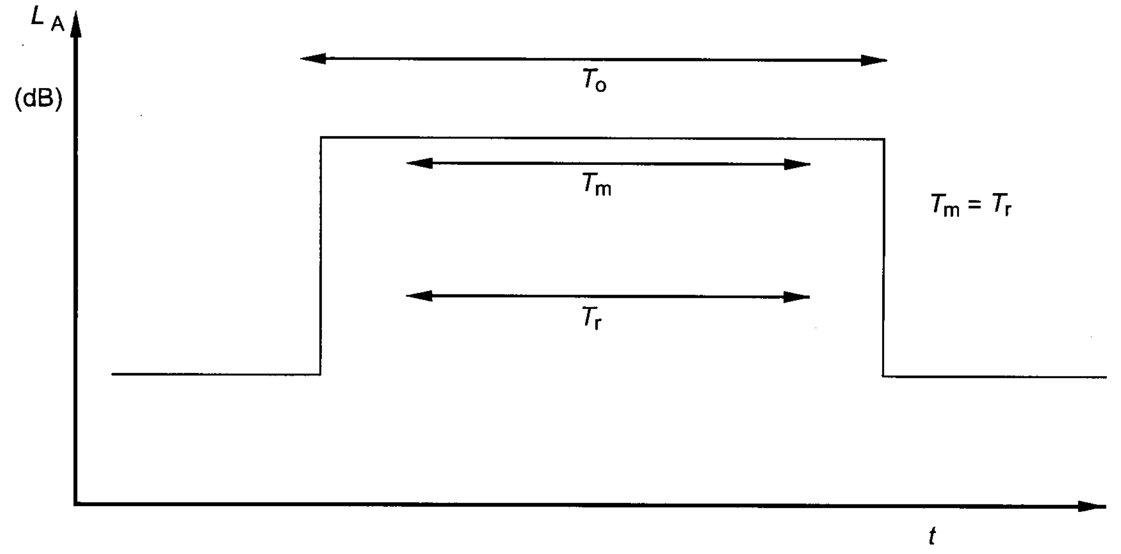


Figure 3. Selecting the measurement time interval

8 Rating level

8.1 Certain acoustic features can increase the likelihood of complaint over that expected from a simple comparison between the specific noise level and the background noise level. Where present at the assessment location, such features are taken into account by adding 5 dB to the specific noise level to obtain the rating level.

8.2 Apply a 5 dB correction if one or more of the following features occur, or are expected to be present for new or modified noise sources:

- the noise contains a distinguishable, discrete, continuous note (whine, hiss, screech, hum, etc.);
- the noise contains distinct impulses (bangs, clicks, clatters, or thumps);
- the noise is irregular enough to attract attention.

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

9 Assessment method

Assess the likelihood of complaints by subtracting the measured background noise level from the rating level.

NOTE. More than one assessment may be appropriate.

The greater this difference the greater the likelihood of complaints.

A difference of around +10 dB or more indicates that complaints are likely.

A difference of around + 5 dB is of marginal significance.

If the rating level is more than 10 dB below the measured background noise level then this is a positive indication that complaints are unlikely.

10 Information to be reported

The following information shall be reported:

a) source under investigation as follows:
   1) description of source and of specific noise;
   2) hours of operation;
   3) mode of operation (e.g. continuous, twice a day, only in hot weather);
   4) description of premises in which source is situated (if applicable).

b) subjective impressions including:
   1) dominance or audibility of specific noise;
   2) main sources contributing to the residual noise.

c) location of measurement positions, their distance from the specific noise source and the topography of the intervening ground, distance from specific noise source and any reflecting surface other than the ground including a dimensioned sketch with a north marker;

d) noise measuring instruments including calibrator or pistonphone used:
   1) type;
   2) manufacturer;
   3) serial number;
   4) details of the latest verification test including dates.

e) operational test:
   1) reference level of calibrator or pistonphone;
   2) meter reading before and after measurements with calibrator or pistonphone applied.

f) weather conditions, including:
   1) wind speed and direction;
   2) presence of conditions likely to lead to temperature inversion (e.g. calm nights with little cloud cover);
   3) precipitation;
   4) fog.

g) date and time of measurements;

h) specific noise level;
   1) measured noise level(s);
   2) residual noise level and method of determination;
   3) specific noise level and method of determination;
   4) justification of methods;
   5) details of any corrections applied.

i) measurement time intervals;

j) reference time interval(s);

k) rating level;
   1) specific noise level;
   2) any acoustic features of the specific noise;
   3) rating level.

l) background noise level and measurement time interval and in the case of measurements taken at an equivalent location, the reasons for presuming it to be equivalent;

m) excess of the rating level over the measured background noise level and the assessment.

Annex A (informative)

Examples of how to use the standard to obtain noise ratings

NOTE. These examples are merely meant to illustrate how the standard could be applied and are not to be taken as a definitive interpretation of how it should be used.

A.1 EXAMPLE 1

This example deals with a situation where the noise that is to be rated is considerably in excess of the background noise. It is assumed that full information as required in clause **10** of this standard would be included in the report and is not therefore given here.

A factory that has recently become operational and works only during the day produces a continuous steady hum that can be heard at the measurement location.

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

This means that it is reasonable to assume that sample measurements are representative, provided that there is no reason to believe that either the background noise or the factory noise would significantly change over a longer period of time. It is further reasonable to assume in this case that the background level does not change after the machinery is turned on.

The specific noise level, in this case from the entire factory, was measured in terms of $L_{Aeq(7min)}$, as this sample measurement was deemed to be a representative sample of the factory noise.

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

The residual noise was measured when the specific noise was off but when conditions contributing to the fluctuations in the residual noise were similar to those when the specific noise level was measured.

Figure A.1 shows a short extract of the typical time variation of noise level before (when the residual noise was measured) and after the specific noise source was turned on.

Example 1

Results		**Relevant clause**	**Commentary**
Measured noise level	$L_{Aeq(7\ min)}$ = 51 dB	**6.3**	*(specific noise source on and the level unaffected by any other noise sources)*
Residual noise level	$L_{Aeq(7\ min)}$ = 36 dB	**6.3**	*(specific noise off to determine the correction to be made to the measured level using table 1)*
Background level	$L_{A90(15\ min)}$ = 35 dB	**7.3**	*(measured just before the factory started up and was deemed to be representative of the background noise when the factory was in operation)*
Assessment to be made during the daytime thus the reference time period is 1 h		**6.2**	
Correction from table 1 is 0 dB			
Specific noise level	$L_{Aeq(60\ min)}$ = (51 − 0) dB = 51 dB	**6.3**	*(correction from table 1 is zero since measured level is more than 10 dB in excess of residual level. There is no correction for duration as the specific noise operates continuously when on)*
Acoustic feature correction	+ 5 dB	**8.2**	
Rating level	(51 + 5) dB = 56 dB	**8.3**	*(the factory produces a continuous steady hum)*
Background level	$L_{A90(15\ min)}$ = 35 dB		
Excess of rating over background level	(56 − 35) dB = 21 dB	**9**	
Assessment indicates complaints are likely.		**9**	

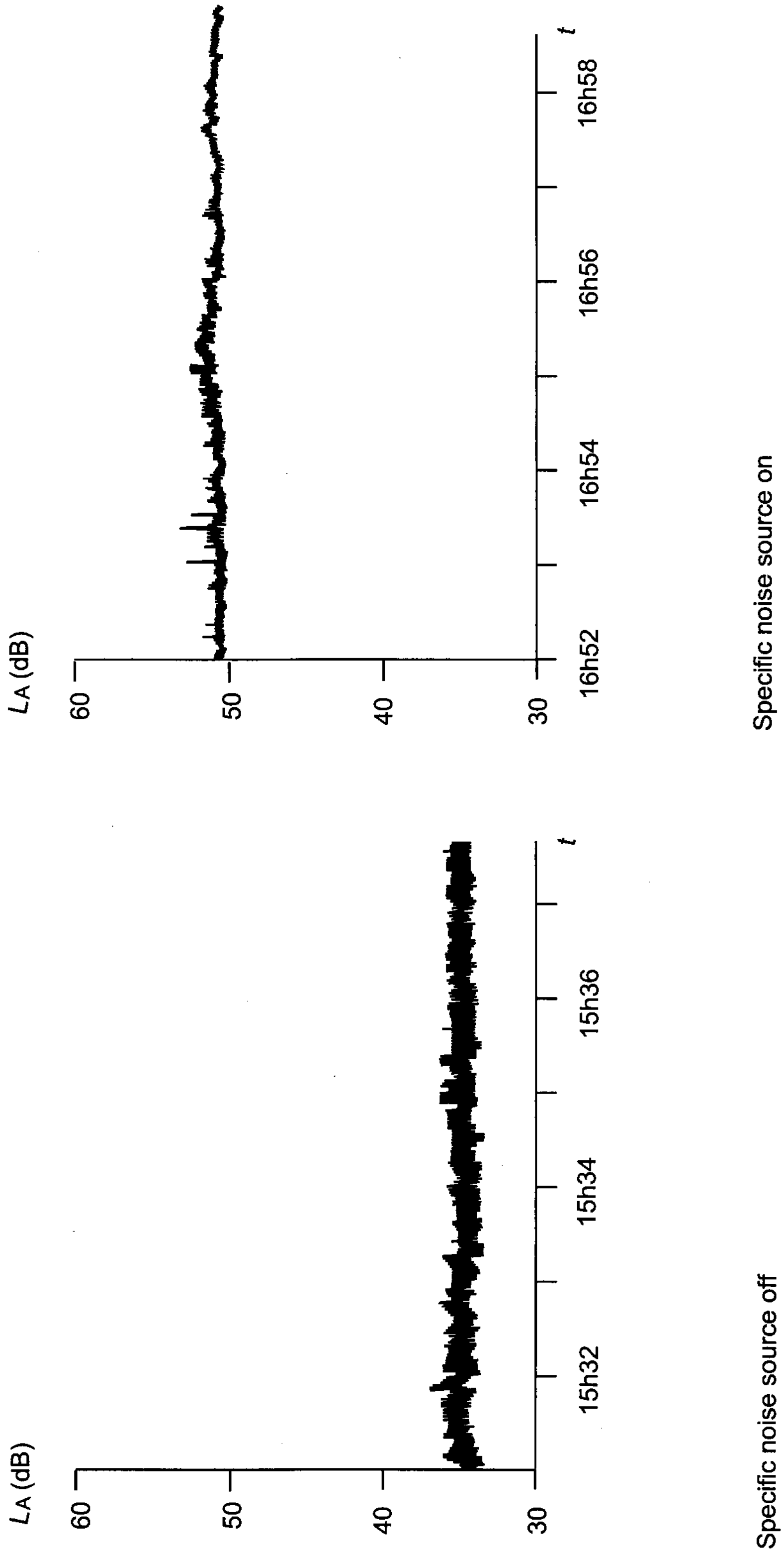


Figure A.1 Noise level variation with time

A.2 EXAMPLE 2

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

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

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

Figure A.2 shows a short extract of the typical time variation of the level before and after the specific noise source was turned on. Since the measured noise level is not much in excess of the residual noise level the choice is either to apply a correction to the measured level or to measure the level on another occasion when the residual noise is lower.

In this example, the specific noise was measured over a 20 min period. This was assumed to be representative of any longer term fluctuations in the specific noise.

The residual noise level was determined over a similar representative time period of 20 min when the specific noise was off.

Example 2

Results		**Relevant clause**	**Commentary**
Measured noise level	$L_{Aeq(20\ min)}$ = 40 dB	**6.3**	*(specific noise on)*
Residual noise level	$L_{Aeq(20\ min)}$ = 35 dB	**6.3**	*(specific noise off to determine the correction to be made to the measured level using table 1)*
Background level (day)	$L_{A90(30\ min)}$ = 33 dB	**7.3**	*(the background noise was measured in a temporary shutdown of the factory but otherwise representative of normal conditions)*
Assessment to be made during the daytime thus the reference time period is 1 h		**6.2**	
Correction from table 1 is 2 dB			
Corrected measured level	(40 − 2) dB = 38 dB	**table 1**	*(the measured level was 5 dB over the residual noise level then the measured specific noise has to be corrected [using table 1])*
Specific noise level	$L_{Aeq(60\ min)}$ = 38 dB	**6.3**	*(Source operates continuously)*
Acoustic feature correction	0 dB	**8.1**	*(No acoustic features were present)*
Rating level	(38 + 0) dB = 38 dB	**8.3**	
Background level	$L_{A90(30\ min)}$ = 33 dB		
Excess of rating over background level	(38 − 33) dB = 5 dB	**9**	
Assessment indicates marginal significance.		**9**	

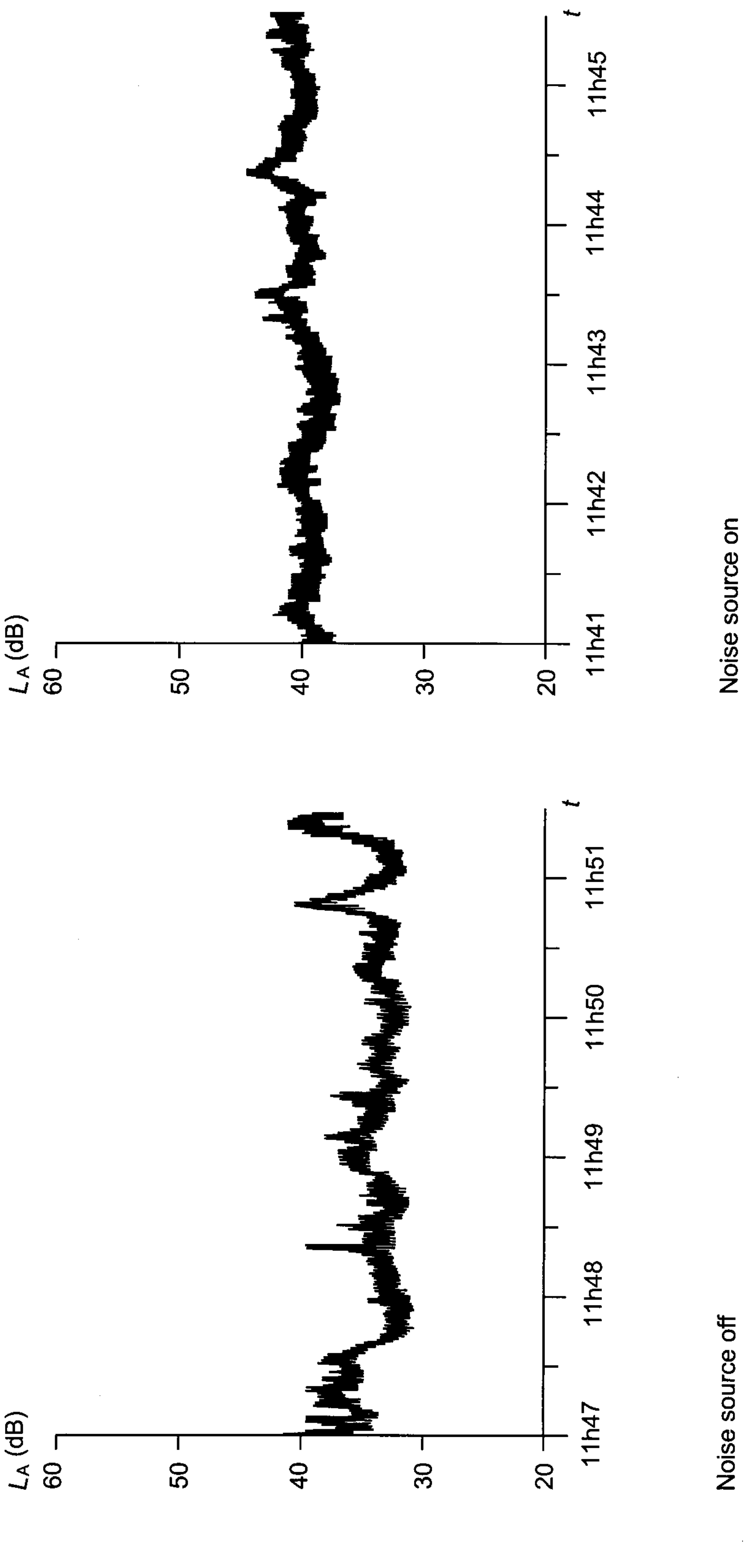


Figure A.2 Measurement of the factory noise affected by the residual noise

A.3 EXAMPLE 3

This example is to illustrate the situation where measurement has been made when the residual noise has subsided to typically low levels.

An existing factory installed a machine which has operated during the day without complaint. They wish to assess the likelihood of complaint if it were to operate at night. The machine operates continuously emitting squeaks and bangs.

The maximum noise levels were produced by the passing traffic and were above the steady noise of the specific noise source. The specific noise source was measured during those periods between passing traffic (this was achieved by pausing the measurement during the passage of individual vehicles).

Figure A.3 shows a 6 min extract of the hour long measurement of the residual noise at night. An hour was used because of the variability of the noise level. The specific source on the noise level was measured during the indicated periods.

In this case when measurement of the specific noise has been made in the typical low level periods of residual noise, an estimate of the residual noise during the typical low level periods is given by the background noise level.

Example 3

Results		Relevant clause	Commentary
Measured noise level	$L_{\text{Aeq(4 min)}}$ = 44 dB	**6.3**	*(the specific noise could clearly be heard in the lulls in the passing night time traffic)*
Residual noise level	(estimate) = 38 dB	**6.3**	*(residual noise estimated from the measured background noise level)*
Background level (night)	$L_{\text{A90(60 min)}}$ = 38 dB	**7.3**	*(a relatively long measurement was used because of the fluctuating level – the background level can be measured over a longer time than the reference time period)*
Correction from table 1 is subtract 1 dB			
Corrected measured level	(44 − 1) dB = 43 dB	**table 1**	*(the measured level was only 6 dB over residual thus correction from table 1 is 1 dB)*
Night time		**6.2**	
Assessment to be made during the night time thus the reference time period is 5 min			
Specific noise level	$L_{\text{Aeq(5 min)}}$ = 43 dB		
Acoustic feature correction	+ 5 dB	**8.2**	
Rating level	(43 + 5) dB = 48 dB	**8.3**	*(There is only a single correction of 5 dB even though the noise emits both squeaks and bangs)*
Background level	$L_{\text{A90(60min)}}$ = 38 dB		
Excess of rating over background level	(48 − 38) dB = 10 dB	**9**	
Assessment indicates complaints are likely.		**9**	

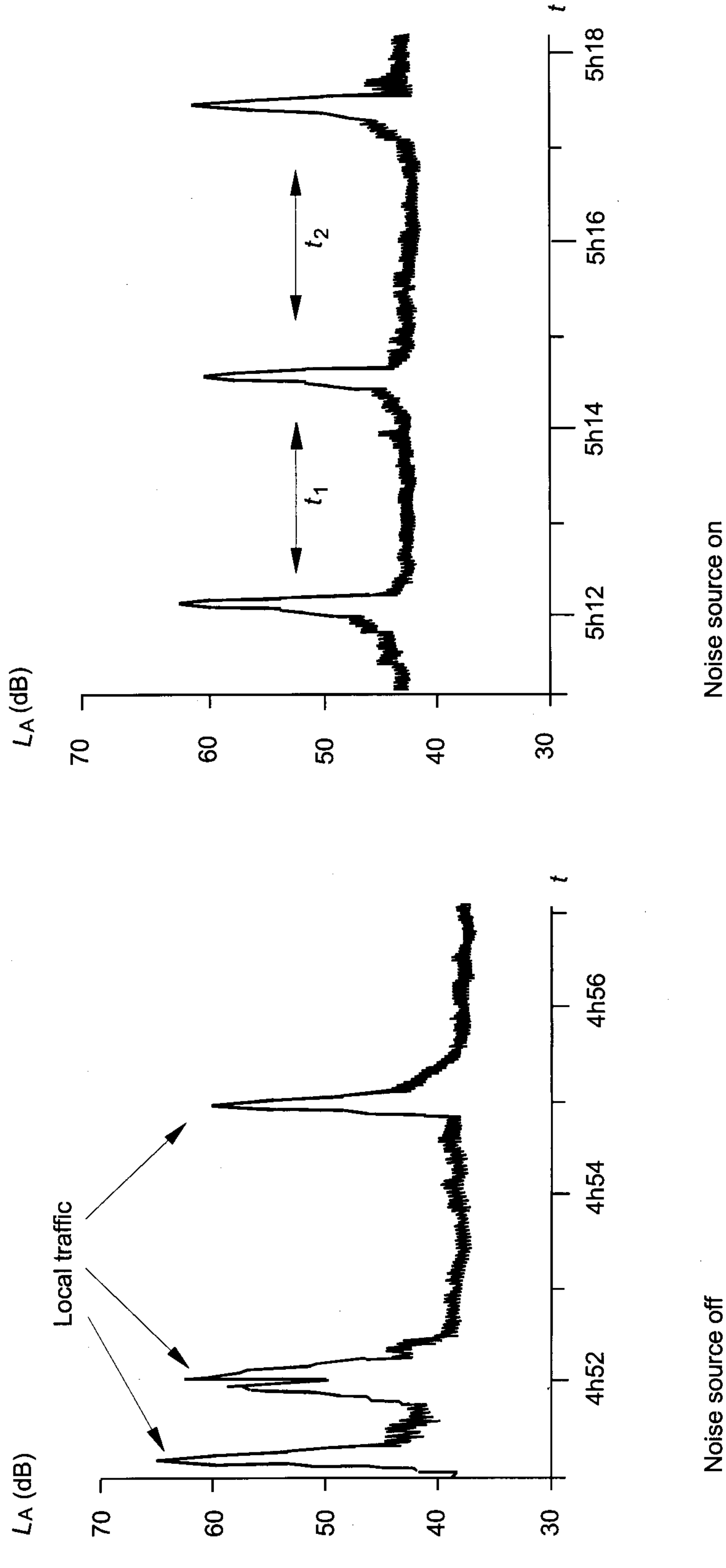


Figure A.3 Measurement of the specific noise made during the lulls in passing vehicles

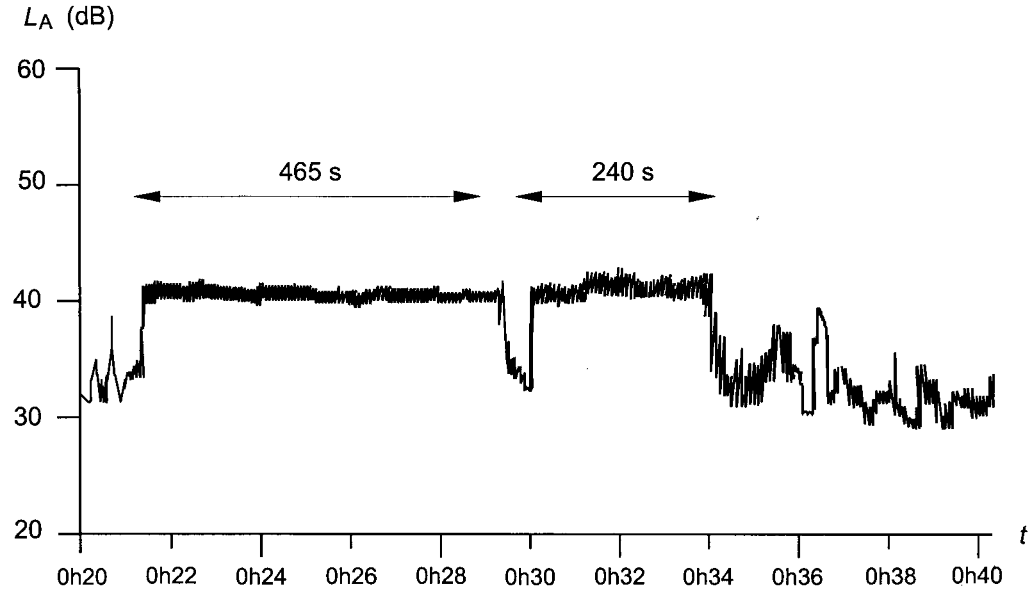
A.4 EXAMPLE 4

This example illustrates a source that is continuous and cyclic.

A factory on the edge of an industrial estate works 24 h a day and is to install a new process which has both a hiss and periodic clatter. The process will operate from 06.00 am to 02.00 am. Figure A.4 shows a typical cycle of operation: the source is on from 00.21:30 to 00.29:15 (465 s) and from 00.30:00 to 00.34:00 (240 s) then does not operate for the rest of the hour.

The background noise level, measured at the nearest residence in terms of $L_{A90(1h)}$ was 31 dB at night and 39 dB during the day.

When the new operation noise was measured at a similar factory the $L_{Aeq(12\ min)}$ was 40 dB. After the specific noise was measured it was turned off and the measured residual noise level was 36 dB.



Noise source cycling on and off

Figure A.4 Noise source cycling on and off

Example 4

Results		**Relevant clause**	**Commentary**
Measured noise level	$L_{Aeq(12\ min)}$ = 40 dB	**6.3**	
Residual noise level	$L_{Aeq(12\ min)}$ = 36 dB	**6.3**	*(the residual noise level was measured on the same night as the specific noise but when it was not on)*
Background level (day)	$L_{A90(60\ min)}$ = 39 dB	**7.3**	
Background level (night)	$L_{A90(60\ min)}$ = 31 dB		*(the background noise level was measured during the day time under similar weather conditions to those that prevailed when the specific noise was measured)*
Correction from table 1 is subtract 2 dB			
Corrected measured level	40 dB − 2 dB = 38 dB	**table 1**	*(the measured level was only 4 dB over residual thus correction from table 1 is 2 dB)*
Daytime			
Assessment to be made during the daytime thus the reference time period is 1 h		**5.2**	
The total on time during a reference period is 465 s + 240 s = 705 s			*(the source is on for two periods during the reference time of 60 min)*
Thus on time correction is	10 lg (705/3600) = −7 dB		
Specific noise level	$L_{Aeq(60\ min)}$ = (38 − 7) dB = 31 dB		
Acoustic feature correction	+ 5 dB	**7.2**	
Rating level	(31 + 5) dB = 36 dB	**7.3**	
Background level	$L_{A90(60min)}$ = 39 dB		*(the noise has a hiss and a clatter)*
Excess of rating over background level	(36 − 39) dB = −3 dB	**8**	*(measured when the specific source will be operating)*
Assessment does not indicate that complaints are likely		**8**	
Night time			
Assessment to be made during the night time thus the reference time period is 5 min.		**5.2**	*(No time correction required since at least one of the on time periods is longer than 5 min)*
Specific noise level	$L_{Aeq(5\ min)}$ = 38 dB		
Acoustic feature correction	+ 5 dB	**7.2**	
Rating level	(38 + 5) dB = 43 dB	**7.3**	
Background level	$L_{A90(60min)}$ = 31 dB		*(the noise has a hiss and a clatter)*
Excess of rating over background level	(43 − 31) dB = 12 dB	**8**	
Assessment indicates complaints are likely.		**8**	

List of references (see clause 2)

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 7189 : 1989	*Specification for sound calibrators*
BS 7580	*Specification for the verification of sound level meters*
BS 7580 : Part 1 : 1996	*Comprehensive procedure*
BS EN 60651 : 1994	*Specification for sound level meters*
BS EN 60804 : 1994	*Specification for integrating-averaging sound level meters*

Informative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 7445	*Description and measurement of environmental noise*
BS 7445 : Part 1 : 1991	*Guide to quantities and procedures*
BS 7445 : Part 2 : 1991	*Guide to the acquisition of data pertinent to land use*
BS 7445 : Part 3 : 1991	*Guide to application to noise limits*

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APPENDIX E
BS 8233:1999

Sound insulation and noise reduction for buildings — Code of practice

ICS 91.120.20

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/209, General building codes, to Subcommittee B/209/18, Sound insulation, upon which the following bodies were represented:

Aggregate Concrete Block Association
Association of Building Engineers
Association of Noise Consultants
Autoclaved Aerated Concrete Products Association
BAA plc
British Precast Concrete Federation Ltd.
Concrete Society
Consumer Policy Committee of BSI
Convention of Scottish Local Authorities
Department of the Environment, Transport and the Regions
Department of the Environment, Transport and the Regions (represented by the BRE)
Gypsum Products Development Association
Institute of Acoustics
Institute of Physics
National House-building Council
Noise Abatement Society
Royal Institute of British Architects
Royal Institution of Chartered Surveyors
Scottish Office — Construction and Building Control Group
Society of Chief Architects of Local Authorities
Wood Wool Slab Manufacturers Association

This British Standard, having been prepared under the direction of the Sector Committee for Building and Civil Engineering, was published under the authority of the Standards Committee and comes into effect on 15 August 1999

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Third revision, August 1999

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Draft for comment 97/105886 DC

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Amendments issued since publication

Amd. No.	Date	Comments

Contents

Foreword

This British Standard code of practice has been prepared by Technical Committee B/209/18. It was first published as CP 3:Chapter III:1972, which was superseded by BS 8233:1987. This revision supersedes BS 8233:1987, which is withdrawn. It takes account of recent legislation and official guidance, and changes have been made to improve clarity and focus on essential information.

This code of practice draws on the results of research and experience to provide information on the design of buildings that have internal acoustic environments appropriate to their functions. It deals with control of noise from outside the building, noise from plant and services within it, and room acoustics for non-critical situations. This code of practice is intended for use by non-specialist designers and constructors of buildings and those concerned with building control, planning and environmental health.

The information in this code of practice follows the typical sequence of activities in building design. Clause **5** gives a general overview of the subject, and clauses **6**, **7**, and **8** cover specific aspects in more detail.

Clauses **5** to **8** are mainly applicable to new build, while clauses **7** and **8** will also be of use where rehabilitation or change of use of an existing building is being considered.

It has been assumed in the drafting of this code of practice that the execution of its provisions will be entrusted to people who, although not experts in acoustics, are appropriately qualified and experienced.

Annexes A, B, C, D and E are informative.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations. In particular, attention is drawn to the Town and Country Planning Act 1990 [1], the Building Regulations 1991 [2], the Building Standards (Scotland) 1990 [3] and the Building Regulations (Northern Ireland) 1994 [4].

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iii, a blank page, pages 1 to 49 and a back cover.

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Introduction

Noise control in and around buildings is treated in this code of practice on an objective and quantifiable basis as far as is currently possible. For many common situations, this code suggests criteria — such as reasonable sleeping/resting conditions — and proposes noise limits that will normally satisfy these criteria for most people. However, it should be borne in mind that people vary widely in their sensitivity to noise, and the limits suggested may have to be adjusted to suit local circumstances. Moreover, noise limits refer only to the physical characteristics of sound and cannot differentiate between pleasant and unpleasant sounds. Important though psychological factors may be, it is not practicable to consider them here.

Attention is drawn to the fact that measures taken to control sound may also impinge on fire precautions and other health and safety requirements; all such requirements should be considered together at an early stage of the design.

1 Scope

This British Standard gives recommendations for the control of noise in and around buildings, and suggests appropriate criteria and limits for different situations. These criteria and limits are primarily intended to guide the design of new or refurbished buildings undergoing a change of use, rather than to assess the effect of changes in the external noise level. It covers room acoustics for simple situations, but not the design of buildings where the acoustics are critical, such as auditoria.

This code of practice does not cover vibration control, except where it is evident in the form of radiated sound.

2 Terms and definitions

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

2.1

sound pressure

p

root-mean-square value of the variation in air pressure measured in pascals (Pa), above and below atmospheric pressure, caused by the sound

2.2

A-weighted sound pressure

p_A

value of overall sound pressure, measured in pascals (Pa), after the electrical signal derived from a microphone has been passed through an A-weighting network

NOTE The A-weighting network modifies the electrical response of a sound level meter with frequency in approximately the same way as the sensitivity of the human hearing system.

2.3

sound pressure level

L_p

quantity of sound pressure, in decibels (dB), given by the formula:

$$L_p = 10 \log_{10} (p/p_o)^2$$

where

p is the root mean square sound pressure in pascals (Pa);

p_o is the reference sound pressure (20 μPa)

NOTE The range of sound pressures for ordinary sounds is very wide. The use of decibels gives a smaller, more convenient range of numbers. For example, sound pressure levels ranging from 40 dB to 94 dB correspond to sound pressures ranging from 0.002 Pa to 1 Pa. A doubling of sound energy corresponds to an increase in level of 3 dB.

2.4

A-weighted sound pressure level

L_{pA}

quantity of A-weighted sound pressure, given by the following formula in decibels (dBA):

$$L_{pA} = 10 \log_{10} (p_A/p_o)^2$$

where

p_A is the A-weighted sound pressure in pascals (Pa);

p_o is the reference sound pressure (20 μPa)

NOTE Measurements of A-weighted sound pressure level can be made with a meter and correlate roughly with subjective assessments of loudness, and are usually made to assist in judging the effects of noise on people. The size of A-weighting, in 1/3 octave bands, is shown in annex A (see **A.5**). An increase or decrease in level of 10 dBA corresponds roughly to a doubling or halving of loudness.

2.5

percentile level

$L_{AN,T}$

A-weighted sound pressure level obtained using time-weighting "F", which is exceeded for N % of a specified time interval

EXAMPLE

$L_{A90,1h}$ is the A-weighted level exceeded for 90 % of 1 h. Percentile levels determined over a certain time interval cannot accurately be extrapolated to other time intervals. Time-weighting "F" or "S" can be selected on most modern measuring instruments and used to determine the speed at which the instrument responds to changes in the amplitude of the signal. Time-weighting "F" is faster than "S" and so its use can lead to higher values when rapidly changing signals are measured.

2.6

equivalent continuous A-weighted sound pressure level

$L_{\mathrm{Aeq},T}$

value of the A-weighted sound pressure level in decibels (dB) of a continuous, steady sound, that within a specified time interval, T, has the same mean squared sound pressure as the sound under consideration that varies with time, given by the formula:

$$L_{\mathrm{Aeq},T} = 10 \log_{10} \left\{ \frac{1}{T} \int_0^T \frac{p_A^2(t)}{p_0^2}\, dt \right\}$$

where

$p_{\mathrm{A}}(t)$ is the instantaneous A-weighted sound pressure in pascals (Pa);

p_{o} is the reference sound pressure (20 μPa)

NOTE Equivalent continuous A-weighted sound pressure level is mainly used for the assessment of environmental noise and occupational noise exposure [5].

2.7

sound exposure level

L_{AE}

level of a sound, of 1 s duration, that has the same sound energy as the actual noise event considered

NOTE 1 The L_{AE} of a discrete noise event is given by the formula:

$$L_{\mathrm{AE}} = 10 \log_{10} \left\{ \frac{1}{t_0} \int_{t_1}^{t_2} \frac{p_A^2(t)}{p_0^2}\, dt \right\}$$

where

$p_{\mathrm{A}}(t)$	is the instantaneous A-weighted sound pressure in pascals (Pa);
$t_2 - t_1$	is a stated time interval in seconds (s) long enough to encompass all significant sound energy of the event;
p_{o}	is the reference sound pressure level (20 μPa);
t_{o}	is the reference time interval (1 s)

NOTE 2 L_{AE} is also known as L_{AX} (single-event noise exposure level).

2.8

rating level

$L_{\mathrm{Ar},Tr}$

equivalent continuous A-weighted sound pressure level of the noise, plus any adjustment for the characteristic features of the noise

NOTE This definition is used in BS 4142 for rating industrial noise, where the noise is the specific noise from the source under investigation.

2.9

free-field level

sound pressure level measured outside, far away from reflecting surfaces

NOTE Measurements made 1.2 m to 1.5 m above the ground and at least 3.5 m away from other reflecting surfaces are usually regarded as being free-field measurements. To minimize the effect of reflections the measuring position should be at least 3.5 m to the side of the reflecting surface (i.e. not 3.5 m from the reflecting surface in the direction of the source). Estimates of noise from aircraft overhead usually include a correction of 2 dB to allow for reflections from the ground.

2.10

façade level

sound pressure level measured 1 m to 2 m in front of the façade

NOTE Façade level measurements *of* L_{pA} are usually 2 dB to 3 dB higher than corresponding free-field measurements.

2.11

noise rating (NR)

graphical method for rating a noise by comparing the noise spectrum with a family of noise rating curves

NOTE Noise rating is described in annex B.

2.12

sound reduction index

R

laboratory measure of the sound insulating properties of a material or building element in a stated frequency band

NOTE For further information see BS EN ISO 140-3 and annex C.

2.13

weighted sound reduction index

R_{w}

single number quantity which characterizes the airborne sound insulating properties of a material or building element over a range of frequencies

NOTE The weighted sound reduction index is used to characterize the insulation of a material or product that has been measured in a laboratory (see BS EN ISO 717-1 and annex C).

2.14

standardized level difference

$D_{\mathrm{n}T}$

difference in sound level between a pair of rooms, in a stated frequency band, normalized to a reverberation time of 0.5 s

NOTE Standardized level difference takes account of all sound transmission paths between the rooms (see BS EN ISO 140-4 and annex C).

2.15

weighted standardized level difference

$D_{nT,w}$

single-number quantity, which characterizes the airborne sound insulation between rooms

NOTE Weighted standardized level difference is used to characterize the insulation between rooms in a building (see BS EN ISO 717-1 and annex C).

2.16

weighted level difference

D_w

single-number quantity that characterizes airborne sound insulation between rooms but which is not adjusted to reference conditions

NOTE Weighted level difference is used to characterize the insulation between rooms in a building as they are; values cannot normally be compared with measurements made under other conditions (see BS EN ISO 717-1).

2.17

impact sound pressure level

L_i

average sound pressure level in a specific frequency band in a room below a floor, when it is excited by a standard tapping machine

NOTE For additional information on impact sound pressure level and the standard tapping machine see BS EN ISO 140-6 and annex C.

2.18

standardized impact sound pressure level

L'_{nT}

impact sound pressure level normalized to a reverberation time in the receiving room of 0.5 s

NOTE Standardized impact sound pressure level is used to characterize the insulation of floors in buildings against impact sounds in a stated frequency band (see BS EN ISO 140-7 and annex C).

2.19

normalized impact sound pressure level

L_n

impact sound pressure level normalized for a standard absorption area in the receiving room

NOTE Normalized impact sound pressure level is usually used to characterize the insulation of a floor in a laboratory against impact sound in a stated frequency band (see BS EN ISO 140-6, BS EN ISO 140-7 and annex C).

2.20

weighted standardized impact sound pressure level

$L'_{nT,w}$

single number quantity used to characterize the impact sound insulation of floors over a range of frequencies

NOTE Weighted standardized impact sound pressure level is used to characterize the insulation of floors in buildings (see BS EN ISO 717-2 and annex C).

2.21

weighted normalized impact sound pressure level

single number quantity used to characterize the impact sound insulation of floors over a range of frequencies

NOTE Weighted normalized impact sound pressure level is usually used to characterize the insulation of floors tested in a laboratory (see BS EN ISO 717-2 and annex C).

2.22

cross-talk

unwanted sound transmission between one room and another room or space via a duct

2.23

break-out

unwanted sound transmission from inside a duct to the outside

2.24

break-in

unwanted sound transmission into a duct from outside

2.25

indoor ambient noise

pervasive noise in a given situation at a given time, usually composed of noise from many sources, inside and outside the building, but excluding noise from activities of the occupants

2.26

octave band

band of frequencies in which the upper limit of the band is twice the frequency of the lower limit

2.27

third octave band

band of frequencies in which the upper limit of the band is $2^{1/3}$ times the frequency of the lower limit

2.28

reverberation time

T

time that would be required for the sound pressure level to decrease by 60 dB after the sound source has stopped

NOTE Reverberation time is usually measured in octave or third octave bands. It is not necessary to measure the decay over the full 60 dB range. The decay measured over the range 5 dB to 35 dB below the initial level is denoted by T_{30}, and over the range 5 dB to 25 dB below the initial level by T_{20}.

2.29

equivalent sound absorption area of a room

A

hypothetical area of a totally absorbing surface without diffraction effects, expressed in square metres (m^2) which, if it were the only absorbing element in the room, would give the same reverberation time as the room under consideration

3 Symbols

The main symbols used in this code, together with relevant symbols used in standards referred to in this code, are given in Table 1.

4 Measuring equipment and accuracy

Measuring equipment should normally conform to the accuracy requirements given in the appropriate standard (BS EN ISO 140, BS 4142, BS EN 20354) or, if not stated, to type 2 or better (see BS EN 60804, BS EN 60651, BS EN 60942). In critical situations, for example, where the measurements are to confirm that a specification has been met or for the resolution of a dispute, the guidance given in the appropriate guidelines published by the Association of Noise Consultants should also be followed [6].

Table 1 — Symbols

Quantity	Symbol	Unit	Relevant standard
Sound pressure level	L_p	dB	
A-weighted sound pressure level	L_{pA}	dB	
Root mean square sound pressure	p	Pa	
Instantaneous A-weighted sound pressure	$p_A(t)$	Pa	
Reference sound pressure	p_o	Pa	
Percentile level	$L_{AN,T}$	dB	
Sound exposure level	L_{AE}	dB	
Equivalent continuous A-weighted sound pressure level	$L_{Aeq,T}$	dB	
Time interval (also used for reverberation time)	T	s	
Reference time interval	t_o	s	
Rating level	$L_{Ar,Tr}$	dB	BS 4142
Impact sound pressure level	L_i	dB	BS EN ISO 140-6
Normalized impact sound pressure level	L_n	dB	BS EN ISO 140-6, BS EN ISO 140-7
Standardized impact sound pressure level	L'_{nT}	dB	BS EN ISO 140-7
Weighted standardized impact sound pressure level	$L'_{nT,w}$	dB	BS EN ISO 717-1
Sound level difference	D	dB	
Weighted level difference	D_w	dB	BS EN ISO 717-1
Weighted standardized level difference	$D_{nT,w}$	dB	BS EN ISO 717-1
Sound reduction index	R	dB	BS EN ISO 140-3
Weighted sound reduction index	R_w	dB	BS EN ISO 717-1
Equivalent sound absorption area	A	m^2	BS EN 20354
Standardized level difference	D_{nT}	dB	BS EN ISO 140-4
Weighted normalized impact sound pressure level	$L'_{n,w}$	DB	BS EN ISO 717-2

5 Planning and design

5.1 Suggested sequence to be followed

The recommended sequence of stages in the planning and early design stages of a development in a noisy area is as follows.

a) Assess the site and identify significant noise sources (see **5.3**), measure or estimate noise levels (see clause **6**).

b) Evaluate layout options (see **5.2**).

c) Decide noise criteria and limits for spaces in and around the building(s) (see **5.4** and clause **7**).

d) Consider internal sound insulation requirements.

e) Consider sound insulation of building envelope.

Much of the advice given here can be applied in the reverse situation where a new noisy development is to be introduced near an existing noise sensitive development, such as housing. This is discussed in **5.7**, where the legal position is also outlined.

5.2 Assessing the site

5.2.1 *Planning requirements*

When planning permission is sought for a new building or for change of use of an existing building, the local planning authority may:

a) refuse permission if the site is too noisy for the proposed use;

b) refuse permission if the proposed use is likely to cause a noise nuisance to the occupants of existing buildings;

c) impose conditions regarding noise levels.

The local planning authority will be guided by the following government publications:

— in England and Wales: Department of the Environment (now Department of the Environment, Transport and the Regions) Planning Policy Guidance PPG 24, 1994: *Planning and Noise* [7] and Circular 1/85 *The use of conditions in planning permissions* [8];

— in Scotland: Scottish Development Department (now The Scottish Administration) Circular 23/73, *Planning and noise*, with SDD Memorandum 24/73, *Planning and Noise* [9];

— in Northern Ireland: as for England and Wales.

5.2.2 *Need for noise assessment*

To ensure a smooth passage through the planning system, even when a full environmental assessment (see **5.7.2**) is not mandatory, proposals for developments on noisy sites, or sites which generate noise, should take account of noise and an assessment should be made of the possible effects of:

a) noise generated outside that enters the building;

b) noise generated inside the building that may disturb people outside the building.

Some noise sources (e.g. airports) may not be active, or may change their mode of operation under different weather conditions and/or at certain times of day or night. Furthermore, buildings may not necessarily be occupied when the outside environment is noisy. It is therefore essential to consider the situation at the actual site when considering the need for noise control.

5.2.3 *Noise originating inside or outside the building*

For noise disturbance originating and heard within the building, the relevant design features are the internal construction and layout of the building (see clause **8** for more details).

For noise sources outside the building under consideration, the initial appraisal should take account of the options for:

a) location of the site in relation to the noise source(s);

b) reduction of noise at source;

c) positioning of buildings on site;

d) orientation of buildings on site;

e) provision of barriers;

f) increasing the sound insulation of the building envelope;

g) replanning the interior layout of the building.

Factors a) to g) may also be applicable for protecting neighbouring buildings that are likely to be disturbed by noise sources operating within the building.

5.3 External noise sources — Meteorological effects

The main sources of noise are air, road and rail traffic, and industrial/commercial activities. Information on these sources is given in clause **6**.

Whether noise levels are measured or predicted, it should be borne in mind that wind gradients, temperature gradients and turbulence affect the level of received sound over short periods. The effects range from increasing the level by typically 2 dB downwind, to reducing it by typically 10 dB upwind — or even more in extreme conditions. It is not usually practicable to use this factor in design, but the prevailing wind direction should be considered when planning building orientation. For example, for a site with similar noise sources on two opposite sides, noise sensitive rooms should be oriented on the leeward side.

5.4 Noise criteria and limits

To achieve a satisfactory noise environment inside the building it is necessary to know how each space will be used so that appropriate criteria can be chosen.

Having chosen the appropriate criteria, noise limits can be set for specific situations.

NOTE Advice on criteria and limits for various building types is given in clause **7**.

5.5 Noise control measures

5.5.1 *General approach*

The purpose of noise control is to ensure that all reasonable steps are taken to ensure that people are neither harmed nor disturbed by noise. Effective design for noise control requires a good understanding of the behaviour of sound.

NOTE While the general approach is explained in this subclause, practical information on the transmission of sound within buildings and propagation across the ground is given in the Building Research Establishment document BR 238/CIRIA report 127 [10]. Specialist advice will be required for more complex situations, such as those listed in annex D.

Noise from outside can be reduced in the following ways:

a) by quietening or removing the source of noise;

b) by attenuating the sound on its path to the receiver;

c) by obstructing the sound path between source and receiver;

d) improving the sound insulation of the building envelope.

5.5.2 *Quietening the source*

Reducing the noise at source should always be considered because the number of people benefiting will often be large and it can be the most cost-effective method.

5.5.3 *Attenuating the noise*

Noise is attenuated as it travels through the air, because it:

a) spreads out;

b) is affected by nearby surfaces such as grass-covered ground; and

c) is partly absorbed by the air itself.

All these mechanisms which attenuate the noise become more effective the greater the distance between the source and the receiver. Spreading is usually the most important effect. For small sources, the reduction is up to about 6 dB for each doubling of distance between source and receiver. For extended sources, there is a smaller reduction with distance. For example, the noise level from dense road traffic diminishes at about 3 dB for each doubling of distance.

The worst situation occurs with traffic in city streets with high buildings on both sides. The noise level diminishes very slowly as the storey height increases because of multiple reflections between the façades (canyon effect).

Ground attenuation is negligible for hard ground. For grassland, the attenuation varies with frequency.

A belt of trees less than about 30 m deep provides little extra sound attenuation. For this reason, tree planting is not normally a practical noise control measure.

5.5.4 *Obstructing the sound*

Complete enclosure of the noise source or receiver is the most effective form of barrier, provided it is impervious and sufficiently heavy. The walls and roof of a building usually perform this function (see clause **8**). Their efficiency as a sound insulator is reduced by weaknesses in the envelope (e.g. ventilation openings, thin glazing, and doorways), especially when windows are open in the summer.

Solid barriers cast a shadow within which the sound level is reduced. Barriers that are not complete enclosures (e.g. fences) are most effective when tall, long and close to either the source or the receiver. They may be solid fences, walls, earth bunds or buildings, and should extend to the ground.

NOTE To calculate the attenuation for road and rail traffic noise and construction noise see the references given in clause **6**. Attenuation values of around 10 dB are common, but a barrier may reduce the benefit of any ground absorption.

5.6 Sound insulation of the envelope

5.6.1 *General*

In the past, experience often played an important role in the design of sound insulation measures, but as limits are set more tightly now, calculation methods should be regarded as the normal approach.

5.6.2 *Calculation*

5.6.2.1 *General*

An assessment should first be made of:

a) the level and characteristics of the noise outside the building (see clause **6**);

b) the desirable/acceptable noise levels in the rooms of the building (see clause **7**).

The noise reduction required can be calculated from a) and b).

Usually, the designer will have a form of construction in mind, which takes into account cost and other constraints. The proposed design should be examined and calculations carried out to see if the target noise reduction is likely to be achieved. The results will indicate whether a higher standard of noise control should be considered or whether a lower standard will be adequate. If a change in the design is indicated, further calculations should be carried out and the process repeated until a satisfactory result is predicted. In a situation where a low standard will suffice it may be prudent to consider future uses of the building.

5.6.2.2 *Initial estimates*

Initial estimates may be no more than simple arithmetic calculations based on single-figure data such as the following.

a) The level of the noise at a key position, such as the equivalent continuous A-weighted sound pressure level ($L_{Aeq,T}$) at the location of the nearest façade of the proposed building. The time period, T, should be chosen to cover the normal operation of the source, or particular occupational requirements of the building if more appropriate. If the source level varies, the maximum level having an appreciable duration should be chosen.

b) The sound reduction of appropriate parts of the building envelope (e.g. estimated from values of R_w, see clause **8** and annex E).

NOTE Annex A contains a method for estimating the sound insulation of non-uniform partitions such as a façade comprising windows and cladding.

c) The target sound level at the receiver (e.g. $L_{Aeq,T}$). If the source operates at night, it may be appropriate to have separate target noise levels for day and night periods.

It is important to stress that there is no simple relationship connecting these single-figure data and that the results will be approximate (see clause **6**).

5.6.2.3 *Detailed calculations*

For detailed calculations, knowledge of the following is required:

a) the frequency characteristics of the noise source;

b) the frequency characteristics of the sound reducing elements;

c) the surface area of the common construction separating the two areas;

d) the reverberation time of the receiving space.

Generally, frequency data should be for contiguous octave bands.

Comprehensive numerical data are essential for the use of performance standards in buildings to become more common [11]. Calculation methods will grow in importance as numerical data on the characteristics of noise sources and sound reducing elements are compiled.

5.7 New noise producing development

5.7.1 *General*

Much of the advice already given in **5.1** to **5.6** can also be applied to a new noise producing development. As the local planning authority may require noise control measures, and if these are not carried out properly there may be widespread annoyance and legal ramifications, it is necessary to consider the legislative framework.

5.7.2 *Legislative framework and guidance*

There now exists a considerable body of legislation and authoritative recommendations on noise. For certain types of project, and projects having a significant environmental impact, a full environmental assessment (EA) is required, an important part of which is often noise. Even when an EA is not mandatory, it is important to avoid complaints and the risk of legal action after the project is completed. It is, therefore, prudent to consult, at an early stage, with local authority and other officials for the area in which building works are proposed.

Organizations which should be consulted may include:

a) the local planning authority;

b) the local authority environmental health department;

c) the building control authority.

5.7.3 *Environmental assessment (EA)*

A limited number of project types, such as major aerodromes, always require an EA [12]. For a wider range of projects, including local roads, other new aerodromes, industrial estate developments, and projects involving disposal of non-toxic waste and mineral extraction, an EA is required if the proposal is likely to have significant environmental effects. Where an EA is required, the likely effects of noise will be among the factors to be assessed, and dealt with in the environmental impact statement prepared by the developer and submitted to the planning authority with the planning application.

NOTE For further information see *Guidelines on noise and vibration assessment* [13].

5.7.4 *Construction noise*

Part III of the Control of Pollution Act 1974 [14] gives local authorities powers to control noise from construction sites.

NOTE Useful advice on controlling construction noise is given in BS 5228-1.

5.7.5 *Noise from other sources*

A local authority can take legal action to prevent or stop a noise from fixed premises, including land, which it considers amounts to a statutory nuisance. Any new noise source is a potential nuisance. Furthermore, an existing industrial/commercial noise source may become a nuisance if people are introduced into its vicinity.

In England and Wales, a local authority's power comes under section 80 of the Environmental Protection Act 1990 [11]; in Scotland it comes under section 58 of the Control of Pollution Act 1974 [14]; in Northern Ireland consult Pollution Control and Local Government (Northern Ireland) Order 1978 [15]. These Acts also make provision for private individuals to take complaints directly to a magistrates court (or Sheriff's court in Scotland).

The main principles established under these Acts are as follows.

a) There is no prescribed level above which a noise becomes a statutory nuisance. Each case is considered on its merits and account taken of the likely reaction of a reasonable person. The noise complained of need not be injurious to health; the criterion can be one of interfering with ordinary comfort or amenity.

b) Where the noisemaker is operating from industrial, trade or business premises, it is a defence to show that the best practicable means to control noise has been used.

5.7.6 ***Common law***

Civil action can be taken against noise nuisance and again each case is assessed on its merits. The criterion for a civil action is how the noise affects the individual compared with the ordinary inconvenience suffered by the public at large, or how it affects land in which the individual has an interest; the defence of best practicable means is not available.

5.7.7 ***Contracts***

It is possible to guard against noise nuisance by express provisions in contracts. This may be useful for certain types of building. For example, it may be possible in a tenancy agreement to restrict the use of musical instruments, providing the restriction is sufficiently specific to be enforceable.

5.8 Checklist for the design

5.8.1 ***General***

The checklist given in **5.8.2** to **5.8.6** is intended as an aid for the designer.

Not all items on the checklist are necessarily applicable (e.g. a noise contour map is not necessary when building a single house). However, quality control and workmanship (see **5.8.6**) should always be considered very carefully. Experience has shown that many noise control measures fail to perform adequately because the construction details are not built as the designer intended. Variations in detailing which might appear ordinarily to be unimportant often have serious implications for noise control, e.g. slight warps in a window frame may reduce the effectiveness of the seals.

5.8.2 ***Evaluation of external noise sources***

The levels of existing and future noise sources can be predicted if there is reliable information. Otherwise measurement will be necessary, either of the existing noise, or of a noise source similar to that proposed.

The noise source(s) should first be located and the designer should apply the following procedures.

a) Select quantities to use for measuring or predicting noise levels (e.g. $L_{\mathrm{Aeq},T}$, or L_{p} in octave or third octave bands).

b) Assess effects of topography and other features such as noise screens or reflecting surfaces.

c) Measure or predict noise levels at strategic points. In some complex situations it may be worth drawing a contour map of external noise levels.

d) If appropriate, assess noise levels due to user activities around the buildings and site.

5.8.3 ***User requirements***

To satisfy user requirements the designer should apply the following procedures.

a) Select measurement quantities to match external noise quantities.

b) Choose criteria and appropriate noise levels for sensitive areas (see clause **7**).

5.8.4 ***Building performance requirements***

To establish performance requirements the designer should carry out the following:

a) compare external noise levels with internal design limits;

b) calculate the noise reduction required between the exterior and interior;

c) if appropriate, assess internal noise sources;

d) calculate the noise reduction required between internal user areas, and if necessary, the noise reduction required to reduce noise from internal sources to an acceptable level outside the building.

5.8.5 ***Design steps***

In the design process the designer should include the following steps, which may be iterative:

a) check the feasibility of reducing noise levels and/or relocating noise sources;

b) consider options for planning the site or building layout;

c) consider the orientation of proposed building(s);

d) select construction methods for meeting building performance requirements (see **5.8.4**);

e) examine the effects of noise control measures on natural ventilation, fire regulation requirements, health and safety etc.;

f) carry out a cost exercise to assess the viability of alternative solutions.

5.8.6 *Quality control and workmanship*

To establish good quality control and workmanship the following activities should be considered by the designer and discussed with the builder.

a) Detailed specifications should be given.

b) The required standards of materials and workmanship should be specified in contract documentation.

c) Consideration should be given to including a performance specification in the contract documentation.

d) Any checking and testing procedures that will be used to assess the finished building should be specified.

e) Specified checks and tests should be conducted when and where appropriate.

6 External noise sources

6.1 Introduction

Noise from commonly encountered sources is dealt with in **6.2** to **6.6**. In each case information is given on the characteristics of the noise, and guidance is given as to how levels can be determined and controlled.

6.2 Noise from road traffic

6.2.1 *Main factors*

Road traffic noise generation depends upon a number of factors including:

— traffic flow (which can vary considerably within and between days of the week);

— type of vehicles (i.e. predominately heavy or light);

— mode of operation (e.g. level or inclined road);

— surface texture of the road;

— speed (and whether flow is continuous or interrupted).

As with other types of noise the propagation depends upon meteorological conditions, topographical features and ground cover characteristics.

6.2.2 *Typical noise spectrum*

NOTE A typical noise spectrum of free flowing traffic on a main road is given in Figure 1.

For a typical urban situation where road speed is below about 60 km/h, sound energy is concentrated in the low frequency end of the spectrum because of high levels of exhaust noise, particularly from diesel commercial vehicles. At greater speeds (80 km/h) more energy is present at higher frequencies due to the road/tyre surface interaction and aerodynamic noise. This difference in spectral characteristics can affect the nature of the sound heard within a building, and should be kept in mind when different sound control measures are being considered.

For initial design purposes, typical noise levels are given in Table 2 for three common situations.

Table 2 — Typical traffic noise levels measured about 1 m from the façade

Situation	$L_{Aeq,16h}$ dB
At 20 m from the edge of a busy motorway carrying many heavy vehicles; average traffic speed 100 km/h; intervening ground grassed	78
At 20 m from the edge of a busy main road through a residential area; average traffic speed 50 km/h; intervening ground paved	68
On a residential road parallel to a busy main road and screened by the houses from the main road traffic; free flowing traffic	58

6.2.3 *Prediction of traffic noise*

The noise from road traffic can be calculated for a specified range of situations using the method in *Calculation of road traffic noise* (CRTN) [16]. This method predicts the $L_{A10,18h}$ for the period 06:00 to 24:00 from the $L_{A10,1h}$ values on a normal working day. This is a well validated method for calculating levels up to 300 m from a road. Typical noise propagation conditions are assumed, e.g. moderately adverse wind velocity and direction. Although not explicitly stated the prediction method also assumes dry conditions. It has been validated for roads carrying more than 1 000 vehicles per 18 h day or 50 vehicles per hour. It is usual to make predictions for flow rates forecast 15 years ahead.

NOTE Conversion of L_{A10} to L_{Aeq} can be achieved by the (approximate) relationship: $L_{Aeq,16h} \approx L_{A10,18h} - 2$ dB. This is generally correct with a 95 % confidence interval of ±2 dB for moderate and heavy traffic flows.

The prediction method takes the following factors into account:

a) hourly traffic flow rate;

b) mean traffic speed;

c) percentage of heavy vehicles (those greater than 1 525 kg).

Other information required for the calculation includes:

— road surface and gradient;

— ground type;

— height of noise source;

— shielding of barriers and cuttings;

— reflections at façades and from nearby buildings;

— angle of view of the road.

The method can be used to draw noise contours on a site plan. However, where traffic conditions are complex or unusual it may be necessary to measure noise levels on site.

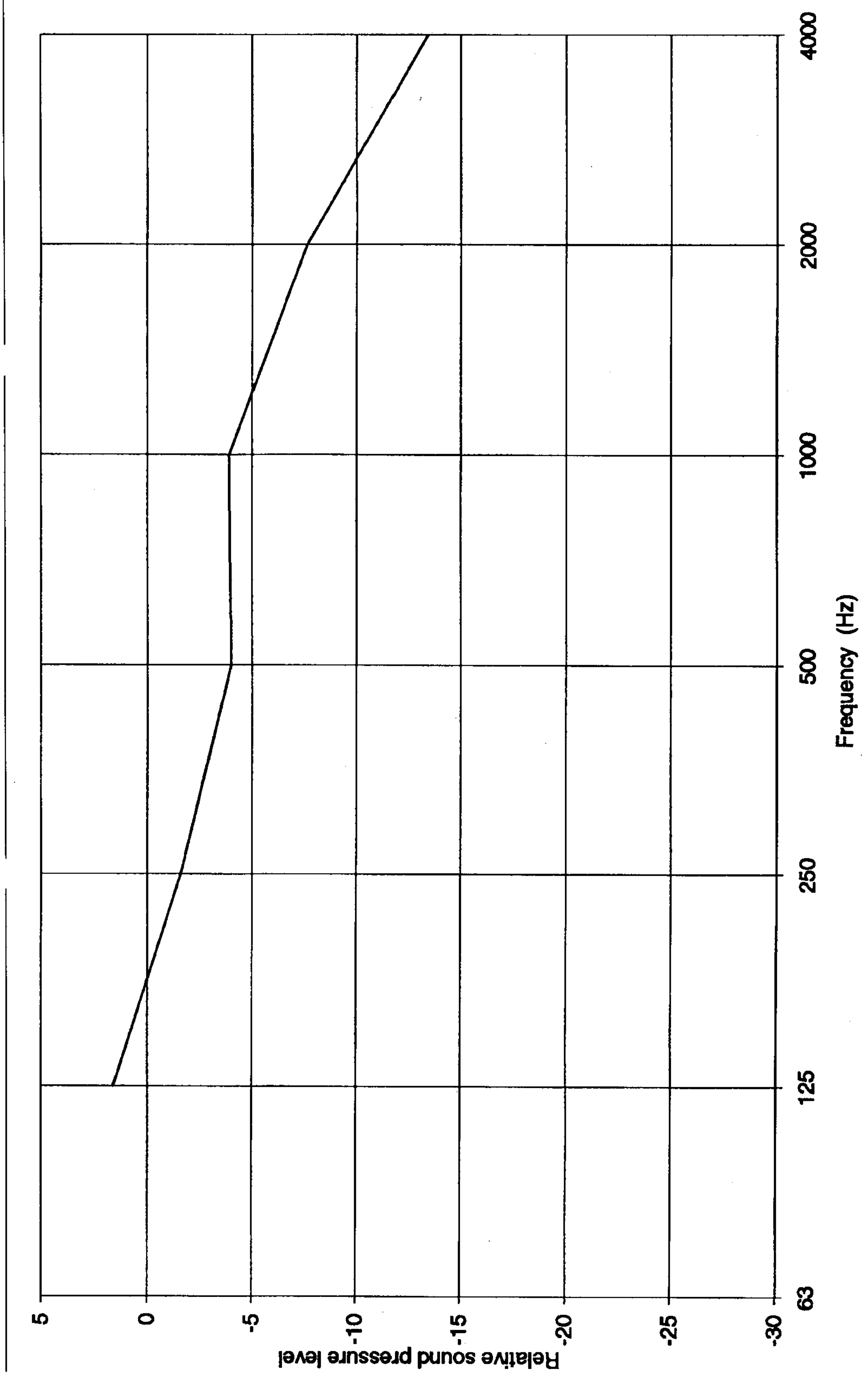


Figure 1 — Normalized road traffic noise spectrum derived from BS EN 1793-3:1998

6.3 Noise from aircraft

6.3.1 *General*

The Department of the Environment, Transport and the Regions (DETR) is responsible for policy on the control of civil aircraft noise in the UK, and specifically for noise control at airports designated for this purpose under section 80 of the Civil Aviation Act 1982 [17], namely Heathrow, Gatwick and Stansted.

NOTE For information about the major Scottish airports contact Scottish Airports Ltd., St Andrew's Drive, Glasgow Airport, Paisley PA3 2SW.

At other airports, noise control is primarily a matter for the airport management. Noise can be controlled by use of noise preferential routes (NPRs) which ensure aircraft avoid centres of population as far as possible. Restrictions can also be made on the number of movements and/or the classes of aircraft that can be used. Unattended noise monitoring sites coupled with radar records are used to monitor aircraft movements and noise levels, more information about which is given in PPG 24 [7].

6.3.2 *Prediction of noise from aircraft*

Prediction of noise from aircraft or airports is complex. However, contours of daytime $L_{Aeq,T}$ levels are available for most major airports (see Figure 2) which can be used to give an estimate of the internal noise climate.

Where it appears that sound insulation treatment will be necessary, noise exposure data should be obtained by on site noise measurements, taking account of wind direction and runway usage. However, take-off and landing spectra can be very different.

NOTE Typical noise spectra for a jet airliner after take-off and before landing are shown in Figure 3.

As noise contours do not include noise from ground running, this should be considered separately.

6.4 Noise from railways

6.4.1 *General*

Noise from railways is characterized by short periods of high noise levels, resulting from the nature of rail time-tabling. The basic noise level of a diesel locomotive is about 90 dBA at 25 m. However, as the level and spectra depend on the operating conditions, the level can vary by up to 20 dBA.

NOTE Typical train noise spectra are given in Figure 4.

6.4.2 *Prediction of noise from railways*

The standard calculation method is given in *Calculation of railway noise (CRN)* [18], [19]. The procedure enables calculation of three $L_{Aeq,T}$ values:

a) day $L_{Aeq,16h}$ (07.00 to 23.00);

b) night $L_{Aeq,8h}$ (23.00 to 07.00);

c) busiest half-hour $L_{Aeq,0.5h}$.

This method takes into consideration the following factors for each type of train:

— L_{AE} of the train(s);
— number, and times of train movements;
— distance from track;
— ground type;
— angle of view;
— reflection effects.

6.5 Noise from industry and construction

6.5.1 *General*

Industrial noise may originate from specific processes, from related transport operations or from construction-related activities.

6.5.2 *Assessment of industrial noise*

Where industrial noise affects residential areas, the method for rating the noise in BS 4142 should be applied. The noise level outside the dwelling should be established, and penalties should be added to this level if the spectrum has subjectively annoying characteristics. For example, if acoustic features such as hums, tones, impulses or banging, are present, a single 5 dB correction should be added. The complaint assessment procedure compares this corrected level (called the rating level) with the background level. If this difference is around 10 dB or more, complaints are to be expected. A difference of around 5 dB is of marginal significance. The rating method thus gives an indication of when further noise control measures may be needed.

6.5.3 *Noise from construction sites*

As noise from construction sites may annoy occupants of nearby buildings, it may be necessary for the contractor to use quiet plant, adopt quiet working methods, and to limit working hours.

6.5.4 *Prediction of construction site noise*

Construction site noise is produced by many different activities and types of plant. Guidance on its control and prediction is covered by BS 5228-1, which uses the following data to estimate $L_{Aeq,T}$ levels:

— source power measurements (from actual measurements or a database of sound powers);
— activity information, e.g. duration of use;
— attenuation due to distance from building and screening.

The levels from the range of equipment used are then combined to give an overall $L_{Aeq,T}$ level.

NOTE Slightly different procedures exist for stationary and mobile plant.

6.6 Other sources of noise

Many other noise sources exist, many of which originate from leisure activities, e.g. model aircraft, clay target shooting, water sports, entertainment noise.

Most of these noise sources have codes of practice associated with them, which give an idea of likely noise levels or frequency of events.

NOTE Codes produced by the Government can normally be obtained from The Stationery Office, and additional advice may be available from local authority environmental health departments.

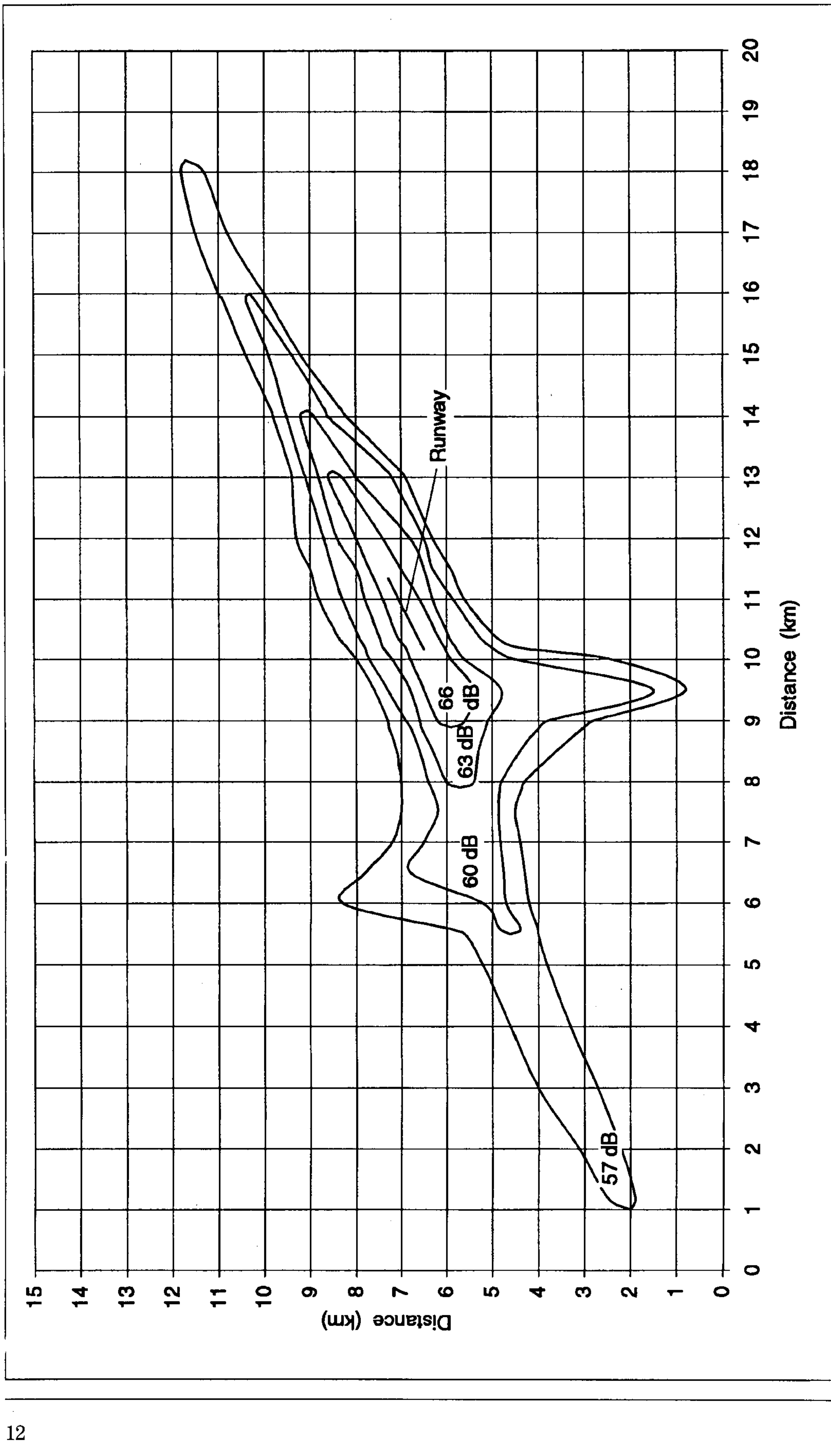


Figure 2 — Typical L_{Aeq} contours around an airport

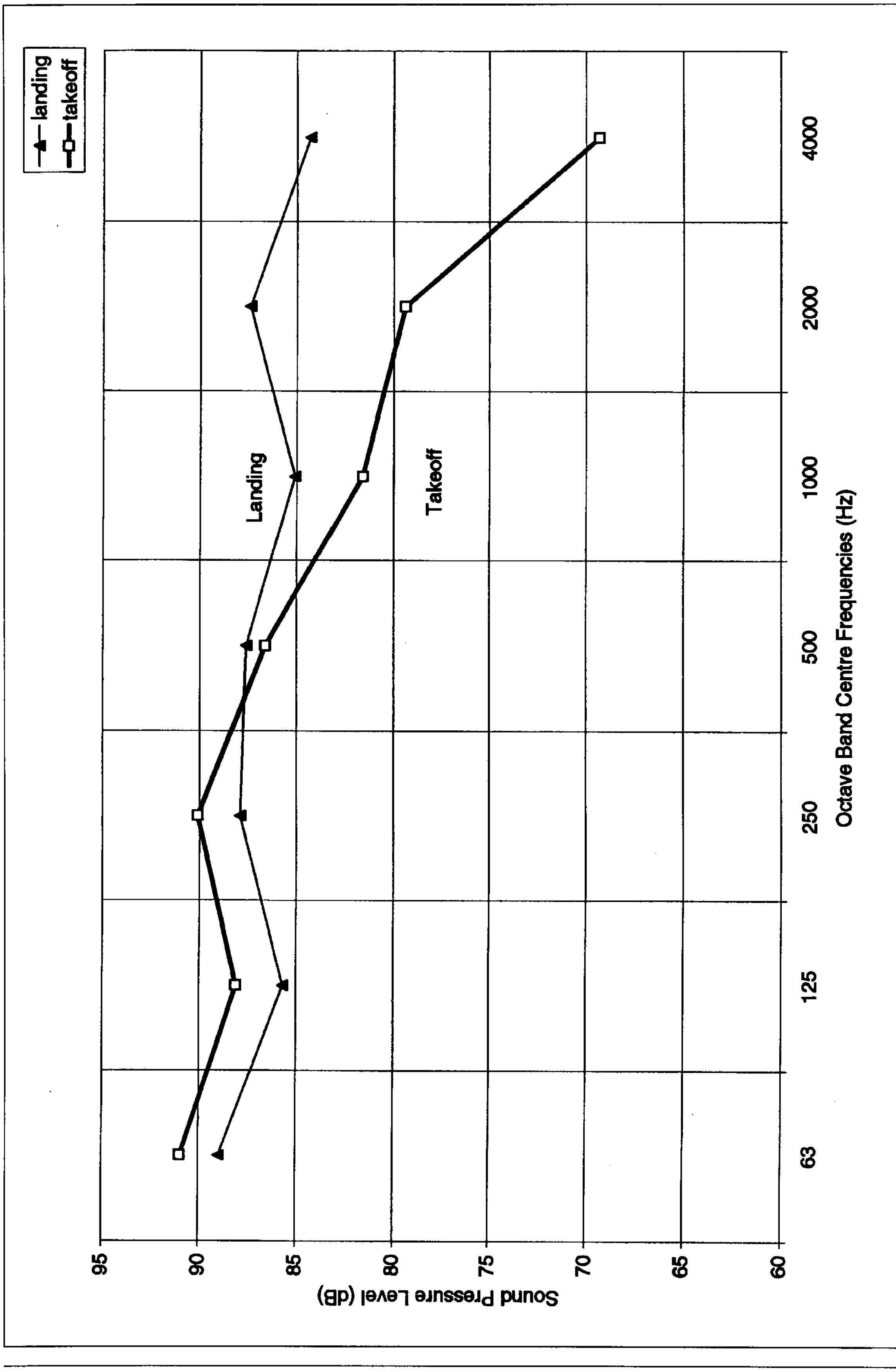


Figure 3 — Average noise spectra of a jet airliner after take-off and before landing

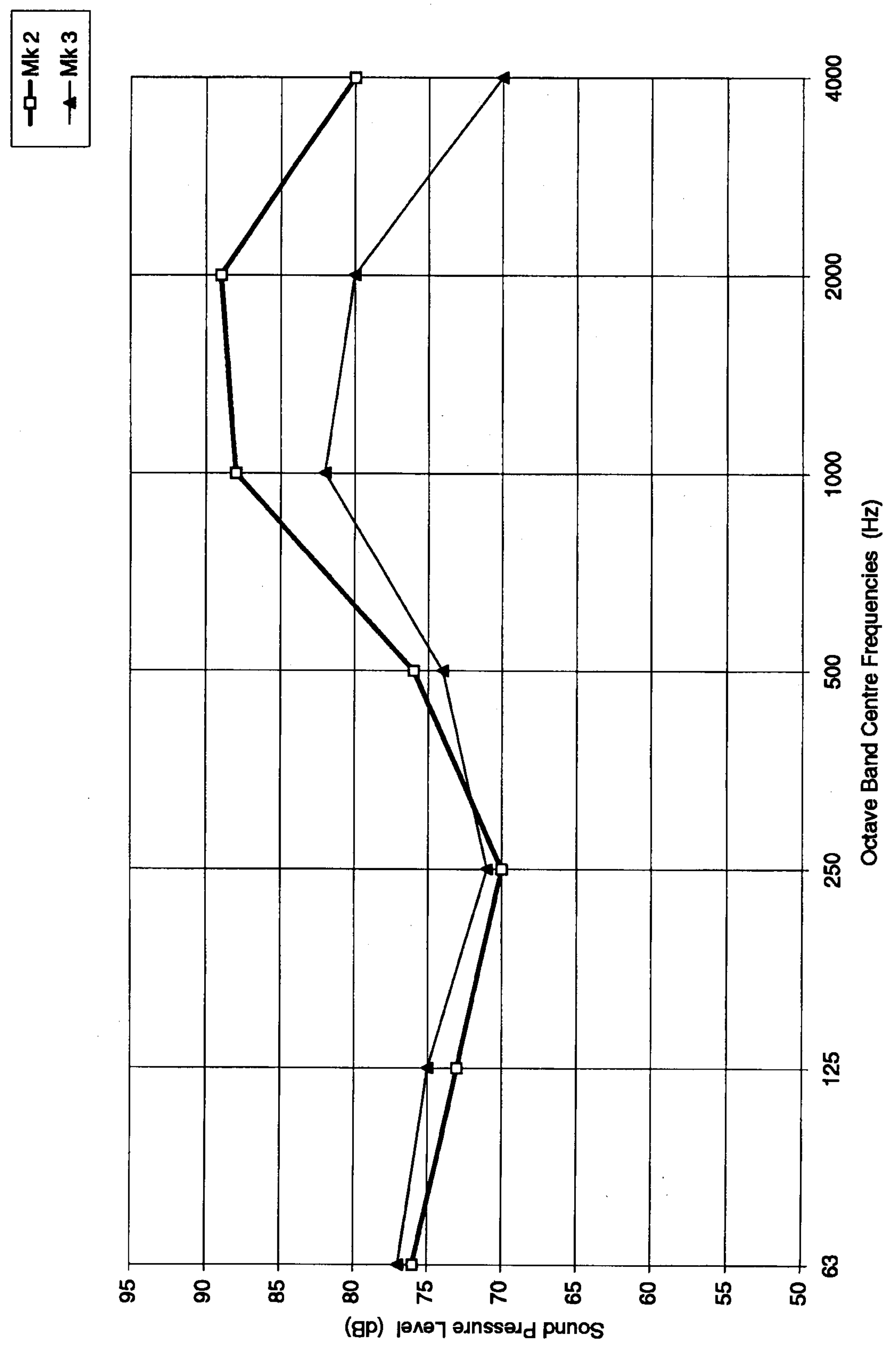


Figure 4 — Train noise spectra with mark 2 and mark 3 coaches measured at 25 m from the track centre line, in a free field, at 160 km/h and on "good quality" conventially ballasted track with continuously welded rail

6.7 Typical design problem

6.7.1 *Typical design problem — Simple calculation*

A small housing development is to be situated 20 m from the edge of an existing road. The average traffic speed is 50 km/h, and the intervening ground is paved.

To establish the noise exposure of the site, the $L_{A10,18h}$ could be calculated or measured for a typical unit near the road. This has been calculated from CRTN [16] to be 69 dB free-field. This is approximately 67 dB $L_{Aeq,16h}$. The local planning authority has taken account of the guidance in PPG 24 [7] and, as the site is in noise exposure category C, has asked for noise control measures; in this case to reduce the noise level inside the bedrooms to 35 dB $L_{Aeq,16h}$ during the day and 30 dB $L_{Aeq,8h}$ at night. The level outside the bedrooms on the first floor will be about 1 dBA higher than the level outside the rooms on the ground floor.

To reduce the noise exposure inside the house, attention should be given to the sound insulation of both the roof and façade. A traditional pitched roof with concrete tiles and a 9 mm plasterboard ceiling, covered in thermal insulating material, will have an insulation of about 43 dB R_w (see clause **8**). The windows, and any trickle ventilators, will normally be the weakest part of a brick and block façade. Insulating glass units will have an insulation of about 33 dB R_w, and assuming sound attenuating trickle ventilators are used the resulting internal noise level, roughly 34 dB, (67 − 33 dB) will be determined by the windows. This level will be acceptable with the windows closed, even with the correction for first floor level. However, if the windows are intended to be opened to provide rapid ventilation and summer cooling, the insulation will reduce to about 10 dB or 15 dB, resulting in an internal level of perhaps 57 dB (67 − 10 dB), which will be unacceptable. An alternative form of rapid ventilation should therefore be considered, such as a mechanical system.

This calculation should be repeated for night-time traffic conditions, and the design should satisfy both sets of requirements.

Strictly, the insulation values used here relate to a pink noise spectrum, and actual values achieved will be lower for traffic noise. Furthermore, the method does not take account of the absorption (e.g. furnishings) in the room. However, the R_w values will suffice for a rough calculation, although it is likely to underestimate the level in the room by up to 5 dBA. Where the estimate is within 5 dBA of the limit, a more rigorous calculation should be carried out using octave bands, as explained in **6.7.2**.

6.7.2 *Typical design problem — More rigorous calculation*

6.7.2.1 *The calculation method*

The calculation method used here is based on the method given in EN 12354-3.

NOTE Measurement methods for the insulation of façade elements are given in BS EN ISO 140-5, a laboratory test method for the insulation of small elements, such as trickle ventilators, is given in BS EN 20140-10, and a laboratory test method for the insulation of other elements is given in BS EN ISO 140-3.

The following equation, which gives the equivalent sound pressure level in the room, $L_{eq,2}$, should be evaluated for each frequency band of interest:

$$L_{eq,2} \approx L_{eq,ff} + 10\log_{10}\left(\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}} + \frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}\right) + 10\log_{10}\left(\frac{S}{A}\right) + 3 \qquad (1)$$

where

$L_{eq,ff}$ is the equivalent continuous sound pressure level outside the room elements under consideration;

NOTE It is the free-field sound level, measured or estimated at the intended position of the element under consideration. It is related to the level $L_{eq,1}$ measured within a few millimetres of the actual façade by the relation: $L_{eq,ff} \approx L_{eq,1} - 6$, and to the level $L_{eq,2M}$ measured 2 m away from the façade by the relation $L_{eq,ff} \approx L_{eq,1} - 3$.

A_0 is a reference absorption area of 10 m^2 and is independent of frequency;

S_f is the total façade area of the room in question in square metres (m^2);

S_{wi} is the area in square metres (m^2) of the windows of the room;

S_{ew} is the area in square metres (m^2) of the external wall of the room;

S_{rr} is the area in square metres (m^2) of the ceiling of the room;

S is the total area of elements through which sound enters the room in square metres (m^2), i.e. $S_f + S_{rr}$;

$D_{n,e}$ is the insulation of the trickle ventilator measured according to BS EN 20140-10;

R_{wi} is the sound reduction index (octave band value) of the window (see annex C);

R_{ew} is the sound reduction index (octave band value) of the external wall (see annex C);

R_{rr} is the sound reduction index (octave band values) of the roof/ceiling (see annex C);

A is the equivalent absorption area of the receiving room being considered (see annex C).

It should be noted that values of L_{eq}, $D_{n,e}$, R, and A are frequency dependent, and the calculation of $L_{eq,2}$ should be repeated using values for each octave band of interest. If the dBA level in the room ($L_{Aeq,2}$) is to be estimated, the resulting values of $L_{eq,2}$ should be A-weighted (to give $L_{Aeq,125}$ in the 125 Hz octave band etc.) and summed logarithmically (see annex A). The equation for summing the levels in each frequency is as follows:

$$L_{Aeq,2} = 10 \log_{10}\left(10^{\frac{L_{Aeq,125}}{10}} + 10^{\frac{L_{Aeq,250}}{10}} +..+\right) \quad (2)$$

6.7.2.2 *The data*

For this example, the values given in Table 3 have been chosen.

6.7.2.3 *The calculation*

The calculation is conducted most easily on a spreadsheet. Each term in the equation is evaluated for each frequency band, as shown in Table 4.

In this example the exposure of the roof and all façade elements is the same. Where this is not the case the calculation should be undertaken on an element by element basis and the resulting internal levels summed using equation (2).

The calculated noise level is above the target of 35 dBA, and Table 4 shows that the main contribution comes from the window (row C), although the roof (row E) dominates at low frequencies. A better product should be selected and the procedure repeated until it has no significant effect on the insulation. The revised value may be compared with the rough estimate of 34 dBA. As before, this procedure should be repeated for night-time conditions and the design should satisfy both sets of requirements. The rapid ventilation problem still needs to be tackled. It should be noted that in this calculation the trickle ventilators were not an important transmission path, however this may not always be the case.

Although this calculation is more rigorous than the simple example, the method still makes assumptions, and it is likely that the estimated levels will differ from measured values. It does, however, indicate the relative performance of each element in each octave band and allows iterative changes. Façade calculations are also covered in [10].

Table 3 — Data used in the calculation of the noise level inside a room

Terms that are frequency dependent								
Term	Description	Single figure rating	Octave band centre frequency Hz					A-weighted level
			125	250	500	1 000	2 000	
$L_{eq,ff}$			70	66	63	61	61	67
$D_{n,e}$	Sound attenuated trickle ventilator		37	36	35	36	34	
R_{wi}	6-12-6 insulated glass unit	33	26	29	33	28	24	
R_{ew}	Brick and block external wall	50	40	44	45	51	56	
R_{rr}	See Table 11	43	28	34	40	45	49	
A			11	14	16	16	15	

Terms that are not frequency dependent		
Term	Derivation	Value
S_f	Façade area (including window)	10 m^2
S_r	Roof area (exposed side)	40 m^2
S_{wi}	Window area	1.5 m^2
S_{ew}	$S_f - S_{wi}$	8.5 m^2
S_{rr}	Area of ceiling	15 m^2
S	$S_f + S_{rr}$	25 m^2
A_0	Given in BS EN 20140-10	10 m^2

Table 4 — The calculation

Term from equation (1)	Reference letter of result	Octave band centre frequency Hz				
		125	250	500	1 000	2 000
$L_{eq,ff}$	A	70	66	63	61	61
$D_{n,e}$		37	36	35	36	34
$\frac{A_0}{S} 10^{\frac{-D_{n,3}}{10}}$	B	0.000 08	0.000 10	0.000 13	0.000 10	0.000 16
R_{wi}		26	29	33	28	24
$\frac{S_{wi}}{S_f} 10^{\frac{-R_{wi}}{10}}$	C	0.000 15	0.000 08	0.000 03	0.000 10	0.000 24
R_{ew}		40	44	45	51	56
$\frac{S_{ew}}{S_f} 10^{\frac{-R_{ew}}{10}}$	D	0.000 03	0.000 01	0.000 01	0.000 00	0.000 00
R_{rr}		28	34	40	45	49
$\frac{S_{rr}}{S_f} 10^{\frac{-R_{rr}}{10}}$	E	0.000 95	0.000 24	0.000 06	0.000 02	0.000 01
$10 \log_{10}$ (B + C + D +E)	F	−29.2	−33.7	−35.4	−36.6	−33.9
A (*furnished*)		11	14	16	16	15
$10 \log \left(\frac{S}{A}\right)$	G	3.6	2.5	1.9	1.9	2.2
$L_{eq,2}$	A + F + G + K	47.4	37.8	31.5	29.3	32.3
A-weighting dB		−16	−9	−3	0	1
$L_{eq,2}$ + A-weighting	$L_{Aeq,125}$ etc.	31.4	28.8	28.5	29.3	33.3
$L_{Aeq,2}$ is obtained by combining these values using equation (2). A-weighted level in the room $L_{Aeq,2}$ is 37.7 dB						

7 Specific types of building

7.1 General

Guidance is given in **7.2** and **7.3** on acoustic criteria and limits which are appropriate for various types of space that have different functions. In addition, attention is drawn to special features needing consideration. Only general guidance is given in **7.2** to **7.5**; where the acoustic performance of spaces or systems is critical [e.g. auditoria or complex heating, ventilating and air-conditioning (HVAC) systems] specialist advice should be sought (see annex D).

It is not practical to give detailed guidance on all types of building. Many types of building include spaces having different functions. For example, a factory may include workshops, offices and meeting rooms; appropriate guidance is given in **7.6.4**.

7.2 Design criteria

This code of practice is mainly concerned with control of indoor ambient noise from sources such as traffic and mechanical services. At the outset the designer should decide which of the following noise criteria are appropriate for all or different parts of the proposed building:

- — reasonable industrial working conditions;
- — reasonable speech and telephone communications;
- — reasonable acoustic privacy in shared spaces;
- — reasonable conditions for study and work requiring concentration;
- — reasonable listening conditions;
- — reasonable resting/sleeping conditions.

The designer should then establish limits for the noise levels that will meet the chosen criterion.

7.3 Limits for noise levels

For each design criterion a range of levels exist that are considered to meet it. The designer should use judgement to select a level appropriate for the particular circumstances. In noisy workshops etc., the activity noise will be dominant and so the indoor ambient noise level will not be critical. In most other situations indoor ambient noise will be important.

NOTE Guidance on limits is given in Table 5 for various types of room having different functions.

Limits for good conditions and reasonable conditions are given. Normally, only the upper noise limit will need to be decided (see Table 5). In some cases, such as open-plan offices and restaurants, a moderate noise level is required to ensure adequate privacy while not causing disturbance, so upper and lower limits should be considered (Table 6).

Unless otherwise stated, the noise should be assumed to be steady, such as that due to road traffic, mechanical services, or continuously running plant, and should be the noise level in the space during normal hours of occupation but excluding any noise produced by the occupants and their activities. The time period T should be appropriate for the activity involved (e.g. 23.00–07.00 for bedrooms). As the noise will be fairly steady, a short measuring period will usually be sufficient to establish the typical outdoor level.

7.4 Noise indices

Noise levels which may be due to traffic or ventilation systems are described in Table 5 using dBA. The noise rating (NR) system, a graphical method described in annex B, is also in common use for rating noise from ventilation systems. Although there is no direct relationship between dBA and NR, the following approximate relation applies in the absence of strong low frequency noise:

$NR \approx dBA - 6$.

Although the NR system is currently the preferred method for rating noise from mechanical ventilation systems in the UK, other methods are also available which are more sensitive to noise at low frequencies [20]. Low frequency noise can be disturbing or fatiguing to occupants, but may not have much effect on the dBA or NR value.

7.5 Limits for reverberation time

As well as indoor ambient noise level, the reverberation time, T, measured in seconds (s), should also be considered because it affects the noise level in the space, and also affects the clarity of speech and the warmth of music. Even where good speech conditions are not paramount, an excessively long reverberation time will accentuate the background noise and reduce the clarity of public address announcements.

Although the acoustic design of auditoria is a specialized subject and is beyond the scope of this code of practice, general guidance on designing rooms for speech (e.g. meeting rooms) is given in **7.6.7**.

7.6 Guidance for specific types of building

7.6.1 *Dwellings*

7.6.1.1 *Mandatory requirements*

The sound insulation between adjoining dwellings is controlled by the Building Regulations [2], [3], [4], which require reasonable standards for certain walls, floors, and stairs. As there are differences between the requirements for England and Wales, Scotland, and Northern Ireland, the appropriate national regulations should be consulted. These are supported by the following technical documents:

— England and Wales, Approved Document for Part E [21];

— Scotland, Part H of the Technical Standards [22];

— Northern Ireland, Technical Booklets G and G1 [23].

The appropriate document should be consulted at an early stage of design.

7.6.1.2 *Design criteria and limits for intrusive external noise*

For dwellings, the main criteria are reasonable resting/sleeping conditions in bedrooms and good listening conditions in other rooms. Occupants will usually tolerate higher levels of anonymous noise, such as that from road traffic, than noise from neighbours which may trigger complex emotional reactions that are disproportionate to the noise level. For simplicity, only anonymous noise is considered in Tables 5 and 6.

As well as protection for the building, barriers or bunds should be considered to protect the gardens. In gardens and balconies etc. it is desirable that the steady noise level does not exceed 50 $L_{Aeq,T}$ dB and 55 $L_{Aeq,T}$ dB should be regarded as the upper limit.

7.6.1.3 *Internal planning*

In order to minimize disturbance from internally generated noise the following points should be considered.

— In houses and flats, services should be kept away from bedrooms.

— As footfall noise can be particularly disturbing, care should be taken to avoid locating stairs next to noise sensitive rooms, such as bedrooms, in adjacent dwellings. It should be noted that footfalls on concrete stairs produce less low frequency noise than on timber stairs.

— In flats, avoid locating bedrooms near the lift and circulation areas; less sensitive rooms may be used as buffers. Compatibility between rooms of adjacent dwellings can be ensured by handing and stacking identical dwelling plans.

Table 5 — Indoor ambient noise levels in spaces when they are unoccupied

Criterion	Typical situations	Design range $L_{Aeq,T}$ dB	
		Good	Reasonable
Reasonable industrial working conditions	Heavy engineering	70	80
	Light engineering	65	75
	Garages, warehouses	65	75
Reasonable speech or telephone communications	Department store	50	55
	Cafeteria, canteen, kitchen	50	55
	Wash-room, toilet	45	55
	Corridor	45	55
Reasonable conditions for study and work requiring concentration	Library, cellular office, museum	40	50
	Staff room	35	45
	Meeting room, executive office	35	40
Reasonable listening conditions	Classroom	35	40
	Church, lecture theatre, cinema	30	35
	Concert hall, theatre	25	30
	Recording studio	20	25
Reasonable resting/sleeping conditions	Living rooms	30	40
	Bedrooms[a]	30	35

[a] For a reasonable standard in bedrooms at night, individual noise events (measured with F time-weighting) should not normally exceed 45 dB L_{Amax}.

Table 6 — Indoor ambient noise levels in spaces when they are unoccupied and privacy is also important

Criterion	Typical situations	Design range $L_{Aeq,T}$ dB
Reasonable acoustic privacy in shared spaces	Restaurant	40–55
	Open plan office	45–50
	Night club, public house	40–45
	Ball room, banquet hall	35–40
	Reception room	35–40

7.6.1.4 *Other precautions*

It is recommended that any partition separating a WC from a noise sensitive room should have a weighted standardized level difference ($D_{nT,w}$) of at least 38 dB.

In flats, sound absorbent materials should be applied to the ceiling surfaces of internal corridors and stairwells to reduce propagation of noise through the building.

NOTE Carpets can also provide useful absorption.

Resilient floor coverings, such as carpet with underlay, can be used to minimize noise from footsteps on stair treads, corridors and landings. Noise will be reduced at the same floor level and to rooms below the floor or stair. The quietest types of sanitary, heating and plumbing equipment (e.g. WCs, ball valves, refuse chutes etc.) should be used; however their location is more important than their detailed design.

It is good practice to isolate vibration in the heating pipework from the building structure, at least near the pump. This may be achieved by using resilient fixings on pipe runs. Where pipes penetrate walls and floors, air gaps should be sealed to reduce airborne noise transmission in such a way that structure-borne noise is not transmitted: this may be achieved by packing the gap with mineral wool, and sealing the faces with non-hardening mastic. Building Regulations guidance for fire safety should be taken into account [24], [25], [26]. Ventilation fans and similar equipment should have resilient mountings where structure-borne noise could be a problem.

Care should be taken to position lifts to minimize noise disturbance from the operation of the control gear. Lift doors should operate quietly, and acoustic signals to herald lift arrival should not be audible within dwellings.

NOTE For additional guidance see [10].

7.6.2 *Hotels*

7.6.2.1 *Design criteria and limits for intrusive external noise*

The recommendations for hotel bedrooms are similar to those for dwellings (see **7.6.1.2**).

7.6.2.2 *Noise control measures for bedrooms, corridors, and stairwells*

Because of the need to be accessible, hotels are often situated near city centres and motorways, and so are especially vulnerable to external noise at night. Double windows and air-conditioning may be necessary. The air-conditioning system should be designed to conform to the recommendations given in Tables 5 and 6, and to avoid compromising sound insulation between rooms. Guest rooms should not be located next to lift shafts, plant rooms or other areas where there are high noise levels. In hotels of all classes, good protection against indoor noise is necessary and partitions and floors between rooms and between rooms and corridors should have a sound insulation ($D_{nT,w}$) of not less than 50 dB.

To avoid unnecessary transmission of airborne noise between adjoining rooms by way of open windows, opening lights of windows should not open in such a way as to direct sound immediately from one room into the next. Where possible, bedrooms should not be planned to overlook courtyards, or to be over kitchens or service vehicle areas which are frequently noisy in the early morning.

Door openings on opposite sides of corridors should be staggered and preferably fitted with draught strip on all four edges to reduce noise transmission (but not make it necessary to slam the door). Doors should have quiet-action latches. Corridors should have resilient floor coverings. Sound absorbent ceilings are beneficial, though not essential if the corridor has fitted carpets. Staircases and lift halls should be separated from the corridors by means of doors that can be used quietly (such as swing doors) and, where possible, isolated from bedrooms by linen stores and similar rooms. If bedroom doors have to be located close to lift doors, acoustic lift signals should not be audible in the bedrooms. Except within the same suite, bathrooms should not be planned next to bedrooms. In all cases, it is important to choose types of sanitary fittings that are quiet in operation and to design the plumbing system to minimize noise by avoiding sharp bends and restrictions of flow.

7.6.2.3 *Function rooms*

Large hotels often have ballrooms, banqueting rooms and meeting rooms, which are hired out separately for public and private functions. Proceedings may go on well into the night and it is essential, therefore, that these rooms can be effectively isolated from bedrooms and that the insulation of all noise paths is considered. For example, a ballroom in an internal court will not be sufficiently insulated from bedrooms in higher storeys if it has windows opening into the well of the court, or a lightweight roof construction. To minimize disturbance the roof should be of concrete or other solid construction, any top lights or windows should be double glazed and sealed, with a separate air-conditioning system if necessary.

The insulation between the public rooms themselves should also be considered. In rooms in which dancing may take place on one side of a division wall and speech-making on the other, a wall of less than 60 dB R_w insulation may not give adequate protection. Folding partitions will not normally suffice to separate rooms where disparate activities take place.

7.6.3 *Offices*

7.6.3.1 *General*

Complaints from office workers arise from the intrusion of external noise, high internal noise levels from services and excessive reflections from room surfaces. Inadequate sound insulation between offices is also a frequent source of complaint from those who require privacy for telephone conversations and interviews.

Privacy between offices and between an office and an occupied space requires good sound insulation and moderate background noise to mask intruding speech. In cellular office layouts the minimum acceptable sound insulation between two offices is about $D_w = 38$ dB. Where privacy is important the minimum sound insulation should be $D_w = 48$ dB although even then it is possible that voices will be heard, but the conversation will not usually be understood. Where the indoor ambient noise level is low it may be necessary to design for higher insulation values. As a rough guide, speech will be audible but not intelligible if $D_w + L_A > 75$, where D_w is the weighted level difference between rooms, and L_A is the indoor ambient noise level in the room. If demountable partitions are used to form cellular offices, it is likely that the sound insulation will be lower than is desirable for good privacy.

7.6.3.2 *Controlling noise in open-plan offices*

In open-plan offices, the maximum reduction that can be expected between screened work-stations separated by about 2.5 m to 3.0 m is 15 dB to 25 dB, but the cumulative noise of equipment and people may provide a masking background level which makes this adequate for general needs. The screening should be absorbent faced and at least 1.5 m high. Ceilings should be low (not exceeding about 3 m) and have high sound absorption (e.g. 0.9 averaged over the frequency range 500 Hz–2 000 Hz), and may be flat. Carpet having good sound-absorbent properties is a desirable floor finish. It should be noted that if the width of the room is small, reflections from the side walls may reduce the effectiveness of the arrangement.

As some office equipment (e.g. photocopying machines) is noisy, large installations should be contained in a well screened area or separate room. This may also simplify control of ventilation noise in mechanically ventilated buildings.

7.6.4 ***Industrial buildings***

7.6.4.1 *Selecting design criteria*

The design criteria inside the building should include provision of reasonable industrial working conditions and reasonable speech and telephone communications. Other acoustic requirements will often include limiting the noise emitted from the buildings and controlling noise from activities outside the buildings (e.g. vehicle movements) to minimize disturbance to neighbours.

7.6.4.2 *Noise inside workshops*

As hearing damage is covered by the Noise at Work Regulations [5], special precautions should be taken and management procedures implemented where it is known that noisy processes will be taking place.

The levels given in Table 7 give guidance on maximum noise levels where speech communication is important. Even where speech communication is not important, it is important that audible warnings and information announcements can be heard clearly.

The recommendations for offices outside production areas are the same as those for other types of office building (see **7.6.3**).

Table 7 — Maximum steady noise levels for reliable speech communication

Distances between talker and listener m	Noise level dBA	
	Normal voice	**Raised voice**
1	57	62
2	51	56
4	45	50
8	39	44

7.6.4.3 *Noise emitted by factories*

Where a proposed factory development is to be situated in the vicinity of noise-sensitive buildings the local planning authority will usually set planning conditions, which may take account of any predicted increase in background noise due to the factory (see clause **5**). Extensive noise control measures may be required, especially if the noise is impulsive, has a strong tonal character, or is otherwise of a distinguishable nature.

On an industrial estate, the noisier factories should be sited near the centre, with warehouses and quieter production areas used as buffers between noisier factories and dwellings. Careful site planning can be used to give some protection to noise sensitive activities on the estate.

Common causes of complaint, which should be taken into consideration, are noise from:

— industrial processes;

— external generators etc.;

— calling systems;

— end of shift indicators;

— vehicle movements;

— night-time working.

7.6.4.4 *Controlling noise in production areas*

A factory divided into a number of smaller workshops is likely to provide a better working environment than one that consists of a single uninterrupted area. As permanent and solid divisions to the full height of the workshop are often not possible, partial enclosures or screens in conjunction with absorbent treatments are useful, both between departments and round individual machines. However, these enclosures or screens should be located so as not to obstruct the flow of work or they will be removed.

Acoustically absorbent materials should be used to reduce the amount of reflected sound within a space. These will reduce the noise exposure of people not exposed to the direct sound from a noisy machine or activity, although the absorbent will have little or no effect on the noise level in the immediate vicinity of the noisy machines etc. These materials can be applied to wall and ceiling surfaces or hung freely in the space (functional absorbers).

NOTE The Health and Safety Executive has published practical examples of noise control measures [27].

7.6.5 ***Schools and hospitals***

Detailed guidance on the design of schools is available from the Department of Education and Employment [28], [29]. NHS Estates produces a series of Health/Hospital Building Notes for the design of audiology suites [30].

7.6.6 ***Agricultural buildings***

Noise attenuation of buildings and structures for agricultural use should be in accordance with the recommendations in BS 5502-32.

7.6.7 ***Rooms for speech***

7.6.7.1 *General*

Lecture theatres, classrooms, and meeting/conference rooms require good acoustic conditions for speakers and listeners. This should be recognized at an early stage of the design as room size and shape influence the acoustic conditions as much as the selection and distribution of finishes. Although room acoustics is a specialized subject which is beyond the scope of this code of practice, general guidance on common situations is given in **7.6.7.5** to **7.6.8.2**.

7.6.7.2 *Design criteria and limits for intrusive external noise*

The criterion for indoor ambient noise level is reasonable listening conditions (see Tables 5 and 6). This requires a low level of background noise and a fairly short reverberation time (see Table 8 and annex A). However, other requirements should also be fulfilled to ensure the acoustic conditions are good. The main parameters are discussed in **7.6.7.3** to **7.6.7.4**.

7.6.7.3 *Design for good speech communication*

The sound that arrives at the listener's ears can be considered to have the following three components.

a) **Direct sound**. This is sound carried by waves that travel directly from the source (e.g. the speaker) to the listeners. It should be the strongest component, and all listeners should have an unobstructed view of the source. The distance between the source and the most distant listener should be kept to a minimum. If this distance exceeds about 20 m an electro-acoustic sound reinforcement system may be required.

b) **Early reflected sound**. Shortly after the direct sound arrives, the listener hears a series of wavefronts, which have been reflected once or a small number of times from the walls, ceiling, or other hard surface. As these have taken a longer path than the direct sound, they arrive later. Sound travels at about 340 m/s so, for the simpler paths, the delay can be estimated. Reflections that arrive within about 35 ms of the direct sound reinforce it, and so are beneficial. Longer delays generally reduce intelligibility, and delays greater than about 50 ms should be avoided. Longer delays may be perceived as echoes.

c) **Reverberant sound**. Sound waves emitted by a source in a room are repeatedly reflected by the room surfaces, and grow weaker because of absorption by the surface at each reflection. The reverberation time (T) is a measure of how long a sound takes to decay after the source has stopped, and it affects the level of sound in a space, and gives an indication of the clarity of speech and the warmth of music. It is proportional to the room volume, and inversely proportional to the total absorption, and so can be estimated if the absorption coefficients of the main surfaces and features in the room are known (see annex A). The optimum T for a space depends on whether it is to be used mainly for speech or music, the type of music, and the volume of the space.

The optimum values for reverberation time also vary with frequency (pitch) of the sound. Guide values of T for rooms of different volume, which are intended mainly for speech or music, can be read from Table 8. The values relate to T at 500 Hz when the rooms are unoccupied. These guide values are only intended to facilitate noise control calculations nd design of non-critical applications such as meeting rooms, which are described in **7.6.7.5**.

Table 8 — Guide to reverberation time T at 500 Hz in unoccupied rooms for speech and music

Room volume m^3	Reverberation time T s	
	Speech	Music
50	0.4	1.0
100	0.5	1.1
200	0.6	1.2
500	0.7	1.3
1 000	0.9	1.5
2 000	1.0	1.6

7.6.7.4 *Sound absorbent materials*

Sound insulating materials work by reflecting sound energy back into the room, whereas sound absorbing materials and devices dissipate sound energy as heat instead of reflecting it. Most types of absorber do not provide high values of sound insulation. Porous materials provide absorption over a reasonably wide range of frequencies, which depends mainly on the structure of the material and its thickness, and they usually perform better at middle and high frequencies. Tuned devices are available which absorb over a limited range of frequencies.

NOTE 1 Typical characteristics of different types of absorber are shown in Figure 5.

Sound absorbers are used to make acoustic corrections to rooms and spaces by changing the reverberation time (see annex A). They are commonly used in rooms designed for music or speech, for general noise reduction in rooms (but with minimal benefit close to the source), and for preventing the spread of noise over large rooms or along corridors, ventilation ducts, etc. The type chosen will be influenced by a number of factors, such as acoustic characteristics, appearance, wearing qualities, maintenance, fire spread, and other health and safety considerations.

The performance of a porous sound absorbing material is given by the sound absorption coefficient α. The coefficient varies with the frequency of the sound and is commonly quoted for frequencies at the following octave intervals: 125 Hz, 250 Hz, 500 Hz, 1 000 Hz, 2 000 Hz and 4 000 Hz. Tests should conform to BS EN 20354.

NOTE 2 A method for assigning a single number rating for porous absorbers is given in BS EN ISO 11654.

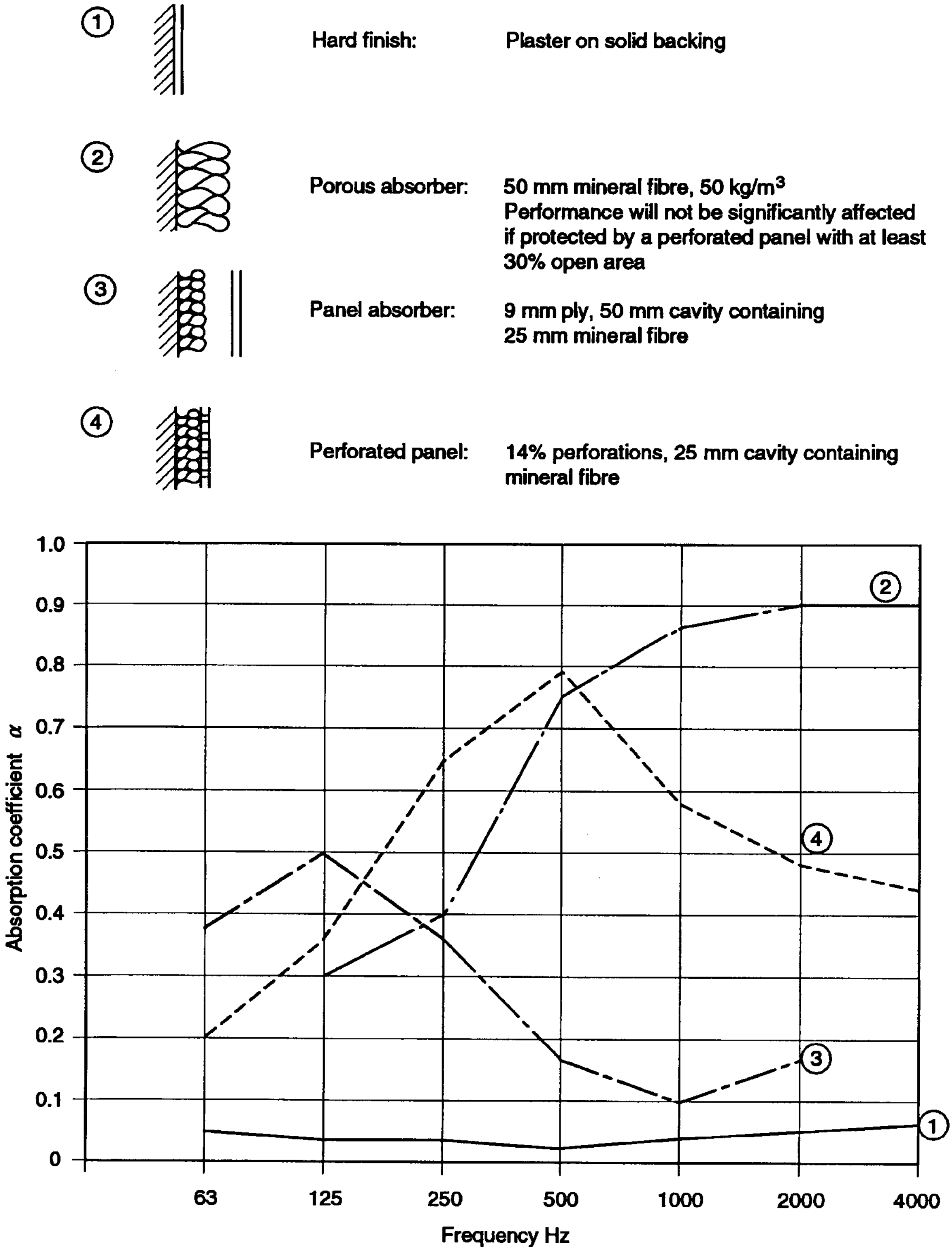


Figure 5 — Characteristics of sound absorbing materials

7.6.7.5 *Committee/meeting rooms*

Seating should be arranged in a circle or oval, rather than in parallel rows facing each other. The ceiling should be acoustically hard and low (not more than 3 m), at least over the table area, to reflect speech. A carpet will minimize noise from chair and foot movements, and reverberation should be controlled by absorbent materials on the walls. Folding partitions should be provided in large rooms so the size can be reduced when it is not fully occupied. The sound insulation of partitions is considered separately in **7.6.3.1**.

7.6.7.6 *Lecture theatres*

Human speakers project sound predominantly in the forward direction, so all listeners should have a reasonable view of the speaker's face. To facilitate this the seating may be splayed in a fan shape around the lecturer's dais, extending about 70° either side of the centre line. The direct sound reaching the rear of the audience will be weakened if the speaker-listener path passes over the heads of intervening listeners at a shallow angle. The effect can be minimized by raising the speaker on a podium or, better, by raking the audience seating at an angle of at least 20°. To reflect the speaker's voice the wall behind the speaker should be reflective. For the same reason, the ceiling should be reflective and horizontal for simplicity. Carpet should be used on the floor and in large rooms the seats should be absorbent to control reverberation when unoccupied. If it is necessary to control reverberation, addition of absorbent material should first be considered on the rear wall and then on the rear side walls.

Door lobbies can be used where it is necessary to minimize noise from people outside the theatre (see **8.4.6**).

7.6.7.7 *Community halls*

Although community halls are used for events that involve speech and music, they should be designed for speech, as the requirements are more critical. The reverberation time could be increased a little above the value shown in Table 8 if there are expected to be frequent unamplified musical events. The need for a level floor means that direct sound from the stage will be attenuated as it passes over rows of the audience. A reflective wall behind the stage, and an angled reflector over it will help to project sound to the back of the room. Making the hall as wide as sight lines allow, rather than long and thin, will also help. In large halls, high level loudspeakers by the stage may be required to reinforce the sound. The rear wall (i.e. behind the last row of the audience) and the rear side walls, if necessary to control reverberation, should be covered in sound absorbing material. If the hall has to be long and thin, smooth, flat side walls should be avoided to prevent sound undergoing repeated reflections between them, giving rise to a "flutter echo". Flutter can be controlled by having random indents and projections and/or patches of absorption on the side walls.

As musical events such as discos involve high noise levels, noise emanating from the building should be controlled to prevent it causing a nuisance to local residents, as well as to prevent external noise affecting events in the hall.

Although the designer has no control over the level at which music will be played in the room, it would be prudent to inform the client that exposure to high noise levels can be harmful to hearing [5].

Electronic sound limiting equipment can be used to control the level of amplified music.

7.6.8 ***Cinemas***

7.6.8.1 *Design limits*

The main objective of the design should be to control noise from adjacent screens, the projection area, the foyer, and outside the cinema. The first of these, controlling noise from adjacent screens, is likely to be the most difficult with modern digital sound systems. As most cinemas are air-conditioned there will be some noise from services. To ensure reasonable listening conditions this should be limited to 35 dBA (see Tables 5 and 6). This will provide some masking of the noise from adjacent screens, but a high performance partition will still be essential. Masonry or lightweight construction may be used, and a typical performance specification for a lightweight wall separating two screens is given in Table 9. Cinema design, however, normally requires specialist acoustic advice.

Table 9 — Typical sound insulation specification for wall separating two cinema screens

Octave band Hz	Sound reduction index R dB
63	38
125	44
250	50
500	61
1 000	57
2 000	58
4 000	57
8 000	55

7.6.8.2 *Lightweight construction*

A suitable construction for cinemas may comprise two frames of metal studs, each lined with three layers of 15 mm acoustic plasterboard, with 100 mm mineral wool in the cavity. To achieve adequate insulation at low frequencies the cavity between the inner faces of the plasterboards should be at least 450 mm. Optimum values for reverberation time may be recommended by the manufacturer of the sound system.

8 Sound insulation in buildings and control of noise from building services

8.1 Factors affecting sound insulation

The main factors which determine the sound insulation of a building element (wall, floor or façade) are mass, air tightness and the isolation between elements (e.g. between the leaves of a cavity wall). Other factors which influence the sound transmission through a building are the characteristics of materials used for construction, the standard of workmanship, and the layout and detailing of the building.

NOTE Some of these factors are discussed in annex E, where typical sound insulation values of common constructions are also listed.

8.2 Flanking transmission

The sound insulation between rooms in a building is not only influenced by the sound insulation of the separating element, but also by transmission via adjoining elements and air paths through or round the element, known as flanking transmission (see annex E). In order to control flanking transmission careful design and high standards of site supervision and workmanship are essential. In addition to obvious air paths, hidden paths may be contained in materials themselves due to porosity and permeability: materials having a high permeability will provide sound insulation considerably lower than an impervious material of similar mass per unit area. Applying a sealing finish such as plaster or cementitious paint can make a substantial improvement to the performance of a permeable material.

The degree of flanking sound transmission depends on the overall design of a building and in some cases flanking transmission can exceed direct sound transmission. It is often a limiting factor where high performance is required. Some factors which should be considered are:

a) junction detail between the separating wall/floor and the flanking wall;

b) mass of flanking elements;

c) transmission through floor voids, loft spaces, service ducts and similar paths.

It is not practicable to consider the sound insulation of all possible combinations of the elements that might form a building. In the initial stages of a design, individual elements are often considered as though they behaved independently of each other, but later in the design process possible interactions between the elements should be considered and the design modified or refined as necessary.

NOTE The characteristics of common types of building element are discussed in **8.4**.

8.3 Sound insulation tests

Standard laboratory measurements of airborne sound insulation in accordance with BS EN ISO 140-3 and impact sound insulation in accordance with BS EN ISO 140-6 do not take account of flanking transmission, and so should only be regarded as a guide to the performance of an element in the field. The performance of the completed construction can be checked by tests carried out in accordance with BS EN ISO 140-4 and BS EN ISO 140-7. From these measurements, single number ratings can be calculated according to BS EN ISO 717-1, for airborne insulation, and BS EN ISO 717-2, for impact insulation (see annex C).

8.4 Sound insulation characteristics of common building elements

8.4.1 *Single leaf masonry walls*

The main parameter which determines sound insulation is mass, and a rough guide to performance can be obtained from the mass law (see annex E). However, all materials have a characteristic reduction in sound insulation due to the coincidence effect at their critical frequency (see annex E); the position of which is mainly dependent on the mass and stiffness of the wall. The reduction in sound insulation in this frequency region depends on the amount of damping present, and for common materials the insulation at the critical frequency is often 5 dB to 10 dB below the trend at lower frequencies and will remain low for an octave above the critical frequency. A typical 225 mm solid, dense masonry wall may show coincidence effects in the 125 Hz octave band, while 100 mm solid lightweight concrete may show the effects in the 500 Hz octave band.

8.4.2 *Double leaf masonry cavity wall*

With masonry double leaf walls, sound energy is transmitted from one leaf to the other through the air in the cavity which separates them, and in the form of mechanical vibrations through any ties or structural links between the two leaves. A wide cavity will assist in providing good sound insulation. A high degree of structural isolation between the two leaves also assists in reducing structure-borne sound transmission. To this end, ties between the two leaves should be as few as possible and be flexible whilst maintaining structural stability. Butterfly pattern ties are better in this respect than most other types which will degrade acoustic performance. Because of unavoidable structural links, masonry cavity walls seldom attain their potential acoustic performance.

Each leaf of double leaf walls is subject to coincidence effects, and in addition, double leaf constructions exhibit a mass-air-mass resonance (see annex E) which reduces the insulation at low frequencies.

8.4.3 *Double leaf stud walls*

The effects described in **8.4.2** are particularly marked where sheet materials such as plasterboard are used. However, the reduction in insulation can be minimized if there is a high degree of mechanical discontinuity between the leaves; this can be achieved by using separate support frames for each leaf, made from metal or timber studs. Sound absorbing infill such as mineral wool batts or quilt is beneficial. Well designed, lightweight double leaf partitions can provide good performance with much lower mass than a masonry construction of comparable acoustic performance.

8.4.4 ***Partition walls***

Lightweight partitions are often used to divide a large floor area into separate rooms, for example, in large office blocks. The needs of flexible room planning and of quick installation have resulted in the production of many proprietary systems of prefabricated lightweight demountable partitions that are easily assembled using dry methods. The mass of these partitions seldom exceeds about 40 kg/m^2. The majority employ room height units about 1 m wide, usually constructed with skins about 50 mm apart, and with mineral wool or other lightweight cavity filling materials. Various methods are used to fix the panels to the structure and to fasten them together. However, for maximum sound insulation the partition should be fitted to the soffit of the structural slab and sealed around all edges.

Particular care should be taken to avoid any significant loss of sound insulation through indirect sound transmission routes. For example, where a partition wall is butted to a suspended ceiling, a continuous barrier should be provided in the space above it. Because of their lightness, and the inevitable small gaps around them, the insulation of prefabricated office partitions usually lies in the range 30 dB R_w to 40 dB R_w, occasionally extending up to 45 dB R_w. Folding and sliding partitions generally provide about 30 dB R_w, but better performance can be achieved with careful design and installation.

8.4.5 ***Construction details***

The following recommendations should be closely followed in order to maximize sound insulation. They are particularly applicable to masonry separating walls between dwellings.

a) Avoid forming recesses in the separating wall but, if it is necessary to recess electrical sockets in the wall, they should not be placed back to back to avoid the risk of complete penetration.

b) Complete filling of mortar joints, particularly perpends, is good practice. In brick walls, if the bricks have frogs they should be laid frog up so that the frogs are filled with mortar.

c) In the case of walls formed from permeable materials, the wall surface should be sealed with cementitious paint or render unless it is to have a plaster finish. Ideally, this sealing should include the wall surface where it passes through a suspended timber floor.

d) The minimum number of connections between the leaves of masonry cavity separating walls consistent with structural stability should be used. Butterfly or similar low stiffness ties are recommended.

e) Care should be taken to ensure that mortar droppings or other foreign matter does not bridge cavities.

f) A cavity separating wall construction should continue right through the roof space.

g) Air paths through or round a separating wall, even in the loft space, should be kept to the minimum possible by careful sealing around any necessary penetration of the wall. Joists should preferably run parallel to a separating wall, but if they are perpendicular joist hangers should be used, or if they are built in all air paths should be filled.

h) The reveals of windows should be well sealed to prevent sound getting into the wall cavity. At the junction with the separating wall it is good practice to stop the external wall cavity with a flexible closer, such as mineral wool, to reduce sound transmission along the cavity. If the cavity is to be filled or partially filled for thermal insulation additional stopping is not necessary.

i) Masonry separating walls should be rigidly bonded or tied to the inner leaf of a cavity wall or only leaf of a solid external masonry wall.

8.4.6 ***Doors***

The main factors determining the sound insulation of single doors are the mass of the door and the gaps around the edges; usually the latter are decisive. For good sound insulation, it is important to see that the door forms airtight joints with the frame when closed and that the joints between frame and wall are sealed. A threshold seal is essential, and even keyhole covers should be fitted in critical situations.

A nomogram is given in annex A for estimating the insulation of elements comprising two components having different values of sound insulation, such as a partition containing a door.

Single doors providing a sound insulation greater than 35 dB R_w are specialist products and are supplied as complete door sets. High performance seals may make the door hard to open and close. The most effective solution, where space is available, is to use two well sealed doors separated by a lobby lined with absorbent. Such sound lobbies are particularly useful where uninterrupted sound insulation is required (e.g. audiometric examination rooms) because one door can be closed before the other is opened. Well constructed lobbies can be expected to provide sound insulation of 45 dB to 60 dB, although the higher figure will only be achieved if the whole construction is carefully designed.

Where infrequent access to a space is required, a removable panel may be considered in place of a door.

8.4.7 *Windows*

8.4.7.1 *General*

Table 10 gives guide values for the sound insulation of windows, as measured in the field.

NOTE Further information is given in BS 6262 and [31].

The nomogram in annex A can be used to estimate the insulation of a wall containing a window.

The full insulation value of any window cannot be realized if there are air gaps. These commonly occur around frames due to insecure fixing, shrinkage of wood and poor maintenance, and between frames and opening lights.

Glass often shows a pronounced dip in insulation at its critical frequency (see annex E). For 6 mm glass this is around 2 000 Hz. Laminated glass performs better because the increased damping reduces the effect.

When adjoining rooms have their windows open the sound reduction from one to the other will be limited to about 30 dB if there are other buildings close to the windows to reflect the sound back. When the window is closed in one of the rooms, a reduction of over 50 dB between the rooms should be obtainable, and with both windows closed, this flanking path should not limit the insulation provided by normal separating elements.

8.4.7.2 *Double glazed thermal insulating glass units*

An insulating unit is unlikely to perform better than a single pane of mass equivalent to the thicker pane of the sealed unit and should be used in a frame with good seals to realize its full potential.

8.4.7.3 *Secondary windows*

In addition to the need for good sealing, the following recommendations apply for double windows.

a) The air space should be at least 100 mm, although for good performance over the main frequency range of interest a cavity of about 300 mm is desirable.

b) The sides and top of the reveal should be lined with sound absorbent (the bottom should be left clear to avoid staining due to condensation).

c) The best results are obtained if both windows are sealed, but this has obvious difficulties for cleaning (and means of escape where appropriate). When opening lights are used some loss of insulation will occur, but this can be minimized by good quality fittings and weather stripping.

d) The outer pane can be an insulating glass unit to improve performance and reduce condensation.

Table 10 — Sound insulation of typical windows

Description	Weighted sound reduction index R_w dB
Any type of window in a façade when partially open	10–15
Single glazed windows (4 mm glass)	22–30
Thermal insulating units (6-12-6)	33–35
Secondary glazed windows (6-100-6)	35–40
Secondary glazed windows (4-200-4)	40–45

8.4.7.4 *Ventilation*

The Building Regulations on ventilation [32], [33], [34] recommend that habitable rooms in dwellings have background ventilation. Trickle ventilators can provide this, and sound attenuating types are available. Where sound insulation requirements preclude opening windows for rapid ventilation and cooling, acoustic ventilation units incorporating fans are available for insertion in external walls; these can provide sound reduction comparable with domestic secondary glazing. However, ducted systems with intakes on the quiet side of the building may be required in very noisy situations, or where appearance rules out through-the-wall fans.

8.4.8 *Floors and ceilings*

8.4.8.1 *General*

As far as sound insulation is concerned, ground floors are of marginal interest except where they may contribute to flanking transmission by passing through a separating wall. Intermediate floors are the main concern and these are available with a variety of structural components and finishes.

Intermediate separating floors suitable for use in dwellings, which are described in the technical documents that support the Building Regulations [21], [22], [23], fall into the following three broad categories for new buildings:

- — a concrete base with a soft covering;
- — a concrete base with a floating layer; and
- — a timber base with a floating layer.

Guidance on upgrading existing floors is also provided. The technical documents contain details of points to watch and should be consulted for work in dwellings. As the gaps between pre-cast units in beam and block floors are difficult to seal well, a bonded screed is strongly recommended.

Dwellings that adjoin other buildings with activities that generate noise levels greater than normal domestic activities may require constructions offering better performance than those described in the documents that support the Building Regulations.

8.4.8.2 *Partitions on floating floors*

It is generally better to build partitions on the structural base rather than on top of a floating floor. This is because a partition built on a floating floor may overload the resilient layer and reduce its isolation properties, and movement of the floating floor may cause cracking in the partitions. A partition built on a floating layer may also provide a flanking path between the floor and the walls.

8.4.8.3 *Pipes and conduits in floating floors*

It is often necessary for services such as electric conduits, gas and water pipes to run across a concrete floor. Whenever possible these pipes should be accommodated within the thickness of the floor slab or levelling screed, but sometimes they have to be laid on top of the slab and contained within the depth of the floating layer. Pipes or conduits need not cause trouble with a floating screed providing they do not extend more than about 25 mm above the base, are properly fixed so as not to move while the floating floor is being laid, and are haunched up with mortar on each side to give continuous support to the resilient quilt. When two pipes cross, one of them should be sunk into the base slab. The resilient quilt should be carried right over the pipes. Although channel systems have been devised to allow access to pipes in concrete and timber floors, the acoustic performance of these is not well documented.

8.4.8.4 *Squeaking floor boards*

Floating floors of timber or similar materials may squeak when walked on. To minimize the risk for boarding or panels, deep battens and long nails or screws should be used. For softwood tongued and grooved boards, latex adhesive between boards and on joists should be used while for tongued and grooved chipboard sheets, a polyvinyl acetate emulsion adhesive is more suitable.

NOTE Further information is given in [35].

Timber joists made from reconstituted wood are available and can also be used to help minimize squeaking.

8.4.9 ***Roofs and mansards***

Roofs and mansards generally have lower sound insulation than masonry façade walls, but in many cases they are required to reduce noise from external sources such as aircraft or road traffic. The performance of various roof types is indicated in Table 11. As rainfall noise can be a problem with lightweight roofs and skylights, these should be avoided in critical situations. Laminated glass should transmit slightly less noise than an equivalent solid pane, but the manufacturer's advice should be sought.

Table 11 — The sound insulation of roofs

Roof type	Weighted sound reduction index R_w dB
Tiles on felt, pitched roof, 9.5 mm plasterboard ceiling	34
Tiles on felt, pitched roof with 100 mm mineral wool on plasterboard ceiling	43
Tiles on felt pitched roof, lath and plaster ceiling	47
Tiles on felt, pitched roof with 100 mm mineral wool on lath and plaster ceiling	51
100 mm flat concrete roof (230 kg/m^2)	52
Flat timber joist roof, asphalt on boarding, 12 mm plasterboard ceiling, thermal insulation	45
Single skin galvanized steel cladding	22
50 mm sandwich panel, galvanized steel panels with thermal foam infill	26
Double skin galvanized steel cladding with mineral fibre infill	38

8.5 Noise from building services

8.5.1 General

As it is beyond the scope of this code to discuss services noise control in detail, it may be necessary to seek advice from an acoustic consultant. A number of useful texts are available, which provide guidance on noise from mechanical services [36].

8.5.2 *Main components*

The components of a heating, ventilating and air-conditioning (HVAC) system perform the tasks of moving air, water, or refrigerant, as appropriate, around the system. As a short guide to the subject, advice on control of noise from the components of a typical air-conditioning system, from intake to outlet, is given below.

a) **Intakes**. There should be sufficient ducting distance between intake grilles and fans to enable fan noise travelling back to the opening to be reduced; common methods of attenuation are splitter attenuators and sound absorbent lined ducts. However, fibrous absorbent materials should be used with caution for health reasons.

b) **Fans**. Type and size of fans are influenced by noise control needs. In general, larger and slower fans are quieter, for a given volume and pressure duty. The casing, fan and drive motors commonly require vibration isolating mountings to reduce structural vibration. It is often essential that the fan casing is isolated from ducting using flexible connectors, and the ducting may need to be supported from resilient hangers.

c) **Chillers**. Chillers create high levels of noise and vibration and so should be located in an enclosure if situated near sensitive areas. Careful attention should be paid to air gaps allowing noise to escape. Resilient mountings are usually necessary. It is essential that all pipework leading to and from the chillers is held by isolating clips or hangers (or is fixed to joists that can be isolated), and passes through the enclosure in sleeves lined with a resilient material.

d) **Ducts**. Ducts may have fan noise propagating inside them, or turbulence noise generated in them by fast-moving air or by drumming of the duct walls. Noise generated in one room can be transmitted to a neighbouring room by a common duct, resulting in poor sound insulation (cross-talk). Noise can escape from inside a duct to the outside (breakout). Consequently, ducts that pass close to sensitive areas may need to be lagged with noise insulating material. Conversely, if a duct passes through a noisy area, noise may break in and be transmitted down the duct. This is most likely to occur in a plant room where, for example, a silencer has been located close to a fan and the silenced duct runs through the plant room. The silencer should be located at the position where the duct penetrates the plant room wall.

e) **Outlets**. Air movement through diffuser grilles can be the source of significant levels of noise (known as regenerated noise). Reduction of the velocity of the air or removal of any obstructions can significantly reduce the regenerated noise from the grilles. In some cases where background noise is needed, noisier grilles can be useful, but to achieve a steady noise level the velocity of the air from the grille should be constant.

8.5.3 *Frequency characteristics of noise*

The frequency ranges of noise from the components can be generalized as follows:

a) fan instability, air turbulence, structure borne noise: 10 Hz to 80 Hz perceived as throb and rumble;

b) fan and pump noise: 50 Hz to 500 Hz perceived as rumble and roar;

c) variable air volume (VAV) unit noise: 125 Hz to 2 500 Hz, perceived as roar and whistle or whirr;

d) chiller noise: 250 Hz to 1 000 Hz, perceived as roar and whistle or whirr;

e) outlet (or diffuser) noise: 800 Hz to 4 000 Hz, perceived as whistle or whirr and hiss.

Many types of silencer are available, and they may work over a wide frequency range (broad band) or be tuned to a particular frequency band.

NOTE For more information about silencers see BS EN ISO 14163.

8.5.4 *Rating noise from services*

Continuous ventilation noise is commonly rated in the UK using noise rating (NR) curves based on an octave band analysis of the noise (see annex B). An approximate dBA level can be found by adding 6 to the NR level. Noise criteria (NC) curves are also used and are broadly similar to NR curves. The room criterion (RC) is recommended by ASHRAE for use in the USA [20] but is not yet widely used in the UK. All criteria are similar in the mid frequencies, from 500 Hz to 2 000 Hz, but the RC is considerably more restrictive than NR on low frequency noise.

8.6 Sound absorbent treatment

The reduction in noise within a room where the source is outside the room is limited to about 3 dB for each doubling of total sound absorption within the room. Increasing absorption is therefore not usually an alternative to improving sound insulation. This approach is most effective in factory buildings. Sound absorbing materials are also used to control noise in ducts, taking into account health and safety considerations.

8.7 Quality control

Experience has shown that good sound insulation and noise control requires careful detailing on the part of the designer and a high standard of workmanship on the part of the contractor. Correct execution of the detailing should be checked on site, and the completed building should be fully commissioned before hand over.

Noise control is only one aspect of environmental design and designers should be aware that the solution to a noise problem can produce difficulties in relation to other aspects, e.g. thermal insulation, cold bridging, solar gain, ventilation and condensation. Much information on the environment in and around buildings is available and should be considered at an early stage of the design process.

Annex A (informative) Noise calculations

A.1 General

Some of the simpler types of noise calculation are described in this annex. For methods of predicting noise from road and rail traffic see clause **6**.

A.2 Addition of two noise levels

To determine the combined sound pressure level (L_c) resulting from the sound pressure levels of two or more noise sources (L_1, L_2 etc.), it is necessary to calculate and add the mean square values of their individual sound pressures and then convert this back to a sound pressure level. This can be done using the following formula:

$$L_c = 10 \log_{10}\left(10^{\frac{L_1}{10}} + 10^{\frac{L_2}{10}}\right)$$

As the individual sound pressure levels are logarithms of the mean square sound pressures, they cannot simply be added arithmetically. Figure A.1 shows a graphical method for adding the sound pressure levels from two independent sources to obtain the combined sound pressure level at a particular place. This graph may also be used for multiple sources by combining sources two at a time to produce virtual sources that can then be combined. The most accurate approach is to start with the lowest levels and work towards the highest.

The graph should be used with caution where the noise sources are not independent. For example, the sound pressure level from two large transformers fed with currents in phase will be very sensitive to the receiving position. This is because the effect of the constructive and destructive interference of the sounds from the two sources is very dependent on position.

A.3 Subtraction of two noise levels

When measuring noise from a source, the true noise level of the source alone will be less than that shown by the meter if the level of extraneous noise is less than about 10 dB below the total noise level. An estimate of the true source level can be obtained from Figure A.2.

A.4 Non-uniform partitions

Figure A.3 shows how to calculate the overall sound insulation of a partition consisting of two parts having different sound-insulating properties, e.g. a window in a wall. It may also be used to give an indication of the effect of gaps or holes in a partition by assigning a sound insulation value of 0 dB to the aperture.

A.5 A-weighting calculations

The equivalent A-weighted level is often required when data on a noise source is available as a set of octave band or one-third octave band levels. The conversion can be done manually, using the standard A-weighting values (Table A.1) and the graph for combining levels (Figure A.1). For all but the simplest situations it is more convenient to use a computer spreadsheet to do the conversion.

A.6 Reverberation time calculation

An estimate of the reverberation time (T) of a room can be obtained from the Sabine formula:

$$T = \frac{(0.16V)}{\sum A_i}$$

where

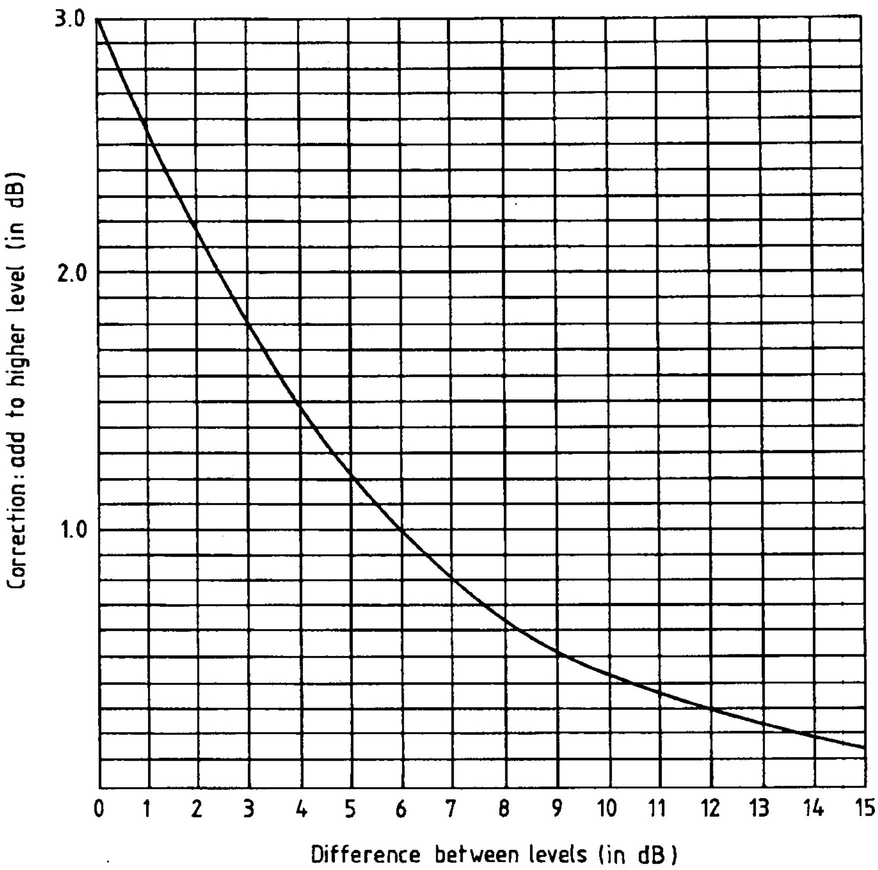
V	is the volume of the room in cubic metres (m^3);
$\sum A_i$	is the equivalent sound absorbing area in the room in square metres (m^2).

The A_i are the absorbing areas of each surface, or other permanent fixture in the room. Each A_i is determined by multiplying the area of that surface in square metres (m^2) by its absorption coefficient α_{si}. The surface of each significant fixture or feature of the room should be considered as well as the walls, ceiling and floor.

The total absorption is obtained by summing the individual A_i values. As the values of α_{si} are frequency dependent, this calculation should be repeated for each octave band of interest.

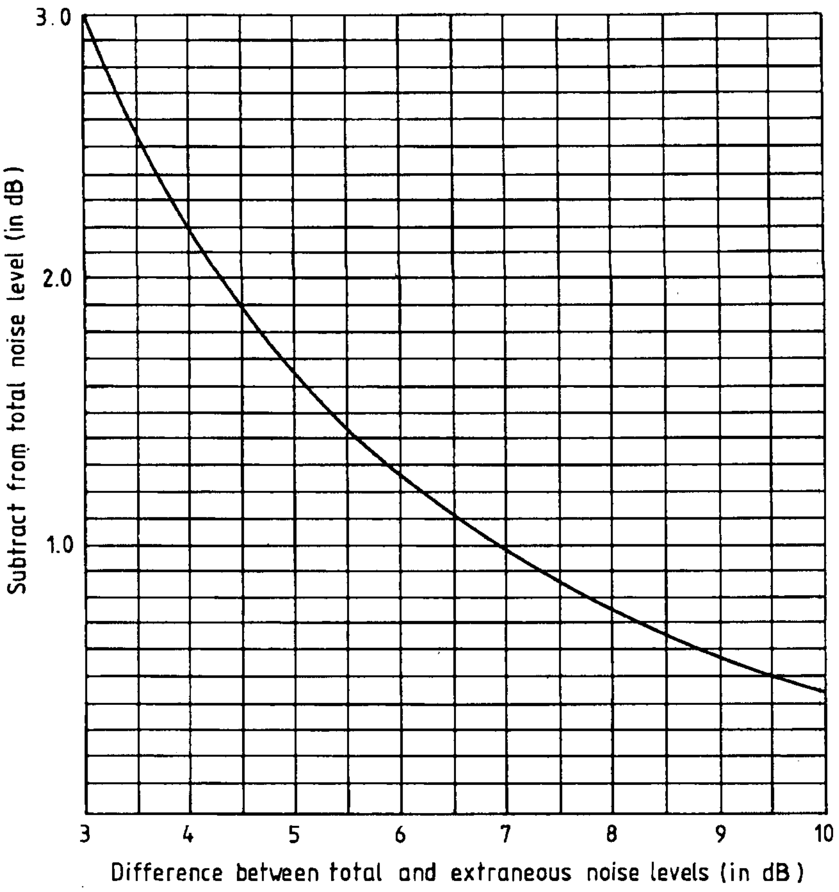
An allowance should also be made for people and furnishings in the room.

NOTE Information on absorption coefficients is given in [36].



NOTE This figure is derived from The Control of Noise (Measurement and Registers) Regulations 1976 SI 37 [37] and is reproduced by kind permission of the Controller of The Stationery Office.

Figure A.1 — The addition of two noise levels



NOTE This figure is derived from The Control of Noise (Measurement and Registers) Regulations 1976 SI 37 [37] and is reproduced by kind permission of the Controller of The Stationery Office.

Figure A.2 — Subtraction of noise levels

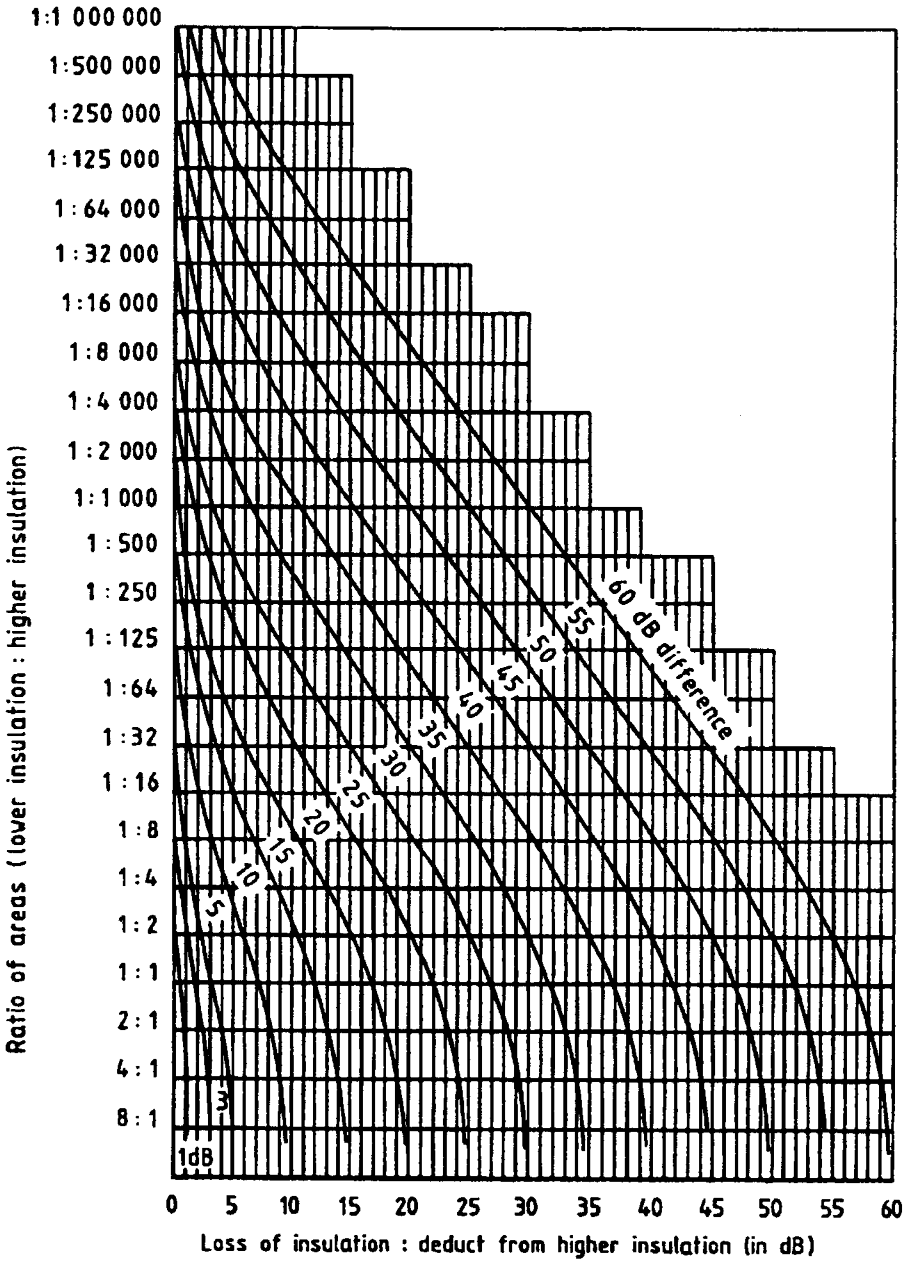


Figure A.3 — Sound insulation of non-uniform partitions

Table A.1 — Standard A-weighting values (dB)

Third octave band centre frequency Hz	A-weighting dB	Third octave band centre frequency Hz	A-weighting dB
10	−70.4	500	−3.2
12.5	−63.4	630	−1.9
16	−56.7	800	−0.8
20	−50.5	1 000	0
25	−44.7	1 250	0.6
31.5	−39.4	1 600	1.0
40	−34.6	2 000	1.2
50	−30.2	2 500	1.3
63	−26.2	3 150	1.2
80	−22.5	4 000	1.0
100	−19.1	5 000	0.6
125	−16.1	6 300	−0.1
160	−13.4	8 000	−1.1
200	−10.9	10 000	−2.5
250	−8.6	12 500	−4.3
315	−6.6	16 000	−6.6
400	−4.8	20 000	−9.3

Annex B (informative)

Noise rating

Noise rating (NR) is a graphical method for assigning a single number rating to a noise spectrum. It can be used to specify the maximum acceptable level in each octave band of a frequency spectrum, or to assess the acceptability of a noise spectrum for a particular application. The method was originally proposed for use in assessing environmental noise, but it is now used in the UK mainly for describing noise from mechanical ventilation systems in buildings. To make a rating, the noise spectrum is superposed on a family of NR contours; the NR of the spectrum corresponds to the value of the first NR contour that is entirely above the spectrum. The data for drawing NR contours (from NR 0 to NR 75) is given in Table B.1 for the frequency range 31.5 Hz to 8 kHz.

For computational methods the curves are defined by the equation:

$$L = a + bN$$

where

L	is the octave band sound pressure level corresponding to NR level N;
a and b	are constants for each frequency band, as given in Table B.2.

NOTE NR values cannot be converted directly to dBA values but the following approximate relationship applies:

NR ≈ dBA − 6.

Although the NR system is currently the preferred method for rating noise from mechanical ventilation systems in the UK, other methods which are more sensitive to noise at low frequencies are available [20], but they are not yet widely accepted in the UK. Low frequency noise can be disturbing or fatiguing to occupants, but may not have much effect on the dBA or NR value.

Table B.1 — Noise rating values

Noise rating	Octave band centre frequency Hz								
	31.5	63	125	250	500	1 000	2 000	4 000	8 000
NR75	106	95	87	82	78	75	73	71	69
NR70	103	91	83	77	73	70	68	66	64
NR65	100	87	79	72	68	65	62	61	59
NR60	96	83	74	68	63	60	57	55	54
NR55	93	79	70	63	58	55	52	50	49
NR50	89	75	66	59	53	50	47	45	43
NR45	86	71	61	54	48	45	42	40	38
NR40	83	67	57	49	44	40	37	35	33
NR35	79	63	52	45	39	35	32	30	28
NR30	76	59	48	40	34	30	27	25	23
NR25	72	55	44	35	29	25	22	20	18
NR20	69	51	39	31	24	20	17	14	13
NR15	66	47	35	26	19	15	12	9	7
NR10	62	43	31	21	15	10	7	4	2
NR5	59	39	26	17	10	5	2	−1	−3
NR0	55	35	22	12	5	0	−4	−6	−8

Table B.2 —Values of a and b

Octave band centre frequency Hz	a	b
31.5	55.4	0.681
63	35.4	0.790
125	22.0	0.870
250	12.0	0.930
500	4.2	0.980
1 000	0.0	1.000
2 000	−3.5	1.015
4 000	−6.1	1.025
8 000	−8.0	1.030

Annex C (informative) Specification of sound insulation

C.1 General

Sound insulating elements work mainly by reflecting sound energy back into the source room, not by absorbing it. The methods of measurement and the terms used are described in **C.2** to **C.4**.

C.2 Insulation against airborne sound

In the standard tests described in BS EN ISO 140-3 and BS EN ISO 140-4 the insulation between a pair of rooms is measured either in third octave bands having centre frequencies which cover at least the range 100 Hz to 3 150 Hz, or in octave bands which cover at least the range 125 Hz to 2 000 Hz. The noise is produced by a loudspeaker in one of the rooms (called the source room) and at each frequency the average noise levels are measured in the source room (L_S) and in the adjacent receiving room (L_R). The difference between these two levels (D) is a measure of the sound insulation between the rooms, regardless of the transmission path(s) the sound energy followed to travel between the rooms. The equation is as follows:

$$D = L_S - L_R$$

The actual level in the receiving room depends on:

— the sound insulation of the separating wall or floor;

— the area of the separating wall or floor;

— the volume of the receiving room;

— the amount of flanking transmission (i.e. the importance of transmission paths other than the separating wall or floor);

— the amount of absorbing material (e.g. furniture) in the receiving room.

For field measurements, apart from the amount of absorption, these factors are a property of the building and should be taken into account by the measurement procedure. As the amount of absorbing material (e.g. soft furniture) in the room at the time of measurement is arbitrary, it should be allowed for separately. This is achieved by measuring the reverberation time (T) of the room in seconds (s), which is a measure of how long it takes a sound to die away after the source has been switched off. As the sound energy is dissipated as heat in the absorbing material (T) it is related to the total amount of absorption in the room. The receiving room level can then be corrected to the level it would be if the room had a standard reverberation time (T_o) which is typical of furnished rooms, and is taken to be 0.5 s. The corrected level difference is known as the standardized level difference, which has the symbol D_{nT} and is calculated using the following equation:

$$D_{nT} = L_S - L_R + 10 \log_{10} (T/T_o)$$

For laboratory measurements the insulation of the separating wall or floor being tested is required in a way which is independent of the actual measuring laboratory. For this reason, laboratories are designed to have minimal flanking transmission and a different correction is applied to account for the other factors.

This correction is $10 \log_{10} (S/A)$

where

S is the common area of the separating wall or floor in square metres (m^2);

A is the equivalent absorption area in the receiving room in square metres (m^2).

The laboratory corrected level difference at each frequency is known as the sound reduction index, which has the symbol R and is calculated using the following equation:

$$R = L_S - L_R + 10 \log_{10} (S/A)$$

If the test wall or floor is mounted in a realistic way in the laboratory and flanking transmission will be low in the field, the sound reduction index may be used to predict its performance in the field. The relation between D_{nT} and R is:

$$D_{nT} = R - 10 \log_{10} (3S/V)$$

where

S is the area of the separating wall or floor in the field in square metres (m^2);

V is the volume of the receiving room in the field in cubic metres (m^3).

This equation shows that if the source and receiving rooms have different volumes, D_{nT} will depend on which is used as the source room; using the larger room as the source room will give the lower value.

C.3 Insulation against impact sound

The procedure to measure the impact insulation of floors is rather different (see BS EN ISO 140-6 and -7). Instead of a loudspeaker, a machine containing five small hammers is placed on the floor. While the hammers strike the floor at a rate of 10 blows a second, the resulting noise level (L_i) is measured in the receiving room below at each of the same frequency bands used for airborne insulation. In the field, the receiving room levels are again "corrected" to a standard reverberation time (T_o) of 0.5 s to give the standardized impact sound pressure level, L'_{nT}, which is calculated as follows:

$$L'_{nT} = L_i - 10 \log_{10} (T/T_o)$$

In the laboratory, the noise level depends mainly on the characteristics of the floor being tested and the amount of absorption (A m^2) in the laboratory. It is therefore appropriate to correct the noise level to a standard area of absorption. The area used is 10 m^2. The resulting normalized impact sound pressure level is given the symbol L_n and calculated as follows:

$$L_n = L_i + 10 \log_{10} (A/10)$$

C.4 Rating sound insulation

Measurements of insulation against both airborne and impact sounds yield values in a number of frequency bands. To make this information more manageable, rating methods such as those in BS EN ISO 717-1 and -2 are used to reduce the frequency band values to single figure ratings. These single figure ratings should be good predictors of subjective assessments of insulation. However, this is not always the case and it is prudent to examine the full measurement data in critical situations. The impact insulation measured on a floor with a carpet is likely to be overestimated by this method.

The more common indices used to describe sound insulation are summarized in Table C.1.

NOTE 1 Further guidance on rating sound insulation is given in BS EN ISO 717-1 and -2. The terminology shown in Table C.1 is used but with additional spectrum adaptation terms (C_x).

For example: R_w (C; C_{tr}) = 41(0; −5) dB.

Here, C (value 0) is the correction needed to convert R_w to a dBA insulation value against a pink noise spectrum; C_{tr} (value −5) is the correction needed to convert R_w to a dBA insulation value against a standardized road traffic noise spectrum. In this case the dBA insulation is: 41 − 5 = 36 dBA.

NOTE 2 Pink noise has the same sound pressure level in adjacent frequency bands, and is used to represent general activity noise.

Table C.1 — Common indices used to describe airborne and impact sound insulation

Airborne (A) Impact (I)	Lab (L) Field (F)	Measured values		Single number quantity	
		Name	Symbol	Name	Symbol
A	F	Standardized level difference	D_{nT}	Weighted standardized level difference	$D_{nT,w}$
A	L	Sound reduction index	R	Weighted sound reduction index	R_w
I	F	Standardized impact sound pressure level	L'_{nT}	Weighted standardized impact sound pressure level	$L'_{nT,w}$
I	L	Normalized impact sound pressure level	L'_n	Weighted normalized impact sound pressure level	$L'_{n,w}$

Annex D (informative)
Special problems requiring expert advice

D.1 General

Certain design problems require reliable advice of a kind which is not easy to find in published material. The advice of an expert should be sought for these kinds of problems, some examples of which are given in **D.2** to **D.9**.

D.2 Acoustic test rooms

The design of rooms in which acoustic measurements are carried out, such as reverberation chambers, free-field rooms and audiometric test rooms, usually requires the advice of an expert.

D.3 Performing spaces

The design of theatres, opera houses, concert halls and similar performing spaces usually requires expertise in room acoustics and noise control. The intrusion of quite low levels of noise can seriously interfere with the enjoyment of the performance and distract the performers. The requirements for low noise levels often mean that more room has to be allocated for low velocity ventilation ductwork and the impact on the design of the ventilation system is often substantial.

D.4 Broadcasting and recording studios

Broadcasting and recording studios have requirements similar to those of performing spaces. For some infrequent intrusive noises, the requirements are sometimes relaxed on the grounds that a re-take of a recording can be done, but this can result in higher operating costs.

D.5 Aircraft noise

As there are many variables affecting the level of aircraft noise heard on the ground, expert advice is almost always required. Contours of daytime $L_{Aeq,T}$ levels are available from most major airports. Where measurements of façade insulation are necessary a test method is described in BS EN ISO 140-5.

D.6 Ground-borne noise

Projects involving ground-borne noise from underground trains usually require expert advice.

D.7 Low-frequency noise

Projects involving low-frequency noise usually require expert advice as accurate measurement is difficult and there is a shortage of reliable data below 100 Hz.

D.8 Active noise control

Active noise control is the reduction of noise by cancellation with a similar noise (anti-noise) generated by electro-acoustic means. The technique is still under development, but commercial systems are available which successfully reduce low frequency noise from mechanical ventilation systems.

D.9 Noise surveys

Noise surveys are carried out for a variety of reasons, for example:

a) before construction, to establish the existing noise climate at the site of a proposed development where reliable prediction is impracticable, as an aid to the design of the building envelope, either to protect against external noise or contain internally produced noise;

b) during construction, to monitor noise from building activity, either to assess the likely nuisance to the local community or the risk of hearing damage to the work force;

c) at the end of a building contract to check the insulation of the building envelope, or the noise levels produced by the services;

d) as part of a planning requirement;

e) to provide objective evidence to support or defend a legal action.

The expense of carrying out a comprehensive noise survey of any kind is likely to be high, so the cost-effectiveness of a full or partial survey should be weighed against alternatives such as prediction. A survey will generally be more accurate and can take account of factors such as prevailing wind conditions.

Annex E (informative)
Airborne and impact sound insulation

E.1 General

Airborne sound refers to sources which produce sound by directly setting the air around them into vibration. Impact sound refers to sources which produce sound by impulsive mechanical excitation of part of a building (e.g. by footsteps, electric light switches, slamming doors). Many sources of impact sound also produce significant levels of airborne sound. The term structure-borne sound has no very precise meaning as the structure can be excited by both airborne and impact sources; it is often used to refer to sound that travels for long distances via the structure, especially in connection with vibrating machinery linked directly to the structure.

E.2 Direct and indirect transmission

Figure E.1 shows diagrammatically a pair of rooms in a house where the construction consists of solid walls etc. bonded together. Sound travelling from room 1 to room 2 can travel via the direct path a-a and by the many indirect, or flanking, paths shown. The term flanking transmission is usually used to mean transmission paths involving the structure, while the term indirect transmission includes flanking paths and airborne paths through gaps and ducts etc. The indirect paths may limit the sound insulation attainable no matter how much the direct sound is reduced by the separating wall or floor. The indirect transmission can be reduced by measures such as the following:

a) increasing the mass of the flanking walls;

b) increasing the mass of the partition and bonding it to the flanking walls;

c) introducing discontinuities in the indirect paths;

d) erecting independent wall linings adjacent to the flanking walls to prevent energy entering the flanking construction;

e) sealing any air gaps and paths through ducts.

Figure E.2 shows a number of indirect paths that have been found in offices.

It is important to remember that standard test laboratories are designed to minimize transmission by all paths other than the direct path. This makes it difficult to relate the results of laboratory measurements to those likely to be obtained in the field.

E.3 Airborne sound insulation

E.3.1 *General*

The sound insulation of structural elements such as walls and floors always varies with frequency, the insulation rising in general as the frequency rises.

E.3.2 *Terminology*

In the UK, results from field measurements are usually expressed in terms of the weighted standardized level difference, while laboratory measurements are usually expressed in terms of the sound reduction index. In the absence of significant flanking transmission the numerical difference between the weighted standardized level difference and the sound reduction index of a wall or floor is usually small for furnished rooms in dwellings, and so either quantity can be used in considering principles; for this purpose it is, therefore, convenient to use the general term insulation.

E.3.3 *Mass law*

An approximate empirical relationship has been established between sound insulation and mass for single leaf constructions as shown in Figure E.3. This so called "mass law" gives a useful first approximation to the behaviour of a single sheet or plate. In practice, the sound insulation predicted by the mass law may not be attained because of factors such as the coincidence effect, which is outlined in **E.3.4**. Results for specific materials vary around the value given by the mass law relationship, and so measured data should be used when available. Table E.1 gives a list of materials and indicates the sound insulation of a single, imperforate sheet when fixed to a suitable wood or metal framework. These values are useful, for example, when assessing existing structures.

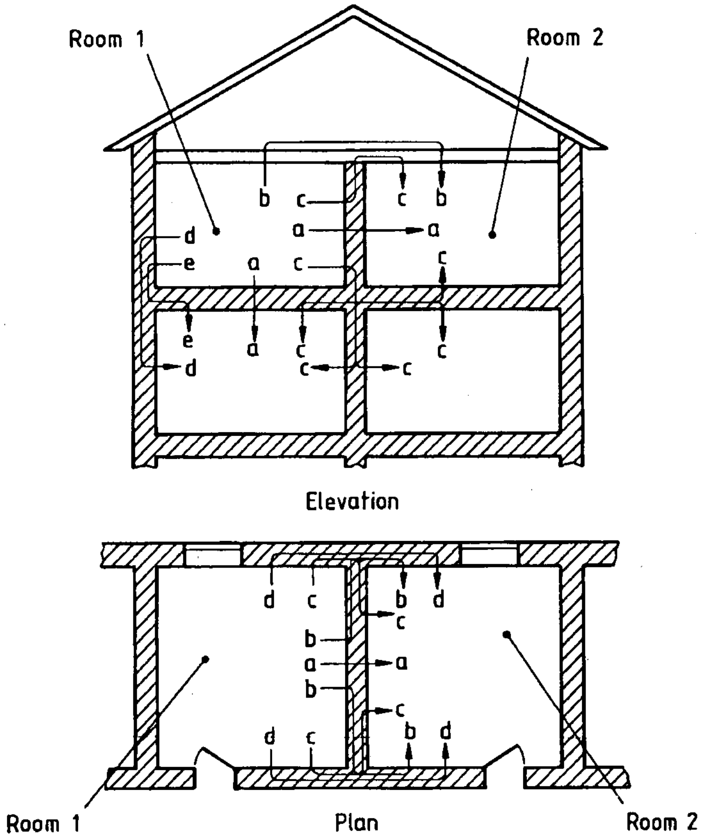
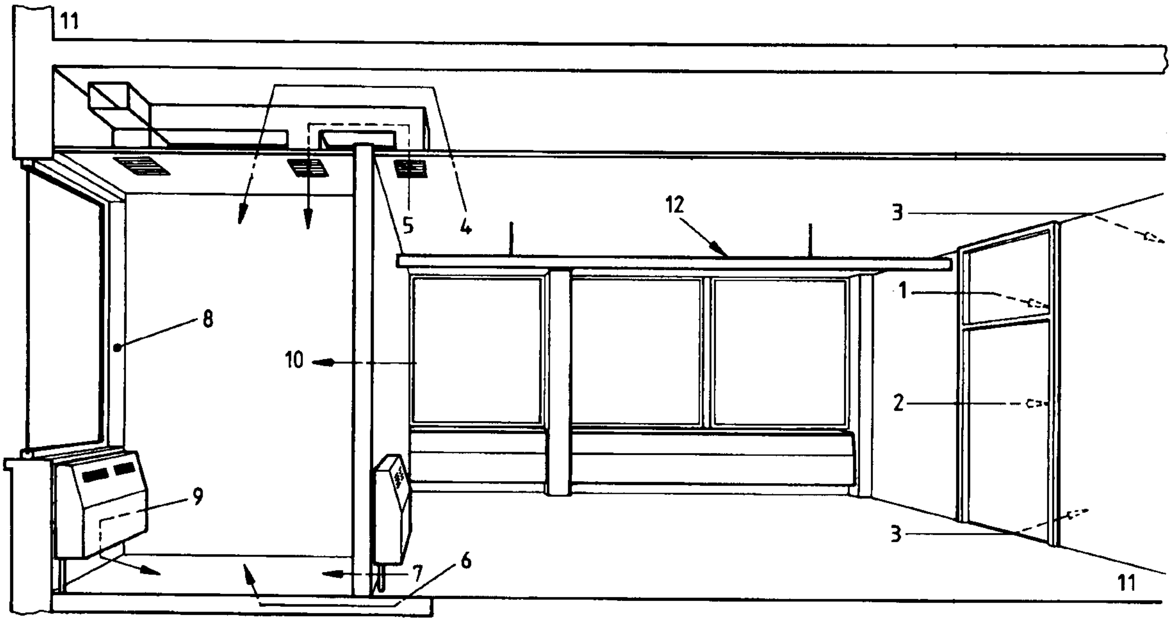


Figure E.1 — Transmission paths (via the structure) of noise originating in room 1 (diagrammatic)



1 Lightweight panels above doors
2 Doors
3 Air leaks through gaps, cracks or holes
4 Sound transmission via suspended ceilings/partitions
5 Common ventilation system without silencers
6 Common floor duct
7 Electrical outlets and service pipes
8 Lightweight mullions or mullion/partition closers
9 Continuous sill line heating
10 Partition performance
11 Appliances
12 Continuous lighting fittings

NOTE This figure is derived from the British Gypsum White Book and is reproduced by kind permission of British Gypsum Ltd.

Figure E.2 — Indirect sound leakage paths

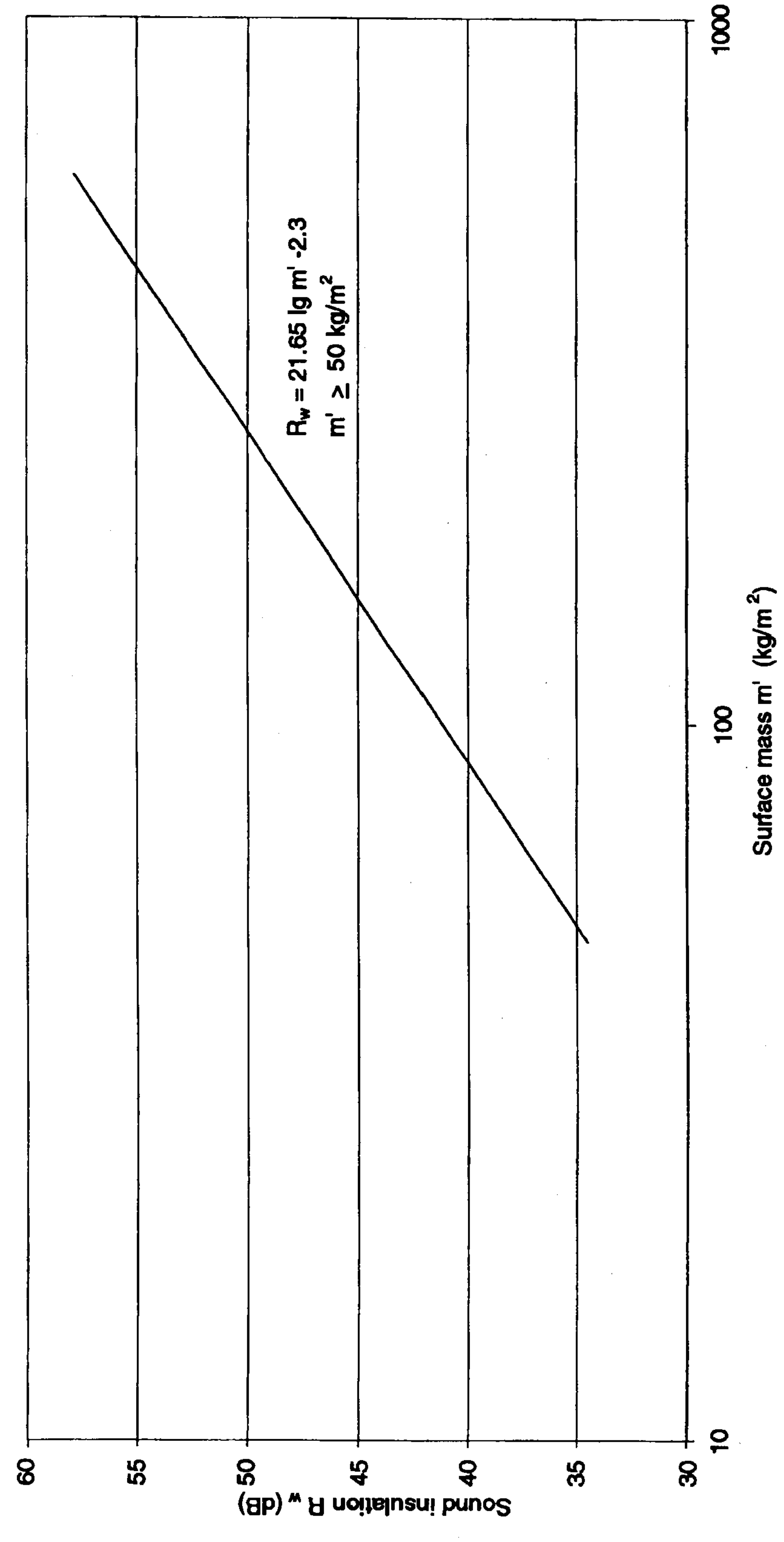


Figure E.3 — Mass law curve

Table E.1 — Sound insulation of imperforate sheet materials

Material	Surface mass kg/m²	Typical weighted sound reduction index R_w dB
3 mm glass sheet	7.0	26
12.5 mm plasterboard	10.5	31
18 mm wood chipboard	8.0	27
9 mm plywood	3.0	24
16 mm plywood	4.5	24
1 mm steel sheet	11.0	29
6 mm hardboard	5.0	25
12 mm wood fibre insulation board	4.0	24
13 mm mineral fibre board	4.0	24
50 mm wood-wool screeded one side	35.0	33

E.3.4 *The coincidence effect*

The coincidence effect occurs when the wavelength of the wave impressed on the panel by the incident sound wave is close to the wavelength of free bending waves in the panel. The effect of coincidence is to lower the sound insulation of a construction by as much as 10 dB below the level expected from its mass per unit area over a limited frequency range. The coincidence effect can be pronounced with thin lightweight partitions, resulting in loss of insulation at middle and high frequencies. Reducing the stiffness without a corresponding reduction of mass can raise the critical frequency above 3 150 Hz, and so improve the insulation over the important 100 Hz to 3 150 Hz range. An increase of stiffness will have the reverse effect.

It is possible to design lightweight stud partitions so that they perform to their maximum effect in the speech frequency region between 250 Hz and 2 000 Hz, i.e. between the mass-spring-mass and coincidence regions respectively. The worst coincidence dips occur in materials such as plate glass and rigid metal sheets. Heavily damped materials such as lead sheets are least affected.

E.3.5 *Mass-spring-mass frequency*

A double leaf wall can perform better than a single leaf wall of similar mass because the sound has to pass through two barriers. If the two leaves are not connected to each other, the insulation values of the two leaves can be added together. However, in practice the leaves are often connected by ties or studs, and the full insulation cannot be achieved. Even where the two leaves are isolated from each other, the full benefit can only be obtained above a certain frequency that depends on the cavity width. This is because the air in the cavity behaves like a spring connecting the leaves together, and causes a resonance at the mass-spring-mass frequency. Below this frequency, the two leaves behave more like an equivalent single leaf.

Making the cavity width wide can reduce the mass-spring-mass frequency, as in the case of sound insulating secondary glazing. The mass-spring-mass frequency (F_0) can be estimated from the following equation:

$$F_0 = 59.6\sqrt{\frac{1}{d}\left(\frac{1}{m_1} + \frac{1}{m_2}\right)}$$

where

m_1 and m_2 are the surface masses of the two leaves in kilograms per square metre (kg/m²);

d is the cavity width in metres (m).

E.3.6 *Impact sound control*

A structure that receives an impact or has a vibrating source in contact with it behaves more like an extension of the source rather than an intervening element between source and listener. For this reason, a relatively small amount of impact energy can produce a loud sound and, if the structure is continuous, the sound may travel a long distance. Control is usually obtained by inserting a resilient surface at the point of contact with the source (e.g. laying a carpet on a floor) or by introducing a structural discontinuity.

Floating floors, which are an example of the latter approach, are a common method of controlling impact sound from footsteps. However, it should be noted that an effective floating floor may result in increased sound from impacts on the source side of the floor. The conventional forms of floating floor may be unsatisfactory if protection against the low-frequency content of impact noise is required (e.g. a dance floor over a restaurant).

E.4 Airborne insulation values of walls and airborne and impact insulation values of floors

Tables E.2 and E.3 give examples of common types of wall and floor construction with sound insulation in the ranges shown. The insulation indices are for field measurements assessed in accordance with BS EN ISO 717-1 and -2. The insulation values given are necessarily approximate since examples of nominally identical constructions may show variations of several decibels. All the figures represent values expected in the field, i.e. in actual buildings. Many are based directly on field measurements, though others (in the absence of representative field measurements) have been assessed from laboratory data, with an allowance for typical flanking conditions in normal buildings.

Variation in the amount of indirect transmission may affect significantly the insulation between two rooms separated by a given barrier. For example, the sound insulation of some types of floor may be reduced by indirect transmission along the walls supporting them, particularly if these walls are of lightweight masonry and carried past the floor.

In many cases, simple solid partitions give insulation values according to their mass (see **E.3.3**). Moreover, with partitions of this type there is usually little variation between field and laboratory test results unless the laboratory insulation exceeds 45 dB. Exceptions may occur in buildings that have not been specially designed to minimize common cavities and strongly coupled elements in lightweight panelling.

The examples given are not exhaustive. Flanking structures are not listed since these can vary widely and are often dependent upon other factors such as thermal insulation, which are outside the scope of this code.

Table E.2 — Airborne sound insulation of walls and partitions

Sound insulation $D_{nT,w}$ dB	Type of wall or partition
26 to 33	a) Honeycomb core panels not less than 50 mm overall thickness, paper honeycombs clad both sides with either 9.5 mm or 12.5 mm plasterboard. Panels fixed to timber perimeter framing and with timber joint battens between panels. Approximate mass per unit area 17 kg/m^2.
	b) 1 mm steel sheet panels fixed to steel frame members to form demountable partition units 50 mm overall thickness. Mineral wool cavity insulation.
	c) Plywood or wood fibre board 12 mm thick nailed both sides of 50 mm × 50 mm timber framing members spaced at 400 mm centres.
	d) Paper faced strawboard or wood wool 50 mm thick panels plastered both sides.
	e) Chipboard hollow panels 50 mm thick tongued and grooved edges, hardboard faced. Joints covered with wood trim.
33 to 37	a) Lightweight masonry blockwork. Plaster or drylining on at least one side. Overall mass per unit area not less than 50 kg/m^2.
	b) Laminated plasterboard at least 50 mm thick fixed to timber perimeter framing, any suitable finish. Approximate mass per unit area 35 kg/m^2.
	c) Timber stud partitions any size timbers greater than 50 mm × 50 mm, 400 mm centres, cross noggins, 9.5 mm plasterboard lining on both sides, any suitable finish.
	d) Metal stud partition, 50 mm studs 600 mm centres, clad both sides with 12.5 mm plasterboard, joints filled and perimeters sealed. Approximate mass per unit area 18 kg/m^2.
	e) 50 mm lightweight masonry blockwork, plastered both sides to 12 mm thickness or drylined with 9.5 mm plasterboard.
37 to 43	a) Lightweight masonry blockwork, plaster or dry lining on at least one side. Overall mass per unit area not less than 75 kg/m^2.
	b) Either 75 mm or 100 mm × 50 mm timber studs (no noggins) spaced 600 mm apart, 50 mm mineral fibre quilt in stud cavity. Frame lined on both sides with one layer 12.5 mm plasterboard. Approximate mass per unit area 19 kg/m^2.

Table E.2 — Airborne sound insulation of walls and partitions *(continued)*

Sound insulation $D_{nT,w}$ dB	Type of wall or partition
43 to 50	a) Masonry wall, joints well filled. Either plaster or dry lining on both sides. Overall mass per unit area not less than 150 kg/m^2.
	b) 100 mm metal stud partition, "C" section studs not greater than 600 mm spacing, not less than nominal 50 mm web depth. Clad on both sides with two layers of plasterboard of not less than 22 mm combined thickness. Mineral fibre quilt hung between studs. Approximate mass per unit area 35 kg/m^2.
	c) 75 mm × 50 mm timber framing using stagged studs at 300 mm spacing with 25 mm stagger forward and back. Frame clad with two layers of 12.5 mm of plasterboard on both sides. Mineral fibre quilt hung between studs. Approximate mass per unit area 36 kg/m^2.
	d) 50 mm × 25 mm timber stud partition to form a 25 mm cavity, clad on both sides with minimum 38 mm wood wool slabs having their outer faces screeded or plastered.
	e) Solid autoclaved aerated concrete blocks 215 mm thick plaster or dry lined finish on both sides, blockwork joints well filled. Overall mass per unit area not less than 160 kg/m^2.
50 to 54	a) Two separate frames of timber studs not less than 89 mm × 38 mm, or boxed metal studwork with 50 mm minimum web depth. Studs at 600 mm maximum centres. A 25 mm mineral wool quilt suspended between frames. Frames spaced to give a minimum 200 mm overall cavity. Clad on outside of each frame with a minimum of 30 mm plasterboard layers (e.g. 19 mm plus 12.5 thickness). Approximate mass per unit area 54 kg/m^2.[a]
	b) Either in situ or pre-cast concrete wall panel not less than 175 mm thick and not less than 415 kg/m^2. All joints well filled.[a]
	c) Brick laid frogs up wall nominal 200 mm thickness, weight (including plaster) not less than 380 kg/m^2. Plaster or dry-lined finish both sides. Brickwork joints well filled.[a]
	d) "No fines" concrete 225 mm thickness, weight (including plaster) not less than 415 kg/m^2. Plaster or dry-lined finish both sides.[a]
	e) Cavity lightweight aggregate block (maximum density of block 1 600 kg/m^3) with 75 mm cavity and wall ties of the butterfly wire type. Dry lined finish on both sides. Joints in blockwork well filled. Overall mass per unit area not less than 300 kg/m^2.[a]
	f) Dense aggregate concrete block cavity wall with 50 mm cavity and wall ties of the butterfly wire type. Dry lined finish on both sides. Joints in blockwork well filled. Overall mass per unit area not less than 415 kg/m^2.[a]
	g) Autoclaved aerated concrete block cavity wall consisting of two leaves, 100 mm blocks not less than 75 mm apart, with wall ties of the butterfly type. Plaster or dry line finish on both sides. Joints in blockwork well filled. Overall mass per unit area not less than 150 kg/m^2.[a]

Table E.2 — Airborne sound insulation of walls and partitions *(continued)*

Sound insulation $D_{nT,w}$ dB	Type of wall or partition
54 to 60	a) Two separate frames of timber studs not less than 100 mm × 50 mm spaced at 600 mm maximum centres. A 50 mm mineral wool quilt in each frame between studs. Frames spaced to give a minimum 300 mm overall cavity. Each frame clad on outside with three layers of 12.5 mm plasterboard nailed to framing. Approximate mass per unit area 51 kg/m^2.[a]
	b) Two separate frames of boxed "C" section galvanized nominal 150 mm steel studs 100 mm apart with a 400 mm overall cavity. 50 mm mineral wool quilt fixed to the back of one frame, each frame clad on outside with three layers of 12.5 mm plasterboard by self drilling or tapping screws. Approximate mass per unit area 47 kg/m^2.[a]
	c) Solid masonry with an overall mass per unit area of not less than 700 kg/m^2 fully sealed both sides.[a]
	d) Dense aggregate concrete block solid wall 215 mm thick plaster finish to both surfaces. Overall mass per unit area not less than 415 kg/m^2.[a]
	e) Cavity lightweight aggregate block (maximum density of block 1 600 kg/m^3) with 75 mm cavity and wall ties of the butterfly wire type. Plaster finish on both sides. Joints in blockwork well filled. Overall mass per unit area not less than 300 kg/m^2.[a]
	f) Dense aggregate concrete block cavity wall with 50 mm cavity and wall ties of the butterfly wire type. Plaster finish on both sides. Joints in blockwork well filled. Overall mass per unit area not less than 415 kg/m^2.[a]

NOTE 1 Construction details and workmanship are important if the levels of sound insulation indicated are to be achieved.

NOTE 2 Where plasterboard is specified it is assumed that the surface mass will be at least 6.5 kg/m^2 for 9.5 mm thick board, at least 8.5 kg/m^2 for 12.5 mm thick board, and at least 14.5 kg/m^2 for 19 mm thick board. If less dense plasterboard is used, the thickness should be increased.

[a] When considering these constructions for separating walls, expert advice should be sought.

Table E.3 — Airborne and impact sound insulation of floor constructions

Sound insulation dB	Type of floor construction
$D_{nT,w}$ = 49 to 54 $L'_{nT,w}$ = 56 to 65	a) A concrete floor having mass per unit area not less than 365 kg/m^2, including any screed or ceiling finish directly bonded to the floor slab; together with a floating floor or resilient floor covering equivalent to rubber or sponge rubber underlay or thick cork tile (e.g. carpet and underlay or sponge rubber backed vinyl flooring).
	b) A solid floor consisting of: — a solid slab; or — concrete beams and infilling blocks; or — hollow concrete planks; together with a floating floor. A ceiling finish is required for a beam and block floor. In each case the slab should have a mass per unit area of at least 300 kg/m^2 including any screed or ceiling finish directly bonded to it. Where a floating floor is laid over a floor of beams and hollow infill blocks or hollow beams along the top of the structural floor should be sealed and levelled before the resilient layer is put down. It is also essential to have due regard for conduits and pipework which should be laid and covered so as to prevent any short circuit of the floor's isolating properties. If precast units are used as a structural floor it is essential that the joints are filled to ensure that the sound insulation performance is maintained. The resilient material is laid to cover completely the structural floor and turned up against the surrounding wall along all edges. The resilient layer is usually of mineral fibre, or a special grade of expanded polystyrene. When the screed is laid, it is important that none of the mix finds its way through the resilient layer to the structural floor, as this will short circuit the isolation between the two decks and significantly reduce the sound insulation.
	c) A floor consisting of boarding nailed to battens laid to float upon an isolating layer of mineral fibre capable of retaining its resilience under imposed loading. With battens running along the joists, a dense fibre layer can be used in strips. The ceiling below to be of metal lath and plaster not less than 29 mm thick, with pugging on the ceiling such that the combined mass per unit area of the floor, ceiling and pugging is not less than 120 kg/m^2. This construction will only give values for $D_{nT,w}$ of 50 to 53 dB, and a value for $L'_{nT,w}$ of 75 dB.
	d) A floor consisting of 18 mm tongued and grooved chipboard on 19 mm plasterboard laid on battens running parallel to the joists and supported on 25 mm thick mineral wool of about 90 kg/m^3 to 140 kg/m^3 density; 100 mm of fibre absorbent (as used for insulation in roof spaces) laid between the joists on top of the plasterboard ceiling.[a]
	e) A floor consisting of 18 mm tongued and grooved chip board on 19 mm plasterboard floating on a 25 mm thick mineral wool layer of about 60 kg/m^3 to 80 kg/m^3 density; this on a 12.5 mm plywood platform; 100 mm of fibre absorbent laid between the joists on top of the plasterboard ceiling.[a]
$D_{nT,w}$ = 32 to 36 $L'_{nT,w}$ = 80 to 85	Timber joist floor consisting of 22 mm tongued and grooved floor boarding or equivalent fixed directly to floor joists. Ceiling of 12.5 mm plasterboard and skim with no floor covering.

NOTE 1 Construction details and workmanship are important if the levels of sound insulation indicated are to be achieved.

NOTE 2 Where plasterboard is specified it is assumed that the surface mass will be at least 8.5 kg/m^2 for 12.5 mm thick board, and at least 14.5 kg/m^2 for 19 mm thick board. If less dense plasterboard is used, the thickness should be increased.

[a] In these types of floor construction, the ceiling can be 19 mm plus 12.5 mm plasterboard. It is imperative that the resilient layer is not punctured by nails.

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APPENDIX F
WORLD HEALTH ORGANISATION (WHO) GUIDELINES FOR COMMUNITY NOISE EXECUTIVE SUMMARRY

Guidelines for Community Noise

Executive Summary

1. Introduction

Community noise (also called environmental noise, residential noise or domestic noise) is defined as noise emitted from all sources except noise at the industrial workplace. Main sources of community noise include road, rail and air traffic; industries; construction and public work; and the neighbourhood. The main indoor noise sources are ventilation systems, office machines, home appliances and neighbours.

In the European Union about 40% of the population is exposed to road traffic noise with an equivalent sound pressure level exceeding 55 dB(A) daytime, and 20% are exposed to levels exceeding 65 dB(A). When all transportation noise is considered, more than half of all European Union citizens is estimated to live in zones that do not ensure acoustical comfort to residents. At night, more than 30% are exposed to equivalent sound pressure levels exceeding 55 dB(A), which are disturbing to sleep. Noise pollution is also severe in cities of developing countries. It is caused mainly by traffic and alongside densely-travelled roads equivalent sound pressure levels for 24 hours can reach 75–80 dB(A).

In contrast to many other environmental problems, noise pollution continues to grow and it is accompanied by an increasing number of complaints from people exposed to the noise. The growth in noise pollution is unsustainable because it involves direct, as well as cumulative, adverse health effects. It also adversely affects future generations, and has socio-cultural, esthetic and economic effects.

2. Noise sources and measurement

Physically, there is no distinction between sound and noise. Sound is a sensory perception and the complex pattern of sound waves is labeled noise, music, speech etc. Noise is thus defined as unwanted sound.

Most environmental noises can be approximately described by several simple measures. All measures consider the frequency content of the sounds, the overall sound pressure levels and the variation of these levels with time. Sound pressure is a basic measure of the vibrations of air that make up sound. Because the range of sound pressures that human listeners can detect is very wide, these levels are measured on a logarithmic scale with units of decibels. Consequently, sound pressure levels cannot be added or averaged arithmetically. Also, the sound levels of most noises vary with time, and when sound pressure levels are calculated, the instantaneous pressure fluctuations must be integrated over some time interval.

Most environmental sounds are made up of a complex mix of many different frequencies. Frequency refers to the number of vibrations per second of the air in which the sound is propagating and it is measured in Hertz (Hz). The audible frequency range is normally considered to be 20–20 000 Hz for younger listeners with unimpaired hearing. However, our hearing systems are not equally sensitive to all sound frequencies, and to compensate for this various types of filters or frequency weighting have been used to determine the relative strengths of frequency components making up a particular environmental noise. The A-weighting is most commonly used and weights lower frequencies as less important than mid- and higher-frequencies. It is intended to approximate the frequency response of our hearing system.

The effect of a combination of noise events is related to the combined sound energy of those events (the equal energy principle). The sum of the total energy over some time period gives a level equivalent to the average sound energy over that period. Thus, LAeq,T is the energy average equivalent level of the A-weighted sound over a period T. LAeq,T should be used to measure continuing sounds, such as road traffic noise or types of more-or-less continuous industrial noises. However, when there are distinct events to the noise, as with aircraft or railway noise, measures of individual events such as the maximum noise level (LAmax), or the weighted sound exposure level (SEL), should also be obtained in addition to LAeq,T. Time-varying environmental sound levels have also been described in terms of percentile levels.

Currently, the recommended practice is to assume that the equal energy principle is approximately valid for most types of noise and that a simple LAeq,T measure will indicate the expected effects of the noise reasonably well. When the noise consists of a small number of discrete events, the A-weighted maximum level (LAmax) is a better indicator of the disturbance to sleep and other activities. In most cases, however, the A-weighted sound exposure level (SEL) provides a more consistent measure of single-noise events because it is based on integration over the complete noise event. In combining day and night LAeq,T values, night-time weightings are often added. Night-time weightings are intended to reflect the expected increased sensitivity to annoyance at night, but they do not protect people from sleep disturbance.

Where there are no clear reasons for using other measures, it is recommended that LAeq,T be used to evaluate more-or-less continuous environmental noises. Where the noise is principally composed of a small number of discrete events, the additional use of LAmax or SEL is recommended. There are definite limitations to these simple measures, but there are also many practical advantages, including economy and the benefits of a standardized approach.

3. Adverse health effects of noise

The health significance of noise pollution is given in chapter 3 of the *Guidelines* under separate headings according to the specific effects: noise-induced hearing impairment; interference with speech communication; disturbance of rest and sleep; psychophysiological, mental-health and performance effects; effects on residential behaviour and annoyance; and interference with intended activities. This chapter also considers vulnerable groups and the combined effects of mixed noise sources.

Hearing impairment is typically defined as an increase in the threshold of hearing. Hearing deficits may be accompanied by tinnitus (ringing in the ears). Noise-induced hearing impairment occurs predominantly in the higher frequency range of 3 000–6 000 Hz, with the largest effect at 4 000 Hz. But with increasing LAeq,8h and increasing exposure time, noise-induced hearing impairment occurs even at frequencies as low as 2 000 Hz. However, hearing impairment is not expected to occur at LAeq,8h levels of 75 dB(A) or below, even for prolonged occupational noise exposure.

Worldwide, noise-induced hearing impairment is the most prevalent irreversible occupational hazard and it is estimated that 120 million people worldwide have disabling hearing difficulties. In developing countries, not only occupational noise but also environmental noise is an increasing risk factor for hearing impairment. Hearing damage can also be caused by certain diseases, some industrial chemicals, ototoxic drugs, blows to the head, accidents and hereditary origins. Hearing deterioration is also associated with the ageing process itself (presbyacusis).

The extent of hearing impairment in populations exposed to occupational noise depends on the value of LAeq,8h, the number of noise-exposed years, and on individual susceptibility. Men and women are equally at risk for noise-induced hearing impairment. It is expected that environmental and leisure-time noise with a LAeq,24h of 70 dB(A) or below will not cause hearing impairment in the large majority of people, even after a lifetime exposure. For adults exposed to impulse noise at the workplace, the noise limit is set at peak sound pressure levels of 140 dB, and the same limit is assumed to be appropriate for environmental and leisure-time noise. In the case of children, however, taking into account their habits while playing with noisy toys, the peak sound pressure should never exceed 120 dB. For shooting noise with LAeq,24h levels greater than 80 dB(A), there may be an increased risk for noise-induced hearing impairment.

The main social consequence of hearing impairment is the inability to understand speech in daily living conditions, and this is considered to be a severe social handicap. Even small values of hearing impairment (10 dB averaged over 2 000 and 4 000 Hz and over both ears) may adversely affect speech comprehension.

Speech intelligibility is adversely affected by noise. Most of the acoustical energy of speech is in the frequency range of 100–6 000 Hz, with the most important cue-bearing energy being between 300–3 000 Hz. Speech interference is basically a masking process, in which simultaneous interfering noise renders speech incapable of being understood. Environmental noise may also mask other acoustical signals that are important for daily life, such as door bells, telephone signals, alarm clocks, fire alarms and other warning signals, and music.

Speech intelligibility in everyday living conditions is influenced by speech level; speech pronunciation; talker-to-listener distance; sound level and other characteristics of the interfering noise; hearing acuity; and by the level of attention. Indoors, speech communication is also affected by the reverberation characteristics of the room. Reverberation times over 1 s produce loss in speech discrimination and make speech perception more difficult and straining. For full sentence intelligibility in listeners with normal hearing, the signal-to-noise ratio (i.e. the difference between the speech level and the sound level of the interfering noise) should be at least 15 dB(A). Since the sound pressure level of normal speech is about 50 dB(A), noise with sound levels of 35 dB(A) or more interferes with the intelligibility of speech in smaller rooms. For vulnerable groups even lower background levels are needed, and a reverberation time below 0.6 s is desirable for adequate speech intelligibility, even in a quiet environment.

The inability to understand speech results in a large number of personal handicaps and behavioural changes. Particularly vulnerable are the hearing impaired, the elderly, children in the process of language and reading acquisition, and individuals who are not familiar with the spoken language.

Sleep disturbance is a major effect of environmental noise. It may cause primary effects during sleep, and secondary effects that can be assessed the day after night-time noise exposure. Uninterrupted sleep is a prerequisite for good physiological and mental functioning, and the primary effects of sleep disturbance are: difficulty in falling asleep; awakenings and alterations of sleep stages or depth; increased blood pressure, heart rate and finger pulse amplitude; vasoconstriction; changes in respiration; cardiac arrhythmia; and increased body movements. The difference between the sound levels of a noise event and background sound levels, rather than the absolute noise level, may determine the reaction probability. The probability of being awakened increases with the number of noise events per night. The secondary, or after-effects, the following morning or day(s) are: reduced perceived sleep quality; increased fatigue; depressed mood or well-being; and decreased performance.

For a good night's sleep, the equivalent sound level should not exceed 30 dB (A) for continuous background noise, and individual noise events exceeding 45 dB(A) should be avoided. In setting limits for single night-time noise exposures, the intermittent character of the noise has to be taken into account. This can be achieved, for example, by measuring the number of noise events, as well as the difference between the maximum sound level and the background sound level. Special attention should also be given to: noise sources in an environment with low background sound levels; combinations of noise and vibrations; and to noise sources with low-frequency components.

Physiological Functions. In workers exposed to noise, and in people living near airports, industries and noisy streets, noise exposure may have a large temporary, as well as permanent, impact on physiological functions. After prolonged exposure, susceptible individuals in the general population may develop permanent effects, such as hypertension and ischaemic heart disease associated with exposure to high sound levels. The magnitude and duration of the effects are determined in part by individual characteristics, lifestyle behaviours and environmental conditions. Sounds also evoke reflex responses, particularly when they are unfamiliar and have a sudden onset.

Workers exposed to high levels of industrial noise for 5–30 years may show increased blood pressure and an increased risk for hypertension. Cardiovascular effects have also been demonstrated after long-term exposure to air- and road-traffic with LAeq,24h values of 65–70 dB(A). Although the associations are weak, the effect is somewhat stronger for ischaemic heart disease than for hypertension. Still, these small risk increments are important because a large number of people are exposed.

Mental Illness. Environmental noise is not believed to cause mental illness directly, but it is assumed that it can accelerate and intensify the development of latent mental disorders. Exposure to high levels of occupational noise has been associated with development of neurosis, but the findings on environmental noise and mental-health effects are inconclusive. Nevertheless, studies on the use of drugs such as tranquillizers and sleeping pills, on psychiatric symptoms and on mental hospital admission rates, suggest that community noise may have adverse effects on mental health.

Performance. It has been shown, mainly in workers and children, that noise can adversely affect performance of cognitive tasks. Although noise-induced arousal may produce better performance in simple tasks in the short term, cognitive performance substantially deteriorates for more complex tasks. Reading, attention, problem solving and memorization are among the cognitive effects most strongly affected by noise. Noise can also act as a distracting stimulus and impulsive noise events may produce disruptive effects as a result of startle responses.

Noise exposure may also produce after-effects that negatively affect performance. In schools around airports, children chronically exposed to aircraft noise under-perform in proof reading, in persistence on challenging puzzles, in tests of reading acquisition and in motivational capabilities. It is crucial to recognize that some of the adaptation strategies to aircraft noise, and the effort necessary to maintain task performance, come at a price. Children from noisier areas have heightened sympathetic arousal, as indicated by increased stress hormone levels, and elevated resting blood pressure. Noise may also produce impairments and increase in errors at work, and some accidents may be an indicator of performance deficits.

Social and Behavioural Effects of Noise; Annoyance. Noise can produce a number of social and behavioural effects as well as annoyance. These effects are often complex, subtle and indirect and many effects are assumed to result from the interaction of a number of non-auditory variables. The effect of community noise on annoyance can be evaluated by questionnaires or by assessing the disturbance of specific activities. However, it should be recognized that equal levels of different traffic and industrial noises cause different magnitudes of annoyance. This is because annoyance in populations varies not only with the characteristics of the noise, including the noise source, but also depends to a large degree on many non-acoustical factors of a social, psychological, or economic nature. The correlation between noise exposure and general annoyance is much higher at group level than at individual level. Noise above 80 dB(A) may also reduce helping behaviour and increase aggressive behaviour. There is particular concern that high-level continuous noise exposures may increase the susceptibility of schoolchildren to feelings of helplessness.

Stronger reactions have been observed when noise is accompanied by vibrations and contains low-frequency components, or when the noise contains impulses, such as with shooting noise. Temporary, stronger reactions occur when the noise exposure increases over time, compared to a constant noise exposure. In most cases, LAeq,24h and L_{dn} are acceptable approximations of noise exposure related to annoyance. However, there is growing concern that all the component parameters should be individually assessed in noise exposure investigations, at least in the complex cases. There is no consensus on a model for total annoyance due to a combination of environmental noise sources.

Combined Effects on Health of Noise from Mixed Sources. Many acoustical environments consist of sounds from more than one source, i.e. there are mixed sources, and some combinations of effects are common. For example, noise may interfere with speech in the day and create sleep disturbance at night. These conditions certainly apply to residential areas heavily polluted with noise. Therefore, it is important that the total adverse health load of noise be considered over 24 hours, and that the precautionary principle for sustainable development be applied.

Vulnerable Subgroups. Vulnerable subgroups of the general population should be considered when recommending noise protection or noise regulations. The types of noise effects, specific environments and specific lifestyles are all factors that should be addressed for these subgroups. Examples of vulnerable subgroups are: people with particular diseases or medical problems (e.g. high blood pressure); people in hospitals or rehabilitating at home; people dealing with complex cognitive tasks; the blind; people with hearing impairment; fetuses, babies and young children; and the elderly in general. People with impaired hearing are the most adversely affected with respect to speech intelligibility. Even slight hearing impairments in the high-frequency sound range may cause problems with speech perception in a noisy environment. A majority of the population belongs to the subgroup that is vulnerable to speech interference.

4. Guideline values

In chapter 4, guideline values are given for specific health effects of noise and for specific environments.

Specific health effects.

Interference with Speech Perception. A majority of the population is susceptible to speech interference by noise and belongs to a vulnerable subgroup. Most sensitive are the elderly and persons with impaired hearing. Even slight hearing impairments in the high-frequency range may cause problems with speech perception in a noisy environment. From about 40 years of age, the ability of people to interpret difficult, spoken messages with low linguistic redundancy is impaired compared to people 20–30 years old. It has also been shown that high noise levels and long reverberation times have more adverse effects in children, who have not completed language acquisition, than in young adults.

When listening to complicated messages (at school, foreign languages, telephone conversation) the signal-to-noise ratio should be at least 15 dB with a voice level of 50 dB(A). This sound level corresponds on average to a casual voice level in both women and men at 1 m distance. Consequently, for clear speech perception the background noise level should not exceed 35 dB (A). In classrooms or conference rooms, where speech perception is of paramount importance, or for sensitive groups, background noise levels should be as low as possible. Reverberation times below 1 s are also necessary for good speech intelligibility in smaller rooms. For sensitive groups, such as the elderly, a reverberation time below 0.6 s is desirable for adequate speech intelligibility even in a quiet environment.

Hearing Impairment. Noise that gives rise to hearing impairment is by no means restricted to occupational situations. High noise levels can also occur in open air concerts, discotheques, motor sports, shooting ranges, in dwellings from loudspeakers, or from leisure activities. Other important sources of loud noise are headphones, as well as toys and fireworks which can emit impulse noise. The ISO standard 1999 gives a method for estimating noise-induced hearing impairment in populations exposed to all types of noise (continuous, intermittent, impulse) during working hours. However, the evidence strongly suggests that this method should also be used to calculate hearing impairment due to noise exposure from environmental and leisure time activities. The ISO standard 1999 implies that long-term exposure to LAeq,24h noise levels of up to 70 dB(A) will not result in hearing impairment. To avoid hearing loss from impulse noise exposure, peak sound pressures should never exceed 140 dB for adults, and 120 dB for children.

Sleep Disturbance. Measurable effects of noise on sleep begin at LAeq levels of about 30 dB. However, the more intense the background noise, the more disturbing is its effect on sleep. Sensitive groups mainly include the elderly, shift workers, people with physical or mental disorders and other individuals who have difficulty sleeping.

Sleep disturbance from intermittent noise events increases with the maximum noise level. Even if the total equivalent noise level is fairly low, a small number of noise events with a high maximum sound pressure level will affect sleep. Therefore, to avoid sleep disturbance, guidelines for community noise should be expressed in terms of the equivalent sound level of the noise, as well as in terms of maximum noise levels and the number of noise events. It should be noted that low-frequency noise, for example, from ventilation systems, can disturb rest and sleep even at low sound pressure levels.

When noise is continuous, the equivalent sound pressure level should not exceed 30 dB(A) indoors, if negative effects on sleep are to be avoided. For noise with a large proportion of low-frequency sound a still lower guideline value is recommended. When the background noise is low, noise exceeding 45 dB LAmax should be limited, if possible, and for sensitive persons an even lower limit is preferred. Noise mitigation targeted to the first part of the night is believed to be an effective means for helping people fall asleep. It should be noted that the adverse effect of noise partly depends on the nature of the source. A special situation is for newborns in incubators, for which the noise can cause sleep disturbance and other health effects.

Reading Acquisition. Chronic exposure to noise during early childhood appears to impair reading acquisition and reduces motivational capabilities. Evidence indicates that the longer the exposure, the greater the damage. Of recent concern are the concomitant psychophysiological changes (blood pressure and stress hormone levels). There is insufficient information on these effects to set specific guideline values. It is clear, however, that daycare centres and schools should not be located near major noise sources, such as highways, airports, and industrial sites.

Annoyance. The capacity of a noise to induce annoyance depends upon its physical characteristics, including the sound pressure level, spectral characteristics and variations of these properties with time. During daytime, few people are highly annoyed at LAeq levels below 55 dB(A), and few are moderately annoyed at LAeq levels below 50 dB(A). Sound levels during the evening and night should be 5–10 dB lower than during the day. Noise with low-frequency components require lower guideline values. For intermittent noise, it is emphasized that it is necessary to take into account both the maximum sound pressure level and the number of noise events. Guidelines or noise abatement measures should also take into account residential outdoor activities.

Social Behaviour. The effects of environmental noise may be evaluated by assessing its interference with social behavior and other activities. For many community noises, interference with rest/recreation/watching television seem to be the most important effects. There is fairly consistent evidence that noise above 80 dB(A) causes reduced helping behavior, and that loud noise also increases aggressive behavior in individuals predisposed to aggressiveness. In schoolchildren, there is also concern that high levels of chronic noise contribute to feelings of helplessness. Guidelines on this issue, together with cardiovascular and mental effects, must await further research.

Specific environments.

A noise measure based only on energy summation and expressed as the conventional equivalent measure, LAeq, is not enough to characterize most noise environments. It is equally important to measure the maximum values of noise fluctuations, preferably combined with a measure of the number of noise events. If the noise includes a large proportion of low-frequency components, still lower values than the guideline values below will be needed. When prominent low-frequency components are present, noise measures based on A-weighting are inappropriate. The difference between dB (C) and dB(A) will give crude information about the presence of low-frequency components in noise, but if the difference is more than 10 dB, it is recommended that a frequency analysis of the noise be performed. It should be noted that a large proportion of low-frequency components in noise may increase considerably the adverse effects on health.

In Dwellings. The effects of noise in dwellings, typically, are sleep disturbance, annoyance and speech interference. For bedrooms the critical effect is sleep disturbance. Indoor guideline values for bedrooms are 30 dB LAeq for continuous noise and 45 dB LAmax for single sound events. Lower noise levels may be disturbing depending on the nature of the noise source. At night-time, outside sound levels about 1 metre from facades of living spaces should not exceed 45 dB LAeq, so that people may sleep with bedroom windows open. This value was obtained by assuming that the noise reduction from outside to inside with the window open is 15 dB. To enable casual conversation indoors during daytime, the sound level of interfering noise should not exceed 35 dB LAeq. The maximum sound pressure level should be measured with the sound pressure meter set at "Fast".

To protect the majority of people from being seriously annoyed during the daytime, the outdoor sound level from steady, continuous noise should not exceed 55 dB LAeq on balconies, terraces and in outdoor living areas. To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound level should not exceed 50 dB LAeq. Where it is practical and feasible, the lower outdoor sound level should be considered the maximum desirable sound level for new development.

In Schools and Preschools. For schools, the critical effects of noise are speech interference, disturbance of information extraction (e.g. comprehension and reading acquisition), message communication and annoyance. To be able to hear and understand spoken messages in class rooms, the background sound level should not exceed 35 dB LAeq during teaching sessions. For hearing impaired children, a still lower sound level may be needed. The reverberation time in the classroom should be about 0.6 s, and preferably lower for hearing impaired children. For assembly halls and cafeterias in school buildings, the reverberation time should be less than 1 s. For outdoor playgrounds the sound level of the noise from external sources should not exceed 55 dB LAeq, the same value given for outdoor residential areas in daytime.

For preschools, the same critical effects and guideline values apply as for schools. In bedrooms in preschools during sleeping hours, the guideline values for bedrooms in dwellings should be used.

In Hospitals. For most spaces in hospitals, the critical effects are sleep disturbance, annoyance, and communication interference, including warning signals. The LAmax of sound events during the night should not exceed 40 dB(A) indoors. For ward rooms in hospitals, the guideline values indoors are 30dB LAeq, together with 40 dB LAmax during night. During the day and evening the guideline value indoors is 30 dB LAeq. The maximum level should be measured with the sound pressure instrument set at "Fast".

Since patients have less ability to cope with stress, the LAeq level should not exceed 35 dB in most rooms in which patients are being treated or observed. Attention should be given to the sound levels in intensive care units and operating theaters. Sound inside incubators may result in health problems for neonates, including sleep disturbance, and may also lead to hearing impairment. Guideline values for sound levels in incubators must await future research.

Ceremonies, Festivals and Entertainment Events. In many countries, there are regular ceremonies, festivals and entertainment events to celebrate life periods. Such events typically produce loud sounds, including music and impulsive sounds. There is widespread concern about the effect of loud music and impulsive sounds on young people who frequently attend concerts, discotheques, video arcades, cinemas, amusement parks and spectator events. At these events, the sound level typically exceeds 100 dB LAeq. Such noise exposure could lead to significant hearing impairment after frequent attendances.

Noise exposure for employees of these venues should be controlled by established occupational standards; and at the very least, the same standards should apply to the patrons of these premises. Patrons should not be exposed to sound levels greater than 100 dB LAeq during a four-hour period more than four times per year. To avoid acute hearing impairment the LAmax should always be below 110 dB.

Headphones. To avoid hearing impairment from music played back in headphones, in both adults and children, the equivalent sound level over 24 hours should not exceed 70 dB(A). This implies that for a daily one hour exposure the LAeq level should not exceed 85 dB(A). To avoid acute hearing impairment LAmax should always be below 110 dB(A). The exposures are expressed in free-field equivalent sound level.

Toys, Fireworks and Firearms. To avoid acute mechanical damage to the inner ear from impulsive sounds from toys, fireworks and firearms, adults should never be exposed to more than 140 dB(lin) peak sound pressure level. To account for the vulnerability in children when playing, the peak sound pressure produced by toys should not exceed 120 dB(lin), measured close to the ears (100 mm). To avoid acute hearing impairment LAmax should always be below 110 dB(A).

Parkland and Conservation Areas. Existing large quiet outdoor areas should be preserved and the signal-to-noise ratio kept low.

Table 1 presents the WHO guideline values arranged according to specific environments and critical health effects. The guideline values consider all identified adverse health effects for the specific environment. An adverse effect of noise refers to any temporary or long-term impairment of physical, psychological or social functioning that is associated with noise exposure. Specific noise limits have been set for each health effect, using the lowest noise level that produces an adverse health effect (i.e. the critical health effect). Although the guideline values refer to sound levels impacting the most exposed receiver at the listed environments, they are applicable to the general population. The time base for LAeq for "daytime" and "night-time" is 12–16 hours and 8 hours, respectively. No time base is given for evenings, but typically the guideline value should be 5–10 dB lower than in the daytime. Other time bases are recommended for schools, preschools and playgrounds, depending on activity.

It is not enough to characterize the noise environment in terms of noise measures or indices based only on energy summation (e.g., LAeq), because different critical health effects require different descriptions. It is equally important to display the maximum values of the noise fluctuations, preferably combined with a measure of the number of noise events. A separate characterization of night-time noise exposures is also necessary. For indoor environments, reverberation time is also an important factor for things such as speech intelligibility. If the noise includes a large proportion of low-frequency components, still lower guideline values should be applied. Supplementary to the guideline values given in Table 1, precautions should be taken for vulnerable groups and for noise of certain character (e.g. low-frequency components, low background noise).

Table 1: Guideline values for community noise in specific environments.

Specific environment	Critical health effect(s)	L_{Aeq} [dB(A)]	Time base [hours]	L_{Amax} fast [dB]
Outdoor living area	Serious annoyance, daytime and evening	55	16	-
	Moderate annoyance, daytime and evening	50	16	-
Dwelling, indoors	Speech intelligibility & moderate annoyance;	35	16	

Inside bedrooms	daytime & evening Sleep disturbance, night-time	30	8	45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School class rooms & pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication	35	during class	-
Pre-school bedrooms, indoor	Sleep disturbance	30	sleeping-time	45
School, playground outdoor	Annoyance (external source)	55	during play	-
Hospital, ward rooms, indoors	Sleep disturbance, night-time Sleep disturbance, daytime and evenings	30 30	8 16	40 -
Hospitals, treatment rooms, indoors	Interference with rest and recovery	#1		
Industrial, commercial shopping and traffic areas, indoors and outdoors	Hearing impairment	70	24	110
Ceremonies, festivals and entertainment events	Hearing impairment (patrons:<5 times/year)	100	4	110
Public addresses, indoors and outdoors	Hearing impairment	85	1	110
Music and other sounds through headphones/ earphones	Hearing impairment (free-field value)	85 #4	1	110
Impulse sounds from toys, fireworks and firearms	Hearing impairment (adults) Hearing impairment (children)	- -	- -	140 #2 120 #2
Outdoors in parkland and conservations areas	Disruption of tranquillity	#3		

#1: As low as possible.
#2: Peak sound pressure (not LAF, max) measured 100 mm from the ear.
#3: Existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background sound should be kept low.
#4: Under headphones, adapted to free-field values.

5. Noise Management

Chapter 5 is devoted to noise management with discussions on: strategies and priorities in managing indoor noise levels; noise policies and legislation; the impact of environmental noise; and on the enforcement of regulatory standards.

The fundamental goals of noise management are to develop criteria for deriving safe noise exposure levels and to promote noise assessment and control as part of environmental health programmes. These basic goals should guide both international and national policies for noise management. The United Nation's Agenda 21 supports a number of environmental management principles on which government policies, including noise management policies, can be based: the principle of precaution; the "polluter pays" principle; and noise prevention. In all cases, noise should be reduced to the lowest level achievable in the particular situation. When there is a reasonable possibility that the public health will be endangered, even though scientific proof may be lacking, action should be taken to protect the public health, without awaiting the full scientific proof. The full costs associated with noise pollution (including monitoring, management, lowering levels and supervision) should be met by those responsible for the source of noise. Action should be taken where possible to reduce noise at the source.

A legal framework is needed to provide a context for noise management. National noise standards can usually be based on a consideration of international guidelines, such as these *Guidelines for Community Noise*, as well as national criteria documents, which consider dose-response relationships for the effects of noise on human health. National standards take into account the technological, social, economic and political factors within the country. A staged program of noise abatement should also be implemented to achieve the optimum health protection levels over the long term.

Other components of a noise management plan include: noise level monitoring; noise exposure mapping; exposure modeling; noise control approaches (such as mitigation and precautionary measures); and evaluation of control options. Many of the problems associated with high noise levels can be prevented at low cost, if governments develop and implement an integrated strategy for the indoor environment, in concert with all social and economic partners. Governments should establish a "National Plan for a Sustainable Noise Indoor Environment" that applies both to new construction as well as to existing buildings.

The actual priorities in rational noise management will differ for each country. Priority setting in noise management refers to prioritizing the health risks to be avoided and concentrating on the most important sources of noise. Different countries have adopted a range of approaches to noise control, using different policies and regulations. A number of these are outlined in chapter 5 and Appendix 2, as examples. It is evident that noise emission standards have proven insufficient and that the trends in noise pollution are unsustainable.

The concept of environmental an environmental noise impact analysis is central to the philosophy of managing environmental noise. Such an analysis should be required before implementing any project that would significantly increase the level of environmental noise in a community (typically, greater than a 5 dB increase). The analysis should include: a baseline description of the existing noise environment; the expected level of noise from the new source; an assessment of the adverse health effects; an estimation of the population at risk; the calculation of exposure-response relationships; an assessment of risks and their acceptability; and a cost-benefit analysis.

Noise management should:

a. Start monitoring human exposures to noise.
b. Have health control require mitigation of noise immissions, and not just of noise source emissions. The following should be taken into consideration:

- specific environments such as schools, playgrounds, homes, hospitals.

- environments with multiple noise sources, or which may amplify the effects of noise.

- sensitive time periods such as evenings, nights and holidays.

- groups at high risk, such as children and the hearing impaired.

c. Consider the noise consequences when planning transport systems and land use.
d. Introduce surveillance systems for noise-related adverse health effects.
e. Assess the effectiveness of noise policies in reducing adverse health effects and exposure, and in improving supportive "soundscapes".
f. Adopt these *Guidelines for Community Noise* as intermediary targets for improving human health.
g. Adopt precautionary actions for a sustainable development of the acoustical environments.

Conclusions and recommendations

In chapter 6 are discussed: the implementation of the guidelines; further WHO work on noise; and research needs are recommended.

Implementation. For implementation of the guidelines it is recommended that:

- Governments should protection the population from community noise and consider it an integral part of their policy of environmental protection.
- Governments should consider implementing action plans with short-term, medium-term and long-term objectives for reducing noise levels.
- Governments should adopt the *Health Guidelines for Community Noise* values as targets to be achieved in the long-term.
- Governments should include noise as an important public health issue in environmental impact assessments.
- Legislation should be put in place to allow for the reduction of sound levels.
- Existing legislation should be enforced.
- Municipalities should develop low noise implementation plans.
- Cost-effectiveness and cost-benefit analyses should be considered potential instruments for meaningful management decisions.
- Governments should support more policy-relevant research.

Future Work. The Expert Task Force worked out several suggestions for future work for the WHO in the field of community noise. WHO should:

- Provide leadership and technical direction in defining future noise research priorities.
- Organize workshops on how to apply the guidelines.
- Provide leadership and coordinate international efforts to develop techniques for designing supportive sound environments (e.g. "soundscapes").
- Provide leadership for programs to assess the effectiveness of health-related noise policies and regulations.

- Provide leadership and technical direction for the development of sound methodologies for environmental and health impact plans.
- Encourage further investigation into using noise exposure as an indicator of environmental deterioration (e.g. black spots in cities).
- Provide leadership and technical support, and advise developing countries to facilitate development of noise policies and noise management.

Research and Development. A major step forward in raising the awareness of both the public and of decision makers is the recommendation to concentrate more research and development on variables which have monetary consequences. This means that research should consider not only dose-response relationships between sound levels, but also politically relevant variables, such as noise-induced social handicap; reduced productivity; decreased performance in learning; workplace and school absenteeism; increased drug use; and accidents.

In Appendices 1–6 are given: bibliographic references; examples of regional noise situations (African Region, American Region, Eastern Mediterranean Region, South East Asian Region, Western Pacific Region); a glossary; a list of acronyms; and a list of participants.

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APPENDIX G
ISO 9613 pt2 – GENERAL METHOD OF CALCULATION

INTERNATIONAL STANDARD

ISO 9613-2

First edition
1996-12-15

Acoustics — Attenuation of sound during propagation outdoors —

Part 2:
General method of calculation

Acoustique — Atténuation du son lors de sa propagation à l'air libre —

Partie 2: Méthode générale de calcul

Reference number
ISO 9613-2:1996(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 9613-2 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

ISO 9613 consists of the following parts, under the general title *Acoustics — Attenuation of sound during propagation outdoors:*

— *Part 1: Calculation of the absorption of sound by the atmosphere*

— *Part 2: General method of calculation*

Part 1 is a detailed treatment restricted to the attenuation by atmospheric absorption processes. Part 2 is a more approximate and empirical treatment of a wider subject — the attenuation by all physical mechanisms.

Annexes A and B of this part of ISO 9613 are for information only.

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Introduction

The ISO 1996 series of standards specifies methods for the description of noise outdoors in community environments. Other standards, on the other hand, specify methods for determining the sound power levels emitted by various noise sources, such as machinery and specified equipment (ISO 3740 series), or industrial plants (ISO 8297). This part of ISO 9613 is intended to bridge the gap between these two types of standard, to enable noise levels in the community to be predicted from sources of known sound emission. The method described in this part of ISO 9613 is general in the sense that it may be applied to a wide variety of noise sources, and covers most of the major mechanisms of attenuation. There are, however, constraints on its use, which arise principally from the description of environmental noise in the ISO 1996 series of standards.

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Acoustics — Attenuation of sound during propagation outdoors —

Part 2:
General method of calculation

1 Scope

This part of ISO 9613 specifies an engineering 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 parts 1 to 3 of ISO 1996) under meteorological conditions favourable to propagation from sources of known sound emission.

These conditions are for downwind propagation, as specified in 5.4.3.3 of ISO 1996-2:1987 or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night. Inversion conditions over water surfaces are not covered and may result in higher sound pressure levels than predicted from this part of ISO 9613.

The method also predicts a long-term average A-weighted sound pressure level as specified in ISO 1996-1 and ISO 1996-2. The long-term average A-weighted sound pressure level encompasses levels for a wide variety of meteorological conditions.

The method specified in this part of ISO 9613 consists specifically of octave-band algorithms (with nominal midband frequencies from 63 Hz to 8 kHz) for calculating the attenuation of sound which originates from a point sound source, or an assembly of point sources. The source (or sources) may be moving or stationary. Specific terms are provided in the algorithms for the following physical effects:

- geometrical divergence;
- atmospheric absorption;
- ground effect;
- reflection from surfaces;
- screening by obstacles.

Additional information concerning propagation through housing, foliage and industrial sites is given in annex A.

This method is applicable in practice to a great variety of noise sources and environments. It is applicable, directly or indirectly, to most situations concerning road or rail traffic, industrial noise sources, construction activities, and many other ground-based noise sources. It does not apply to sound from aircraft in flight, or to blast waves from mining, military or similar operations.

To apply the method of this part of ISO 9613, several parameters need to be known with respect to the geometry of the source and of the environment, the ground surface characteristics, and the source strength in terms of octave-band sound power levels for directions relevant to the propagation.

NOTE 1 If only A-weighted sound power levels of the sources are known, the attenuation terms for 500 Hz may be used to estimate the resulting attenuation.

The accuracy of the method and the limitations to its use in practice are described in clause 9.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 9613. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 9613 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1996-1:1982, *Acoustics — Description and measurement of environmental noise — Part 1: Basic quantities and procedures.*

ISO 1996-2:1987, *Acoustics — Description and measurement of environmental noise — Part 2: Acquisition of data pertinent to land use.*

ISO 1996-3:1987, *Acoustics — Description and measurement of environmental noise — Part 3: Application to noise limits.*

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

IEC 651:1979, *Sound level meters,* and Amendment 1:1993.

3 Definitions

For the purposes of this part of ISO 9613, the definitions given in ISO 1996-1 and the following definitions apply. (See table 1 for symbols and units.)

3.1 equivalent continuous A-weighted sound pressure level, L_{AT}: Sound pressure level, in decibels, defined by equation (1):

$$L_{AT} = 10 \lg \left\{ \left[(1/T) \int_0^T p_A^2(t)\, dt \right] \Big/ p_0^2 \right\} \text{ dB} \qquad \dots (1)$$

where

$p_A(t)$ is the instantaneous A-weighted sound pressure, in pascals;

p_0 is the reference sound pressure ($= 20 \times 10^{-6}$ Pa);

T is a specified time interval, in seconds.

The A-frequency weighting is that specified for sound level meters in IEC 651.

NOTE 2 The time interval T should be long enough to average the effects of varying meteorological parameters. Two different situations are considered in this part of ISO 9613, namely short-term downwind and long-term overall averages.

Table 1 — Symbols and units

Symbol	Definition	Unit
A	octave-band attenuation	dB
C_{met}	meteorological correction	dB
d	distance from point source to receiver (see figure 3)	m
d_p	distance from point source to receiver projected onto the ground plane (see figure 1)	m
$d_{s,o}$	distance between source and point of reflection on the reflecting obstacle (see figure 8)	m
$d_{o,r}$	distance between point of reflection on the reflecting obstacle and receiver (see figure 8)	m
d_{ss}	distance from source to (first) diffraction edge (see figures 6 and 7)	m
d_{sr}	distance from (second) diffraction edge to receiver (see figures 6 and 7)	m
D_I	directivity index of the point sound source	—
D_z	screening attenuation	—
e	distance between the first and second diffraction edge (see figure 7)	m
G	ground factor	—
h	mean height of source and receiver	m
h_s	height of point source above ground (see figure 1)	m
h_r	height of receiver above ground (see figure 1)	m
h_m	mean height of the propagation path above the ground (see figure 3)	m
H_{max}	largest dimension of the sources	m
l_{min}	minimum dimension (length or height) of the reflecting plane (see figure 8)	m
L	sound pressure level	dB
α	atmospheric attenuation coefficient	dB/km
β	angle of incidence	rad
ρ	sound reflection coefficient	—

3.2 equivalent continuous downwind octave-band sound pressure level, L_{fT}(DW): Sound pressure level, in decibels, defined by equation (2):

$$L_{fT}(\mathrm{DW}) = 10 \lg \left\{ \left[(1/T) \int_0^T p_f^2(t)\,\mathrm{d}t \right] \Big/ p_0^2 \right\} \text{ dB} \quad \ldots (2)$$

where $p_f(t)$ is the instantaneous octave-band sound pressure downwind, in pascals, and the subscript f represents a nominal midband frequency of an octave-band filter.

NOTE 3 The electrical characteristics of the octave-band filters should comply at least with the class 2 requirements of IEC 1260.

3.3 insertion loss (of a barrier): Difference, in decibels, between the sound pressure levels at a receiver in a specified position under two conditions:

a) with the barrier removed, and

b) with the barrier present (inserted),

and no other significant changes that affect the propagation of sound.

4 Source description

The equations to be used are for the attenuation of sound from point sources. Extended noise sources, therefore, such as road and rail traffic or an industrial site (which may include several installations or plants, together with traffic moving on the site) shall be represented by a set of sections (cells), each having a certain sound power and directivity. Attenuation calculated for sound from a representative point within a section is used to represent the attenuation of sound from the entire section. A line source may be divided into line sections, an area source into area sections, each represented by a point source at its centre.

However, a group of point sources may be described by an equivalent point sound source situated in the middle of the group, in particular if

a) the sources have approximately the same strength and height above the local ground plane,

b) the same propagation conditions exist from the sources to the point of reception, and

c) the distance d from the single equivalent point source to the receiver exceeds twice the largest dimension H_{max} of the sources ($d > 2H_{max}$).

If the distance d is smaller ($d \leq 2H_{max}$), or if the propagation conditions for the component point sources are different (e.g. due to screening), the total sound source shall be divided into its component point sources.

NOTE 4 In addition to the real sources described above, image sources will be introduced to describe the reflection of sound from walls and ceilings (but not by the ground), as described in 7.5.

5 Meteorological conditions

Downwind propagation conditions for the method specified in this part of ISO 9613 are as specified in 5.4.3.3 of ISO 1996-2:1987, namely

— wind direction within an angle of ± 45° of the direction connecting the centre of the dominant sound source and the centre of the specified receiver region, with the wind blowing from source to receiver, and

— wind speed between approximately 1 m/s and 5 m/s, measured at a height of 3 m to 11 m above the ground.

The equations for calculating the average downwind sound pressure level L_{AT}(DW) in this part of ISO 9613, including the equations for attenuation given in clause 7, are the average for meteorological conditions within these limits. The term average here means the average over a short time interval, as defined in 3.1.

These equations also hold, equivalently, for average propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs on clear, calm nights.

6 Basic equations

The equivalent continuous downwind octave-band sound pressure level at a receiver location, L_{fT}(DW), shall be calculated for each point source, and its image sources, and for the eight octave bands with nominal midband frequencies from 63 Hz to 8 kHz, from equation (3):

$$L_{fT}(\mathrm{DW}) = L_W + D_c - A \quad \ldots (3)$$

where

L_W is the octave-band sound power level, in decibels, produced by the point sound source relative to a reference sound power of one picowatt (1 pW);

D_c is the directivity correction, in decibels, that describes the extent by which the equivalent continuous sound pressure level from the point sound source deviates in a specified direction from the level of an omnidirectional point sound source producing sound power level L_W; D_c equals the directivity index D_I of the point sound source plus an index D_Ω that accounts for sound propagation into solid angles less than 4π steradians; for an omnidirectional point sound source radiating into free space, D_c = 0 dB;

A is the octave-band attenuation, in decibels, that occurs during propagation from the point sound source to the receiver.

NOTES

5 The letter symbol A (in italic type) signifies attenuation in this part of ISO 9613 except in subscripts, where it designates the A-frequency weighting (in roman type).

6 Sound power levels in equation (3) may be determined from measurements, for example as described in the ISO 3740 series (for machinery) or in ISO 8297 (for industrial plants).

The attenuation term A in equation (3) is given by equation (4):

$$A = A_{\text{div}} + A_{\text{atm}} + A_{\text{gr}} + A_{\text{bar}} + A_{\text{misc}} \qquad \ldots (4)$$

where

A_{div} is the attenuation due to geometrical divergence (see 7.1);

A_{atm} is the attenuation due to atmospheric absorption (see 7.2);

A_{gr} is the attenuation due to the ground effect (see 7.3);

A_{bar} is the attenuation due to a barrier (see 7.4);

A_{misc} is the attenuation due to miscellaneous other effects (see annex A).

General methods for calculating the first four terms in equation (4) are specified in this part of ISO 9613. Information on three contributions to the last term, A_{misc} (the attenuation due to propagation through foliage, industrial sites and areas of houses), is given in annex A.

The equivalent continuous A-weighted downwind sound pressure level shall be obtained by summing the contributing time-mean-square sound pressures calculated according to equations (3) and (4) for each point sound source, for each of their image sources, and for each octave band, as specified by equation (5):

$$L_{AT}(\text{DW}) = 10 \lg \left\{ \sum_{i=1}^{n} \left[\sum_{j=1}^{8} 10^{0,1\left[L_{fT}(ij) + A_f(j)\right]} \right] \right\} \text{ dB} \qquad \ldots (5)$$

where

n is the number of contributions i (sources and paths);

j is an index indicating the eight standard octave-band midband frequencies from 63 Hz to 8 kHz;

A_f denotes the standard A-weighting (see IEC 651).

The long-term average A-weighted sound pressure level L_{AT}(LT) shall be calculated according to

$$L_{AT}(\text{LT}) = L_{AT}(\text{DW}) - C_{\text{met}} \qquad \ldots (6)$$

where C_{met} is the meteorological correction described in clause 8.

The calculation and significance of the various terms in equations (1) to (6) are explained in the following clauses. For a more detailed treatment of the attenuation terms, see the literature references given in annex B.

7 Calculation of the attenuation terms

7.1 Geometrical divergence (A_{div})

The geometrical divergence accounts for spherical spreading in the free field from a point sound source, making the attenuation, in decibels, equal to

$$A_{\text{div}} = \left[20 \lg(d/d_0) + 11\right] \text{ dB} \qquad \ldots (7)$$

where

d is the distance from the source to receiver, in metres;

d_0 is the reference distance (= 1 m).

NOTE 7 The constant in equation (7) relates the sound power level to the sound pressure level at a reference distance d_0 which is 1 m from an omnidirectional point sound source.

7.2 Atmospheric absorption (A_{atm})

The attenuation due to atmospheric absorption A_{atm}, in decibels, during propagation through a distance d, in metres, is given by equation (8):

$$A_{atm} = \alpha d/1\,000 \quad \ldots (8)$$

where α is the atmospheric attenuation coefficient, in decibels per kilometre, for each octave band at the midband frequency (see table 2).

For values of a at atmospheric conditions not covered in table 2, see ISO 9613-1.

NOTES

8 The atmospheric attenuation coefficient depends strongly on the frequency of the sound, the ambient temperature and relative humidity of the air, but only weakly on the ambient pressure.

9 For calculation of environmental noise levels, the atmospheric attenuation coefficient should be based on average values determined by the range of ambient weather which is relevant to the locality.

7.3 Ground effect (A_{gr})

7.3.1 General method of calculation

Ground attenuation, A_{gr}, is mainly the result of sound reflected by the ground surface interfering with the sound propagating directly from source to receiver. The downward-curving propagation path (downwind) ensures that this attenuation is determined primarily by the ground surfaces near the source and near the receiver. This method of calculating the ground effect is applicable only to ground which is approximately flat, either horizontally or with a constant slope. Three distinct regions for ground attenuation are specified (see figure 1):

a) the source region, stretching over a distance from the source towards the receiver of $30h_s$, with a maximum distance of d_p (h_s is the source height, and d_p the distance from source to receiver, as projected on the ground plane);

b) the receiver region, stretching over a distance from the receiver back towards the source of $30h_r$, with a maximum distance of d_p (h_r is the receiver height);

c) a middle region, stretching over the distance between the source and receiver regions. If $d_p < (30h_s + 30h_r)$, the source and receiver regions will overlap, and there is no middle region.

According to this scheme, the ground attenuation does not increase with the size of the middle region, but is mostly dependent on the properties of source and receiver regions.

The acoustical properties of each ground region are taken into account through a ground factor G. Three categories of reflecting surface are specified as follows.

Table 2 — Atmospheric attenuation coefficient α for octave bands of noise

Temperature	Relative humidity	Atmospheric attenuation coefficient α, dB/km							
		Nominal midband frequency, Hz							
°C	%	63	125	250	500	1 000	2 000	4 000	8 000
10	70	0,1	0,4	1,0	1,9	3,7	9,7	32,8	117
20	70	0,1	0,3	1,1	2,8	5,0	9,0	22,9	76,6
30	70	0,1	0,3	1,0	3,1	7,4	12,7	23,1	59,3
15	20	0,3	0,6	1,2	2,7	8,2	28,2	88,8	202
15	50	0,1	0,5	1,2	2,2	4,2	10,8	36,2	129
15	80	0,1	0,3	1,1	2,4	4,1	8,3	23,7	82,8

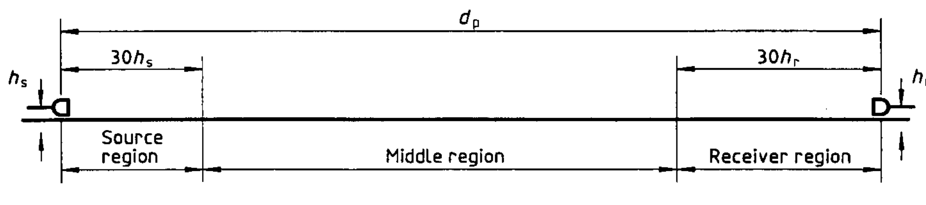


Figure 1 — Three distinct regions for determination of ground attenuation

a) **Hard ground,** which includes paving, water, ice, concrete and all other ground surfaces having a low porosity. Tamped ground, for example, as often occurs around industrial sites, can be considered hard. For hard ground $G = 0$.

NOTE 10 It should be recalled that inversion conditions over water are not covered by this part of ISO 9613.

b) **Porous ground,** which includes ground covered by grass, trees or other vegetation, and all other ground surfaces suitable for the growth of vegetation, such as farming land. For porous ground $G = 1$.

c) **Mixed ground:** if the surface consists of both hard and porous ground, then G takes on values ranging from 0 to 1, the value being the fraction of the region that is porous.

To calculate the ground attenuation for a specific octave band, first calculate the component attenuations A_s for the source region specified by the ground factor G_s (for that region), A_r for the receiver region specified by the ground factor G_r, and A_m for the middle region specified by the ground factor G_m, using the expressions in table 3. (Alternatively, the functions a', b', c' and d' in table 3 may be obtained directly from the curves in figure 2.) The total ground attenuation for that octave band shall be obtained from equation (9):

$$A_{gr} = A_s + A_r + A_m \qquad \ldots (9)$$

NOTE 11 In regions with buildings, the influence of the ground on sound propagation may be changed (see A.3).

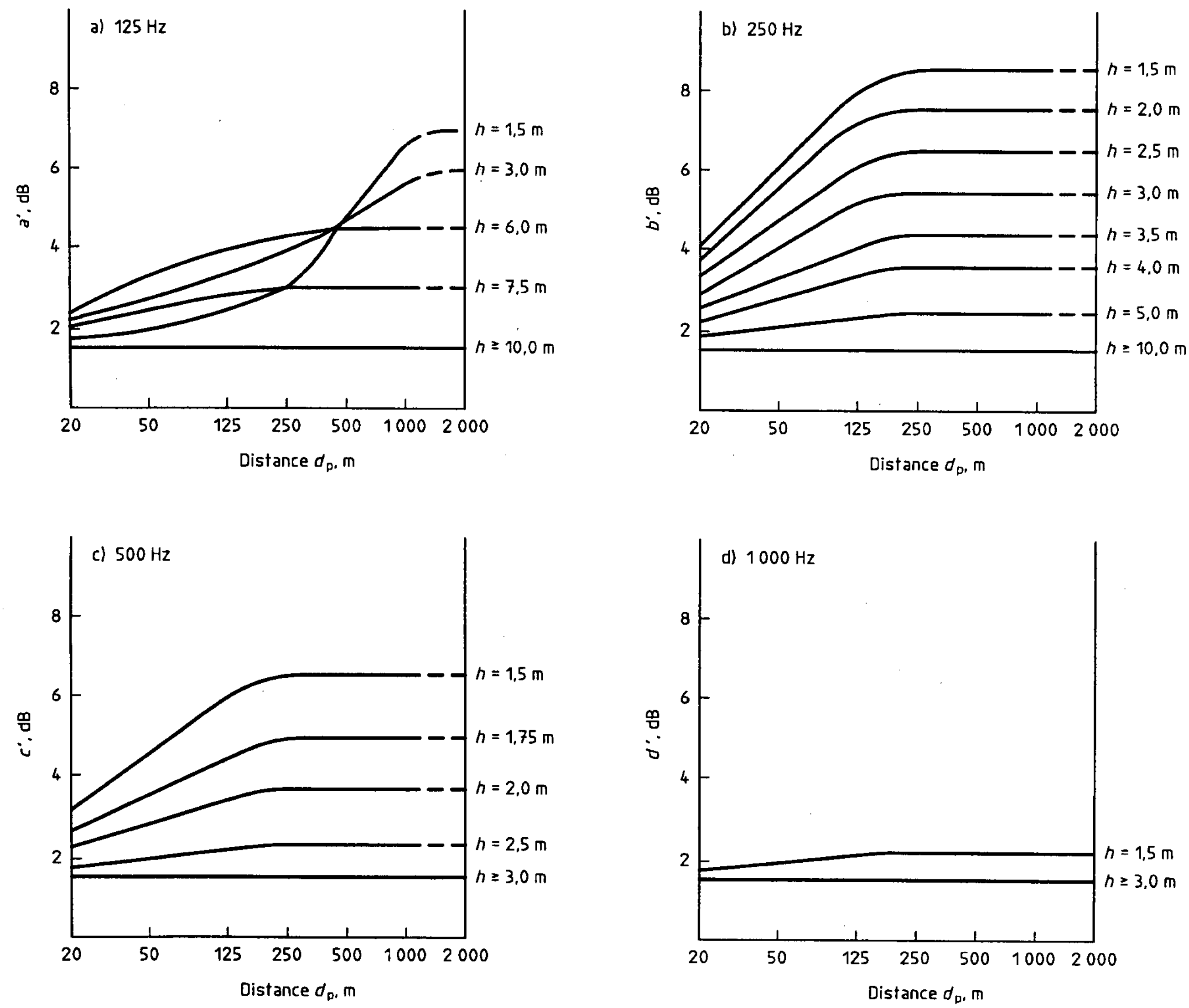


Figure 2 — Functions a', b', c' and d' representing the influence of the source-to-receiver distance d_p and the source or receiver height h, respectively, on the ground attenuation A_{gr} (computed from equations in table 3)

Table 3 — Expressions to be used for calculating ground attenuation contributions A_s, A_r and A_m in octave bands

Nominal midband frequency Hz	A_s or A_r 1) dB	A_m dB
63	$-1{,}5$	$-3q$ 2)
125	$-1{,}5 + G \times a'(h)$	$-3q(1 - G_m)$
250	$-1{,}5 + G \times b'(h)$	
500	$-1{,}5 + G \times c'(h)$	
1 000	$-1{,}5 + G \times d(h)$	
2 000	$-1{,}5(1 - G)$	
4 000	$-1{,}5(1 - G)$	
8 000	$-1{,}5(1 - G)$	

NOTES

$$a'(h) = 1{,}5 + 3{,}0 \times e^{-0{,}12(h-5)^2}\left(1 - e^{-d_p/50}\right) + 5{,}7 \times e^{-0{,}09h^2}\left(1 - e^{-2{,}8 \times 10^{-6} \times d_p^2}\right)$$

$$b'(h) = 1{,}5 + 8{,}6 \times e^{-0{,}09h^2}\left(1 - e^{-d_p/50}\right)$$

$$c'(h) = 1{,}5 + 14{,}0 \times e^{-0{,}46h^2}\left(1 - e^{-d_p/50}\right)$$

$$d'(h) = 1{,}5 + 5{,}0 \times e^{-0{,}9h^2}\left(1 - e^{-d_p/50}\right)$$

1) For calculating A_s, take $G = G_s$ and $h = h_s$. For calculating A_r, take $G = G_r$ and $h = h_r$. See 7.3.1 for values of G for various ground surfaces.

2) $q = 0$ when $d_p \leqslant 30(h_s + h_r)$

$$q = 1 - \frac{30(h_s + h_r)}{d_p} \quad \text{when } d_p > 30(h_s + h_r)$$

where d_p is the source-to-receiver distance, in metres, projected onto the ground planes.

7.3.2 Alternative method of calculation for A-weighted sound pressure levels

Under the following specific conditions

— only the A-weighted sound pressure level at the receiver position is of interest,

— the sound propagation occurs over porous ground or mixed ground most of which is porous (see 7.3.1),

— the sound is not a pure tone,

and for ground surfaces of any shape, the ground attenuation may be calculated from equation (10):

$$A_{gr} = 4{,}8 - (2h_m/d)\left[17 + (300/d)\right] \geqslant 0 \text{ dB} \quad \ldots (10)$$

where

h_m is the mean height of the propagation path above the ground, in metres;

d is the distance from the source to receiver, in metres.

The mean height h_m may be evaluated by the method shown in figure 3. Negative values for A_{gr} from equation (10) shall be replaced by zeros.

NOTE 12 For short distances d, equation (10) predicts no attenuation and equation (9) may be more accurate.

When the ground attenuation is calculated using equation (10), the directivity correction D_c in equation (3) shall include a term D_Ω, in decibels, to account for the apparent increase in sound power level of the source due to reflections from the ground near the source.

$$D_\Omega = 10 \lg\left\{1 + \left[d_p^2 + (h_s - h_r)^2\right] / \left[d_p^2 + (h_s + h_r)^2\right]\right\} \text{ dB} \quad \ldots (11)$$

where

h_s is the height of the source above the ground, in metres;

h_r is the height of the receiver above the ground, in metres;

d_p is the source-to-receiver distance projected onto the ground plane, in metres.

7.4 Screening (A_{bar})

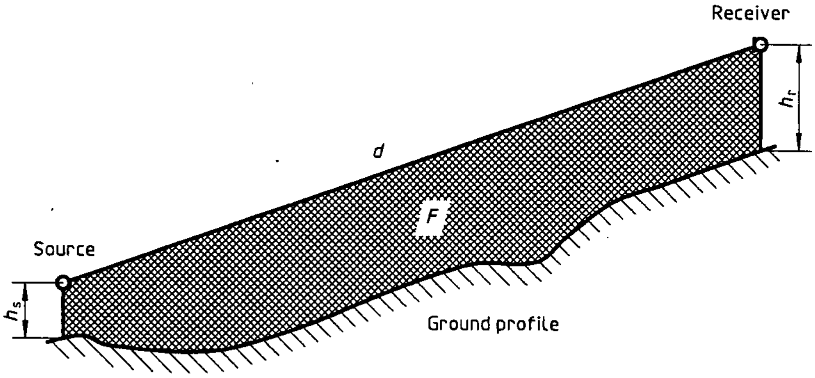
An object shall be taken into account as a screening obstacle (often called a barrier) if it meets the following requirements:

— the surface density is at least 10 kg/m²;

— the object has a closed surface without large cracks or gaps (consequently process installations in chemical plants, for example, are ignored);

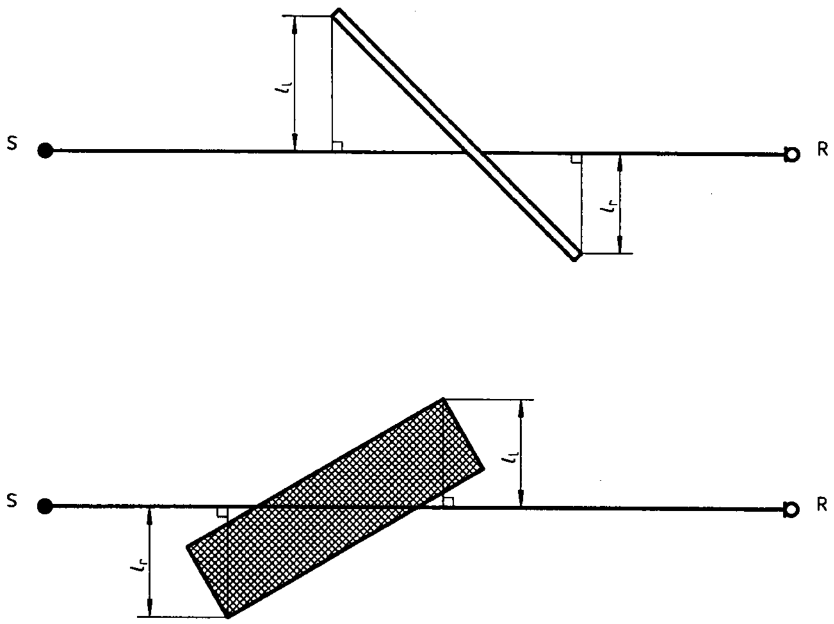
— the horizontal dimension of the object normal to the source-receiver line is larger than the acoustic wavelength λ at the nominal midband frequency for the octave band of interest; in other words $l_l + l_r > \lambda$ (see figure 4).

Each object that fulfils these requirements shall be represented by a barrier with vertical edges. The top edge of the barrier is a straight line that may be sloping.



$h_m = F/d$, where F is the area

Figure 3 — Method for evaluating the mean height h_m



NOTE — An object is only considered to be a screening obstacle when its horizontal dimension perpendicular to the source-receiver line SR is larger than the wavelength: $(l_l + l_r) > \lambda$

Figure 4 — Plan view of two obstacles between the source (S) and the receiver (R)

For the purposes of this part of ISO 9613, the attenuation by a barrier, A_{bar}, shall be given by the insertion loss. Diffraction over the top edge and around a vertical edge of a barrier may both be important. (See figure 5.) For downwind sound propagation, the effect of diffraction (in decibels) over the top edge shall be calculated by

$$A_{bar} = D_z - A_{gr} > 0 \qquad \ldots (12)$$

and for diffraction around a vertical edge by

$$A_{bar} = D_z > 0 \qquad \ldots (13)$$

where

D_z is the barrier attenuation for each octave band [see equation (14)];

A_{gr} is the ground attenuation **in the absence of the barrier** (i.e. with the screening obstacle removed) (see 7.3).

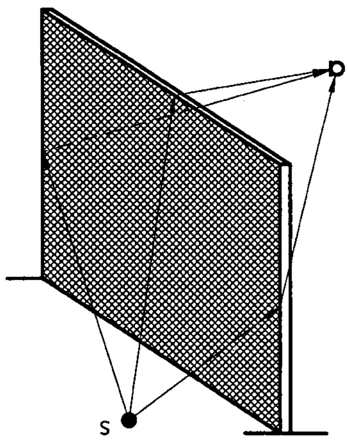


Figure 5 — Different sound propagation paths at a barrier

NOTES

13 When A_{bar} as defined by equation (12) is substituted in equation (4) to find the total attenuation A, the two A_{gr} terms in equation (4) will cancel. The barrier attenuation D_z in equation (12) then includes the effect of the ground in the presence of the barrier.

14 For large distances and high barriers, the insertion loss calculated by equation (12) is not sufficiently confirmed by measurements.

15 In calculation of the insertion loss for multisource industrial plants by high buildings (more than 10 m above the ground), and also for high-noise sources within the plant, equation (13) should be used in both cases for determining the long-term average sound pressure level [using equation (6)].

16 For sound from a depressed highway, there may be attenuation in addition to that indicated by equation (12) along a ground surface outside the depression, due to that ground surface.

To calculate the barrier attenuation D_z, assume that only one significant sound-propagation path exists from the sound source to the receiver. If this assumption is not valid, separate calculations are required for other propagation paths (as illustrated in figure 5) and the contributions from the various paths to the squared sound pressure at the receiver are summed.

The barrier attenuation D_z, in decibels, shall be calculated for this path by equation (14):

$$D_z = 10 \lg \left[3 + (C_2/\lambda) C_3 z K_{met}\right] \text{ dB} \qquad \ldots (14)$$

where

C_2 is equal to 20, and includes the effect of ground reflections; if in special cases ground reflections are taken into account separately by image sources, $C_2 = 40$;

C_3 is equal to 1 for single diffraction (see figure 6);

$$C_3 = \left[1 + (5\lambda/e)^2\right] \Big/ \left[(1/3) + (5\lambda/e)^2\right] \qquad \ldots (15)$$

for double diffraction (see figure 7);

λ is the wavelength of sound at the nominal midband frequency of the octave band, in metres;

z is the difference between the pathlengths of diffracted and direct sound, as calculated by equations (16) and (17), in metres;

K_{met} is the correction factor for meteorological effects, given by equation (18);

e is the distance between the two diffraction edges in the case of double diffraction (see figure 7).

For single diffraction, as shown in figure 6, the pathlength difference z shall be calculated by means of equation (16):

$$z = \left[(d_{ss} + d_{sr})^2 + a^2\right]^{1/2} - d \qquad \ldots (16)$$

where

d_{ss} is the distance from the source to the (first) diffraction edge, in metres;

d_{sr} is the distance from the (second) diffraction edge to the receiver, in metres;

a is the component distance parallel to the barrier edge between source and receiver, in metres.

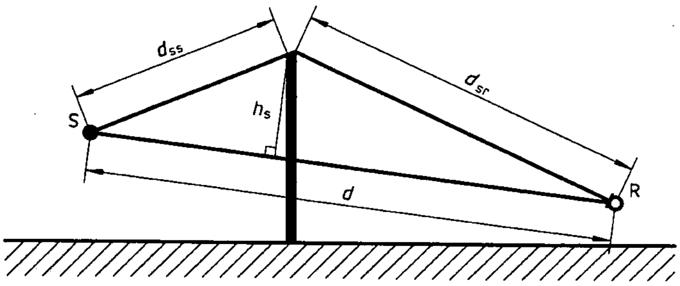


Figure 6 — Geometrical quantities for determining the pathlength difference for single diffraction

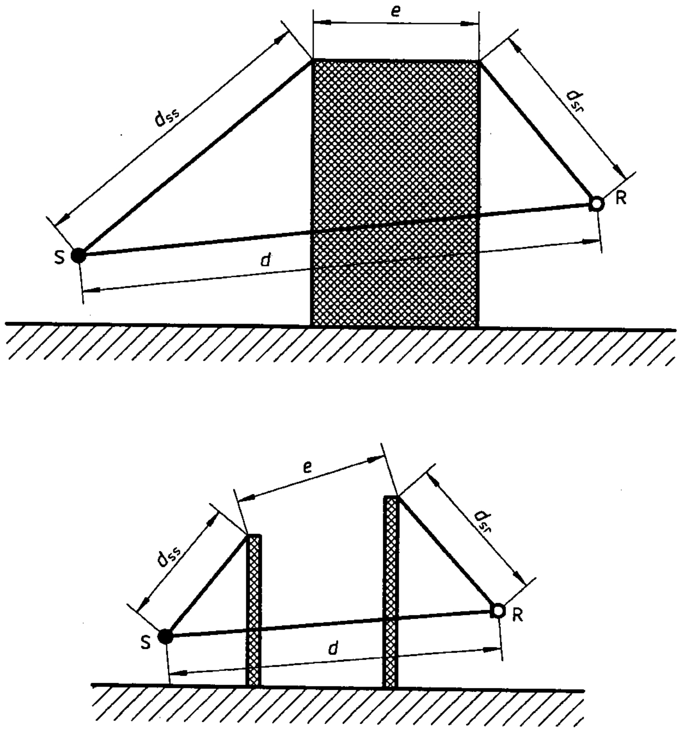


Figure 7 — Geometrical quantities for determining the pathlength difference for double diffraction

If the line of sight between the source S and receiver R passes above the top edge of the barrier, z is given a negative sign.

For double diffraction, as shown in figure 7, the pathlength difference z shall be calculated by

$$z = \left[\left(d_{ss} + d_{sr} + e \right)^2 + a^2 \right]^{1/2} - d \qquad \ldots (17)$$

The correction factor K_{met} for meteorological conditions in equation (14) shall be calculated using equation (18):

$$K_{met} = \exp\left[-(1/2000)\sqrt{d_{ss} d_{sr} d/(2z)} \right] \quad \text{for } z > 0$$

$$K_{met} = 1 \quad \text{for } z \leqslant 0 \qquad \ldots (18)$$

For lateral diffraction around obstacles, it shall be assumed that $K_{met} = 1$ (see figure 5).

NOTES

17 For source-to-receiver distances less than 100 m, the calculation using equation (14) shows that K_{met} may be assumed equal to 1, to an accuracy of 1 dB.

18 Equation (15) provides a continuous transition from the case of single diffraction ($e = 0$) where $C_3 = 1$, to that of a well-separated double diffraction ($e \gg \lambda$) where $C_3 = 3$.

19 A barrier may be less effective than calculated by equations (12) to (18) as a result of reflections from other acoustically hard surfaces near the sound path from the source to the receiver or by multiple reflections between an acoustically hard barrier and the source.

The barrier attenuation D_z, in any octave band, should not be taken to be greater than 20 dB in the case of single diffraction (i.e. thin barriers) and 25 dB in the case of double diffraction (i.e. thick barriers).

The barrier attenuation for two barriers is calculated using equation (14) for double diffraction, as indicated in the lower part of figure 7. The barrier attenuation for more than two barriers may also be calculated approximately using equation (14), by choosing the two most effective barriers, neglecting the effects of the others.

7.5 Reflections

Reflections are considered here in terms of image sources. These reflections are from outdoor ceilings and more or less vertical surfaces, such as the façades of buildings, which can increase the sound pressure levels at the receiver. The effect of reflections from the ground are not included because they enter into the calculation of A_{gr}.

The reflections from an obstacle shall be calculated for all octave bands for which all the following requirements are met:

— a specular reflection can be constructed, as shown in figure 8;

— the magnitude of the sound reflection coefficient for the surface of the obstacle is greater than 0,2;

— the surface is large enough for the nominal midband wavelength λ (in metres) for the octave band under consideration to obey the relationship

$$1/\lambda > \left[2/(l_{min} \cos\beta)^2\right]\left[d_{s,o} d_{o,r}/(d_{s,o} + d_{o,r})\right] \quad \ldots (19)$$

where

λ is the wavelength of sound (in metres) at the nominal midband frequency f (in hertz) of the octave band $\left(\lambda = \frac{340 \text{ m/s}}{f}\right)$;

$d_{s,o}$ is the distance between the source and the point of reflection on the obstacle;

$d_{o,r}$ is the distance between the point of reflection on the obstacle and the receiver;

β is the angle of incidence, in radians (see figure 8);

l_{min} is the minimum dimension (length or height) of the reflecting surface (see figure 8).

If any of these conditions is not met for a given octave band, then reflections shall be neglected.

The real source and source image are handled separately. The sound power level of the source image $L_{W,im}$ shall be calculated from

$$L_{W,im} = L_W + 10 \lg(\rho) \text{ dB} + D_{Ir} \quad \ldots (20)$$

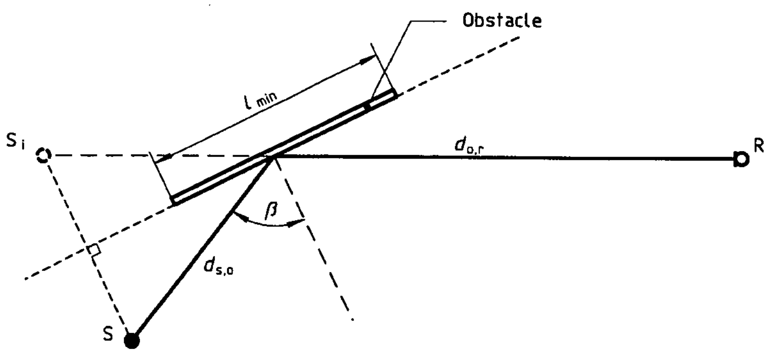
where

ρ is the sound reflection coefficient at angle β on the surface of the obstacle ($\geqslant 0{,}2$) (see figure 8);

D_{Ir} is the directivity index of the source in the direction of the receiver image.

If specific data for the sound reflection coefficient are not available, the value may be estimated using table 4.

For the sound source image, the attenuation terms of equation (4), as well as ρ and D_{Ir} in equation (20), shall be determined according to the propagation path of the reflected sound.



NOTE — A path $d_{s,o} + d_{o,r}$ connecting the source S and receiver R by reflection from the obstacle exists in which β, the angle of incidence, is equal to the angle of reflection. The reflected sound appears to come from the source image S_i.

Figure 8 — Specular reflection from an obstacle

Table 4 — Estimates of the sound reflection coefficient ρ

Object	ρ
Flat hard walls	1
Walls of building with windows and small additions or bay	0,8
Factory walls with 50 % of the surface consisting of openings, installations or pipes	0,4
Cylinders with hard surfaces (tanks, silos)	$\frac{D \sin(\phi/2)}{2d_{sc}}$ *) where D is the diameter of the cylinder; d_{sc} is the distance from the source to the centre C of the cylinder; ϕ is the supplement of the angle between lines SC and CR.
Open installations (pipes, towers, etc.)	0
*) This expression applies only if the distance d_{sc} from the source S to cylinder C is much smaller than the distance d_{cr} from the cylinder to receiver; see figure 9.	

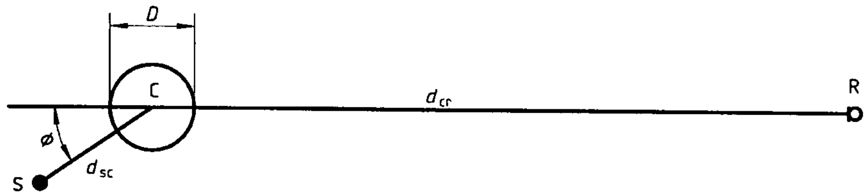


Figure 9 — Estimation of sound reflection coefficient for a cylinder

8 Meteorological correction (C_{met})

Use of equation (3) leads directly to an equivalent continuous A-weighted sound pressure level L_{AT} at the receiver for meteorological conditions which are favourable for propagation from the sound source to that receiver, as described in clause 5. This may be the appropriate condition for meeting a specific community noise limit, i.e. a level which is seldom exceeded (see ISO 1996-3). Often, however, a long-term average A-weighted sound pressure level L_{AT}(LT) is required, where the time interval T is several months or a year. Such a period will normally include a variety of meteorological conditions, both favourable and unfavourable to propagation. A value for L_{AT}(LT) may be obtained in this situation from that calculated for L_{AT}(DW) via equation (3), by using the meteorological correction C_{met} in equation (6).

A value (in decibels) for C_{met} in equation (6) may be calculated using equations (21) and (22) for the case of a point sound source with an output which is effectively constant with time:

$$C_{met} = 0 \quad \text{if } d_p \leq 10(h_s + h_r) \qquad \ldots (21)$$

$$C_{met} = C_0 \left[1 - 10(h_s + h_r)/d_p\right] \quad \text{if } d_p > 10(h_s + h_r) \qquad \ldots (22)$$

where

h_s is the source height, in metres;

h_r is the receiver height, in metres;

d_p is the distance between the source and receiver projected to the horizontal ground plane, in metres;

C_0 is a factor, in decibels, which depends on local meteorological statistics for wind speed and direction, and temperature gradients.

The effects of meteorological conditions on sound propagation are small for short distances d_p, and for longer distances at greater source and receiver heights. Equations (21) and (22) account approximately for these factors, as shown in figure 10.

Values in metres

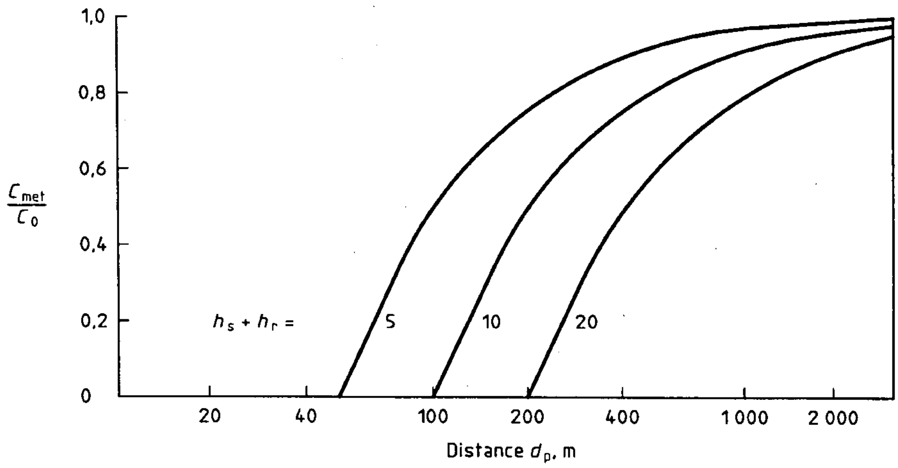


Figure 10 — Meteorological correction C_{met}

NOTES

20 A value for C_0 in equations (21) and (22) may be estimated from an elementary analysis of the local meteorological statistics. For example, if the meteorological conditions favourable to propagation described in clause 5 are found to occur for 50 % of the time period of interest, and the attenuation during the other 50 % is higher by 10 dB or more, then the sound energy which arrives for meteorological conditions unfavourable to propagation may be neglected, and C_0 will be approximately + 3 dB.

21 The meteorological conditions for evaluating C_0 may be established by the local authorities.

22 Experience indicates that values of C_0 in practice are limited to the range from zero to approximately + 5 dB, and values in excess of 2 dB are exceptional. Thus only very elementary statistics of the local meteorology are needed for a ± 1 dB accuracy in C_0.

For a source that is composed of several component point sources, h_s in equations (21) and (22) represents the predominant source height, and d_p the distance from the centre of that source to the receiver.

9 Accuracy and limitations of the method

The attenuation of sound propagating outdoors between a fixed source and receiver fluctuates due to variations in the meteorological conditions along the propagation path. Restricting attention to moderate downwind conditions of propagation, as specified in clause 5, limits the effect of variable meteorological conditions on attenuation to reasonable values.

There is information to support the method of calculation given in clauses 4 to 8 (see annex B) for broad-band noise sources. The agreement between calculated and measured values of the average A-weighted sound pressure level for downwind propagation, L_{AT}(DW), supports the estimated accuracy of calculation shown in table 5. These estimates of accuracy are restricted to the range of conditions specified for the validity of the equations in clauses 3 to 8 and are independent of uncertainties in sound power determination.

NOTE 24 The estimates of accuracy in table 5 are for downwind conditions averaged over independent situations (as specified in clause 5). They should not necessarily be expected to agree with the variation in measurements made at a given site on a given day. The latter can be expected to be considerably larger than the values in table 5.

The estimated errors in calculating the average downwind octave-band sound pressure levels, as well as pure-tone sound pressure levels, under the same conditions, may be somewhat larger than the estimated errors given for A-weighted sound pressure levels of broad-band sources in table 5.

In table 5, an estimate of accuracy is not provided in this part of ISO 9613 for distances d greater than the 1 000 m upper limit.

Throughout this part of ISO 9613 the meteorological conditions under consideration are limited to only two cases:

a) moderate downwind conditions of propagation, or their equivalent, as defined in clause 5;

b) a variety of meteorological conditions as they exist over months or years.

The use of equations (1) to (5) and (7) to (20) (and therefore also table 5) is limited to case a): meteorological conditions only. Case b) is relevant only to the use of equations (6), (21) and (22). There are also a substantial number of limitations (non-meteorological) in the use of individual equations. Equation (9) is, for example, limited to approximately flat terrain. These specific limitations are described in the text accompanying the relevant equation.

Table 5 — Estimated accuracy for broadband noise of L_{AT}(DW) calculated using equations (1) to (10)

Height, h *)	**Distance, d *)**	
	$0 < d < 100$ m	$100 \text{ m} < d < 1\,000$ m
$0 < h < 5$ m	± 3 dB	± 3 dB
$5 \text{ m} < h < 30$ m	± 1 dB	± 3 dB

*) h is the mean height of the source and receiver.
d is the distance between the source and receiver.

NOTE — These estimates have been made from situations where there are no effects due to reflection or attenuation due to screening.

Annex A
(informative)

Additional types of attenuation (A_{misc})

The term A_{misc} in equation (4) covers contributions to the attenuation from miscellaneous effects not accessible by the general methods of calculating the attenuation specified in clause 7. These contributions include

— A_{fol}, the attenuation of sound during propagation through foliage,

— A_{site}, the attenuation during propagation through an industrial site, and

— A_{hous}, the attenuation during propagation through a built-up region of houses,

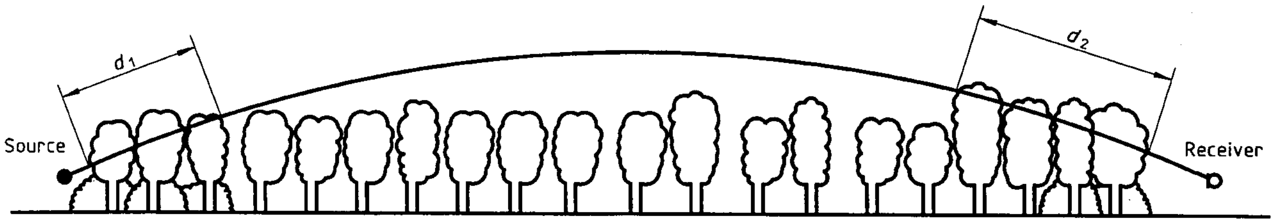
which are all considered in this annex.

For calculating these additional contributions to the attenuation, the curved downwind propagation path may be approximated by an arc of a circle of radius 5 km, as shown in figure A.1.

A.1 Foliage (A_{fol})

The foliage of trees and shrubs provides a small amount of attenuation, but only if it is sufficiently dense to completely block the view along the propagation path, i.e. when it is impossible to see a short distance through the foliage. The attenuation may be by vegetation close to the source, or close to the receiver, or by both situations, as illustrated in figure A.1. Alternatively, the path for the distances d_1 and d_2 may be taken as falling along lines at propagation angles of 15° to the ground.

The first line in table A.1 gives the attenuation to be expected from dense foliage if the total path length through the foliage is between 10 m and 20 m, and the second line if it is between 20 m and 200 m. For path lengths greater than 200 m through dense foliage, the attenuation for 200 m should be used.



NOTE — $d_f = d_1 + d_2$

For calculating d_1 and d_2, the curved path radius may be assumed to be 5 km.

Figure A.1 — Attenuation due to propagation through foliage increases linearly with propagation distance d_f through the foliage

Table A.1 — Attenuation of an octave band of noise due to propagation a distance d_f through dense foliage

Propagation distance d_f m	**Nominal midband frequency** Hz							
	63	125	250	500	1 000	2 000	4 000	8 000
	Attenuation, dB:							
$10 \leq d_f \leq 20$	0	0	1	1	1	1	2	3
	Attenuation, dB/m:							
$20 \leq d_f \leq 200$	0,02	0,03	0,04	0,05	0,06	0,08	0,09	0,12

A.2 Industrial sites (A_{site})

At industrial sites, an attenuation can occur due to scattering from installations (and other objects), which may be described as A_{site}, unless accounted for under A_{bar}, or the sound source radiation specification. The term installations includes miscellaneous pipes, valves, boxes, structural elements, etc.

As the value of A_{site} depends strongly on the type of site, it is recommended that it is determined by measurements. However, for an estimate of this attenuation, the values in table A.2 may be used. The attenuation increases linearly with the length of the curved path d_s through the installations (see figure A.2), with a maximum of 10 dB.

A.3 Housing (A_{hous})

A.3.1 When either the source or receiver, or both are situated in a built-up region of houses, an attenuation will occur due to screening by the houses. However, this effect may largely be compensated by propagation between houses and by reflections from other houses in the vicinity. This combined effect of screening and reflections that constitutes A_{hous} can be calculated for a specific situation, at least in principle, by applying the procedures for both A_{bar} and reflections described in 7.4 and 7.5. Because the value of A_{hous} is very situation-dependent, such a calculation may be justified in practice. A more useful alternative, particularly for the case of multiple reflections where the accuracy of calculation suffers, may be to measure the effect, either in the field or by modelling.

A.3.2 An approximate value for the A-weighted attenuation A_{hous}, which should not exceed 10 dB, may also be estimated as follows. There are two separate contributions

$$A_{hous} = A_{hous,1} + A_{hous,2} \qquad \text{. . . (A.1)}$$

A.3.3 An average value for $A_{hous,1}$ (in decibels) may be calculated using the equation

$$A_{hous,1} = 0{,}1 B d_b \quad \text{dB} \qquad \text{. . . (A.2)}$$

where

B is the density of the buildings along that path, given by the total plan area of the houses divided by the total ground area (including that covered by the houses);

d_b is the length of the sound path, in metres, through the built-up region of houses, determined by a procedure analogous to that shown in figure A.1.

The path length d_b may include a portion d_1 near the source and a portion d_2 near the receiver, as indicated in figure A.1.

The value of A_{hous} shall be set equal to zero in the case of a small source with a direct, unobstructed line of sight to the receiver down a corridor gap between housing structures.

NOTE 25 The A-weighted sound pressure level at specific individual positions in a region of houses may differ by up to 10 dB from the average value predicted using equations (A.1) and (A.2).

Table A.2 — Attenuation coefficient of an octave band of noise during propagation through installations at industrial plants

Nominal midband frequency, Hz	63	125	250	500	1 000	2 000	4 000	8 000
A_{site}, dB/m	0	0,015	0,025	0,025	0,02	0,02	0,015	0,015

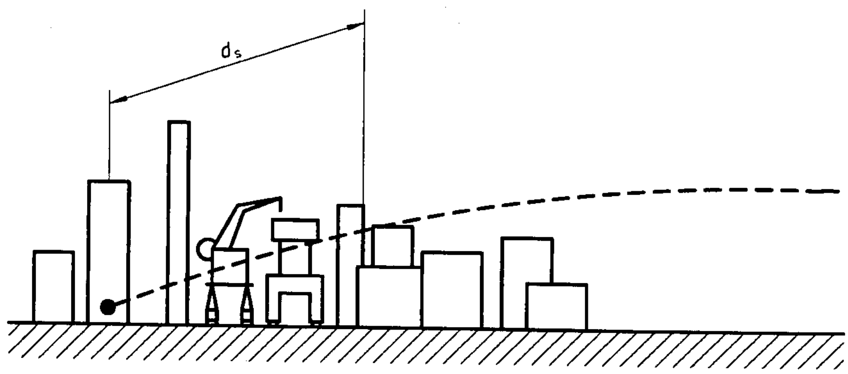


Figure A.2 — The attenuation A_{site} increases linearly with the propagation distance d_s through the installations at industrial plants

A.3.4 If there are well-defined rows of buildings near a road, a railway, or a similar corridor, an additional term $A_{hous,2}$ may be included (provided this term is less than the insertion loss of a barrier at the same position with the mean height of the buildings):

$$A_{hous,2} = -10 \lg[1 - (p/100)] \text{ dB} \qquad \ldots \text{(A.3)}$$

where p (the percentage of the length of the façades relative to the total length of the road or railway in the vicinity) is $\leqslant 90$ %.

A.3.5 In a built-up region of houses, the value of $A_{hous,1}$ [as calculated by equation (A.2)] interacts as follows with the value for A_{gr}, the attenuation due to the ground [as calculated by equation (9) or equation (10)].

Let $A_{gr,b}$ be the ground attenuation in the built-up region, and $A_{gr,0}$ be the ground attenuation if the houses were removed [i.e. as calculated by equation (9) or equation (10)]. For propagation through the built-up region in general, $A_{gr,b}$ is assumed to be zero in equation (4). If, however, the value of $A_{gr,0}$ is greater than that of A_{hous}, then the influence of A_{hous} is ignored and only the value of $A_{gr,0}$ is included in equation (4).

The interaction above is essentially to allow for a range of housing density B. For low-density housing, the value of A_{gr} is dominant, while for high-density housing A_{hous} dominates.

Annex B
(informative)

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ICS 17.140.01

Descriptors: acoustics, noise (sound), airborne sound, wave propagation, attenuation, rules of calculation.

Price based on 18 pages

APPENDIX H
DEFRA REPORT NANR 5

DEFRA Ref. NANR 5

Review and analysis of published research into the adverse effects of industrial noise, in support of the revision of planning guidance.

FINAL REPORT

MARCH 2004

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EXECUTIVE SUMMARY

Introduction

This project is a review and analysis of published research into the adverse effects of industrial noise, in support of the revision of planning guidance. It was funded by DEFRA and the Environmental Agency, and has been conducted by BEL in conjunction with Nicole Porter.

It was considered that the current review of PPG24 being led by DEFRA would benefit from a deeper understanding of the impacts of industrial noise on humans and in particular the potential for it to cause adverse impact in the community. This study was therefore commissioned to investigate the effects of industrial noise. The aims of the project were set up as:

- to gain a better understanding of potential disturbance and impact on amenity by industrial noise which will assist in the review of PPG 24; and
- to investigate the reported relationship between industrial noise and people's response.

The objectives of the study were:

- to review existing published literature on industrial noise impacts on humans, excluding noise at work; and
- to highlight possible relationships between reported adverse effects and factors such as the types and acoustic characteristics of noise, geographical location and demographic profile.

The main work tasks were to review examples of the application of PPG24, to review and analyse key literature on the effects of industrial noise, to overview non-auditory effects of industrial noise, and to consider the design of any future industrial noise surveys.

Review examples of the application of PPG 24

The aim of the review was to build up a set of examples of how PPG24 has been used in practice for industrial noise in England, and to learn lessons from these examples, relevant to assessing human response and the setting of criteria and limits. The review was principally made up of an analysis of published papers at conferences etc where PPG 24 has been evaluated, and a structured email survey of key personal contacts. The findings identified the key practical areas of PPG24 that require clarification or improvement with respect to industrial noise as:

- the scope of application,
- the treatment of acoustic features and character corrections,
- the treatment of mixed sources,
- the difference between responses to industrial versus transportation sources
- inconsistency between assessments particularly absolute versus relative noise level comparisons,
- the treatment of short duration, temporary or intermittent sources,
- the choice of criterion levels,
- dealing with socio-economic issues

- the appropriateness of NECs for new industrial developments or new housing,
- how to deal with low background noise,
- the variation of noise levels through the day, night, week and weekend, and
- reported stringency of IPPC requirements.

Methodology of literature review
Whilst the previous section focussed on the practical issues surrounding PPG24 and industrial noise, the literature review centred around more academic research findings on the response to industrial noise. There were three main parts to the literature review;

1. the establishment of an extensive bibliography,
2. the development of a searchable database, using MS Access software,
3. a descriptive review of the key findings from the various studies.

Sources of publications
Initially the key publication were identified and collated from a number of sources including the NASA catalogue, TNO archive, conference proceedings, journals, library searches, personal contacts, and secondary references. A much larger number of publications were identified than had been anticipated before the project commenced.

Database
A searchable database was designed and implemented using MS Access software. Although this originally had been planned to form a major part of the work, after 10 studies had been carefully assessed and entered into the database, the usefulness of the database was re-evaluated in the light of the vast number of publications and the type of useful information to this project. The entering of more data was halted, with the work resources being focussed towards the analysis of the publications.

Review and analysis of literature review
Annoyance surveys
The review and analysis of the literature was divided into a number of sections. Firstly information relating to annoyance surveys was examined. This identified work in Japan, Canada, Germany, Australia, and the Netherlands. The work in Japan and Canada was in the 70s, are can be considered mainly as 'historical markers', with the data not being very useful for any time of meta-analysis. There were a number of German studies. One of these studies, carried out between 1975 and 1978, included a dose-response relationship for activity disturbance against mean noise level although Miedema has used the data in a later meta-analysis. Of the other German studies, one is limited in use as it only provides one data point per source and adopts somewhat idiosyncratic annoyance scales, and the other is of most significance in providing data on non-acoustic factors. The Australian work related to community reaction to noise from power stations and includes a comparison of data against the Schultz dose-response curve for annoyance to many sources.

The most useful work on response to industrial noise has been conducted in the Netherlands. In 1992, Miedema of TNO examined a number studies including the datasets from some 1980 Dutch work on industrial noise and shunting yards and the 1982/3 CEC studies on impulse noise which included industrial noise sources). He concluded that industrial noise appears to be more annoying than transportation noise at equal levels. In this work he goes on to compare his results with the earlier German study, and against the Schultz curve for annoyance. He however points out that there is insufficient data on industrial noise for a full analysis or comparison. In 2002, TNO conducted more work documenting 11 surveys of annoyance from industrial noise, carried out to meet the limitations of the previous work with its small number of respondents, and large variance in annoyance. This work at first sight seems to show lower annoyance values than for those found in the 1992 work. It also suggests that when the data is compared against curves for transportation noise, no significance differences are found for responses between industrial and the general transportation noise sources. However, the work is still to be reported in full in English.

It is clear that, compared to the number of surveys of the effects of transportation noise - aircraft, road traffic and railways - far fewer surveys have been conducted into industrial noise. Furthermore, of the small number that have been done, only those conducted in the last 5 to 10 years are anywhere near suitable for inter-comparisons in order to identify trends, and to attempt to combine in terms of a dose-response curve. Even when such comparisons are made, as we have done, the results are not clear-cut, and, in general there is no strong evidence that industrial noise produces higher annoyance response than transportation noise.

Laboratory experiments
Next, the data from laboratory experiments is reviewed with respect to the response to noise containing the acoustic features of impulses and tones. It has been generally found that an acoustic feature (impulse or tone) in a noise complex can increase the annoyance when compared to response to the same noise without that feature present. Listening tests have been used to derive 'penalties' which act as a correction factor to be added to the level of a steady state background noise to take account of the added annoyance due to the feature. It is clear that the response to complex noise is not simple, it varies between people and different situations. The experiments have shown that not only do the derived penalties vary, but also it is unclear as to how to deal with complex features. What has become more clear over time however is that in order to both assess and control industrial noise, we need good descriptors of the physical magnitudes of the various features that are meaningful in terms of the subjective characteristics that they are supposed to represent. There are a number of methods that have been developed from the laboratory experiments for describing the sensation level of features, but the work has shown that these are often over simplified and do not apply to real life situations which are usually more complex. Therefore we still need improved descriptors of the sensation levels of the features before we can fully describe and assess noise from industrial sources.

Windfarms
There remains some uncertainty over the way the assessment of situations involving Windfarm developments will fit into the revision of PPG 24. However this work has identified some interesting publications have come to light as a direct result of our searches, and also from the email enquiry to international contacts. Much of the work has been conducted in the Nordic countries. The main findings seem to suggest that although dose-response relationship may be derived for windfarm noise, these may be weak due to variables other than sound level that can influence noise annoyance. More emphasis is placed in the various reports on the "intervening variables", which we would call non-acoustic factors. These included - general

attitude, landscape impact, satisfaction with the neighbourhood, "daily hassles", stress and time of day of operations. Therefore because of the special nature of the visual component in influencing response, and the unique acoustic characteristics, of windfarms, we recommend that noise form this type of source may have to be treated as a special category of "industrial" noise.

Non-acoustic factors
The extent of an adverse response to noise, however described or reported, is clearly influenced by numerous non-acoustic factors. It may be that due to these non-acoustic factors, that the use of any dose-response relationship is limited, in fact we may never be able to derive generalised dose-response relationship for industrial noise and perhaps should not ultimately aim to do so. There have been a number of important published reviews. Job's review work on modifiers includes the importance of attitude to response to noise from drop forging. Fields' work demographic, attitudinal and situational intervening variables suggest that the attitudinal variables have the strongest effect on response. Miedema's investigation into the systematic effects of demographic and other personal factors on annoyance revealed that fear and noise sensitivity is very important although he also identified some other factors. He concluded that there is at present no combined model of all the interrelations between noise exposure, annoyance and all these non-acoustic variables that can influence noise annoyance. Two questions have been raised in the context of our study:

1. Are the generalised findings concerning these variables, from previous reviews, such as those just outlined, actually applicable to cases involving Industrial noise?
2. Are there perhaps other non-acoustic factors that are "unique" to the industrial noise situation?

The practical significance of these studies and the identified factors needs to be considered in the context of revising PPG24. It may be that the most that can be done is for the factors to be listed in some form of guidance material to indicate that noise level alone is only part of the story in determining planning issues and that sensible judgement has to be applied.

Change in noise exposure
None of the annoyance studies reported so far has involved "changes" in the industrial noise environment. Much of the scientific literature in which surveys of response have been compared and integrated, including literature underpinning the important EU work on dose-response curves for transportation noise, has only considered situations where conditions are "steady-state". The scientific study of situations where there have been such changes is very much in its infancy, and here again the emphasis has been on transportation noise situations, such as new runways at airports. This lack of knowledge on how changes influence reported annoyance is, if anything, more significant for the present project, where the "real-world" context is that of planning for new industrial development, or for new residential development.

A 1997 review of 12 studies is described which concluded that most of the studies did show a change greater than that expected from a baseline dose-response curve, but that studies designed specifically to measure adaptation or habituation to the changes generally failed to detect such decay. A number of models are described that attempt to account for change. As with the topic of non-acoustic factors, the question arises as to how we can make practical use of these various models

Overview of non-auditory effects of industrial noise

The effects of noise are examined in terms of annoyance, speech interference, performance (concentration and task interference), mental health, noise induced stress related effects, and sleep disturbance. Various generic models have been proposed to illustrate and explain the complex interaction between physical noise exposure, non-acoustic factors, and the noise effects, and 7 models have been outlined.

From this rather academic overview of some of these models, and our knowledge of the published literature, it is clear that no models have been developed which are specific to the issue of industrial noise. However, the models show plenty of commonalities including the short- to longer-term effects categorisations, and the importance of the centralised role of perception and control. Although not specific to industrial noise, all the models could be applied in examining the potential effects of industrial noise, but with various links being more important than others. In fact all of the models are qualitative in nature and no attempts have been made to quantify the relative "weighting" of the various interactions between all the different aspects. The closest we get to this is the knowledge that has been built up from analysis and meta-analysis of social surveys on the relative proportions of the variance in annoyance response that can be ascribed to various factors. But, as we have seen, there is much less relevant literature on surveys of industrial noise than, for example, aircraft noise. We therefore feel there is considerable scope for further work to explore this issue of models, to help to fully describe response to industrial noise. This could be done in conjunction with any planned future surveys.

However, although these models are useful at understanding our response to noise, a further issue is to build on these fundamental models to develop approaches for the practical control of industrial noise. An example of this type of work is given but to be successful, we need more information. We therefore feel there is scope to not only look at the models of effects, but to build up our knowledge even further by using these models to help develop practical approaches for assessment and control of industrial noise.

Observations on the design of a future survey

In the course of this project we have examined a large number of publications reporting the design and implementation of surveys of the effects of industrial noise. Through our attempts to analyse the results of such surveys in the present context of the review of PPG24, we can see specific aspects of the design and planning of new surveys, which would need to be carefully addressed. A possible new survey on industrial noise in the UK should therefore consider.

- Clear definition of the use of the survey findings
- The need for comprehensive monitoring of physical exposure.
- The heterogeneous nature of industrial noise sources
- Use of standardised annoyance questions
- Exploring other effects

- Seasonal variations
- Change situations
- Socio-economic and other non-acoustic issues
- Absolute versus relative levels
- Practical noise control issues
- The role of IPPC

Recommendations

1. A more extensive survey of examples of application of PPG24 should be considered, based on the experience gained in this project.

2. Additional documentation of the Bibliography should be considered in order to develop a resource to aid future research.

3. Further research should be funded to develop improved descriptors of acoustic features in order to describe and assess noise from industrial sources that are meaningful in terms of the subjective characteristics that they are supposed to represent.

4. A more detailed study should be undertaken on non-acoustic factors, with a view to implementing practical guidance.

5. The lack of hard information from the review of previous surveys, and the review of the importance of "change" situations indicate the need to conduct a new survey, or surveys.

6. Further work is required to explore the issue of models, to help to fully describe response to industrial noise and to consider their practical application. This could be done in conjunction with any planned future surveys.

APPENDIX I **Planning appeal decisions APP/W1850/A/O3/1124124 & APP/A5840/A/04/1142305**

Report to the First Secretary of State

by Diane Lewis BA(Hons) MCD MA LLM MRTPI

an Inspector appointed by the First Secretary of State

The Planning Inspectorate
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Date

COUNCIL OF THE LONDON BOROUGH OF SOUTHWARK

APPEAL BY

CONRAD PHOENIX (CANADA WATER) LTD

Inquiry opened on 16 November 2004 and resumed on 6 April 2005

Land at: Site E, currently units 3-4 Canada Water Retail Park, Surrey Quays Road, Canada Water, Southwark, London SE16 2XU

File Ref: APP/A5840/A/04/1142305

File Ref: APP/A5840/A/04/1142305
Site E, currently units 3-4 Canada Water Retail Park, Surrey Quays Road, Canada Water, Southwark, London SE16 2XU

- The appeal is made under section 78 of the Town and Country Planning Act 1990 against a failure to give notice within the prescribed period of a decision on an application for planning permission.
- The appeal is made by Conrad Phoenix (Canada Water) Ltd against the Council of the London Borough of Southwark.
- The application Ref 03-AP-2071 is dated 31 October 2003.
- The proposed development, as described on the application form, is demolition of existing retail warehouse and construction of three buildings, comprising of a single 10 storey building and two 13 storey buildings, to accommodate 320 flats with community facilities at ground level, 200 car parking spaces at basement level with vehicular access from Canada Street, central internal courtyard to provide landscaped amenity area, ball court and additional 5 car parking spaces.
- The First Secretary of State by letter dated 1 March 2004 directed that he shall determine this appeal because it raises issues relating to residential development of 5 or more hectares or 150 or more dwellings.
- The Inquiry sat on 16 to 19 November 2004, 6 to 8 April and 12 to 14 April 2005.

Summary of Recommendation: That the appeal be dismissed

1. PROCEDURAL MATTERS

The Proposal

1.1 In March 2004 the Appellant submitted amendments to the appeal application. In summary, these consisted of (a) a general reduction in height of block B by the removal of one storey and by two storeys at the Canada Street end, (b) rearrangement of the internal layout and corresponding alterations to the external elevations, and (c) the repositioning of blocks B and C to allow for a planting strip on the Surrey Quays Road frontage. The amendments brought the appeal scheme in line with a duplicate application on which there had been consultation. Evidence was presented at the Inquiry on the basis of the amended scheme.

1.2 The Council resolved in June 2004 that it would have refused the application and *Document 9 para. 2.7* sets out the reasons, namely:

1. The proposed development by reason of its design and layout particularly with regard to blocks B & C would result in noise and general disturbance for future occupiers of the new development given its proximity to a 24 hour industrial use. This is contrary to Policy E.3.1 (Protection of Amenity) of the Southwark Unitary Development Plan and Policy 3.2 (Protection of Amenity) of the Southwark Plan Revised Deposit Unitary Development Plan April 2004.
2. The close proximity of the proposed development to a 24 hour industrial use is likely to result in complaints from future residents against the operations of the industrial use with regard to noise and general disturbance. This is likely to be prejudicial to the effective functioning of a successful business contrary to the advice in PPG24: Planning and Noise.
3. The proposal would result in an over-intensive development having an excessive density contrary to Policy H.1.7 (Adopted UDP), Policy 3.10 (Efficient Use of Land) and Policy

4.1 (Density of Residential Development) of the Southwark Plan (2nd deposit draft 2004).

4. The proposed buildings by virtue of their height are out of keeping with the surroundings and harmful to the appearance of the area contrary to Policy E.2.2 (Heights of Buildings) of the adopted UDP and Policy 3.20 (Tall Buildings) and Policy 3.13 (Urban Design) of the Southwark Plan.

5. The proposal by virtue of its limited number of large family units, specifically within block A (affordable housing) is unacceptable and would be contrary to Policy H.1.5 (Dwelling Mix of New Housing) of the adopted UDP and Policy 4.3 (Mix of Dwellings) of the Southwark Plan.

1.3 Shortly before the Inquiry the Appellant put forward a revision to the affordable housing mix, increasing to 9 the number of three bedroom flats in block A (*Document 29 Appendix 18 para.23, Plan E.1, E.2*). The Council did not raise any objections to this change as it overcame the fifth refusal reason and there would be no external impact. In the light of this adjustment the Council did not pursue its objection to dwelling mix at the Inquiry.

1.4 Having regard to publicity on the appeal I am satisfied that the proposal, as amended in terms of site layout, building height and dwelling mix, may be determined without prejudice to the interests of any party. The development, as amended, is now described as "redevelopment of the site to provide 320 residential dwellings, 1,150 square metres of community uses (D1), plus associated car parking and amenity space" (*Document 80 page 2*).

1.5 The First Secretary of State by letter dated 22 April 2004 directed that the appeal proposal is not EIA development.

Consultation and Rulings

1.6 At the start of the Inquiry a new issue was raised by Harmsworth Quays Printing Limited, a third party accorded Rule 6 status (HQP). The issue concerned the relationship of the appeal site and proposal to a protected strategic view Greenwich Park to St Paul's Cathedral identified in RPG3 (*Document 35*). It appeared to me from the submissions that part of the appeal site came within the Wider Setting Consultation Area (WSCA) and that part of the development would exceed the applicable threshold height of 30 metres AOD (*Documents 52-55*). The matter had not been picked up by the Appellant and the Council, who both had understood that the threshold height was 50 metres AOD. Although it is a fundamental point there was no reason for me to believe that it was anything but a genuine misunderstanding. Accordingly I ruled that the Appellant should be allowed to address this matter. I also ruled that consultation should be carried out in order to properly inform the First Secretary of State. I decided that the Inquiry should proceed as arranged to hear evidence on other issues. The Inquiry adjourned on 19 November to allow consultation to take place with the Mayor and relevant local authorities.

1.7 The Appellant had submitted a supplementary proof of evidence and appendices shortly before the Inquiry opened (*Documents 31 and 32*). I ruled that this evidence was admissible and that HQP be allowed time to verify the evidence. Subsequently the Appellant withdrew the evidence on residential developments in close proximity to printworks and results of research studies on bad neighbour developments, *Document 32 Appendices 4 to 9 inclusive*.

1.8 When the Inquiry adjourned in November I set out a timetable for submission of evidence on the WSCA consultation, planning conditions, the unilateral undertaking and the traffic survey carried out by the Appellant. I ruled that for reasons of fairness no other evidence would be admissible, unless there was a significant change in circumstances. When the Inquiry resumed in April 2005 the documentation indicated that the Appellant had submitted additional information to the Greater London Authority (GLA) on affordable housing (*Document 21 Response 6*). As originally proposed, the appeal scheme includes 80 affordable housing units on site in block A, equivalent to 25% provision. Following the GLA's evaluation of a Three Dragons affordable housing assessment the Appellant agreed to provide six additional intermediate housing units by way of a financial contribution[1]. Increased and additional contributions to environmental improvements and traffic signal enhancement were also proposed. These amendments were reflected in a unilateral undertaking (*Document 65*).

1.9 Having heard submissions from all parties on the affordable housing matter I ruled there should be the opportunity to consider the further evidence on affordable housing in order to ensure no prejudice resulted and to enable the matter to be assessed in the knowledge of all available information. The Appellant then withdrew the amendment to the affordable housing provision and confirmed that the proposed 25% provision was justified solely by adopted UDP policy. No reliance was to be placed on economic viability and the Three Dragons model. On that basis I decided no prejudice would be caused to any party and there was no need for an adjournment of the Inquiry.

Report and Documentation

1.10 In addition to the written and oral evidence my Report is informed by various site visits. Accompanied visits took place on 11 April 2005 at Harmsworth Quays Printing Works, the appeal site and the strategic viewing points in Greenwich Park. There was an accompanied late night site visit to Harmsworth Quays on 14 April. I have made other unaccompanied visits to the Canada Water area.

1.11 This Report includes a description of the site, its surroundings and relevant planning history together with details of the proposal. I outline the planning policy context, with particular reference to the policies debated at the Inquiry. I set out the main points of the cases presented by the Council, HQP, the Appellant and interested persons. I then refer to written representations, agreed planning conditions and the unilateral undertaking. My conclusions and recommendation follow. A schedule of appearances, documents and plans is attached and a list of planning conditions forms Appendix 1. In my Report I have added footnotes for clarification where appropriate.

1.12 The cases of the principal parties and HQP are informed by a set of core documents CD1 to CD38 inclusive, as identified in the schedule. A statement of common ground is found in *Document 29* at *Appendix 18*.

2. APPEAL SITE AND ITS SURROUNDINGS

2.1 Canada Water is located within the Rotherhithe Peninsula. The appeal site is located at the junction of Surrey Quays Road and Canada Street (*Plan A*). It is roughly triangular in

[1] The London Plan anticipates that in estimating provision economic viability will be taken into account. A development control toolkit developed by the Three Dragons and Nottingham Trent University is recognised as one mechanism that will help (*CD8 para. 3.41*). I was informed that a Three Dragons assessment relies on computer modelling. Intermediate housing is defined in the London Plan as sub-market housing which is above target rents for social housing but substantially below open market levels (*CD8 para. 3.26*).

shape, relatively flat and with an area of about 0.8 hectare. The site is occupied by a retail warehouse and associated car parking. There are maturing trees within the car park and along the Surrey Quays Road frontage (*Plan B*). The retail unit dates from the 1980's, one of a group of four units built at the junction. Two of the units, on the west side of Surrey Quays Road, have been retained and occupied by the Decathlon trading group. On the opposite side of Canada Street one of the units has been demolished leaving a vacant site awaiting redevelopment, known as Site D. The main redevelopment sites in Canada Water are identified in *Document 15* at *Figure 1*.

2.2 A major printing, publishing and distribution premises known as Harmsworth Quays Printing Works occupies land to the south east. The main building, containing the printing plant, is sited some 10 metres from the boundary of the appeal site. The access to the works is from Surrey Quays Road. Further to the south is a leisure complex. The Mulberry Business Park, a relatively modern industrial estate, adjoins the site to the north east. Surrey Quays shopping centre is within easy walking distance. Beyond this core of commercial activity the area is largely residential, notable developments nearby including Wolfe Crescent and Woodlands Crescent (*Document 10 Appendix 3*). The plan at *Document 29 Appendix 3 Figure 1* shows the location of the site in this wider context. It also indicates the location of Canada Water underground and bus station, as well as Canada Water dock in the centre and Albion Channel to the north east. Photographs of the area are included in *Document 15 Figures 5-14*.

3. PLANNING HISTORY

3.1 There are two extant permissions on the site, both dated 23 December 2002 (*Document 10 Appendix 4*). One of the permissions allows a 6 and 7 storey building to provide offices and a telehotel. The second is for the construction of a part 6 to part 11 storey office building (*Document 15 Figure 3*). This scheme is linked to a planning agreement that provides for contributions towards employment and/or training initiatives (£95,000), childcare initiatives (£85,000), landscape and environmental works (£15,000) and a green travel plan (£230,000) (*Document 29 Appendix 6 page 64*).

3.2 On Site D outline planning permission was granted in March 2002 for 224 residential units, 18 live/work units and business and retail space. The scheme comprises of two 7 storey buildings, three 8 storey buildings and one 10 storey building. The development provides for an open aspect to the canal walk, from which the main entrance would lead to a central landscaped public area and water feature. Plans of the development form *Document 62*. Site preparation works were underway in April 2005.

3.3 There are proposals to redevelop the Mulberry Business Park to provide part 7, part 8 and part 10 storey buildings for mixed use development comprising B1 office space, 14 live/work units, 407 flats and a gymnasium with car parking and landscaping. The proposed development is subject to an appeal against non-determination, with the public inquiry adjourned to later in the year (*CD33*).

4. THE PROPOSAL

The development

4.1 The proposal would involve redevelopment of the site with three buildings around the perimeter enclosing a central space. *Document 16* includes plans of the site layout, building design and floor plans, together with schedules of areas and accommodation.

- Block A, nearest the Harmsworth Quays building, would be 'L' shaped in plan, a total of 10 storeys in height (28.5 metres above street level) with the single aspect residential units facing over the courtyard. Controlled entry would be positioned in the elbow of the 'L' and the central lift core, rising to 31 metres, would provide access to each floor as well as the basement car park.

- Block B would front Surrey Quays Road and Canada Street. The building would vary in height. Starting at 7 storeys (21.5 metres) in Canada Street, it would rise to 12 storeys (36.2 metres) to turn the corner and then step down to 10 storeys (28.5 metres) along Surrey Quays Road. The roof would curve to reflect the elevations, with roof terraces and a garden within the curvature. Community facilities would occupy the ground floor and at the axis a walkway would lead through to the central courtyard.

- Block C would have a triangular footprint to occupy the southern corner of the site. Like block B there would be space for community facilities at street level. The block would range from 12 to 15 storeys, increasing in height from 34.5 metres up to 45 metres at the apex on Surrey Quays Road.

- External finishes to the main elevations are proposed to be timber and metal panels, with extensive areas of glazing.

4.2 The development would provide 320 units, a density of 1072 habitable rooms per hectare (hr/ha). The 80 dwellings in block A are proposed as affordable housing, representing 25% of the total number of units. As amended, nine of the affordable units would have 3 bedrooms. As a result the dwelling size mix is: 136 x 1 bedroom (43%), 161 x 2 bedroom (50%) and 23 x 3 bedroom (7%) (*Document 28 para. 5.5*).

4.3 The proposals for the amenity space indicate a landscaped central courtyard, a ball court and a play area (*Plan C*). Ground floor flats in block A would have small enclosed gardens, all other flats a balcony. In blocks B and C all flats would have either a balcony or roof terraces. At basement level there would be 200 car parking spaces, 30 motorcycle spaces and 365 bicycle spaces. Access to the car park would be from Canada Street. There would be 5 additional car parking spaces within the courtyard for use by visitors to the community facilities.

4.4 Supporting statements were submitted on design, planning matters, transport, noise and sustainability (*Documents 3 to 7*). Section 12 of this Report provides details of the unilateral undertaking.

Consultations

4.5 The Mayor of London in July 2003 was generally supportive of the proposal. However, the affordable housing package was considered inadequate both in terms of the level and the range of provision. The site was likely to have significant residual values that could support a higher level of provision than 25% and there was concern about the balance between intermediate housing and social rented accommodation. Transport for London identified that Selective Vehicle Detection traffic signals would be a requirement for all new highways infrastructure, with a view to ensuring traffic movements from the flats would not impede buses. A financial contribution was required towards a package of transportation measures to improve pedestrian connectivity in the area as well as finance bus infrastructure. The comments of the Mayor and the accompanying GLA officer report are to be found in *Document 29 Appendix 14*. There was further consideration of the proposal in February 2005 and in strategic planning terms the proposal was found to be acceptable (*Document 21 Response 6*).

4.6 The Council's Design and Conservation team and Traffic Group raised no objections subject to conditions. The Council's Department of Public Protection had concerns about noise and disturbance (*Document 29 page 20 para. 16)*. The Environment Agency has no objections in principle subject to conditions on surface water drainage and a validation report on site remedial works. The Agency refers to a site investigation undertaken in 1997 and advises that if shown to be necessary suitable gas protection techniques should be incorporated into the design of the building (*Document 51a*).

Illustrative material

4.7 In *Document 17* at *pages 5-12* are plans of possible acoustic treatment to blocks B and C. The Appellant confirmed that the plans are for illustrative purposes only, with any necessary mitigation measures proposed to be secured through a planning condition. Three dimensional views of the proposal are included in *Document 16 pages 4-6* and *Document 17 page 14*. A model was displayed at the resumed Inquiry to show the relationship of the proposal to Harmsworth Quays, the Mulberry Business Park, Site D and Wolfe Crescent both now and with approved and proposed redevelopment. Photographs of the model are in *Document 22*.

Wider Setting Consultation Area

4.8 Following the adjournment of the Inquiry in November 2004, additional information was collated to enable consultation on the proposal specific to the effect on strategic views. The package of information sent to consultees forms *Document 73*. The responses received stated either no objection or no observations (*Document 21*).

4.9 The Council considered there would be no noticeable impact on the views to St Paul's and concluded the impact of the height of block C on strategic views would be acceptable (*Document 12 paras. 5.2, 5.3*)

5. PLANNING POLICY CONTEXT

The development plan

5.1 The development plan for the area comprises The London Plan, adopted in February 2004 (*CD8*) and the London Borough of Southwark Unitary Development Plan adopted in July 1995 (*CD9*).

The London Plan

5.2 Three balanced and interwoven themes of growth, equity and sustainable development underpin the Plan's strategies. An overarching Policy 2A.1 identifies sustainability criteria to guide the approach to development in London. The spatial strategy for development involves sensitive intensification in locations that are or will be well served by public transport. The main spatial categories identified are Opportunity Areas, Areas for Regeneration and Areas for Intensification. The spatial strategy through Policy 2A.5 also seeks to enhance and diversify the role of town centres with good public transport access.

5.3 Consistent with the concept of a sustainable and compact city, the aim is for future residential development needs to be located so as to maximise the use of scarce land, to conserve energy and to be within easy access of jobs, shops, schools and public transport.

Policy 3A.1 seeks the maximum provision of additional housing towards achieving an output of 30,000 additional homes per year. Provision to 2006 is to be monitored against a minimum target of 23,000 additional homes per year, the annual monitoring target for Southwark being 1480 homes. The figure is to be reviewed by 2006 and periodically thereafter. Policy 3A.2 encourages Boroughs to exceed these targets. The provision of affordable housing is covered by Policies 3A.6, 3A.7 and 3A.8. The strategic target is for 50% of new housing provision to be affordable. Within that, the Londonwide objective is to achieve a balance of 70% social housing and 30% intermediate provision and the promotion of mixed and balanced communities.

5.4 Policy 4B.1 sets out the design principles for a compact city. Policy 4B.3 seeks to maximise the potential of sites compatible with those principles, the local context and public transport capacity. Table 4B.1 provides a density and parking matrix, relating density ranges to location, setting, in terms of existing building form and massing and the index of public transport accessibility (PTAL). Guidance on the location of tall buildings is provided through Policy 4B.8. The design and impact of large scale buildings is covered by Policy 4B.9. The London panorama from Greenwich Park to central London is one of the designated important views under Policy 4B.15. The proposed management of protected views will not become operative until Supplementary Planning Guidance is published and the existing Strategic View Directions are withdrawn. Policy 4A.14 is concerned with reducing noise and refers to separating new noise sensitive development from major noise sources wherever practicable.

5.5 Southwark is in the Central London sub-region and strategic priorities for the sub-region are set out in Policy 5B.1. More intensive development is envisaged in four types of location – The Central Activities Zone, Opportunity Areas, Areas for Intensification and other areas with good public transport access, especially the sub-region's 14 'Major' town centres. Within Southwark, London Bridge and the Elephant and Castle are Opportunity Areas and Canada Water is identified as a District Centre within the town centre network. In implementing the Plan phasing of development and transport provision is addressed by Policy 6A.8

Southwark Unitary Development Plan (the UDP)

5.6 The Rotherhithe Peninsula, formerly part of the London Docklands Area, is identified as a Regeneration Area by Policy R.2.1. The policy encourages proposals that generate employment, improve the environment, meet the needs of local residents and bring back into beneficial use vacant land or buildings, unless environmental or amenity considerations suggest otherwise. Within the Regeneration Area, Proposal 26 applies to land north of Surrey Quays, which includes the appeal site. Business, entertainment, housing, shops, ancillary open space and community facilities are proposed. With reference to Policy H.1.3 Proposal 26 is specified as a mixed use site where housing would be acceptable together with other identified uses.

5.7 Policy E.2.2 states Southwark is not considered an appropriate area for high buildings and it identifies criteria for assessing whether new development would be of an appropriate height. Policy E.2.3 requires high standards of design and Policy E.2.5 requires new developments to display a high standard of landscape and townscape design compatible with security and safety. Under Policy E.3.1 development will not be allowed where it would involve nuisance or loss of amenity to adjacent users, residents and occupiers of the surrounding area.

5.8 Policy H.1.4 seeks the maximum reasonable proportion of affordable housing and Policy H.1.5 seeks a mix of dwelling sizes to cater for family and non-family households. Density of new residential development is covered by Policy H.1.7. An objective of Policy H.1.8 is to ensure new housing developments result in satisfactory standards of accommodation for future occupiers.

5.9 Other relevant policies include Policy E.1.1 safety and security in the environment, Policy T.4.1 measures for cyclists and Policy T.6.3 parking in new developments (*Document 29 Appendix 18 para.15*).

Other Material Considerations

The Southwark Plan (the draft UDP)

5.10 The Revised Deposit Unitary Development Plan 2004 (*CD10*) has been subject to Pre-Inquiry Changes (*CD11*) and Final Changes (*CD26*). A public inquiry commenced in April 2005.

5.11 Canada Water is designated as an Action Area, an area undergoing or about to undergo significant change. The vision for Canada Water is for "a mixed-use district town centre providing an attractive public realm and community facilities, new retail and leisure outlets, increased employment opportunities, additional residential dwellings with a range of sizes and tenures and transport improvements to encourage sustainable modes of travel" (*CD11 page 12 ref. 9.4.2*).

5.12 The appeal site is in the Urban Zone where development should typically be 3 to 6 storeys and at a density of 300 to 700 hr/ha. The site is also in a Public Transport Accessibility Zone (PTAZ), where densities may exceed this range subject to an exemplary standard of design with an excellent standard of living accommodation and a significant contribution to environmental improvements. (*CD10 Appendix 3 paras. 3.3 and 3.5*).

5.13 The appeal site is identified as 31P in the proposals sites schedule. In the revised deposit plan B1 business use is required, with other acceptable uses listed as residential and any other uses (*CD10 Appendix 4 page X*). In the Pre-Inquiry Changes other acceptable uses are deleted, although the schedule refers to the expectation of an employment buffer between the Harmsworth Quays site and any new residential use (*CD11 page 62*). In the Final Changes the required use is the B use class (*CD26 page 4*). Harmsworth Quays is site 34P where the B use class is the required use, with the Pre-Inquiry Changes specifying C3 residential in the other acceptable uses column (*CD10 Appendix 4 page X and CD11 page 63*).

5.14 Of general application, Policy 3.2 seeks to protect the amenity of an area and the quality of life. Unlike the UDP, it refers not only to residents of the surrounding area but also present or future occupiers of the application site or development. Policy 3.10 seeks to ensure all developments maximise the efficient use of land whilst safeguarding amenity and responding to the local context. Policy 3.13 requires principles of good urban design to be taken into account in all developments. Policy 3.20 sets out the requirements for tall buildings, defined as being over 30 metres in height except in the Thames Special Policy Area. The Pre-Inquiry Changes refers to specific guidance in Polices 4B.8 and 4B.9 of the London Plan and the English Heritage /CABE Guidance on Tall Buildings (*CD11 page 45* and see *para. 5.20* below). Policy 3.21 seeks to protect and enhance the strategic views of St Paul's Cathedral. The focus of the policy is on the viewing corridor and there is no direction in relation to the WSCA.

5.15 Quality of residential accommodation is covered by Policy 4.2 and includes high standards of protection from noise pollution. Policy 4.3 seeks a mix of dwellings to cater for the range of housing needs of the area. One of the requirements is that the majority of units should have two or more bedrooms, and developments of 15 or more dwellings will be expected to provide at least 10% of the units with three or more bedrooms with direct access to private garden space (*CD11 page 53*). The policy therefore responds to the need for larger family units and the shortfall in three bedroom affordable homes identified in the most recent housing needs survey (*Document 10 Appendix 6 page 10*). Policy 4.4 seeks to secure at least 35% of all new dwellings as affordable housing on relevant sites in the urban density zone. Such housing should be of an appropriate mix of dwelling type and size. Tenure mix should normally be at a 70:30 social rented : intermediate housing ratio (*CD11 pages 53, 54*).

5.16 Additional policies relevant to the proposal are identified in the Statement of Common Ground (*Document 29 Appendix 18 para. 15*).

Supplementary Planning Guidance (SPG)

5.17 The purpose of the SPG for Canada Water is to establish a framework for the future development of the Action Area (*CD35*). Adopted in February 2005 after several phases of public consultation, the SPG includes further guidance and clarification on the strategy and policies in the UDP and the draft UDP as they apply to the Action Area and the key development sites. Referring to Site E, proposal site 31P, it notes the UDP does not provide a designation. It then states that the draft UDP (2004) designates the required use of the site as employment (B class) and that other uses are not acceptable.

5.18 The Affordable Housing SPG 2002 provides an updated interpretation of UDP policies in light of Government advice and research and guidance on how the UDP policy should be implemented. Where affordable housing is to be provided on site a minimum of 25% of the gross increase in the residential content should be made available as affordable accommodation (*Document 86 para. 2.11*).

National Planning Guidance

5.19 Relevant Planning Policy Guidance (PPG) includes PPG3: Housing, PPG4: Industrial, commercial development and small firms, PPG24: Planning and Noise. Planning Policy Statement 1: Creating Sustainable Communities (PPS1) and The Planning System General Principles are also pertinent.

5.20 The companion guide to PPG3, By Design: Better places to live, illustrates how better attention to good design can enhance the quality of life experienced in peoples' home environment. English Heritage and the Commission of Architecture and the Built Environment (CABE) have published Guidance on Tall Buildings (*Document 29 Appendix 15*).

Other material considerations

5.21 Attention is drawn to British Standards and World Health Organisation guidance on noise, together with the Mayor's Ambient Noise Strategy (*CD18 - CD21*).

5.22 Reference was made to various Topic Papers produced in connection with the draft UDP (*CD27-CD29, CD31*) and also to studies on housing capacity and provision (*CD34, CD36, CD37*).

6. THE CASE FOR THE LONDON BOROUGH OF SOUTHWARK

6.1 The Council's opposition to the scheme focuses on three matters: noise, density and height.

Noise

Design Approach

6.2 The scheme has been designed with insufficient thought as to the noise context. The timing of the submission of the planning application was dictated by the Appellant's contractual obligations and the scheme progressed from brief to the application in a mere 49 days. The initial PPG24 assessment was based on a different scheme in terms of both siting and building height, at no more than 10 storeys (*Document 24 AA1 page 16*). It failed to identify any noise issues relating to the site's proximity to Harmsworth Quays. Accordingly noise implications were not considered at the design stage, despite advice from the local planning authority that noise was a matter of concern (*Document 76*). The recommended sequence in BS 8233 was not followed (*CD19 para. 5.1*). The position did not change prior to the submission of amendments, which form the basis of the scheme under consideration by the First Secretary of State.

6.3 The Appellant's failure to understand the noise context of the site at higher level, where bedrooms are proposed, was again evident in February 2004. Apparently because of availability of equipment, noise readings were taken at a height of 15 metres, even though block C would be 45 metres in height. The data was analysed only at 1 hour intervals. In June 2004 the Appellant had the benefit of the noise report prepared on behalf of the Council. Even so, the Appellant rejected the recommendation of its own noise consultant that the scheme be redesigned so that bedrooms on floors 1 to 11 of block C be taken out or relocated[2].

Noise Context

6.4 The Council's analysis of the high level noise survey establishes that the noise at 34 metres is of a different character to that at ground level. The measured noise levels between approximately 0100 and 0530 hours showed a distinct intermittent pattern of variation based on a repeated short term cyclical fluctuation with rapid onset and decline (*Document 8 para. 4.7*). Therefore as one moves up the façade of block C the mix of noise changes. The road traffic noise from Surrey Quays Road attenuates and the noise from air chillers on the façade of Harmsworth Quays becomes dominant (*Document 8A Appendix B*). The other element of the noise climate which has not been evaluated by the Appellant is the intermittent noise described in detail in the evidence of HQP. Neither component of the noise climate informed the design.

Policy Approach

6.5 PPG24 advises that the character of industrial noise, as well as its level, should be taken into account. The Noise Exposure Categories for dwellings (NECs) contained in Annex 1 to PPG24 should not be used for assessing the impact of industrial noise on proposed residential development (*CD6 para. 3*). At high level the noise levels measured at night are dominated by the noise from a cyclical event, an industrial noise source (*Document 8 para. 4.8*). Thus the Appellant's attempt to use the high level readings, which reveal the industrial noise components, in an analysis based on NECs is flawed and contrary to the

[2] Evidence of Mr Arnold, the Appellant's noise consultant, in cross examination.

approach set out in PPG24 (*Document 23 para. 5.78*). Moreover, the Appellant's analysis failed to acknowledge the characteristics of the noise climate identified at high level, relying instead on their own acoustic survey that revealed no intermittent or tonal components (*Document 23 paras. 5.52, 5.53*).

6.6 BS 4142 is the appropriate standard for assessing industrial noise. This is clear from the references in PPG24, namely footnote 3 to the table in Annex 1 and Annex 3 paragraph 19. BS 8233 also directs the use of BS 4142 where industrial noise affects residential areas (*CD19 para. 6.5.2*). The Appellant relies on the recommended internal noise levels from Table 5 in BS 8233 as suitable targets to be achieved within habitable rooms in the proposed development. However, BS 8233 advises that these noise criteria apply to steady, anonymous noise (*CD19 para. 7.3*).

6.7 The purpose of the BS 4142 standard is to measure the noise at the outside façade of a building to assess whether the noise is likely to give rise to complaints from those inside the building. It is intended to be used with existing and new industrial premises. Applying the BS 4142 methodology, whereby the measured background noise level is subtracted from the rating level, a difference of +9 dB is obtained (*Document 8 paras. 4.11-4.12*). A difference of around +10 dB or more indicates that complaints are likely. The Appellant did not challenge the accuracy of the Council's measurements at 34 metres, the description of the character of the noise as industrial, non-steady and non-anonymous, the BS 4142 methodology used or the result that complaints would be likely at night. It was accepted that BS 4142 would be the standard used to investigate the legitimacy of any complaints were the development to be built. There was no challenge to the applicability of BS 4142 where noise of an industrial nature is found to be dominant.

6.8 The Appellant belatedly carried out a BS 4142 assessment, producing a result of -2 dB (*Document 27 para. 5.21*). However, it was accepted in cross examination that allowances should be made for all the chillers working, lack of screening and a canyon effect. On this revised basis the analysis produces a BS 4142 assessment of +12 dB, demonstrating complaints at night would be likely.

Other noise matters and conclusions

6.9 In respect of traffic noise the Appellant has relied on the use of a single figure assessment process for considering noise mitigation measures, including the sound reduction performance of glazing, windows and passive ventilation. Such an approach is relatively unsophisticated, in part because it does not take into account the frequency spectrum of the noise affecting the façade. There is a risk that the degree of sound insulation required to achieve the acceptable internal levels would be under-estimated. A more rigorous method should be used for a project of this kind. Nevertheless it is accepted that closed windows and enclosure of balconies would produce a significant reduction in noise. This type of mitigation can be acceptable for traffic noise because the noise source is self-evident to the occupier and the local authority has no legal powers of mitigation available, unlike the position with industrial noise. Enclosure of the balconies would affect the external appearance of the building and would be inconsistent with achieving an exemplary standard of design.

6.10 The Appellant sought to rely on conditions imposed on Harmsworth Quays to regulate noise. However, the overarching planning permission relating to the premises did not contain any conditions protecting residential development on the appeal site from noise. Any specific planning conditions for equipment can only regulate the development which they permit and there are no conditions specific to the air chillers. A range of noise events and changes could occur without the need for planning permission[3].

6.11 The design has proceeded in ignorance of a proper understanding of the noise climate at higher levels and this element of the noise climate must be a material consideration of real significance. The only robust basis for evaluating the noise impact at higher level is by carrying out a BS 4142 assessment given the character of the noise identified. It is common ground that the BS 4142 assessment produces the result that complaints are likely at night in respect of some parts of the façade of block C. This has not been addressed in the scheme. In addition the scheme has not taken any account of the impact of intermittent noise sources. This represents bad planning that would create problems for the future.

Density

6.12 The imperative to maximise the supply of housing is not absolute but as accepted by the Appellant, it should be achieved in a way which respects the local context[4]. This balance is enshrined in the applicable policies at national and local level, namely in PPG3, the London Plan through Policies 4B.1 and 4B.3 and Policy 3.10 of the draft UDP. As stated in the draft UDP "densities that are too high have a negative impact on the environment and on quality of life and are therefore a poor use of land" (*CD11 page 39*).

6.13 The density of the scheme at 1072 hr/ha is at the top of the range for a central setting in the density matrix in the London Plan (*CD8 page 177 table 4B.1*). In the draft UDP the site, within Canada Water, is in the urban zone and also a PTAZ, a classification that the Mayor has not objected to. The policy indicates that densities which exceed the urban zone densities, 300-700 hr/ha, would only be appropriate on some sites. Within this policy context it is a misconceived approach to proceed on the basis that simply because the site is within the Canada Water Action Area densities in excess of the urban range are necessarily appropriate, let alone a density at the very top of the central density range.

6.14 The site is not highlighted as suitable for a landmark development of higher density in any of the relevant planning guidance, a matter accepted by the Appellant. It ranks well behind other sites in the hierarchy of development sites within Canada Water, which are adjacent to or in very close proximity to the tube station or which front the Canada Water basin. The site does not have the strategic significance of these other sites. The way the design emerged and the piecemeal revisions illustrate that the context and setting were not properly addressed at the design stage. The scheme falls well short of achieving exemplary design and an excellent standard of accommodation, which are required for exceeding the densities in the urban range. It is a matter of judgement for the First Secretary of State as to whether or not the level of contribution offered by the Appellant may be described as significant in the context of the environmental and transport priorities identified in the Canada Water SPG (*CD35 page 30*).

6.15 Referring to the criteria for a central setting as set out in the London Plan, Canada Water is not an area characterised by very dense development. Buildings with large footprints are low rise retail units and buildings in the vicinity are not generally four to six storeys and above. The exception is Harmsworth Quays but this is not a building typical of a larger town centre. Canada Water has the status of a district centre and a location within

[3] These points regarding planning conditions were accepted by Mr Arnold in cross examination.
[4] This point was accepted by Mr Crosby, the architect of the scheme and Mr Brisbane, the Appellant's planning consultant, in cross-examination.

the Central London sub-region, which applies to most of Southwark, does not bestow a central setting. Similarly good transport links, which are contemplated for both urban and suburban settings, do not mean the site is within a central setting. Reliance on the GLA character map is misconceived given that it was a desk-top study, meant as a starting point for more detailed work (*CD34 para. 5.13*). In any event the map shows the site within an urban location (*Document 68*).

6.16 The expressions of the vision for Canada Water in the SPG and the draft UDP are not consistent with the proposal for the site in terms of density range, scale and design. The proposal is too much development in the wrong place. Furthermore, the master plan document[5] cited by the Appellant contemplates 'mid-scale courtyard style housing suitable for larger families with generous internal spaces' for the area of the appeal site (*Document 29 Appendix 16 page 141*). The Appellant's reliance on the permitted density of the development for Site D is a further illustration of the flaws in the design approach. The appeal site is much more constrained by reason of its proximity to Harmsworth Quays.

6.17 The limits on peak time capacity and congestion on the Jubilee line are a further material constraint on a density at the top end of the range (*CD10 page 31 CD35 page 8*). The proposed improvements need to be treated with caution in the absence of any evaluation of the likely calls on any planned increase in capacity.

6.18 For all these reasons the Council's objection on density and over-development should be upheld.

Height

6.19 Policies 4B.8 and 4B.9 of the London Plan are supportive of tall buildings in the right locations and where the highest standards of design are met. Large scale buildings are to be suited to their wider context. As illustrated by the evidence on the design process, the proposal does not match the highest possible standards of design. Similarly, the proposal is inconsistent with the local policy context as adopted and as it emerges in conformity with the London Plan. Policy E.2.2 of the UDP makes clear that Southwark is not considered to be an appropriate area for high buildings and the guiding criterion is that new developments should 'fit in with their surroundings'. The development is not located in a position or context envisaged for tall buildings by the draft UDP. The Canada Water SPG, supported by community consultation, states the area is not considered suitable for tall buildings. Additional height may exceptionally be allowed subject to criteria on some sites. In summary, the policy context does not support a tall building of this height in this location.

6.20 The immediate surroundings are characterised by comparatively low rise development in the two Decathalon retail stores and the Mulberry Trading Centre. Harmsworth Quays is the exception but its impact is clearly mitigated by its distance from the road. The development on Site D will comprise mainly 6 to 8 storey blocks with a single 10 storey block on Canada Street. Beyond to the west lies a residential development which ranges in height from 4 to 7/8 storeys. In contrast, the bulk of the proposed development would be substantially higher than any of its neighbours and out of character with its surroundings.

[5] In his evidence in chief Mr Brisbane considered that the vision for Canada Water anticipated a range of building heights and quite high density development. As one illustration he referred to a master plan being prepared by British Land that anticipated densities of 900-1000 hr/ha. (*Document 29, table at page 145*). He accepted in cross examination that the master plan document has no status as a development plan document.

6.21 The design objective of seeking to screen Harmsworth Quays is not inappropriate. This objective would be achieved with block A, at 10 storeys. Block C would provide some screening too but it would rise to 15 storeys, well in excess of the height of the print works. Sited almost on the back edge of the footway it would be over-dominant and out of scale with its surroundings. It would create its own adverse impact. Block B, sitting in front of block A and to the west of block C would make no contribution to this mitigating measure.

6.22 The further design justification for the proposed height of blocks B and C relies on the alleged need to provide a landmark building. As made clear in the discussion on density, the appeal site does not have strong landmark characteristics when compared with other sites in Canada Water. It is not located in a prominent position on Surrey Quays Road. It does not have any special characteristics that differentiate it from any of the other three sites at the junction of Surrey Quays Road and Canada Street. It is some distance from key locations in the area because it does not form part of the shopping centre, nor is it within the immediate environs of the tube station. The site is unlikely to be visible from the entrance to the tube station in the future as sites with greater prominence and accessibility will be developed. The appeal site would be in the background, not a focus.

6.23 The design approach also took the permitted office scheme as a clear precedent. The fall back is a material consideration but, as accepted by the Appellant, the weight to be attached depends upon the likelihood of the permission being implemented. In Southwark as a whole there is more than enough office space in the pipeline to meet future needs. There is no market for office space in Canada Water and no strategic justification for promoting large scale office development there (*Document 10 Appendix 5*). It is common ground that the permitted office scheme will not be implemented. There has also been a material change in policy circumstances. In November 2002 the First Draft UDP accepted that tall buildings would be appropriate in the Action Area. Now reflecting the London Plan, the more advanced draft UDP and the adopted Canada Water SPG do not provide such support. Little weight if any should be given to the extant permission. The acceptability of the height of what is proposed should be judged on its own merits, having regard to its use, design and impacts.

Housing Supply

6.24 The Appellant has sought to justify the proposal by reference to alleged shortcomings in the housing supply in Southwark. However, in cross examination the Appellant confirmed that it is not being contended that the housing need case could be used to outweigh any defect in the appeal scheme, such as inadequate design. Also, no case is being advanced that there is an unmet housing need that requires the delivery of any particular number of houses from the appeal site at all.

6.25 The UDP inquiry is the appropriate place to advance a detailed housing need case in a plan led system. To rely on partial information could be misleading, as demonstrated by the Appellant's evidence on completion rates. The latest analysis shows that Southwark is on course to exceed its housing targets set out in table 3A.1 of the London Plan (*CD8 page 56, CD28 page 12*). The Appellant's contention that housing targets for Southwark will increase when the 2006 review occurs is conjecture at this stage. In this context the suggestion of serious under-performance in the delivery of housing is greatly overstated and not robust.

7. THE CASE FOR HARMSWORTH QUAYS PRINTING LIMITED

7.1 Harmsworth Quays Printing Ltd (HQP) occupies a substantial printing, publishing and distribution premises within the central industrial/commercial core of Canada Water. (*Document 45 Appendix D*). HQP became operational in 1988 and since then it has invested heavily in plant, machinery and buildings. Major plant comprising air cooled chillers and a plant room are located towards the northern corner of its building on a raised deck (*Document 38 Fig 1*). HQP does not wish to relocate. Planning permissions have been granted to enable the processes and businesses to expand (*Document 45 Appendix A*). Planning conditions regulating noise from Harmsworth Quays on the initial permission dated 1986 were framed by reference to residential properties in existence at that time, a minimum of 135 metres away and have been so exercised ever since (*Document 38 paras. 6.1-6.9*). Presently there is no residential development as a neighbour along its boundaries.

7.2 Four principal functions are carried out from the site, namely printing various titles, high speed bagging, Metro editorial and distribution of printed material. The Daily Mail, Mail on Sunday, Evening Standard and the Supplements of these titles are all produced at HQP. Two new presses were installed in November 2004, increasing the number of printing presses to eight. The site functions 24 hours a day, 7 days a week all year. Maintaining the maximum flexibility in the use of the site is essential to the process because of the time sensitive nature of the operation, the competitive nature of the industry and the need to maximise the use of the expensive equipment. The original permission limited the use to printing and publishing and given the intensity of the activity there is no doubt that it is a Class B2 general industrial use. HQP is a major employer, with 1,142 employees on site in November 2004[6]. The company's business plan envisages significant further growth and intensification of the use.

7.3 The main entrance to the premises is in Surrey Quays Road, an important factor when considering the noise environment for residents on the appeal site. Surveys carried out in 2002 and 2004 show an increase in traffic, including an increase in HGV movements, equivalent to 19% a year. The period from 2200 to 0500 hours is particularly busy, this being the time when the Daily Mail and Mail on Sunday are being distributed. (*Document 45 Appendices E, F, G*). The increase in HGV and MGV movements is again reflected in surveys carried out in December 2004 and January 2005 (*Document 47 para. 4.5*). The rise in HQP traffic is attributable to the growth in the company's business and is expected to continue.

7.4 Under the UDP Harmsworth Quays is located within a designated Regeneration Area. It is part of a designated employment area numbered 32 in the Proposals Schedule subject to Policy B.2.1. It is also protected for employment use by Policy B.1.1.

Impact of proposal on area character

7.5 The proposal is for very substantial development characterised by tall and large scale buildings. Such proposals should be closely scrutinised as part of the planning process and be judged against the highest standards because they impact over a wide area and the consequences of mistaken planning judgements are very large. The policy framework relating to tall and large scale buildings, in the EH/CABE document and the London Plan, reflects this in-principle position. Policy is relevant and up-to-date and gives rise to a

[6] Mrs Robinson, the planning witness for HQP, explained that the 1142 does not include drivers employed by 3rd party haulage companies but it does include drivers of the 155 Evening Standard vans.

series of criteria. Some go to the adequacy of the presentation necessary to support a grant of permission, others to the substantive quality of design which is a prerequisite of a permission.

7.6 The advice in the EH/CABE document on the representational material necessary to support a successful application for a tall building is unambiguous (*Document 29 Appendix 15 paras. 3.2, 3.3*). It has to be of a scope, quality, clarity and detail to enable a proper assessment of the architectural quality of the building and its effect on the immediate and wider context. The presentation of the scheme at this Inquiry is wholly inadequate to allow such judgements to be made. Only one photomontage reflects an existing real vantage point (*Plan W*). The quality of the resolution associated with the photomontages is poor and all photomontages are significantly inaccurate in their depiction of the existing context, a key element in any planning determination. The scheme architect accepted that the representations were not produced to meet requirements of the type identified in the EH/CABE guidance.

7.7 Policy deliberately requires all tall and large scale buildings to be of exemplary design, to set a design example which can be admired and copied by future generations. Architecture adequate to other circumstances will not do. Failure to meet the very highest standards of design would mean the proposal would fail its single most important policy test and should not be granted permission. This was accepted by the scheme architect on behalf of the Appellant.

7.8 Exemplary design derives from and responds to a proper understanding of context. In this case the programme for the submission of the planning application and its underlying design content was driven by a contractual imperative, not by the desire for architecture of the highest quality. The architect was given about 7 weeks to produce a scheme of the highest quality. Much of the information crucial to a proper design at this location was not available until well into the design process.

7.9 The architect specifically designed the building to be a beacon, a landmark of significant status in the area. In planning policy terms there is no support for a landmark building in this location at either strategic or local level. Functionally and visually the site is on the periphery of the Action Area. A predominantly single residential use building in such a location does not require to be marked by a beacon, nor is there justification in terms of visibility from the tube station and the ordinary principles of legibility. There is no rational requirement for a tall landmark building in terms of the position of the site now and in the future. It would harm the prospect of achieving a townscape focus at the heart of the Action Area around Canada Water itself and hence undermine the emerging vision for the area.

7.10 The wider setting of St Paul's Cathedral is protected by the development plan. At the time the building was designed the architect incorrectly understood the development plane began at 50 metres and hence he designed to that height. Exemplary architecture is not consistent with this type of misunderstanding and no design imperative is advanced requiring the WSCA plane to be breached by almost 20 metres.

7.11 There is no support for the designer's reliance on the office permission to set the building height. All parties agree there is no prospect of the permission being implemented and hence the fallback carries no weight. The policy matrix for the Canada Water area has moved on. The vision for the area is to be given significant weight, even on the Appellant's own evidence. An architectural focus on the periphery is not consistent with that vision. Policies on tall buildings have become more rationalised and focused, seeking to guide tall buildings to appropriate locations. On the Council's evidence the office application would be treated differently today.

7.12 The design has been a function of density, rather than density being led by high quality design. This has resulted in 3 blocks monolithic in effect. Whilst there is a different form of architectural treatment for each block it is not of such variety to relieve the mass of the scheme. Block A, in particular, has a grid like formulation, the elevational treatment monotonous in the disposition of windows, balconies, bays and panels and relieved only to some extent by the use of materials and colour. Overall, the use of colour is inconsistent and would not appear to reflect anything else in the area. The roof forms of blocks B and C would have some interest, but in the case of block C the roof slope would be compromised by the building elements springing from it. The base of the two blocks is unresolved, the plans showing the mass of the buildings placed above a narrow ground floor plinth and columns. The buildings would appear awkward in reality. The proposal also fails to provide any active frontages, a consequence of the uses, the lack of any articulation or openings and the functional separation from the public realm by the landscaped area. At first and second floor the intention now is to enclose the balconies along the entire Surrey Quays Road frontages and along some part of the returns. This last minute alteration to achieve the required standards in relation to noise will not be an acceptable townscape element and again does not demonstrate exemplary design.

7.13 There would be a poor inter-building relationship, evident in the flank elevation of block A sited 10 metres from the press hall at HQP. The design aims to use this elevation to attenuate the noise from HQP but the elevation at 10 storeys high would be of monumental character. Similarly the elevation facing the Mulberry site would be monotonous and unattractive. It is a specific requirement of Policy 4B.9 of the London Plan that large scale buildings are attractive city elements as viewed from all angles. This requirement recognises redevelopment may occur in the future and its importance is illustrated by the fact there is a proposed mixed use/residential scheme on the Mulberry site.

7.14 The UDP policy on density, H.1.7, is greatly exceeded and the circumstances envisaged for exceptions to the policy do not arise in the appeal location. The proposal is at the top of the density range identified in the London Plan for the most central, most accessible and least constrained sites in London. The site is properly identified as urban, even in its aspirational form and is not lacking constraints. The attempt to deal with these constraints, unsuccessfully, and to achieve the highest central area densities in such a short space of time, has led to a poor design.

Impact on the local environment

7.15 The proposal is insular and inward looking by design. The blocks have little connection with the public realm and the scheme would not aid the general permeability of the area. This aspect would be contrary to the EH/CABE requirement that opportunities should be taken to improve legibility of the city and wider townscape (*Document 29 Appendix 15 para. 4.6(vii)*).

7.16 The quality of the open green space would be mean, the landscape manufactured and constrained by the deck of the basement car park. No thought at all has been given to its maintenance or upkeep. Appropriately it is intended to be available to the public. However it has not been designed to encourage such use, being insular and not on any other pedestrian or community desire line. The level of amenity for residents would be poor. For a significant proportion of the day, parts of the courtyard will be in shade thereby limiting its use. The Appellant has not sought to rely upon any sun on the ground analysis. The space looks substantial but the elements that could be used are small. On a more detailed matter, the design has not allowed for access to the private gardens from the ground floor units of block A. All these matters are contrary to the design imperative in Policy 4B.9 of the London Plan to provide high quality spaces, integrate green spaces and support vibrant communities.

7.17 There has been no analysis of the impact of the proposal upon the micro-climate, contrary to Policy 4B.9 of the London Plan. This is a serious omission in view of the 'canyons' between the tall buildings, the tall, sharp wind deflecting apex to block C and the proximity to the Thames, where London's wind speeds are at their highest.

7.18 The original contribution of £15,000 towards environmental improvements in the locality was insubstantial against the scale of the development and the £0.5 million with the approved office scheme. The unspecified and uncosted increase made during the adjournment of the Inquiry indicates the Appellant's realisation of the paucity of the sum. How it will be spent is unknown and applying the advice in Circular 1/97 it should be given little weight. Overall, a proposal that seeks to extract the maximum possible density from this difficult site would not make a good contribution to the surrounding environment.

Compatibility of use with HQP

Policy

7.19 PPG24 advises that where practicable noise sensitive developments should be separated from major sources of noise, such as certain types of industrial development (*CD6 para. 2*). In the present case there is no requirement for housing to be placed hard against the boundary of the B2 use – there is no housing shortage to justify such a juxtaposition and no townscape reason why a buffer of an alternative use could not be provided. PPG4 also advises the operation of a policy of separation when considering the specific relationship between industry and housing (*CD3 para.18*).

7.20 Policy 4A.14 of the London Plan requires the separation of new noise sensitive development from major noise sources wherever practicable. As explained in the Mayor's Ambient Noise Strategy this is because industrial noise can be challenging to predict at the planning stage. Because established industrial users are not immune from action on statutory nuisance grounds it advises that opportunities should not be lost to achieve noise control at the planning stage (*CD21 paras. 4E.12 and 4E.20*). In this case nobody has argued that greater separation between the residential and the B2 use is not practicable.

7.21 The UDP, through Policy R.2.1, accepts certain uses in the Regeneration Zone, 'unless environmental or amenity considerations indicate otherwise'. A wide range of uses is identified for proposal site 26, including B2 and residential. The Canada Water SPG provides further guidance. The SPG has been subject to full consultation, where identified it is adopted SPG to the UDP and as such it should be given full weight as a material consideration. Applying an approach of separation, the guidance in the SPG is unambiguous. Mixed use development susceptible to problems of amenity from the printworks is unacceptable. Policy R.2.1 is specifically identified as a parent policy of this supplementary guidance (*CD35 para.4.2*). There is no reason to set it aside.

7.22 The draft UDP takes the matter a stage further and indicates only B class uses ought to be acceptable on the appeal site, a matter that will be considered at the local plan inquiry. It is inevitable that some degree of buffer will be required because the principle of separation is so firmly established at national, London and local level. This is particularly the case where the SPG identifies a need for development to cater for small and start-up business units (*CD 35 para.4.2*).

Noise sources

7.23 There are three potential sources of noise generated by the industrial operation: plant noise, intermittent noise and traffic noise. When setting the framework of the design of the development the Appellant's understanding of all three noise sources was deficient and in these circumstances it is not surprising that the scheme fails to address them adequately.

7.24 The operation at HQP is industrial. Temperature control is critical to the process and air coolers are required for the process to operate. Noise emanating from them is industrial noise. The clear advice in PPG24 is that NEC noise levels should not be used for assessing the impact of industrial noise on proposed residential development (*CD6 Annex 1 para.3*). In order to gauge the impact, PPG24 directs one to the use of BS 4142 (*CD6 Annex 1 footnote to table and Annex 3 para.19*). Confirmation that BS 4142 is the correct approach is found in the Appellant's acceptance that a complaint of nuisance would be judged by reference to BS 4142.

7.25 The Council demonstrated that within the building a rating level of 9 dB in excess of the background noise level would be experienced. This evidence is uncontested as to accuracy or methodology. Complaints would be likely. If anything the assessment is conservative as it takes no account of the coolers operating at capacity, the screening effects of block B on the overall background noise and the canyon effect. HQP has undertaken a similar assessment and results are comparable. These are to be given significant weight. To say that very few residents or only a limited number of bedrooms would be affected is a weak and unattractive argument. The harming of amenities of future residents should be dealt with by proper design. It takes only one resident to succeed in an action for nuisance or to prompt the service of an abatement notice. Measures to mitigate the noise from the chillers would not be practicable because their operation would be affected by further enclosure.

7.26 The analysis demonstrates that living conditions for future residents of the proposal would be unacceptable and give rise to legitimate cause for complaint. This is by itself sufficient to dismiss the appeal. Its importance is magnified when consequences of the other elements of noise are taken into account.

7.27 The presses are a 24 hour operation and the operation needs around the clock maintenance and repair. There are doors from the printworks that open directly onto the fire alley and block C is proposed to be sited adjacent to the boundary. External areas are often busy at night. When equipment malfunctions, such as the dust extractor, noise levels can be very high. Mechanical breakdowns may involve several hours of emergency activity. The standard applicable to these intermittent noise events is 45 dB L_{Amax} as set out in BS 8233 (*CD19 Table 5 page19*) and the WHO Guidance on Community Noise (*CD18 Table 4.1 page 65*). The Appellant's suggestion that the standard is breached after it has been exceeded more than 10-15 times per night is inconsistent with the documentation and is based on a study on aircraft noise (*Document 78*).

7.28 When intermittent noise events occur, such as emergency delivery of paper, maximum noise levels have been measured at 97 and 107 dB (*Document 43 Schedule 2*). The noise levels inside bedrooms and living rooms in block C would be well in excess of the WHO levels, even with windows closed. None of the residents of block C would be screened from these intermittent noises at all. There is no planning control because there is no restriction on hours of operation and no control over the noise sources.

7.29 The plant and intermittent noise cannot be considered in isolation, the continuous plant noise having an effect upon the way occupiers would perceive the intermittent noise. Living conditions would be unacceptable from the outset and it should not be necessary to seek a remedy through environmental proceedings. In so far as such actions are unsuccessful, problems would remain. If successful, they would restrict the flexibility of the employment plant, potentially placing its long term viability in jeopardy.

7.30 For the entire frontage of the development along Surrey Quays Road the night-time traffic content of a high proportion of heavies places it within NEC C. The advice in PPG24 is that planning permission should not be granted. The site also abuts a B2 use to the rear and this has meant that the amenity space for many of the flats would be provided by way of balconies directly overlooking the NEC C noise source. On the balconies the noise levels, including those above second floor, would be well above the standard of $55L_{Aeq}dB$[7]. This is so even with the Appellant's figures, whereby the Appellant relies on flats at higher levels falling within NEC B, categorised by noise levels of 55-63 $L_{Aeq,T}dB$. There has been no analysis of whether there are any quieter sites to begin to rebut the presumption against permission set by PPG24, nor has a different design solution been explored.

Affordable housing

7.31 The UDP does not contain a policy requiring 25% of new housing to be affordable, as submitted by the Appellant. The maximum reasonable proportion is to be negotiated having regard to all the circumstances. The SPG indicates a minimum of 25%. Thus it is possible to provide 25% and still to breach the policy unless it is established that the site at 25% is providing the maximum reasonable proportion.

7.32 This policy has now to be read in the light of the London Plan and the emerging target in the draft UDP of 35%. Any eventual adopted target at 25% would be inconsistent with the London Plan since the Mayor objected to the potential for such a target at first deposit stage (*Document 29 Appendix 14 para.18 page 129*). There is no sustainable evidence upon which the First Secretary of State is able to conclude that 25% is the maximum reasonable amount of affordable housing deliverable from this site. The attempt to demonstrate this outside the Inquiry process does not alter this conclusion – the appraisal is not relied upon by the Appellant, it is now no part of the Appellant's case that the site cannot viably produce more and the appraisal was premised on a misunderstanding of the policy at the time of purchase of the site.

Wider Setting Consultation Area

7.33 The consultation package submitted to the consultees was materially inaccurate (*Document 73*). It purported to show the worst view of the proposal's impact on the WSCA with particular reference to the dialogue between St Paul's and the Wren dome at the Royal Naval College. In the images the proposal stood well clear of the Wren dome. The true position is different, the photomontages produced by Hayes Davidson being accepted by the Appellant as accurate (*Document 37*). As a result of the inaccuracies in

[7] The guideline value/design standard for balconies is contained in the WHO Guidelines (*CD18 page 65 Table 4.1*) and BS 8233 (*CD19 page 18 para. 7.6.1.2*). It is desirable that the steady noise level does not exceed $50L_{AeqT}dB$ and $55L_{AeqT}dB$ is the upper limit

the consultation exercise the First Secretary of State does not have the benefit of statutory consultees' comments on which to base a decision. The relevance is shown by the change in the stance of English Heritage on receipt of the Hayes Davidson material. English Heritage has clearly read and understood the material and has identified harm (*Document 67*).

7.34 The Hayes Davidson assessment accurately shows that a proportion of the proposed development would fall both within the WSCA and also above the 30 metres AOD development plane (*Document 37 para. 8.6 and figure 8f*). Currently the profile of the Naval College drum has great clarity, a clarity repeated in the dome of St Paul's from this vantage point. The clear juxtaposition and positive dialogue between the two domes by the same renowned architect is a condition worthy of preservation. The proposal would interfere with the visual dialogue by directly impinging on the base of dome of the College, thus having an adverse impact upon the strategic view. There is no need to encroach into the WSCA and the degree of harm would be sufficient to warrant dismissal of the appeal.

Prematurity

7.35 The number of objections made by the Appellant in relation to the draft UDP indicates the significant extent to which the scheme cuts across emerging policies and the vision for Canada Water. To grant a permission would almost certainly prejudge decisions made through the local planning process on density, height, juxtaposition of uses and the shape of a vision over a wide area. This falls squarely within the parameters permitting refusal on prematurity grounds set out in General Principles (*CD38*).

Conclusion

7.36 The design was driven by a contract, not good planning, which led to omissions and misunderstanding of policies. It is a greedy development that fails to respect the context and character of its surroundings. As a result the scheme displays poor architecture and an unacceptable juxtaposition of uses and should be rejected.

8. THE CASE FOR THE APPELLANT CONRAD PHOENIX (CANADA WATER) LTD

Background and scheme design

8.1 The aims and aspirations for redevelopment of the site were:

- To provide a predominantly residential development incorporating community uses with adequate on-site car parking;
- To achieve a high residential density offering a full range of unit sizes and types appropriate for a central and highly accessible location;
- To provide affordable housing in accordance with the Council's policies and local housing needs;
- To provide highly accessible space to accommodate a range of community facilities targeting child and health care and community offices;
- To create buildings and 'a place' to provide a statement appropriate for their location and also to act as a landmark;

- To create a scheme of the highest architectural quality and to be the initiator of the redevelopment of the Canada Water Action Area. (*Document 13 para. 2.1*).

8.2 The initial brief was for predominantly housing although there was no aversion to other uses. A variety of uses were considered. There is no demand for B1 office use and if combined with a residential use there would not be the necessary prominence and visibility. The site is not big enough to mix residential and light industrial uses because of amenity problems. There would be no demand for A3 and A4 uses because of the peripheral location. Following dialogue with the community, contact was made with the primary health care trust. This established there is an urgent need for consulting rooms and that the trust would be very interested in Site E. A local history society has also expressed interest in occupying some space. Therefore provision has been made for some 1,150 square metres of community space on the ground floor of blocks B and C. These uses would provide an active frontage with beneficial movements wholly appropriate for the location.

8.3 The scheme design was informed by a number of design objectives, policy requirements, the challenging site setting and its constraints (*Document 13 paras. 2.2 to 5.4*). In the area around the Canada Water basin the scale and footprints of the buildings, both residential and commercial, are generally much larger than the more intimate texture of the surrounding residential areas. The area around the basin is somewhat bleak, lacking a focus and a heart. Harmsworth Quays dominates the skyline and Site E sits uncomfortably in its shadow. To address these characteristics redevelopment needs to be substantial and powerful in physical form with a clear identity. The extant planning permission for a part 6 part 11 storey office building on the site and the permission for a 1100 hr/ha residential development on Site D established a clear precedent for the appropriate height and massing (*Document 16 pages 26 and 27*). Redevelopment of Site E offers the opportunity to mitigate the adverse impact of Harmsworth Quays on the area. Furthermore because the site lies on a natural sight line from the tube station the provision of a statement building in a landmark location would start to address the lack of legibility and focus in the area.

8.4 The general strategy is to group linear building forms around the perimeter of the site tight to the boundaries, thus forming an internal protected courtyard (*Document 15 figure 15*). The two linked buildings forming block A, rising to 10 storeys and single aspect, would isolate the site from the overbearing presence and dominance of Harmsworth Quays. There would be no merit in opening vistas towards the unattractive and forbidding flank wall of the print works and single aspect housing is a valid solution for the site. With block A providing the buffer and a backdrop, the other buildings on the site are dual aspect. Block B lowers itself and has full regard to the nearby residential development in Canada Street, avoiding any overshadowing or encroachment on privacy. It rises up to a prominence at the junction and then falls to provide balance around the pivotal centre of the building and the gateway to the central courtyard. Block C is designed with a curved sloping roof and sharp leading bow. It would give direction and orientation from the station and create the beacon and excitement that the area sadly lacks.

8.5 The scheme is broken down into clearly separate and identifiable articulated elements. The storey heights and external elevations would be of a human scale. The elevations on all blocks comprise an assembly of carefully proportioned elements arranged in a balanced formation to provide interest and harmony, whilst avoiding spurious ornamentation. Constructed as framed buildings with a cladding system the approach to the external finishes envisages hard concrete and masonry materials on the rear boundaries, cool finishes on the highway frontages and soft finishes on the internal courtyard elevations. The scheme would provide excellent daylighting, privacy and amenity to all units and avoids overshadowing (*Document 17 page 13*).

8.6 The three blocks would combine into a coherent and unified entity around a generous landscaped courtyard, with vistas and paths penetrating the central open area. Permeability of the internal courtyard space is addressed by the two storey high portal at the corner of Canada Street and Surrey Quays Road and it is envisaged that the entry would include a form of public art. Additional permeability allowing views and access through the site is provided in the space between blocks B and C. The scheme also allows for connectivity with Canada Street and Surrey Quays Road from any of the flat access points, these routes providing direct access to the surrounding facilities. Furthermore, the external public spaces and facilities at street level would re-establish a 'live' street frontage in Surrey Quays Road and allow the public realm to extend into the site. A wide landscape strip, incorporating tree planting, would provide a soft green band around the site frontage. This positive contribution to the surroundings at street level would create vitality and a sense of place.

8.7 In terms of proportion, composition and in relation to adjoining buildings and streets the development would fit comfortably and positively into its setting. The scheme complies with the criteria of Southwark's policies and guidance, policies in the London Plan on tall and large scale buildings and the criteria set out in the EH/CABE's guidance (*Document 13 paras. 7.19-7.21*)

Residential use on Site E

8.8 The site is previously developed land in a highly sustainable location, close to very good public transport, shopping and leisure facilities, all of which are planned for improvement. It is therefore a first preference site at the top of the sequential hierarchy, where residential development is encouraged by policies at all levels. The current retail warehouse use is a waste of a well located resource.

8.9 The only potential obstacle to residential redevelopment is the presence of HQP. In response to objections from HQP the Council has proposed to alter the draft UDP. In the Final Changes the only acceptable use of the site is for B class uses, although the Pre-Inquiry Changes still refer to potential residential provided there is an employment buffer. In the adopted SPG the site is an employment site, reflecting the stage reached in the evolution of the emerging UDP. However there is no evidence of any need or demand for B class use. Both the Council and HQP accept the extant planning permission for offices is unlikely to be implemented. Accordingly, this is the type of site that the recent revision to PPG3 envisages should be released for housing. The only reason for the employment allocation is the assertion that noise from HQP precludes residential redevelopment because the site is too small to accommodate a buffer between housing and HQP (*CD27 para. 4.4.11, CD35 para. 4.2*)

8.10 The evidence from all parties is that noise from HQP does not preclude residential redevelopment. Site E is part of a wider designation in the UDP, site 26, where one of the acceptable uses is housing. The Council has no in-principle objection to residential development (*Document 29 Appendix 18 para. 14*). The Council's evidence confirms residential is acceptable provided that it is protected from HQP (*Document 8 para. 2.2*). The HQP's witnesses did not contend that residential redevelopment was precluded (*Document 44 para. 4.13*). Furthermore it is no part of the Council's or HQP's case that the residents of some 248 flats in block A and /or block B, or that those parts of block C which face away from HQP, would be unacceptably affected by noise from activities on the HQP site. As for the façade of block C alongside the boundary with HQP, the case made against the proposals concerns one bedroom window on each floor. In view of the no in-principle objection to the entirety of Site E being redeveloped for residential the weight to be given to the draft UDP and the SPG falls away.

8.11 The housing situation is severe. The requirements are set out in the London Plan. The annual housing requirement in Policy 3A.1 is 30,000 additional homes. The minimum interim requirement until 2006 is 23,000 homes per annum. Southwark has the second highest annual requirement of 1480 per annum. The Borough is urged by Policy 3A.2 to exceed the minimum figure and by Policy 5B.1 to maximise the provision of additional homes. To date the Borough has accumulated a 1262 shortfall against the interim minimum figure (*CD36 pp.8&9, table 4.3*). Southwark is heavily dependent upon windfalls, the release of employment land and residential redevelopment in the Canada Water Action Area in order to try and meet the interim housing requirements set by the London Plan (*CD36 pp.17&24, CD28 p.12*). Site E meets all these criteria. Increased densities are also a pre-requisite (*CD28 p.20 para.4.3*).

8.12 It is certain that when the interim figure is reviewed in 2006 the requirements will increase. An independent research paper commissioned by the GLA identifies an annual requirement of some 35,400 dwellings (*CD37 p.13*). London has to meet its own housing needs otherwise greater housing pressures will be exerted in the rest of the south east.

8.13 In all these circumstances it is important that opportunities presented by Site E are not foregone. The Mayor advised the new housing would be an important windfall and welcome contribution to housing supply in the capital. In addition the proposed housing mix, with 297 or 93% comprising smaller units, is a good fit with the latest assessment of housing need.

Noise

8.14 HQP's concern is that noise nuisance complaints would require the business to be run in a different way, not that it may lead to the overall closure of the operation[8]. In terms of statutory nuisance, best practical means may be relied on as a ground of appeal against an abatement notice or as a defence to a prosecution for a breach of a notice. Best practical means relate to the business remaining in situ (*Document 93 at 40C-41H*). As to the ability of individuals to bring a private law action, there is a long established tradition in common law that the nuisance must be judged in context, so that residents living near to an industrial area are expected to be more tolerant that those living in a residential area (*Document 92 at 733*). Case law has also established that causing disturbance to sleep is not necessarily a common law nuisance and the whole situation must be taken into account, including whether WHO guidelines are met (*Document 92 at 737,738*).

8.15 Virtually the entirety of the scheme has passed rigorous technical analysis unscathed. Accordingly there is no basis for insisting that residential development be physically separated from HQP, especially when there is an ever-increasing need for housing. The protection of residents on Site E can be achieved by design. The HQP building has been designed to ensure that there is no noise break-out and hence the noise at issue arises from activities outside the building, such as vehicles manoeuvring and plant noise. None of the noises are unique to industrial premises nor are they especially industrial in character.

[8] This statement is based on the evidence of Mrs Robinson in cross examination

They are found at other types of premises, such as retail superstores where the principle of separation from residential is not applied.

8.16 In respect of noise from activities on the HQP site, the issue only relates to one bedroom window per floor on the block C elevation facing HQP. Even then the issue arises from a high level noise measurement at 34 metres which has picked up noise from the air chillers at the far end of the HQP building. At worst only 7 windows would be affected, taking account of the floor plans and the attenuation shown to occur lower down the building by the measurements taken at 15 metres (*Document 24 AA4*). The issue would only arise at night.

8.17 As to which BS applies to the situation, PPG24 refers to both BS 4142 and to BS 8233, the latter on the basis that it gives advice on acceptable noise levels within buildings. BS 4142 is a standard of comparison and, as stated in PPG24, used to assess the likelihood of complaints with a new industrial development, not an existing industry (*CD6 Annex 3 para. 19*). Therefore it must be used with great care. A BS 4142 exercise shows that in certain circumstances, the one bedroom window on a few, not all, the floors would be affected. BS 8233 suggests that with the window shut and thermal double glazing the inside noise level would be 25 dBA, compared to the standard of 30-35 dBA for bedrooms (*CD19 page 19 Table 5*). The internal environment would be satisfactory and there is no basis for concluding that sleep would be disturbed. The details of the type of glazing and ventilation can be dealt with by condition. If there were to be complaints HQP could take further steps to attenuate the noise from the air chillers.

8.18 The noise events in the fire alley between the HQP building and the site boundary are either exceptional or infrequent. Residential use is not inhibited in view of the NEC B categorisation. Again only one bedroom window on a few of the floors is in question. For some of the more extreme events there is the potential to cause sleep disturbance, although research suggests the event would have to reoccur on several occasions to do so (*CD18 page 46*). If complaints were made HQP may well have to alter their activities. There is no evidence that HQP would have to incur excessive or unreasonable expense and / or take excessive or unreasonable steps. Were HQP to propose extensions in the future, planning permission conditions would be able to ensure protection of the amenity of residents in the same way that conditions have been imposed in the past (*Document 23 pp.12-14*).

8.19 In relation to traffic noise, there is no dispute that the site is NEC C. As the Council acknowledged, Southwark does not have an abundance of NEC A and B sites and so it cannot afford to preclude the use of NEC C sites for housing (*Document 8 para. 4.6*). There are already hundreds of flats built or under construction along Surrey Quays Road. HQP heavies[9] do not predominate in the traffic along the road during the day or night (*Document 71*). There is no basis for excluding buses from the calculations, as HQP have done (*Document 79*). There is no issue about the acceptability of the internal noise environment within the flats facing Surrey Quays Road. If it were considered that the proposed balconies on the lower two floors should be enclosed to meet BS guidance for acceptable noise conditions, the matter could be dealt with by condition. The suggestion that balconies at higher levels would benefit from enclosure is based on measurements taken at a wholly inappropriate location on the HQP site near to the site entrance (*Document 27 para. 5.13*).

[9] The term 'heavies' was used at the Inquiry to describe HGVs plus MGVs and buses.

8.20 The use of single figures in the assessment of glazing is normal practice at the stage of a PPG24 assessment. At the detailed design stage full octave band data would be used for the design of the external building fabric. The use of closed windows would only be necessary at certain times and would be within the control of the occupier.

8.21 Very little turns upon noise from activities on the HQP site. Placing it in context, Site E has been identified for Class B use in the draft UDP and SPG when it is just across the street from a large residential scheme on Site D. This illustrates that industry like HQP is not fundamentally irreconcilable with residential neighbours and that heavy vehicle movements along Surrey Quays Road are not incompatible with the residential development alongside it.

Density

8.22 Density is a planning tool intended to prevent any undesirable consequences which can arise from over-development of a site. The policy imperative is to maximise the utilisation of brownfield sites in sustainable locations, as set out in PPG3 and Policies 4B.1 and 4B.3 of the London Plan.

8.23 The recognition of the need for significant intensification is reflected by the shift in policy in Southwark. The UDP refers to densities of 175-210 hr/ha. The draft UDP sets a range of up to 700 hr/ha for urban zones and potentially higher in the PTAZ. Canada Water is an Action Area of strategic significance to London. It is highly accessible and the Jubilee line is scheduled for improvement (*Document 32 Appendix 1 pp.2-6*). There is no evidence that the density level for the urban area is set by reference to the peak hour capacity of the Jubilee line, nor any evidence the scheme would have a significant effect. The SPG identifies Sites A, B and C as potential higher density sites and Site D is underway at a similar density to the appeal proposals. Site E is within a few minutes walk of the bus/tube interchange and the town centre. To describe is as peripheral does not make sense in planning terms. The SPG, adopted in advance of the adoption of the Southwark Plan, has not been through any independent scrutiny and earlier drafts advocated higher densities. In the officer's report on the proposal in 2003 the density for Site E was considered acceptable. In June 2004 officer advice was that the high density was consistent with the emerging plans for Canada Water (*Document 29 page13 para. 5.9 and at page19*).

8.24 The recognition that Canada Water is potentially appropriate for higher densities is broadly consistent with a categorisation of the area as Central, rather than Urban in London Plan terms. This categorisation is based on the characteristics of the area today and the denser Canada Water that will be the inevitable result of making better use of this sustainable area. Referring to the general characteristics of a Central area, the central and eastern part of the Action Area is dominated by buildings with large footprints. Buildings of more than four to six storeys are a common and prominent feature and include the residential blocks on Surrey Quays Road and the tower blocks near the tube station. The Surrey Quays shopping centre is a large centre with 'major centre' attributes, as indicated by the total amount of retail floorspace and the large amount of comparison floorspace (*Document 81, Document 29 Appendix 17 page 149*). It is a centre planned for further growth and a step up the hierarchy.

8.25 The GLA in 2001 assessed much of Canada Water as Central, Surrey Quays Road being the boundary with the Urban area (*Document 68*). With a sequence of higher density redevelopment lining Surrey Quays Road, including Site D, it is appropriate to consider the eastern side of Surrey Quays Road to be an aspirant Central area. The GLA raises no strategic objection, a strong indication the proposed density is consistent with strategy of the London Plan. Site E is in a PTAZ, where there is no density ceiling specified, demonstrating that high density does not preclude high quality design.

Height

8.26 The Council's objection is that the proposed building heights would be out of keeping with the surrounding area and harmful to its appearance. The proposals were referred to the Mayor because of their height. There is no strategic objection in relation to Policies 4B.8 and 4B.9 of the London Plan.

8.27 The extant office permission for a 6 to 12 storey development shows that there can be no in-principle objection to buildings of this order of height on Site E and that buildings up to the height of the appeal proposals are neither out of keeping with the surroundings nor harmful. The decision was taken on the basis of the more stringent policy advice in the UDP (*Document 29 pp. 67, 68*). The evidence of the Council also shows that the site is appropriate for buildings of 30 metres or more – although block C is said to be too tall by several storeys, the height of block A is considered acceptable and with block B the issue is the height at the pivotal point on the corner[10]. The officer reports in 2003 and 2004 on the appeal scheme advised the building heights were acceptable. The issue is not one of principle but of degree.

8.28 The appropriateness of the proposed heights must not be judged only in the existing context. Significant change is planned to take place. The SPG supports a range of heights and the guidelines recognise the potential for taller buildings on Sites A, B and C. All are within proximity of Site E, which is itself bounded by a high and dominant building at HQP. The Council does not object to the height of the proposed development on the Mulberry site, up to 29.5 metres. Site D will rise to 10 storeys above a podium deck. Site E also lies within the District Centre, accepted by the Council and HQP as the most appropriate location for taller buildings (*Document 66*). As redevelopment of the surrounding sites progresses, Site E will mark a limit of the town centre before the very large and tall building at Harmsworth Quays. Architecturally this requires a building of comparable significance on Site E.

8.29 It does not follow that because a building would be taller than others in the vicinity it would be harmful. The appeal proposals handle the varying heights with architectural and urban design skill. The site has the inherent prominence of a corner site, justifying an architectural statement at the junction. The additional height of block B emphasises the corner. The culmination of the development is marked by block C. The block would lie on an axis with the transport hub, the highest part of the building 'pointing out' towards the edge of Canada Water. As designed the bulk of the building reduces significantly as the height increases, thus creating an interesting and positive skyline. The proposals would improve the architectural and urban design characteristics of the area immensely and fit in with Site E's context.

Design

8.30 There has been a lack of objection on design grounds by any of the relevant bodies and authorities. The GLA raises no objection to the proposals in respect of Policies 4B.2 and 4B.9 of the London Plan. The Council does not regard the design of the proposed buildings as an issue and does not criticise the proposed inclusion of community and

[10] Evidence given in cross examination by Ms O'Connor, the Council's planning witness

health-care facilities at ground floor level. Despite the reliance placed on the EH/CABE guidance by HQP, English Heritage has not objected to the scheme and CABE was not interested in having the scheme presented to them. Little weight if any should be attached to HQP's criticisms of the design.

8.31 There is no reasonable basis for finding that the scheme would be other than an architectural and urban design asset to Canada Water. It would set an example and thus be exemplary in raising the standard in a tangible and significant fashion. Well designed buildings would enclose a generous landscaped courtyard. The affordable housing is designed to an equally high standard as the market housing and the accommodation would be of an excellent standard, avoiding the potential dis-benefits of high density housing (*CD31 para.4.23*). The scheme had to be drawn up to meet a deadline but this is not unusual in the commercial world. It is the product of the intense period of analysis and design that counts.

Wider Setting Consultation Area

8.32 The distance between the Greenwich Park viewing point and St Paul's Cathedral is some 8 kms (5 miles). The low mass of HQP is discernible within the panorama, some 4 kms (2.5 miles) distant and divorced from the St Paul's aspect by the Aragon Tower and somewhat lost under the Manhattanesque City skyline beyond. Within the panorama, Site E lies out of sight immediately behind the HQP buildings and well outside the viewing corridor. The scheme would be insignificant, having no effect on the view or setting of St Paul's Cathedral as seen from the strategic viewing point in front of the Wolfe Memorial adjacent to the Royal Observatory (*Document 21 Figure 3*).

8.33 Within the WSCA the general panorama is similar, although the prospect is more dominated by the historic buildings of Greenwich in the foreground. Site E is out of sight behind the HQP works. Because of the distance and the array of buildings within the panorama there would be no effect whatsoever upon the setting of St Paul's from the sliver of part of block C that is just within the WSCA (*Document 21 Figure 5*). This is so whether one stands on the outermost point of the WSCA on One Tree Hill in Greenwich Park or a few paces away so as to obtain a clearer and better view. This conclusion was emphatically supported by the Council's planning witness.

Prematurity

8.34 It is significant that the Council has not raised this as a reason for refusal, as it is the Council's emerging UDP which would have been prejudiced. Granting permission for the appeal proposals would not infringe the advice given to local planning authorities in the recent policy statement (*CD38*). The issues raised by the appeal scheme are all issues which can be properly determined by an analysis of the appeal proposals. The UDP inquiry will not consider the scheme at all. There is no sound basis for a refusal on prematurity grounds.

Affordable housing

8.35 The proposals include 25% affordable housing on-site in block A. This level of affordable housing is acceptable to the Council as it complies with the UDP as supplemented by the SPG dated 2002. The Council has not sought the higher 35 % suggested in the draft UDP or more than 25%. The Council's approach is to utilise the percentage figure in place at the date of acquisition of the site so as to enable firm financial planning (*CD29 pp.23 and 24*). This approach is consistent with emerging Government policy on planning obligations that acknowledges the need for greater certainty for developers (*Documents 82, 83*).

8.36 The quality of the affordable units is comparable to the market housing and if anything block A has the best of the site. It would be free from any noise from HQP or Surrey Quays Road and all units face the courtyard.

8.37 The Mayor/GLA object to the 25% affordable housing, the level that has been maintained in the appeal proposal in view of the matters raised at the resumption of the Inquiry[11]. If the First Secretary of State is not satisfied with the level of provision, the Appellant invites him to issue an interim letter allowing the Appellant the opportunity to increase the percentage. In the circumstances this procedure would protect the interests of everyone.

Conclusion

8.38 The proposed residential development would be compatible with HQP in terms of noise, traffic and general disturbance. The proposals would be acceptable in relation to their height, design and density in terms of their effect on the character and appearance of the area. Adequate provision is made for affordable housing and the dwelling mix is satisfactory. The scheme's design, layout and environmental/landscape improvements would make more than adequate contribution to greening the local environment and enhanced sustainability measures can be secured by condition.

9. THE CASE FOR MR PARTRIDGE AND WARD COUNCILLORS

9.1 Mr Partridge spoke on behalf of himself and the three Ward Councillors, based on the objections set out in *Documents 51 and 60*. The main points expressed are as follows.

9.2 The evidence by HQP on over-development, building height, density, design and the effect on the environment are fully supported. The site is unsuitable for residential development, in view of the inevitable problems of noise disturbance that would arise from the neighbouring print works. The affordable dwellings would be nearest the industrial premises and therefore there would be a disproportionate adverse effect on those residents. It should be an employment generating site, as set out in the emerging Southwark Plan.

9.3 Too many 1 and 2 bedroom flats have been built in the area and, as emphasised through the Council's housing need survey, there is a need for more 3 and 4 bedroom family units. Families have to move away from the area and there is pressure for unsuitably large extensions. The scheme would provide too few family units and would not sufficiently encourage a stable, diverse and mixed community.

10. THE CASE FOR THE CANADA WATER CAMPAIGN, CANADA WATER CONSULTATIVE FORUM AND WOLFE CRESCENT RESIDENTS ASSOCIATION

10.1 *Document 49* sets out the background to the community groups and their concerns about the proposal.

10.2 The Canada Water Campaign (CWC) does not oppose the development of sites in the area. It seeks to ensure that developments recognise the uniqueness of the Rotherhithe Peninsula, are in keeping with the area and meet community needs and aspirations. It was instrumental in pressing for the establishment of the Canada Water Consultative Forum so

[11] See paragraphs 1.8 and 1.9 on my Report

that the local community could engage with the Council, land owners and developers on the future development of Canada Water. Wolfe Crescent is currently the only residential development in the vicinity of Site E. It is a complex of town houses and 3 storey blocks of flats.

10.3 The local community view the site as a buffer between the employment uses and the residential areas on the other side of Canada Street. Housing development would be inappropriate because of the proximity to Harmsworth Quays, where there is 24 hour 7 day a week working. Residents of Wolfe Crescent are sometimes disturbed by noise from HQP, in their gardens and back bedrooms. The Forum considers that any change of use of the site should be determined through the master planning process. The Southwark Housing Capacity Study is anticipated to show that the Borough will be able to meet its housing targets without the need to use opportunity sites such as Site E. The GLA's developing Industrial Capacity SPG shows that rather than losing industrial land Southwark needs 1 hectare more. Community facilities should be planned as part of the Master Plan process, close to Canada Water. There is a need for doctors, not surgeries and there is also a desperate need for facilities for young people.

10.4 The height of the development would be out of keeping with the surrounding area which is predominantly 3 storey family housing. The height and the density would be in excess of the provisions in the London Plan, the UDP, the emerging Southwark Plan and the draft supplementary planning guidance[12]. There is no exceptional design quality to justify exceeding the stated density. The proposal would be contrary to Policies 3.20 and 4.1 of the draft UDP.

10.5 The proposal contains few larger dwellings, especially affordable units of 3 bedrooms or over, which the Southwark Housing Needs Survey highlights as being in short supply. The proposal would be contrary to Policy H.1.5 of the UDP and Policy 4.4 of the draft UDP. The community opposed the proposals for Site D on matters such as the design and height.

10.6 The Wolfe Crescent Residents Association has particular concerns about the inadequate provision of parking places for the proposed number of units. This would be likely to lead to an increase in on-street parking in an area where such parking is increasing with the introduction of congestion charging.

11. WRITTEN REPRESENTATIONS

11.1 In addition to the letters of objection by the Ward Councillors and the community associations, there were 14 letters of objection arising from neighbour consultation in April 2004 on the application and 6 letters of objection as a result of the appeal notification (*Documents 50, 51*). Objections relate primarily to the following matters:-

- The scheme is considered too high and too dense for the area in comparison to the scale of existing housing.
- The site is unsuitable for residential development because of its position next to Harmsworth Quays, a 24 hour operation.
- The development would add pressure on public facilities. Attention is drawn to congestion on the Jubilee line, the lack of doctors' surgeries and schools for the current population and the pressing need for activities for young people in the area.

[12] The submissions were made at the Inquiry in November 2004 before the SPG was adopted.

- The proposed level of parking would be inadequate, bearing in mind the existing parking problems caused by people seeking to avoid the congestion charge.
- A general point is made about the proposal increasing the level of traffic in the area. More specifically, the access onto Canada Street is of concern because of the proximity to the primary school and the adverse effect it would have on trying to establish safe routes to school.
- The development would result in environmental pollution. In particular there is objection is to the adverse effect on sunlight to housing on Woodland Crescent.
- There is objection to the loss of existing trees along the site frontage.

12. CONDITIONS AND OBLIGATIONS

Planning conditions

12.1 A list of planning conditions prepared by the Council and agreed by the Appellant forms *Document 85*. The conditions were discussed further at the Inquiry.

12.2 As a general point is was accepted that the wording of the conditions should reflect, where possible, the model conditions in Circular 11/95 'The Use of Conditions in Planning Permissions'. Otherwise no matters were raised in connection with condition 1 on external materials, condition 6 on cycle parking, condition 7 on refuse disposal, condition 9 on submission of typical bay details, condition 12 regarding details of ground floor elevations and condition 13 controlling the use of surface car parking.

12.3 The parties agreed there should be a more comprehensive set of conditions on landscaping, to include the submission of a scheme, its implementation, future replacement of species and future maintenance and management. It was agreed that boundary treatment, covered by condition 4 would be appropriately covered in the landscape details.

12.4 Referring to condition 3, the Council confirmed that contamination is likely to be present on the site and that there may be methane from made-up ground. Condition 5, on affordable housing, was accepted to be unnecessary in view of the unilateral undertaking. It was agreed that condition 8 should control all proposed plant and ventilation equipment.

12.5 Condition 10 requires the submission of a noise insulation scheme. HQP fundamentally objected to this condition because it would not overcome the inherent design problems of the scheme. The Appellant reserved its position on the extent the design would be changed but expected that the insulation scheme would reflect the illustrative scheme in *Document 17*.

12.6 The Council explained that the proposed restriction on the ground floor uses in blocks B and C was derived from consideration of amenity for future residents and the implications for traffic and parking. The Appellant considered that the range of permitted uses, as set out in the condition, would reflect current expectations for the use of the space. To reduce the range of permitted uses within Class D would be unduly restrictive and not justified by the likely local impact.

12.7 There was general agreement for additional conditions to restrict the use of the basement car parking to the occupiers of the buildings and to require details of design measures to deliver a sustainable development. The Council did not consider that the conditions put forward by the Environment Agency on surface water drainage were necessary (*Document 51*).

Unilateral Undertaking

12.8 The unilateral undertaking dated 12 April 2005 is given by Conrad Phoenix (Canada Water) Limited to the Mayor and Burgesses of the London Borough of Southwark (*Document 80*). The undertaking includes obligations on affordable housing and contributions towards environmental works and accessibility.

12.9 Schedule 1 provides for the affordable housing units to be constructed by the developer and made ready for occupation. The units are defined as the 80 dwellings in block A, which would be provided on a rental/shared ownership basis under the control of a registered social landlord (RSL). Until the completion of these matters there would be a restriction on occupation whereby no more than 180 of the remaining units on the development could be occupied. The affordable units are to be used only for providing housing accommodation to households in need of affordable housing in Southwark.

12.10 Schedule 2 provides for a £28,900 car share scheme payment, £42,450 cycle networks payment and £30,000 environmental improvement payment. The payments are to be made before the first occupation of the 120th market housing unit and are for improvements in the vicinity of the site. There are similar timescales for the payment of £50,000 as a pedestrian access contribution and a sum of £40,000 towards selective vehicle detection traffic signals at the junction of Surrey Quays Road and Canada Street and pedestrian connectivity improvements.

12.11 HQP raised two matters. The first related to the lack of provision for indexation of the environmental contributions. HQP considered this to be an important omission because of the inflation in the building industry and the payments could be a long way off. The second matter concerns Clause 3.8, which states that the deed replaces the unilateral undertakings dated 18 October 2004 and 31 March 2005 previously delivered by the developer to the Council. HQP considered that such a clause was not lawful, having regard to s.106 of the 1990 Act.

12.12 The Council did not consider that the latter point had any practical significance because the undertaking dated 18 October 2004 was not signed and that dated 31 March 2005 incorrectly provided for the undertaking to come into effect with the grant of planning permission by the Council. The Appellant submitted that there was no substance in the point.

12.13 The Appellant confirmed that the environmental contributions were based on the sums put forward by the Council (*Document 87*) and the traffic lights payment reflected the advice of Transport for London.

13. CONCLUSIONS

The numbers in square brackets refer to relevant earlier paragraphs in my Report

Policy Context

13.1 The policy context for the Canada Water area, and hence the appeal site, is evolving. The development plan for the area now comprises not only the Southwark Unitary Development Plan adopted in 1995 but also the more recently adopted London Plan. Where there is policy conflict the London Plan will take precedence. The UDP will be replaced by the Southwark Plan, currently in draft form. The draft UDP has been prepared within the strategic framework of the London Plan. It has progressed through several consultation phases and is at the public inquiry stage. In general terms I consider that it is a material consideration of significant weight. However, this degree of weight may not be appropriate where policies and proposals are subject to objection, a matter I comment on further in my assessment. Similar considerations apply to the SPG for Canada Water where it supplements the draft UDP rather than the adopted UDP. [5.1, 5.10, 5.17].

13.2 The thrust of the London Plan is to maximise housing provision and to promote policies that seek to exceed targets, within an overarching strategy of balanced, sustainable growth. Within this framework Southwark's housing strategy will be scrutinised at the public inquiry on the draft UDP. Even so, some appreciation of the position on housing supply is relevant to the proposal. The Southwark housing capacity study indicates that the borough's current targets should be exceeded, despite an accumulated shortfall to date. Windfall sites are an important component in housing supply. The targets will be reviewed by 2006 and the evidence points to a revision significantly upwards. Therefore I conclude that as a windfall site the proposal could make a significant contribution to housing supply provided that the site specific issues are satisfactorily addressed by the scheme. [5.2, 5.3, 6.25, 8.11-8.13]

13.3 A common theme is that Canada Water is an area likely to change. It is within the Central London sub-region, a town centre with good public transport access. It is a type of location the London Plan identifies for more intensive development. Canada Water is an Action Area in the draft UDP, carrying forward the policy objective for regeneration set out in the adopted UDP. In this appeal it is the use and scale of development appropriate to Site E that is at issue. [5.5, 5.6, 5.11]

Main Considerations

13.4 In the light of the policy context and the submitted evidence I identify the main considerations as:

- Whether the proposed residential development would be compatible with the adjacent printing works, Harmsworth Quays, having particular regard to the effect of plant noise, intermittent noise and traffic noise on the living conditions of future occupiers of the flats.

- Whether the proposed development would be appropriate to its context, having particular regard to density, building height and design, the treatment of spaces and its contribution to environmental improvements in the area.

- Whether the proposal would make adequate provision for meeting local housing needs in terms of the level of affordable housing and dwelling mix.

Proposed use and noise impact

13.5 The appeal site shares a common boundary with Harmsworth Quays, a major printing, publishing and distribution premises. HQP is a well-established, successful and expanding operation and an important employer. By reason of the nature and scale of the business the operation is constant, continuing 24 hours a day, seven days a week. The characterisation of a Class B2 general industrial use was not questioned. [7.1-7.3]

13.6 Site E is a first preference site at the top of the sequential hierarchy in respect of several of the criteria in PPG3. However, in accordance with PPG3, the potential and suitability for residential development is also subject to assessment against environmental constraints. The proposal for 320 flats would place a noise sensitive development adjacent to a general industrial site. As a general principle, national policy in PPG4 advises careful consideration of such a juxtaposition. PPG24 states that wherever practicable noise sensitive developments should be separated from major sources of noise, a principle that is repeated in Policy 4A.14 of the London Plan. [8.8, 7.19, 7.20]

13.7 The underlying policy objectives are to prevent problems of annoyance and disturbance for future residential occupiers and to prevent pressures being placed on existing industrial users that may threaten their continued viability. The emphasis is on achieving noise control at the planning stage. The principle of separation has not been adopted in any form by the proposal, residential development in blocks A and C being sited hard on the boundary with HQP. However, in my view it does not necessarily follow that the proposal is unacceptable in principle. It has to be established whether or not HQP is a major source of noise and whether there would be potential problems for the occupiers of the new and existing development.

13.8 Turning to policy at the local level, similar objectives are apparent. Policy R.2.1 of the UDP identifies housing and community facilities within a range of uses for a larger proposal area that includes the appeal site. Proposals are, however, subject to environmental and amenity considerations. More recently through the draft UDP there has been recognition of the significant employment at HQP and the possibility that the nature of activities may make it difficult to accommodate sensitive uses on the adjacent sites. These concerns have led to a Class B use designation on Site E, rather than the use being justified by a need for employment land. In my view the site guidelines in the SPG for Canada Water reflect this approach. However, the Class B use will be under review at the forthcoming UDP inquiry and is therefore by no means certain to be adopted. I also note there is some inconsistency with the approach taken by the draft UDP and the SPG to the Harmsworth Quays site, where residential is an acceptable use alongside the required employment Class B use. I conclude there is no definitive policy guidance at a local level as to the appropriate use(s) for the appeal site. [5.6, 5.13, 7.21, 7.22, 8.9]

13.9 Given the national and local policy background I consider that the scheme needs to be assessed on its merits in the light of the available information on the noise environment and policy objectives. Significantly the Council's case in respect of noise focused on the design of the scheme, not the principle of a residential use. [8.10]

13.10 The main building at HQP has been designed and constructed to ensure that there is no noise break-out. Noise primarily arises from activities outside the building and is appropriately categorised as plant noise, intermittent noise and traffic noise. The noise climate does not display consistent characteristics across the HQP site and a further dimension is the variation in dominant noise sources according to height above ground. The 24 hour nature of the operation results in noise during the night, a period when residents would reasonably expect quieter conditions. The existing planning conditions applicable to the HQP site have been framed with existing, not the proposed, residential development in mind and do not cover all existing noise sources. In future, operational changes and intensification could occur outside planning control. Therefore I consider that achievement of a satisfactory environment for future residents on Site E relies on the ability to secure any necessary mitigation by layout and design. [6.4, 6.10, 7.1, 7.23, 8.15]

13.11 The general design strategy has been to group linear building forms around the perimeter of the site tight to the boundaries, thus forming a protected internal courtyard. Block A is designed as a single aspect building to provide a buffer and a backdrop to blocks B and C, which would be dual aspect. The evidence has shown this approach is a response to the physical mass and height of the HQP building rather than being informed by a comprehensive noise assessment. From the analyses of the noise climate by all three parties I have no reason to be concerned about the living conditions for the future occupants of block A. Attention focussed on block C in particular as a result of its aspect towards both HQP and Surrey Quays Road and to a lesser extent on block B in relation to its main elevation facing Surrey Quays Road. [6.2, 6.3, 8.4, 8.10]

13.12 The plant noise that would affect the living environment for residents of block C has been identified to come from a bank of air chillers towards the back of the HQP building. The noise measurements taken by the Council have demonstrated that at night it is the dominant noise source with a distinctive and repetitive pattern of short term cyclical fluctuations. I consider that the character of the noise is aptly described as industrial, non-steady and non-anonymous noise. As advised by PPG24 the NEC noise levels should not be used for assessing the impact of industrial noise on proposed residential development. The character as well of the level of the noise has to be taken into account. [6.4, 6.5, 7.24]

13.13 In these circumstances there was disagreement between the Appellant and the Council/HQP as to the appropriate British Standard to use for assessing the noise environment for residents. PPG24 refers to both BS 4142 and BS 8233. BS 8233 is general guidance on acceptable noise levels within buildings. BS 4142 is specific to noise of an industrial nature and through the rating correction it takes account of certain acoustic features that can increase the likelihood of complaint from people residing in a building. As indicated by PPG24, BS 4142 has limited scope and because it is an instrument of comparison it is more particularly used to assess the noise effect of new industrial development on existing dwellings and as an enforcement tool. However, in this case, the Council's noise measurements allow the component noise elements to be distinguished, thus enabling a comparison with the background noise level. The Council's methodology was not questioned. I consider that BS 4142 is an appropriate standard to apply to the identified circumstances. [6.6, 6.7, 7.24, 7.25, 8.17]

13.14 The BS 4142 methodology indicates that complaints would be likely. The Appellant seeks to minimise the significance by stating that at worst only 7 bedrooms would be affected. In my view that misses the point. As set out in PPG3 it is a national policy objective to promote good design in order to create attractive, high quality living environments. For the residents of the affected flats there would be the prospect of sleep disturbance for a prolonged number of nights given that internal temperature control is critical to the printing process, a factor which was obvious on the site visit. The harmful impact would be a result of poor design stemming from a lack of understanding of the noise constraints posed by HQP. [6.7, 6.8, 7.25, 8.16, 8.17]

13.15 BS 8233 assumes the noise is steady. I consider the standard is not directly applicable to this case where the industrial noise, occurring well above ground level, is not constant.

Even using the standard as an indicator, the achievement of acceptable noise levels within block C relies on windows being shut. I do not regard it acceptable to deny residents through poor design the option of opening bedroom windows, especially on summer nights. It is just that time of year when the chillers are likely to be fully operational. The Appellant's suggestion that HQP could take further steps to attenuate the noise from the air chillers again ignores the fact that the problem should be designed out from the start. Moreover, because of his experience of dealing with HQP plant, I prefer the evidence of HQP's noise expert that noise attenuation at source would no longer be an option. [6.6, 7.25, 8.17]

13.16 Intermittent noise is the term used to describe the irregular noise events along the fire alley near to block C, such as maintenance, movement of pallets, emergency paper deliveries or activities to resolve mechanical breakdowns. Such activities have been shown to produce high maximum noise levels. Despite the research quoted on aircraft noise, the advice in the WHO guidelines is that individual events of 45 dB LAmax should be avoided and that for intermittent events account should be taken of the maximum sound pressure level, as well as the number of noise events. The NEC B obtained along the boundary also requires that in determining planning proposals noise should be taken into account. As with plant noise, I consider that the potential disturbance from intermittent noise should be addressed through initial design. This would be consistent with the underlying principle of the NEC procedure, whereby reliance is placed on the ability to protect the new housing through the planning system. HQP has demonstrated that with some activities the noise levels inside bedrooms and living rooms in block C adjoining the fire alley would be well in excess of the WHO levels, even with windows closed. [7.27, 7.28, 8.18]

13.17 The evidence is that future residents in block C would be likely to complain about plant and /or intermittent noise from HQP. Referring to PPG4, this may set in train proceedings that could result in costly new conditions or restrictions being imposed on HQP. In the alternative, if any actions were to be successfully defended, residents would continue to be troubled by noise disturbance. There is no evidence to show that the proposed layout is the only way of achieving residential development on the site. The evidence has also demonstrated that the noise environment was not a fundamental consideration in the design of block C. Given the circumstances, I agree with HQP that future residents should not have to seek a remedy through environmental proceedings. They would be time-consuming and costly for all parties concerned. [7.29, 8.14]

13.18 In relation to traffic noise the site falls within NEC C. I consider that this factor should not rule out the use of the site for housing, having regard to the advice in PPG24 that noise mitigation may make development acceptable, the evidence of the Council as to the shortage of NEC A and B sites in Southwark and the use of other sites fronting Surrey Quays Road for housing. Having said that, I recognise Site E is distinctive in its proximity to HQP. However, the traffic surveys have shown that whilst HQP 'heavies' form a significant and increasing proportion of traffic during the night, HQP traffic is not dominant during the day or night. From the survey information and my visits to the area I consider that overall buses are a major source of traffic noise. Furthermore, the noise from vehicles accelerating and stopping at the traffic lights at the junction adjacent to block B seems to me to be of potentially greater consequence than the vehicle movements at the HQP entrance, which is displaced to the south of the site. Therefore my conclusion is that HQP traffic does not require special consideration and the key issue is how the design has responded to the traffic noise constraints as a whole. In this respect I have most concern over the balconies proposed on the Surrey Quays Road elevations and on the return side elevations. [7.3, 7.30, 8.19]

13.19 The balconies are a distinctive and integral feature in the design, a feature which is not present to a comparable degree either on existing flats to the north within the development at Woodlands Crescent or as proposed in the scheme for site D. I also noted that the flats with balconies on the Woodlands Crescent frontage are set well back from Surrey Quays Road. In contrast, flats in blocks B and C have been designed with generous balconies overlooking and in close proximity to Surrey Quays Road. In particular the balconies at the apex of block C have been designed as an integral aspect of the living accommodation and as a striking townscape feature (*Plan W*). Noise levels on the lower floor balconies at least would exceed the BS standard and community guideline values. I consider that this would be likely to deter residents from using the balcony space and the quality of the living accommodation would be reduced. The proposed solution is to enclose the space. As explained by the Council's planning witness the nature of the space would then change and in effect it would become an internal room. I consider the appearance of the building would be compromised, especially in respect of block C. There could well be implications for the internal layouts because some flats are designed with the balconies spanning the living room and the bedroom. For these reasons I consider the matter would not be appropriately resolved through a planning condition. [2.2, 3.2, 6.9, 7.30, 8.19]

13.20 The likelihood is that acceptable noise levels could be achieved within habitable rooms facing Surrey Quays Road with the provision of suitable forms of construction, glazing and ventilation. I have concern that to date assessment has not been sufficiently rigorous in view of the policy test for exemplary design. However, unlike the treatment of the balconies, this matter does not have significant implications for the external appearance and therefore could be appropriately dealt with by condition. [6.9, 8.20]

13.21 I conclude that future occupiers of a significant number of the flats would experience noise and disturbance from plant and intermittent noise from HQP and from traffic using Surrey Quays Road. The harm to living conditions would be a consequence of the poor design of the scheme. Complaints from future occupiers could eventually lead to restrictions on the business at HQP, the effects of which could be disruptive given the importance of flexibility for its efficient operation. The proposal is contrary to the objectives of Policy H.1.8 of the UDP and Policies 3.2 and 4.2 of the draft UDP, which seek to ensure good standards of living accommodation and protection of amenity. The proposal also fails to comply with national policy objectives in PPG3, PPG4 and PPG24 that promote good design and quality of life and seek to prevent unreasonable burdens on business. The failings are, however, specific to this particular scheme and hence it does not necessarily follow residential development would be incompatible with HQP.

Effect on Context

Density

13.22 The agreed density of the development is 1072 hr/ha, substantially above the 175-210 hr/ha. normally acceptable under Policy H.1.7 of the UDP. I consider this policy is no longer up-to-date given the emphasis in PPG3 on creating more sustainable patterns of development and making more efficient use of land. The London Plan provides the up-to-date development plan context through Policy 4B.3. This policy seeks to ensure developments achieve the highest possible intensity of use compatible with local context, the design principles for a compact city in Policy 4B.1 and with public transport capacity. [4.2, 5.4]

13.23 I found that a good way of appreciating the local setting within a wider context was from the roof of the main HQP building. The panorama clearly demonstrated the contrast between the very dense development of central London and Canary Wharf and the less dense urban development with a predominance of lower buildings in Canada Water and the surrounding Rotherhithe Peninsula. The Surrey Quays shopping centre has a large building footprint but is low rise and has extensive areas of surface car parking uncharacteristic of a central area. Significantly, the London Plan categorises Canada Water not as a major centre but as a district centre within the town centre hierarchy. Although an early character map by the GLA identifies land to the west of Surrey Quays Road as central, the map has been shown to have little weight. Overall I consider that Site E is in a site setting defined as urban in the London Plan, where the density range is 450-700 hr/ha in the density matrix. By reason of the intensity of development the proposal would not be compatible with the existing local context. [5.4, 5.5, 6.15, 7.14, 8.24, 8.25]

13.24 The density matrix is not intended to be static. In future the character of Canada Water is likely to change with the development of vacant sites around the tube station and redevelopment and expansion of the shopping centre. As a town centre with good public transport access, the London Plan considers the location provides an opportunity for more intensive development. No strategic objections have been raised by the Mayor on the density of the proposal. [8.24, 8.25]

13.25 The vision for Canada Water is set out in the draft UDP and the SPG and was not disputed by the Appellant. The draft UDP identifies the area as a PTAZ within the urban zone, where densities may exceed the range of 300 to 700 hr/ha on some sites where design and amenity criteria are met. I consider this density zoning has significant weight because it has not been the subject of an objection by the Mayor. Given the wording of the policy increased densities are not intended to be applied throughout the PTAZ but only where appropriate and where justified by exemplary design and environmental benefits. [5.11, 6.13, 7.11]

13.26 The Council have referred to a hierarchy of sites and certainly I envisage any higher density development would be concentrated on the most accessible sites nearest the bus and tube interchange. In contrast, the appeal site is more towards the periphery of the centre, on the opposite side of Surrey Quays Road without a frontage to Albion Channel and the key pedestrian route to the 'dock'. It is adjacent to industrial development at HQP, which imposes specific constraints on development. Because of this combination of features the site is not as favourably located as Site D, where future redevelopment has been permitted at 1100 hr/ha. The Site D planning permission was also granted in a different and less well developed policy context. In my opinion Site D does not set a precedent that has to be followed. [6.14, 6.16, 7.11, 8.3, 8.23]

13.27 My conclusion is that the location of Site E within Canada Water does not support the proposed density at the top of the range for a central setting. However, bearing in mind the strategic background and its location within a PTAZ the appropriateness of the density also rests on considerations of urban and building design and impact on the locality. [8.25]

Building height and design

13.28 The buildings would range from 7 to 15 storeys or some 21 to 45 metres in height, the greater proportion of the built form being 10 storeys or above. With the exception of HQP the development would be considerably taller than its neighbours. For these reasons the scheme falls within the scope of policies for tall buildings. National, strategic and local policy requires tall buildings to be appropriately located, of the highest quality of design and to satisfy a number of exacting criteria. The importance of context and exemplary design are highlighted by Policy 4B.9 of the London Plan and the EH/CABE evaluation criteria, which seek to ensure that tall buildings do not result in a harmful impact on the environment. [4.1, 6.19, 7.5]

13.29 Referring to Policy 4B.8 of the London Plan I consider there is no underlying policy rationale as to why Site E is an appropriate location for a group of tall buildings. Site E has no obvious landmark characteristics in visual or functional terms, either now or in the future vision for the area. Although within the district centre as currently defined, the site is not at the heart of the area and the building height would not signal a transport interchange or important public building. Being a predominantly residential development there would be no functional requirement to specifically identify its presence in views from the tube station. Indeed the peripheral nature of the site was acknowledged by the Appellant to be a factor when identifying suitable secondary uses within the scheme. Referring to the SPG, I consider legibility would be more appropriately enhanced by the creation of an identifiable centre and a well defined network of walkways. Furthermore, a tall building is not essential to act as a catalyst for regeneration, experience along Surrey Quays Road and elsewhere in the surrounding area showing that building height is not a pre-requisite for redevelopment. Instead, the development could have a negative effect, deflecting from the aspirations of achieving a townscape focus around Canada Water itself. There is no evidence to suggest that Site E would be part of an economic cluster of related activities, rather it would form part of a residential quarter along Surrey Quays Road. [6.14, 6.22, 7.9, 8.1, 8.3, 8.4, 8.29]

13.30 At local level policy is generally not supportive of tall buildings at Canada Water, whether in the UDP, draft UDP or SPG. More specific policy tests are whether the proposed tall buildings would fit in with their surroundings and be of exemplary design. Existing development varies in height but there is a noticeable discipline and I consider the area is characterised by low and medium rise residential and commercial buildings. There are exceptions, although they are dispersed. The two 1960's tower blocks are some distance to the north west, visually well separated from Site E. Whilst distinctive local landmarks they are not of the highest standard of design and offer no justification for the proposal. Of more immediate relevance is Harmsworth Quays, atypical not only because of its height but also its mass and its industrial and functional appearance. However, the development would be well in excess of what would be necessary to overcome its dominant presence. Within the existing environment, I conclude the proposed building group by reason of its height would be intrusive and completely out of keeping with its surroundings. [6.19, 6.20, 8.3, 8.4, 8.29]

13.31 The Appellant has sought to narrow the issue down to one not of principle but of degree. I consider the design objectives of reduced height on Canada Street and prominence at the corner are appropriate but in my view the composition needs to be assessed as a whole rather than as individual elements. I also consider that the extant office permission on the site does not provide a sound justification the proposed building height. It is common ground that there is no likelihood of the permission being implemented and as such it has minimal weight. Moreover, policy for tall buildings and Canada Water has evolved since 2002. Although acceptable in principle to the Council then in the context of the UDP, there is now a broader national, strategic and local policy base against which proposals have to be assessed. [6.23, 7.11, 8.27, 8.29]

13.32 Looking to the future and potential change within the Action Area, the proposal would be significantly greater in overall height when compared with the future development on Site D, where blocks would be typically 6 to 8 storeys and only a single block would be 10 storeys above a podium deck. The redevelopment scheme under consideration for the Mulberry Business Park does not propose buildings above 30 metres. On the sites closest to the tube station additional height may be allowed in exceptional circumstances. Even if a cluster of tall buildings is to be developed, and that is by no means certain, the peripheral location of Site E does not support development forming part of that group. [6.20, 8.3, 8.28]

13.33 Therefore within both the existing and possible future context I consider that the proposal would be of an excessive height. The harmful visual impact would be increased by the siting of the blocks close to the back edge of the footway and the oppressive degree of enclosure created by the strong linear building forms. I am not satisfied that there would be sufficient detail and variation in the treatment of the elevations to provide a human scale and relieve the dominance of the buildings. The curved roof profiles to blocks B and C would add interest to the roofscape and complement the building composition and form. However, I consider that they would emphasise the sheer height of the blocks and the expanse of the elevations below. My conclusion is that the development would be over-dominant and out of keeping with its surroundings and therefore visually harmful to the area. The limited amount of visual presentation does not persuade me otherwise. [6.20, 7.6, 8.4, 8.5, 8.29]

13.34 I also consider that the level of detail on the building elements is disappointing and not of a standard to demonstrate the building would be of exemplary design. For example, there has been little consideration of the treatment to the base of blocks B and C, where community facilities are proposed. Even though the precise nature of the uses and the occupiers may be uncertain, I would expect to see an indication of basic design principles to show how the frontages would contribute positively to the public realm. As it is the proportions and height of the ground floor appear weak, with no solid base to the weight of the blocks above. This is a fundamental design element and not a matter to be appropriately resolved by condition. Similarly there is minimal indication on plan of the treatment of the approach into the internal courtyard, yet it would be at a focal point of the scheme. The bulky roof top additions on block C would be incongruous with the curve of the roof (*Plan K*) and, as discussed above in relation to noise mitigation, enclosure of the balconies would detract from the design concept. [7.12, 8.2, 8.4, 8.5]

13.35 I consider the relationship to adjacent buildings has not been adequately addressed despite the use of a project model. The development would turn its back on the adjacent sites of HQP and the Mulberry Business Park and result in block A being sited almost on their boundaries. The single aspect treatment of block A may well be necessary to ensure satisfactory living conditions but I consider the elevations would be unattractive and overbearing. This design failing is particularly relevant given the prospect of mixed use redevelopment of the Mulberry site. Furthermore, the six upper floors of block B would span over the car park entrance on Canada Street almost to the boundary with the Mulberry site (*Plans C, S*). Although not shown as a street elevation on plan I consider there would be a poor relationship with the existing industrial buildings because of the lack of separation space and the contrasting style and appearance of the buildings. In the future, the siting and design of this end of the block, which incorporates principal windows in the side elevation, may well unduly constrain development on the adjacent site (*Plans T, U*). Turning to a different aspect, the layout and design has failed to resolve the noise constraints imposed by HQP and Surrey Quays Road. Consequently the development would not provide the high standard of living accommodation required by policy. [4.7, 7.13, 8.4]

13.36 The effect of the development on local views has not been accurately and realistically represented, but I consider that it would be over-dominant particularly in views from the residential areas around Wolfe Crescent and along Surrey Quays Road. The effect on longer distance views primarily concerns the protected strategic views of St Paul's Cathedral. I am satisfied that the proposal would have no effect on the view or setting of St Paul's Cathedral as seen from the strategic viewing point. However, the corner of the site, where the apex of block C would be positioned, would encroach into the wider setting consultation area (WSCA). No objections were raised as a result of the consultation. However this consultation was not based on the view from the outermost point of the WSCA, but from a point a number of metres to the west. On the site visit to Greenwich Park I found the views from the two points were materially different. The difference concerns the relationship of the proposal to the western dome of the Royal Naval College. From the outermost point I consider the proposal would affect the integrity and clarity of the College dome. From the viewpoint used by the Appellant the relationship of the College dome to the backdrop of tall buildings in the City is such that the effect would become less relevant. Therefore the point made by HQP over the accuracy of the consultation exercise has some validity. [4.8, 7.6, 7.33, 7.34, 8.33]

13.37 The purpose of the WSCA is to protect views of St Paul's Cathedral. I did not find the visual 'dialogue' between St Paul's and the College, as identified by HQP, to be particularly strong and this was on a very clear day. Furthermore the 'dialogue' has already been compromised by the two tower blocks, identified as Columbia and Regina Point by the Appellant. In my opinion this impact would remain dominant. From my experience the views from One Tree Hill change very quickly. They would also be affected very much by the seasons and the weather. Certainly the clarity of the views I had are not represented by the images in the documents produced either by the Appellant or HQP. The Council's planning witness, who clearly was very familiar with the views from Greenwich Park, confirmed to me that in the light of all the evidence she remained of the opinion that the proposal would have no impact. I am conscious of English Heritage's opinion that it would be a matter of regret. However, this does not represent a formal consultation response and hence I consider its weight is reduced. For all these reasons I conclude the proposal would not detract from the protected setting of St Paul's Cathedral. [4.9, 7.34, 8.33]

Treatment of spaces

13.38 The creation of high quality spaces and an active street frontage along Surrey Quays Road are commendable objectives. However, I do not have confidence that sufficient thought has been given to ensure their achievement [8.6].

13.39 By Design, the companion guide to PPG3, advises that as the density of development increases so does the importance of a complete and robust landscape treatment. There is no full landscape plan and specification as part of the submitted scheme and little thought has been given to future maintenance arrangements. The significance of these omissions is increased because the site layout plan shows a mix of spaces for relaxation and active play and I was informed that the courtyard is intended as a semi-public area. In my view the apparent strong sense of enclosure, the lack of definition to access points and the lack of clarity between the public and private realm would not encourage use by the local community. [4.3, 7.16, 8.6, *Plan C*]

13.40 I also have concern that the implications for community safety, and the amenity and privacy of residents, have not been adequately addressed. For example the position of a play area near to Surrey Quays Road would require secure enclosure and both the play and ball play areas would be in close proximity to residents' balconies above. The scheme architect confirmed to me that there has been no consideration of the effects of the proposal on micro-climate, despite the importance of this issue in relation to tall buildings. Similarly there has been no detailed assessment of the implications of solar orientation and overshadowing, matters that are important in relation to the use of the courtyard and also to energy requirements. [7.16, 7.17, *Plan C*]

13.41 The proposed ground floor use of blocks B and C would fulfil a community need. However, with such uses, imaginative design is required to ensure the frontage to Surrey Quays Road would contribute to the vitality and enhancement of the public realm. I have commented on the lack of design detail for the ground floor facades and with all the entrances proposed to the side of the buildings there is no information on how they will be signposted. There are no specific proposals for the treatment of the space to the front of the buildings and hence I have no understanding as to how the buildings, spaces and uses would function and visually complement one another. The maturing trees along the site frontage, a significant landscape asset, are proposed to be replaced by trees planted at the back of the kerb. However, it was clear through the discussion of conditions that little thought, if any, has been given as to practicalities or the contribution of the trees to the local landscape structure. [7.12, 8.2, 8.6, 11.1].

Environmental Improvements

13.42 The draft UDP requires high density developments to make significant contributions to environmental improvements in the area, particularly relating to public transport, cycle and pedestrian movement, safety and security and the public realm. Similar requirements on permeability and improved linkages on foot are included in the EH/CABE evaluation criteria for tall buildings and therefore they are a material consideration in relation to this proposal. [5.12, 5.20]

13.43 The scheme provides for permeability into and through the courtyard and access onto Surrey Quays Road and Canada Street. However, whilst there has been attention to movement into and through the site there appears to have been little consideration of the linkages to the surrounding area. In my opinion this has resulted in a lost opportunity through layout and design to link spaces and encourage pedestrian movement through the locality. The possibility of improved connectivity with Site D is an obvious example, bearing in mind the approved scheme for that site includes a central public space and pedestrian access to Albion Channel. The fact pedestrian and cycle movement were not addressed as part of the transport statement is an illustration of the scheme's lack of attention to context. [3.2, 4.4, 7.8, 7.15, 8.6]

13.44 The intention is that improvements to cycle networks, pedestrian access and the local environment would be secured through the financial provisions made in the unilateral undertaking. It appears that the contributions, as revised, are based on the sums put forward by the Council as being significant to accord with draft UDP policy and which would assist in alleviating the impact caused by the development. I understand from the evidence of the Council that the sums were derived from several projects that are being developed in the Canada Water area, especially projects directed at creating new pedestrian connections. Improvements to public transport infrastructure would take the form of selective vehicle detection traffic signals at the junction of Surrey Quays Road and Canada Street to aid bus movement. The balance from the £40,000 would contribute towards pedestrian connectivity improvements. This approach is acceptable to Transport for London and the Mayor. [4.5, 12.10, 12.13]

13.45 The development of infrastructure and transport related improvements in Canada Water are at a relatively early stage. To this extent the generic approach taken in connection with the development of Site E is not unreasonable. On the limited evidence available and more particularly the lack of objection by the relevant public authorities, I have no reason to doubt the reasonableness of the sums and that they would represent a significant contribution. The financial contributions secured in connection with the office development on the site are not a useful comparator because of the different nature of the schemes and the different emphasis in funding. [3.1, 7.18]

Other matters

13.46 Maximising the potential of sites in accordance with Policy 4B.3 of the London Plan has to be achieved within public transport capacity. Improvements are proposed to relieve the current peak time capacity problems on the Jubilee line. When considered in isolation the number of passengers generated by the proposal on Site E would have no significant impact on the operation and capacity of the line. As explained by the Council, there has been no specific evidence presented on the cumulative effects of development in areas served by the line and the implications of increased site densities on capacity. However, there has been no objection from the Mayor on strategic grounds. I have also referred to the reasoning on Policy 6A.8 of the London Plan, which advises there is a good correlation between increases in public transport capacity and the indicative increases in jobs and homes for each sub-region. The intention is to keep the situation under review through the plan, monitor and manage approach. Accordingly I conclude that the density of the proposal would be compatible with public transport capacity. [4.5, 5.4, 5.5, 6.17, 8.23]

13.47 I consider that the transport statement adequately demonstrates that the proposal would be unlikely to have adverse effects on the capacity of the local road network. The proposed level of car, motorcycle and bicycle parking and provision for a car share club are consistent with the good accessibility of the site and prevailing policy to encourage reduced reliance on the car. No objections were raised by either the Council or Transport for London/GLA on these matters. [4.3, 4.4, 4.6, 10.6]

13.48 I consider there would be sufficient separation distance between the development and existing housing to ensure that there would be no adverse effects on the living conditions of local residents [11.1].

Conclusion

13.49 The proposal is for 320 dwellings enabling about 1000 people to live on the site. The density would be at the top of the range for a central setting and above the indicative densities emerging through the draft UDP. To achieve this density the development would be characterised by a group of tall buildings.

13.50 The proposal does not comply with the guidance for the location of tall buildings in Policy 4B.8 of the London Plan. More specifically regarding its design and impact, the proposal would be within the transport capacity of the area, it would not impinge directly on the living conditions of nearby residents and it offers an opportunity to meet local accommodation needs for community uses. There are however, serious failings in terms of building composition and relationship to other buildings, streets and spaces. The buildings would not be of the highest standards of design nor has it been shown that the scheme would provide high quality spaces. A number of fundamental design elements have not been resolved, unsurprising given the time period in which a scheme of this scale was drawn up. The proposal would not comply with Policy 4B.9 of the London Plan. The proposal does not demonstrate that it would achieve the highest possible intensity of use compatible with local context and design principles for a compact city, thereby conflicting with Policy 4B.3 of the London Plan. Although the proposal would respect important strategic views, blocks B and C would not be of an appropriate height to fit in with their surroundings and accordingly the scheme fails to comply with Policy E.2.2 of the UDP. The scheme does not demonstrate the high standards of building and landscape design required by Policies E.2.3 and E.2.5 of the UDP. I conclude that the proposed development would be contrary to the development plan. [5.4, 5.7, 7.8, 8.31]

13.51 Material considerations also weigh against the proposal. I consider the development does not comply with national policy requirements for good design in PPS1 and PPG3, or with evaluation criteria set out in the EH/CABE guidance on tall buildings. The scheme does not meet the criterion for exemplary design set down in the draft UDP for high density developments in an urban zone and a PTAZ, albeit there is provision for significant contributions to environmental improvements. The development, by reason of its height and density, is not sufficiently sensitive to local guidelines in the SPG for Canada Water. The Appellant drew attention to the lack of objection on design issues but in my opinion this needs to be considered in context. In respect of the Mayor, the location of the site was thought unlikely to raise townscape interests of strategic significance or design issues that could not be dealt with adequately by the Council. Possibly the lack of objection by English Heritage and lack of interest by CABE was for similar reasons. [5.12, 8.26, 8.30]

13.52 In sum the proposal would not be appropriate to its context and there would be a negative impact on the local environment and the quality of life. The scheme has not demonstrated that the proposed density would be satisfactorily achieved. [6.12, 7.7, 8.22, 8.29]

Affordable housing and dwelling mix

13.53 Policy H.1.4 of the UDP requires the maximum reasonable proportion of affordable housing. The associated SPG requires a minimum of 25 %, although it does not identify under what circumstances, if any, a greater proportion will be required. Nor does it include any guidance on how to assess a maximum reasonable proportion. In the light of the SPG, I conclude that the proposed 25% affordable housing does not conflict with Policy H.1.4. [7.31, 8.35]

13.54 However, the UDP and SPG pre-date and do not take account of the strategic target now identified in Policy 3A.7 of the London Plan, whereby 50% of provision should be affordable. Within this framework, the borough target for Southwark is likely to be above the 25% of the adopted UDP and Policy 3A.8 of the London Plan seeks the maximum reasonable amount of affordable housing in individual schemes. Significantly, the Mayor considered the proposed 25% inadequate both in terms of the level and range of provision. No case has been made on viability. I conclude that the proposed affordable housing falls well short of the target of the London Plan and there has been no evidence on the individual circumstances of the site to justify the proposed level of provision. [1.9, 4.5, 5.3, 7.32]

13.55 Policy 4.4 of the draft UDP indicates that at least 35% of all new dwellings in the proposal should be affordable housing. However, the Council's approach has been to utilise the 25% in place at the date of acquisition of the site so as to enable firm financial planning. The emerging policy is subject to objection and hence there is no certainty that either the policy requirement or approach to its application will form part of the adopted plan. Therefore I attach only limited weight to these considerations. [5.15, 8.35]

13.56 The position is therefore one where there is conflict between the policies of the development plan and no up-to-date adopted local policy guidance. In the light of all material considerations my conclusion is that the proposal should respond more positively to the London Plan target and be justified by an economic appraisal.

13.57 In terms of implementation the affordable housing would be appropriately secured through the unilateral undertaking and would take the form of units provided on a rental/shared ownership basis under the control of a Registered Social Landlord. There is nothing in the undertaking to control the split between the two different housing tenures. Accordingly there is no certainty that the proposal would comply with the Londonwide objective of 70% social housing and 30% intermediate provision identified in Policy 3A.7 of the London Plan. [5.3, 12.9]

13.58 The affordable housing would be sited at the back of the site in part adjacent to Harmsworth Quays. The units would not enjoy the long distance views or roof gardens available to a number of the 'market' flats and when assessing design earlier in my Report I have been critical of the unattractive appearance of the rear elevations of block A. However, because of the single aspect design all the units would overlook the courtyard. There would be no adverse effect on living conditions either in terms of an oppressive outlook or noise from HQP. It also appears to me that the approach to block A has been developed as part of an overall design concept for the site as a whole. Balancing these various factors I conclude that the affordable housing would be integrated satisfactorily with the rest of the development. [8.31, 8.36, 9.2]

Dwelling Mix

13.59 In the revised proposal a majority of units would have two or more bedrooms and some provision is made for larger units for large families in block A. I consider the revised proposal complies with Policy H.1.5 of the UDP. However, because the policy was not derived from the most recent housing needs survey it is not up-to-date and hence not definitive policy guidance [4.2, 5.8, 5.15]

13.60 Policy 4.3 of the draft UDP expects at least 10% of the units to have 3 or more bedrooms. The need for larger units of accommodation in the Canada Water area has been supported by the local community. The proposal has achieved this proportion for the affordable housing, although the overall proportion at 7% falls short. I do not regard this shortfall as critical because the housing needs survey indicates that the requirement for larger units falls predominantly within the social rented rather than the private sector. Accordingly there would be a suitable mix of dwelling sizes based on the level of affordable housing proposed. However, I also consider that account has to be taken of the shortfall of affordable homes within the development and in the light of this factor I conclude that the dwelling mix would not be satisfactory. [4.2, 5.15, 8.13, 9.3, 10.5]

Other matters

Prematurity

13.61 I consider that the proposed 320 flats on a 0.8 hectare site is not a substantial development in a borough-wide context. The impacts would be confined to the locality of Canada Water. The site is identified for redevelopment within the Action Area. There is no evidence to suggest that failure to secure an employment use on the site would undermine the strategy for employment land supply either in the Action Area or in the borough. Emerging policy allows for central area densities provided the stringent requirements on building design and environmental improvements are met. Analysis of the appeal proposals enable conclusions on such issues to be reached. Therefore my conclusion is that a grant of permission would not prejudice the Southwark Plan by predetermining decisions about the scale, location or phasing. [7.35, 8.34]

Conclusion

13.62 Policy 2A.1 of the London Plan provides an overall framework to bring together the conclusions arising from the main considerations in this appeal [5.2].

13.63 The proposal would optimise the use of previously-developed land in a town centre location that is accessible to employment, shops and services by public transport, walking and cycling. There are no identified constraints in existing or planned infrastructure capacity and the scheme makes provision for improving community facilities.

13.64 Good design is central to all the objectives of the plan. I have concluded the proposal does not respect local context and character, even allowing for the change envisaged for the Action Area. The scheme has not demonstrated that the intensity of development is compatible with design principles for a compact city. On more specific design issues, the location of the site is not appropriate for tall buildings and the proposal does not achieve the highest quality of design required for large scale buildings. The harm to local character and identity would be magnified and the quality of the residential environment would be compromised. Insufficient account has been taken of the constraints of the site, the design failing to adequately address the noise climate. The result would be poor living conditions for a significant number of occupants, potentially adverse implications for the operation of the adjoining employment site and a weakening of the design concept.

13.65 The proposal would be a welcome contribution to housing supply in the borough, providing for a mix of housing types including affordable homes. Nevertheless the contribution to meeting housing needs is not a consideration of sufficient weight to overcome the serious failings in design. Furthermore the level of affordable housing would be inadequate when measured against up-to-date targets.

13.66 My conclusion is that the proposal is not acceptable when assessed against Policy 2A.1 of the London Plan. In addition it fails to meet the amenity and environmental tests in Policy R.2.1 of the UDP and the design requirements of the UDP set out in Policies E.2.2, E.2.3 and E.2.5. In sum, the proposal would be contrary to the development plan. The proposal would not fulfil national policy objectives for good design set out in PPS1 and PPG3; it would not minimise the adverse effects of noise and hence be contrary to the principles in PPG4 and PPG24. The EH/CABE evaluation criteria for tall buildings would not be adequately met. The proposal would not comply with the vision and policies for Canada Water set out in the draft UDP and the relevant SPG for Canada Water. The conflicts with the development plan and other material policy considerations substantially outweigh the positive factors identified and I conclude the development is unacceptable.

Planning conditions and unilateral undertaking

13.67 If the First Secretary of State is minded to allow the appeal I attach a list of conditions as Appendix 1, based on the conditions put forward by the Council and discussed at the Inquiry. As a general point, the conditions are wherever possible worded to follow the model conditions in Circular 11/95 'The Use of Conditions in Planning Permissions' and ordered so that conditions on a similar topic are grouped together [12.2].

13.68 Conditions controlling external materials, typical bay details and details of the treatment of the ground floor elevations to blocks B and C are necessary to ensure good quality design and materials in accordance with Policy E.2.3 of the UDP. A condition controlling roof top plant and/or ventilation equipment is necessary in order that the appearance of the buildings would not be compromised and to safeguard the amenity of the occupiers and users of the development. Such control is in accordance with an objective of Policy E.2.3 of the UDP. [12.2, 12.4]

13.69 A comprehensive landscape scheme, a schedule of maintenance and details of the arrangements for their implementation are necessary to ensure external spaces positively contribute to the appearance of the development and to the amenity of residents and users of the spaces in accordance with Policy E.2.5 of the UDP. The condition requires details of boundary treatment to form part of the landscape scheme and therefore a separate condition is unnecessary [12.3].

13.70 A condition requiring an investigation of ground conditions and the implementation of any proposed decontamination measures is necessary in the interests of public safety in compliance with Policy E.1.1 of the UDP. Having regard to the comments of the Environment Agency I consider that any necessary gas protection techniques would be appropriately covered through Building Regulations. I consider that the submission of a noise insulation scheme would be important to mitigate the effects of noise and disturbance for future residents of the flats in accordance with advice in PPG24. The plans indicate spaces for domestic refuse collection and recycling but such arrangements for the community uses are not clear. Therefore on this site where space is tightly constrained approval of the proposed arrangements is necessary to safeguard visual amenity and the general amenity of the occupiers of the development. [4.6, 12. 2, 12.4, 12.5].

13.71 Referring to Policy E.3.1 of the UDP a restriction on the use of the ground floor accommodation of blocks B and C, and future changes of use, is justified in order to safeguard the living conditions of residents of the development and the surrounding area and in the interest of highway convenience and safety. However, Circular 11/95 advises that restrictions should be no more onerous than necessary. On that basis I consider that the condition should only preclude use as a public hall or exhibition hall and use in connection with public worship or religious instruction, Class D1 (g) and (h), uses that could generate large numbers of people over a short period of time [8.2, 12.6].

13.72 A condition requiring the provision of cycle parking facilities before first occupation of the flats is necessary to encourage cycling in preference to the use of the car in accordance with Policy T.4.1 of the UDP. A condition restricting the use of the basement and surface car parking to the occupiers of the development is necessary to preclude parking in neighbouring streets and to safeguard residential amenity in accordance with Policies E.3.1 and T.6.3 of the UDP. [12.2, 12.7]

13.73 A condition on affordable housing is not necessary because such provision would be controlled through the unilateral undertaking. A number of the objectives identified in the sustainability statement would be covered through the conditions on landscaping, refuse disposal and parking. However, I consider a condition is necessary requiring details of measures to promote energy and water efficiency, sustainable construction and to prevent groundwater pollution in order to comply with Policy 4B.9 of the London Plan. [4.4, 12.4, 12.7]

Unilateral undertaking

13.74 I have explained in paragraphs 13.54 and 13.56 above that I consider the proportion of affordable housing to be inadequate in relation to Policy 3.A7 of the London Plan. If the First Secretary of State concludes that affordable housing provision is the only shortcoming of the scheme the issue arises as to whether the Appellant should have the opportunity to increase the level of provision. In my opinion this would raise issues not only in relation to viability and emerging policy but also on scheme design and dwelling mix. In other words affordable housing provision is not a discrete matter but it has implications for other aspects of the scheme. Therefore in this case I do not regard it appropriate for the Appellant to be afforded the opportunity to address the matter further. If the First Secretary of State disagrees, I consider the opportunity should also be taken to address and clarify the ratio of social to intermediate housing provision. [8.37]

13.75 I have concluded that the financial contributions would be fairly and reasonably related in scale and kind to the proposed development. They would help to mitigate the impact of the proposal on the locality and they would contribute towards more sustainable patterns of movement. Accordingly they would be necessary, relevant to planning, directly related to the proposed development and reasonable in all other respects. However, it is normal practice to provide for indexation and if the commencement of the development was towards the end of the five year period, the significance of the contributions would be reduced. In my view this is an appropriate matter for the Appellant to address if the First Secretary of State be minded to allow the appeal. [12.10, 12.11]

13.76 There is a reference in Clause 3.8 to previous undertakings in connection with the proposed development. Whilst it is a matter of law, I agree with the Council those previous documents have no practical significance, the first because it was unsigned and the second because there was no relevant clause to give effect to the undertaking. [12.11, 12.12].

14. RECOMMENDATION

14.1 For all the reasons given in paragraphs 13.5 to 13.66, I recommend that the appeal be dismissed.

14.2 Should my recommendation not be accepted I draw attention to the suggested conditions in Appendix 1. I consider all the conditions are necessary for the reasons stated in paragraphs 13.68-13.73 and that they would comply with advice in Circular 11/95.

INSPECTOR

APPEARANCES

FOR THE LOCAL PLANNING AUTHORITY:

Daniel Kolinsky of Counsel	Instructed by the Borough Solicitor, London Borough of Southwark
He called	
Dani Fiumicelli MSc MIOA	Principal Noise Consultant, Hyder Consulting Ltd (formerly with Casella Stanger)
Bridin O'Connor BA Hons M.Phil	Town Planning Consultant, Chiltern House, Portland Street, London SE17

FOR THE APPELLANT:

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He called	
Michael Crosby BSc DipArch RIBA	Director of C A Cornish & Associates Ltd, Chartered Architects, Priory House, 25 St Johns Lane, London EC1M 4HD
Chris Arnold MIOA MSEE	Associate Director of WSP Acoustics, Buchanan House, 24-30 Holborn, London EC1N 2HS
Bill Brisbane BSc DipTP MRTPI FRICS	Managing Partner of Roger Tym & Partners, Fairfax House, 15 Fulwood Place, London WC1V 6HU

FOR HARMSWORTH QUAYS PRINTING LIMITED:

Russell Harris Q.C.	Instructed by CMS Cameron McKenna, Mitre House, 160 Aldersgate Street, London EC1A 4DD
He called	
Michael Lowndes BAHons DipTP MSc	Planning Director at Turley Associates, 25 Savile Row, London W1S 2ES
Neil Jarman BSc(Hons) CEng MCIBSE MIOA	Director of Cole Jarman Associates, 95 The Street, West Horsley, Surrey KT24 6DD
Christine Robinson BAHons M.Phil FRTPI	Principal, Planning & Environmental Services Limited 101A Clifton Hill, St Johns Wood, London NW8 0JR

INTERESTED PERSONS:

Derek W Partridge CMG	Speaking on behalf of himself and Councillors of Surrey Docks Ward, 16 Wolfe Crescent, London SE16 6SF
Brian R Hodge	Chair, Canada Water Campaign Planning Group, speaking on behalf of Canada Water Consultative Forum, Canada Water Campaign and Wolfe Crescent Residents Association,

DOCUMENTS

Document 1	List of persons present at the Inquiry
Document 2	Letters of notification and lists of people notified
Document 3	Supporting Planning Statement
Document 4	Design Statement in support of planning application
Document 5	Transport Statement

Document	6	PPG24 Assessment
Document	7	Sustainability Statement in support of planning application
Document	8	Proof of evidence of Mr Fiumicelli
Document	8A	Appendices to proof of evidence of Mr Fiumicelli
Document	9	Proof of evidence of Ms O'Connor
Document	10	Appendices to Ms O'Connor's proof of evidence
Document	11	Summary proof of Ms O'Connor
Document	12	Supplementary proof of evidence of Ms O'Connor
Document	12A	Appendices to supplementary proof of evidence of Ms O'Connor
Document	13	Proof of evidence of Mr Crosby
Document	14	Summary of proof of evidence by Mr Crosby
Document	15	Appendix A (maps & photographs) to proof of evidence of Mr Crosby
Document	16	Appendix B Drawings and Schedule to proof of evidence of Mr Crosby
Document	17	Appendix C to proof of evidence of Mr Crosby
Document	18	Supplementary proof of evidence (response to Mr Lowndes) of Mr Crosby
Document	19	Supplementary proof of evidence (response to Ms O'Connor) of Mr Crosby
Document	20	Supplementary proof of evidence regarding the effect on the setting of the strategic view by Mr Crosby
Document	21	Appendix D plans photographs and consultation responses to supplementary proof of evidence by Mr Crosby
Document	22	Project model submitted by Mr Crosby
Document	23	Proof of evidence of Mr Arnold
Document	24	Appendices to proof of evidence of Mr Arnold
Document	25	Summary proof of evidence by Mr Arnold
Document	26	Supplementary proof of evidence (response to Mr Fiumicelli) of Mr Arnold
Document	27	Supplementary proof of evidence (response to Mr Jarman) of Mr Arnold
Document	28	Proof of evidence of Mr Brisbane
Document	29	Appendices to proof of evidence of Mr Brisbane
Document	30	Summary of proof of evidence by Mr Brisbane
Document	31	Supplementary proof of evidence of Mr Brisbane
Document	32	Appendices to supplementary proof of evidence of Mr Brisbane
Document	33	Proof of evidence of Mr Lowndes
Document	34	Summary of proof of evidence by Mr Lowndes
Document	35	Supplementary proof of evidence of Mr Lowndes November 2004
Document	36	Supplementary proof of evidence ofMr Lowndes March 2005
Document	37	Verifiable Photomontage and Diagram Methodology Statement by Hayes Davidson for Turley Associates
Document	38	Proof of evidence of Mr Jarman
Document	39	Appendices to proof of evidence of Mr Jarman
Document	40	Appeal decision APP/T2929/A/02/1086822 submitted by Mr Jarman
Document	41	*Bryant Homes Limited v First Secretary of State* [2003] EWHC 579 submitted by Mr Jarman
Document	42	Summary of proof of evidence by Mr Jarman
Document	43	Supplementary proof of evidence of Mr Jarman
Document	44	Proof of evidence of Mrs Robinson
Document	45	Appendices to proof of evidence by Mrs Robinson
Document	46	Summary of proof of evidence by Mrs Robinson
Document	47	Supplementary proof of evidence of Mrs Robinson
Document	48	Summary of traffic surveys Rowland Bilsland Traffic Planning submitted by Mrs Robinson
Document	49	Statement by Mr Hodge

Document	50	Representations on the appeal application
Document	51	Representations on the appeal
Document	52	Direction under Articles 10 and 27 for protecting the strategic view of St Paul's Cathedral from Greenwich Park dated 16 June 2000 submitted by the Appellant
Document	53	Variation Direction under Articles 10 and 27 for protecting the strategic view of St Paul's Cathedral from Greenwich Park dated 11 August 2000 submitted by the Appellant
Document	54	Statutory Instrument 2000 N0.1493 submitted by the Appellant
Document	55	Plan of WSCA and plans of proposal submitted by the Appellant
Document	56	Opening Statement on behalf of HQP
Document	57	Site layout plan with overlay of existing building submitted by the Appellant
Document	58	Committee report on the Mulberry Business Centre 9 November 2004
Document	59	Supporting photographs for tall buildings submitted by HQP
Document	60	Letter from Ward Councillors submitted by Mr Partridge
Document	61	Canada Water SPG dated October 2004
Document	62	Bundle of plans for Site D
Document	63	Measuring Public Transport Accessibility Levels Summary TfL June 2003
Document	64	Bundle of documents on Canada Water SPG submitted by the Council
Document	65	Draft unilateral undertaking
Document	66	Boundaries of Canada Water District Centre
Document	67	E-mail from English Heritage submitted by HQP
Document	68	Character map submitted by the Appellant
Document	69	Figure 17 of Hayes Davidson document with WSCA boundary added submitted by the Appellant
Document	70	Objection to district centre boundary by HQP
Document	71	Analysis of traffic surveys submitted by the Appellant
Document	72	Details of Cornish Architects submitted by the Appellant
Document	73	Consultation document for WSCA submitted by the Appellant
Document	74	Note of meeting on 4 February 2003 submitted by the Council
Document	75	Plan of typical enclosed balcony submitted by the Appellant
Document	76	Note of meeting on 11 February 2003
Document	77	Site layout plan 10341/TP/003B to show site features
Document	78	Night Aircraft Noise Index and Sleep Research Results by Vallet and Vernet submitted by HQP
Document	79	HQP contribution to Surrey Quays Road traffic note submitted by HQP
Document	80	Unilateral undertaking dated 12 April 2005 submitted by the Appellant
Document	81	Retail floorspaces submitted by the Appellant
Document	82	A new approach to planning obligations – ODPM statement on reform proposals submitted by the Appellant
Document	83	Draft revised Circular on planning obligations submitted by the Appellant
Document	84	Note on ink tanker deliveries submitted by HQP
Document	85	Revised list of agreed conditions submitted by the Council
Document	86	Affordable Housing SPG February 2002
Document	87	Letter on unilateral undertaking dated 11 March 2005
Document	88	Closing submissions on behalf of HQP
Document	89	Closing submissions on behalf of the Council
Document	90	Extract from the Encyclopaedia of Planning Law submitted by the Council
Document	91	Closing submissions on behalf of the Appellant
Document	92	*Murdoch and Murdoch v Glacier Metal Company Limited* [1998] Env.L.R

		732 submitted by the Appellant
Document	93	*Manley and another v New Forest District Council* [1999] 4PLR 36 submitted by the Appellant
		NB. Proofs may not accurately reflect the evidence of the witness at the Inquiry.

CORE DOCUMENTS

CD	1	PPG1: General Policy and Principles
CD	2	PPG3: Housing
CD	3	PPG4: Industrial, commercial development and small firms
CD	4	PPG12: Development Plans
CD	5	PPG23: Planning and pollution control
CD	6	PPG24: Planning and Noise
CD	7	Consultation Paper on PPS1
CD	8	The London Plan 2004
CD	9	London Borough of Southwark Unitary Development Plan 1995
CD	10	The Southwark Plan (Revised Deposit UDP) March 2004
CD	11	Pre-Inquiry Changes to the Southwark Plan (Revised Deposit UDP) October 2004
CD	12	Canada Water Draft SPG 2002
CD	13	Canada Water Draft SPG 2004
CD	14	Tall Buildings Draft SPG 2002
CD	15	Residential Design Standards Draft SPG 2002
CD	16	Towards an Urban Renaissance – Final Report of the Urban Task Force 1999
CD	17	Sustainable Communities – Building for the Future 2003
CD	18	World Health Organisation Guidelines for Community Noise
CD	19	BS 8233 1999 Sound insulation and noise reduction – Code of Practice
CD	20	BS 4142 1997 Method for Rating industrial noise affecting mixed residential and industrial areas
CD	21	Sounder City – The Mayor's Ambient Noise Strategy 2004
CD	22	CABE Design Review 2002
CD	23	PPS1: Creating Sustainable Communities
CD	24	PPG3: Housing Update – Supporting the delivery of new housing
CD	25	Employment Land Review Guidance Note 2004
CD	26	Final Changes to the draft Southwark Plan February 2005
CD	27	Southwark Plan Public Local Inquiry: Employment and Enterprise Topic Paper
CD	28	Southwark Plan Public Local Inquiry: Housing Topic Paper
CD	29	Southwark Plan Public Local Inquiry: Affordable Housing Topic Paper
CD	30	Southwark Plan Public Local Inquiry: Open Space Topic Paper
CD	31	Southwark Plan Public Local Inquiry: Density Topic Paper
CD	32	Affordable Housing draft SPG 2004
CD	33	Committee report regarding the Mulberry Business Centre Appeal January 2005
CD	34	Mayor of London draft SPG on Housing Provision 2004
CD	35	Adopted Canada Water SPG February 2005
CD	36	Southwark Housing Capacity Study 1997-2016 January 2005
CD	37	Greater London Housing Requirements Study December 2004
CD	38	The Planning System General Principles

PLANS

Plan	A	Site location 10341/TP/001
Plan	B	Existing site plan 10341/TP/002
Plan	C	Proposed site plan 10341/TP/003B

Plan	D	Basement car park 10341/TP/005
Plan	E.1	Block A floor plans 10341/TP/006 and as amended 10341/TP/049
Plan	E.2	Block A floor plans as amended 10341/TP/049
Plan	F	Block C floor plans 10341/TP/011
Plan	G	Block C floor plans 10341/TP/012
Plan	H	Block A elevations 10341/TP/013
Plan	I	Block A elevations 10341/TP/014
Plan	J	Block C elevations 10341/TP/017
Plan	K	Block C elevations 10341/TP/018
Plan	L	Block A sections 10341/TP/023
Plan	M	Block C sections 10341/TP/025
Plan	N	Block B plans sheet 1 10341/TP/041
Plan	O	Block B plans sheet 2 10341/TP/042
Plan	P	Block B plans sheet 3 10341/TP/043
Plan	Q	Block B plans sheet 4 10341/TP/044
Plan	R	Block B plans sheet 5 10341/TP/045
Plan	S	Block B sections 10341/TP/046
Plan	T	Block B elevations 10341/TP/047
Plan	U	Block B elevations sheet 2 10341/TP/048
Plan	V	3D View 10341/TP/19A
Plan	W	3D View 10341/TP/20A
Plan	X	3D View 10341/TP/21B

APPENDIX 1: PLANNING CONDITIONS

1) The development hereby permitted shall begin before the expiration of five years from the date of this decision.

2) No development shall take place until samples of the materials to be used in the construction of the external surfaces of the buildings hereby permitted have been submitted to and approved in writing by the local planning authority. Development shall be carried out in accordance with the approved details.

3) No development shall take place until plans of typical bay details, including sections of not less than 1:20 for each of the three buildings hereby permitted showing cladding, windows, balconies and screens, have been submitted to and approved in writing by the local planning authority. Development shall be carried out in accordance with the approved details.

4) Before commencement of the construction of blocks B and C details of the elevations of the ground floor of blocks B and C shall be submitted to and approved in writing by the local planning authority. Development shall be carried out in accordance with the approved details.

5) No development shall take place until details of all roof top plant and all ventilation equipment have been submitted to and approved in writing by the local planning authority. Development shall be carried out in accordance with the approved details

6) No development shall take place until full details of both hard and soft landscape works have been submitted to and approved in writing by the local planning authority and these works shall be carried out as approved. These details shall include proposed finished levels or contours; means of enclosure; surface car parking layout; pedestrian access and circulation areas; hard surfacing materials; minor artefacts and structures (eg. furniture, play equipment, signs, lighting etc); proposed and existing functional services above and below ground (eg. drainage, power, communications cables, pipelines etc. indicating lines, manholes, supports etc.). Soft landscape works shall include planting plans; written specifications (including cultivation and other operations associated with plant and grass establishment); schedules of plants, noting species, plant sizes and proposed numbers/densities where appropriate; implementation programme.

7) All hard and soft landscape works shall be carried out in accordance with the approved details. The works shall be carried out prior to the occupation of any part of the development or in accordance with the programme agreed with the local planning authority. Any trees or plants which within a period of 5 years from the completion of the development die, are removed or become seriously damaged or diseased shall be replaced in the next planting season with others of similar size and species, unless the local planning authority gives written approval to any variation.

8) No development shall take place until a schedule of landscape maintenance for a minimum period of 5 years has been has been submitted to and approved in writing by the local planning authority. The schedule shall include details of the arrangements for maintenance of the play area and ball court and arrangements for its implementation. Maintenance shall be carried out in accordance with the approved schedule.

9) Before the development hereby permitted commences on the site, a soil survey of the site shall be undertaken and the results provided in writing to the local planning

authority. The survey shall be taken at such points and to such depth as the local planning authority may stipulate. Furthermore, a scheme for decontamination of the site shall be submitted to and approved in writing by the local planning authority before commencement of development. The scheme as approved shall be fully implemented and completed before any residential unit hereby permitted is first occupied.

10) No development shall take place until a scheme for protecting the proposed residential development from noise from traffic movements and from Harmsworth Quays printing works has been submitted to and approved in writing by the local planning authority. All works which form part of the scheme shall be completed in accordance with the approved details before any dwelling unit is occupied.

11) No development shall take place until details of the arrangements for the storing of domestic refuse and refuse arising from the ground floor community uses have been submitted to and approved in writing by the local planning authority. The refuse storage facilities shall be provided in accordance with the approved details before the development is first occupied and shall be retained as approved thereafter.

12) The ground floor accommodation of blocks B and C shall be used for purposes falling within Class D1 (a) (b) (c) (d) (e) (f) and for no other purpose including any other purpose in Class D1 (g) and (h) of the Schedule to the Town and Country Planning (Use Classes) Order 1987, or in any provision equivalent to that Class in any statutory instrument revoking and re-enacting that Order with or without modification.

13) No dwelling shall be occupied until cycle storage facilities have been provided in accordance with plan no. 10341/TP/005 for 365 bicycles to be parked. The facilities shall be retained thereafter and shall be used for no other purpose.

14) The basement car parking shall not be used other than by occupiers of the development for the parking of vehicles.

15) The five surface car parking spaces hereby approved shall not be used other than for visitor/drop-off spaces in connection with the ground floor community uses.

16) No development shall commence until a sustainability scheme has been submitted to and approved in writing by the local planning authority. The scheme shall include details of measures to promote sustainable construction and energy and water efficiency in the development; proposals for surface water drainage, incorporating measures to prevent water pollution and to promote sustainable urban drainage systems. Development shall be carried out in accordance with the approved scheme.

MARC

Appeal Decision

Inquiry opened on 24 February 2004

by A Mead BSc(Hons) MRTPI MIQ

an Inspector appointed by the First Secretary of State

The Planning Inspectorate
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Date 27 MAY 2004

Appeal Ref: APP/W1850/A/03/1124124
Orchard Lane, Ledbury HR8 1DQ

- The appeal is made under section 78 of the Town and Country Planning Act 1990 against a refusal to grant planning permission.
- The appeal is made by Tesco Stores Ltd against the decision of Herefordshire Council.
- The application (Ref.NE2003/0483/F), dated 12 February 2003, was refused by notice dated 10 April 2003.
- The development proposed is the variation of condition 10 of planning permission MH95/0535 in order to extend the delivery period on Monday to Saturday to 6.00 - 00.00 and on a Sunday from 08.00 – 19.00 hours.

Summary of Decision: Allowed (Sunday extension only).

Procedural Matters

1. The inquiry sat on 24th and 25th February and 30th March. I inspected the site unaccompanied on 23rd and 25th February and accompanied on 30th March.

2. Planning permission was granted in 1995 for a Class A1 Foodstore of 2068m^2 Gross, service yard, shopper's car park for 170 cars, landscaping, ancillary plant and equipment and access together with non shopper's car parking spaces at the appeal site. Condition 10 of that permissions stated:-" There shall be no deliveries before 7.00am or after 11.00pm, Mondays to Saturdays, before 9.00am or after 6.00pm on Sundays, and at no times on Christmas Day or Easter Day".

3. The application which is the subject of the appeal effectively seeks the facility for delivering goods to the store an hour earlier in the mornings and an hour later in the evenings.

Main Issues

4. I consider that the main issue is whether the extended delivery times would cause significant harm to residential amenities due to noise.

Planning Policies

5. The Statement of Common Ground refers to Policy CTC.9 of the Hereford and Worcester Structure Plan (SP) as the relevant development plan policy. It seeks to ensure that when permitting development, regard is had to the impact on existing communities. However, Policy T5 also governs the control of heavy goods vehicles. In addition, Shopping Policy 7 of the Malvern Hills District Local Plan 1998 states that proposals outside the principal shopping and commercial areas will only be allowed where they would not cause undue disturbance by reason of noise and general activity to residential properties in the locality.

6. Policy DR2 of the Herefordshire UDP Deposit Draft 2002 aims to ensure that proposed development would not prejudice the amenity or continued use of adjoining land and buildings. Policy DR13 seeks to control noise from development and not to allow proposals where noise would not be mitigated to acceptable levels. Policy T9 states that proposal that generate service vehicle movements that would unacceptably affect the amenity, safety and character of the existing or neighbouring environments by virtue of noise, traffic generation and congestion, air pollution, or causing parking problems, will not be permitted.

Reasons

7. In concluding that the additional delivery times would cause unacceptable noise and disturbance to nearby residents, the Council used BS 4142 to assess the impact of the noise levels. The appellants disputed the use of BS4142 suggesting that the noise was not of an industrial nature. The appellants had assessed noise impact by estimating the new levels based on surveys of this and other stores. Both parties submitted copies of appeal decisions to reinforce their claims for their preferred method assessment, although the weight of opinion within the decisions by colleague Inspectors was against the use of BS 4142 for the assessment of noise caused by extending delivery times at retail stores.

8. PPG24 states that the likelihood of noise from industrial development can be assessed, where the standard is appropriate, using guidance in BS4142. Although the retail store is commercial rather than industrial, the BS indicates that noise levels from sources of an industrial nature in commercial premises fall within its scope.

9. It seemed to me that, in this case, delivery was more than the mere arrival and departure of a large HGV. When I visited the site unaccompanied, the noise from dropping the metal tail lift flaps onto the service yard ground during loading and unloading to enable metal cages to be moved on and off the lorry and the rattling of the wheels and cages dominated the noise climate. The level of these intermittent noises, especially the tail flaps, are consistent with the peaks on the noise survey traces presented by the appellants and also the numerical data presented by the Council.

10. The predicted noise levels in the noise assessment submitted by the appellants was based in part on measurement of the noise of service activity at about 40 other Tescos stores. In my opinion, it would not be appropriate to place too much emphasis on experience at an average of other stores which shows an unloading phase of only 30 minutes. The statement provided by the appellants for the store at Ledbury states that unloading usually takes around 1 hr 20 minutes to complete. Furthermore, other evidence also indicates that the unloading time at the store cannot be reduced below 50 minutes. In addition, the Council's noise witness had observed a delivery cycle of 1 hour 20 minutes. Therefore, not only does the extended duration of the delivery activity at the Ledbury store diminish the weight which can be attached to this element of the noise assessment by the appellants but, in my opinion, it increases the appropriateness of the applicability of BS4142.

11. Therefore, in my opinion, if the delivery is extended in duration and it includes the noises of the operations which are undertaken after the lorry has arrived and before it departs, the activity takes on the nature of an industrial process. It may be that in other reported appeal decisions, the impact of the delivery is focussed on the actual movements of the lorry, in which case BS4142 may not be the appropriate evaluation method. But at this site, the proximity of the nearby houses to the delivery yard and the design of the yard has broadened the impact from mere lorry movement to include the on site activities after the lorry has arrived. BS4142 is

aimed at sites which are within a mixed residential and industrial area, which this is not. However, if the duration of the noise is such that it becomes in the nature of an industrial process and the nearest properties affected are residential then, notwithstanding the definition of whether or not the site is in a mixed industrial and residential area, the use of BS4142 becomes more appropriate.

12. I note that of the several appeals decisions referred to at the inquiry involving cases of extended delivery times at food stores, all except one rejected the method of noise assessment using BS4142. However, in judging each case on its merits, it seems to me that the length of the delivery time and the effects of the unloading activity in such close proximity to houses make the use of BS4142 at the very least a good indicator of the acceptability of the noise levels.

13. The BS4142 assessment carried out by the Council indicates that the noise of the delivery cycle when carried out in the night time period for which permission is sought would exceed the 10dB threshold, showing that it would be likely to give rise to complaints. The excess of noise above background was calculated by the Council to be 28.6dB for unrefrigerated deliveries between 0600 – 0700 and 2300 – 0000 on Monday to Saturday and 22.6dB between 1800 – 1900 on Sundays. The assessment for refrigerated deliveries indicated that the exceedence of the 10dB likelihood of complaint threshold would be higher. Accordingly, following the Council's stance on the use of BS4142 and the indications it offers and my experience on my unaccompanied site inspection, the noise from the extended delivery times would, in my view, give rise to levels which would be likely to lead to complaints and would cause significant harm to the residential amenities of the nearby houses opposite the entrance to the service yard of the store, particularly on weekdays.

14. The appellants assessed the likely noise by considering the L_{Amax} levels, the number of noise events, the degree of extraneous noise and the guidance from the World Health Organisation (WHO). Rather then defining acceptable and unacceptable noise levels, this guidance indicates those below which effects can be assumed to be negligible. Therefore, exceedances of the WHO guideline values do not necessarily imply significant noise impact.

15. The WHO guidance recommends noise limits for night time of 60 dB L_{Amax} and 45 $dB_{LAeq8hr}$. The former is appropriate for the assessment of transient events, the latter for continuous noise. The appellants predicted the noise levels on a 45 minute delivery cycle. The Council indicated that the longer delivery cycle would result in the levels exceeding the WHO guideline limits but, in my opinion, when the levels are converted from L_{Aeq1hr} to $L_{Aeq8hrs}$, it is not so clear cut. The Council submitted that it could not be assumed that the health effects caused by the noise levels predicted by this method would only be negligible. Nevertheless, conversely, I am not convinced that this prediction results in noise levels which would cause significant harm to residential amenities. However, I note that the appellants failed in the assessment to consider the L_{Amax} for the unloading phase.

16. The appellants commented that there are already many events 0600 – 0700 where the L_{Amax} exceeds the WHO guidelines, including passing vehicles with levels of 58 – 66dB. Nevertheless, the chart recording trace submitted by the appellants also shows other noise peaks during the later period of unloading not attributable to traffic which, in my view, could easily be caused by the bang and clatter of the tail gate flaps. I consider that if those unloading noises were caused at the earlier time of the day and later time of the weekday evenings sought in the planning application, they would be very intrusive and would cause significant harm to residential amenities.

17. The Council accepted that the proposed extension of delivery times on a Sunday would not extend into the night time period as described in PPG24. Moreover, the Council had not carried out any background noise assessments for the period on Sunday from 0800 – 0900 which, in my view, significantly undermines its calculation of noise levels for that period. In my opinion, the noises which would occur in the delivery cycle would be far less intrusive for residents from 0800 – 0900 and 1800 – 1900 on Sundays compared to the weekday extensions sought. I do not consider that there is a sound objection to the delivery times sought on Sundays. Both parties agreed that I had sufficient evidence to consider the separate times and days within the proposal.

18. There would be an undoubted commercial advantage in extending the delivery times so that fresh produce can be brought in for early display on shelves and subsequent sales at this anchor food store, to the overall benefit of customers. Nevertheless, I do not consider that the disturbance which would be caused by the early and late deliveries on weekdays would outweigh the benefits brought by the proposal.

19. The appellants suggested that a condition to provide for the construction of a screen or wall to act as a noise attenuation barrier could be erected along the open side of the service yard. However, I am not convinced of the practicality of such a screen and how it might inhibit the arrival and manoeuvring of lorries. In any event, I received no substantive evidence such as noise assessment about the attenuating effects of a screen. Therefore, I do not accept that it would be appropriate to impose a Grampian style condition to seek the prior submission and approval of details and construction of a screen. I do not consider that there are any planning conditions which would make the proposal acceptable in its entirety

20. Accordingly, I shall allow the appeal by extending the delivery times as sought on Sundays, but not allow the extended times on weekdays, which I consider would be contrary to SP Policy CTC9 and emergent UDP Policies DR2 and DR13. In suggesting a new condition, I have used a form of words similar to those agree by both parties at the inquiry. I have taken account of all the other points which have been raised but they do not outweigh those which have led to my decision.

Formal Decision

21. For the above reasons and in exercise of the powers transferred to me, I hereby allow the appeal and grant planning permission for the continued use of the retail store at Orchard Lane Ledbury HR8 1DQ in accordance with application No. NE2003/0483/F dated 12 February 2003, without compliance with condition number 10 previously imposed on planning permission MH95/0535 dated 12 May 1995 but subject to the other conditions imposed therein, so far as they are still subsisting and capable of taking effect and subject to the following new condition

"There shall be no deliveries (including delivery or service vehicle movements) unloading or handling of delivered goods in the service area before 7.00am or after 11.00pm Mondays to Saturdays, before 8.00am or after 7.00pm on Sundays and at no time on Christmas day or Easter Day."

22. I dismiss the appeal so far as the extension to the delivery period on Mondays to Saturdays is concerned.

INSPECTOR

APPEARANCES

FOR THE LOCAL PLANNING AUTHORITY

Mr C Rumney of Counsel	instructed by the Council Secretary and Solicitor, Herefordshire Council
He called:	
Mr R J Pryce BA(Hons) Dip TP MRTPI	Senior Planning Officer
Mr M Willimont BA(Hons) MSc CIEH	Senior Environmental Health Officer

FOR THE APPELLANT:

Mr J Maurici of Counsel	instructed by the Development Planning Partnership
He called:	
Mr M Dodds BA (Hons) BTP MRTPI	Development Planning Partnership
Mr D Sharps CEng FIMechE FIOA	Sharps Redmore Partnership, Ipswich

DOCUMENTS

Doc		Lists of persons present at the inquiry
Doc	2	Letter of notification of the inquiry
Doc	3	Letter received from interested party
Doc	4	Statement of Common Ground
Doc	5	Bundle of Appendices 1 – 9 submitted by Mr Pryce
Doc	6	Bundle of Appendices 1 – 10 submitted by Mr Willimont
Doc	7	Bundle of Appendices 1 – 8 submitted by Mr Dodds
Doc	8	Bundle of Appendices A – F submitted by Mr Sharps
Doc	9	Statement from Tescos Stores Ltd
Doc	10	BS4142
Doc	11a/b/c	Details of planning permissions and S106 Obligation at appeal site
Doc	12	Committee report & details: the 1995 planning permission at the appeal site
Doc	13	Correspondence summer 2003 about the proposal

PLANS

Plan	A	Plan of appeal site

Minutes of meeting of Food Standards Agency Audited Authorities	Food Safety, Hygiene and Standards	01 Apr
Situation Report on New Pesticides Safety Directorate Arrangements for Pesticide Residue	Food Safety, Hygiene and Standards	31 Ma
Implementing the Agency's Foodborne Disease Strategy - Progress Report	Food Safety, Hygiene and Standards	26 Ma
FHW - Category B - For Action Ref:06/2003 Methanol Contamination of Original Vodka Russia Export Quality	Food Safety, Hygiene and Standards	25 Ma
Food Policy Forum - Agenda	Food Safety, Hygiene and Standards	25 Ma
Imports of Fishery Products from Russia: New Health Certificates	Food Safety, Hygiene and Standards	25 Ma
Consultation Review of Section 40 Food Safety Act Code of Practice	Food Safety, Hygiene and Standards	24 Ma
Situation Report on FSA Funded Research on Promotion of Foods to Children: Health and Nutrition Implications	Food Safety, Hygiene and Standards	24 Ma
LACORS Food Standards Update: 17 March 2003	Food Safety, Hygiene and Standards	21 Ma
Situation Report on Feedback from EC Inspection Visit to UK to Look at Enforcement of Beef Labelling Rules	Food Safety, Hygiene and Standards	18 Ma
Food Hazard Warning - Information Only - 05/2003 Product Recall of Sainsbury's Soups	Food Safety, Hygiene and Standards	17 Ma
Details of Food Standards Agency Food Standards and Labelling Update Course for Food Requirements Officers: 19-22 May 2003 : Leeds	Food Safety, Hygiene and Standards	13 Ma
Notification of Person Prohibited from Managing a Food Business Under Section 11(4) of the Food Safety Act 1990	Food Safety, Hygiene and Standards	13 Ma
Situation Report on Fish Labelling Regulations 2003	Food Safety, Hygiene and Standards	13 Ma
Food Hazard Warning Category B - Ref 02/2003 Update 1 For Action - Methanol Contamination of Imperial Valkonov Vodka	Food Safety, Hygiene and Standards	12 Ma
Minutes of the LACORS Food Labelling Focus Group Meeting: 21 January 2003	Food Safety, Hygiene and Standards	12 Ma
Minutes of the LACORS Food Sampling and Analysis Focus Group Meeting: 30 January 2003	Food Safety, Hygiene and Standards	12 Ma
LACORS Response to European Commission Request for Information Concerning the Review of Nutrition Labelling Directive: 90/496	Food Safety, Hygiene and Standards	11 Ma