
British Standard
**Noise control on construction
and open sites**

Part 1. Code of practice for
basic information and procedures
for noise control

Lutte contre le bruit sur les chantiers de construction et autres chantiers à l'air libre
Partie 1. Code de bonne pratique sur les données et méthodes fondamentales de la lutte
contre le bruit

Lärmschutz auf Baustellen
Teil 1. Leitfaden für Basisinformationen und Vorgehensweise beim Lärmschutz

Contents

	Page		Page
Foreword	1	3. Examples of prediction of noise from a building site	17
Committees responsible	Back cover	4. Estimation of daily L_{Aeq} according to sampling technique	20
Code		5. Index of site equipment referred to in tables 6 to 14	22
Section one. General		6. Sound level data on demolition	26
1. Scope	2	7. Sound level data on site preparation	27
2. Definitions	2	8. Sound level data on piling	31
3. Legislative background	3	9. Sound level data on concreting operations	35
4. Community relations	4	10. Sound level data on general site activities	38
5. Training	4	11. Sound level data on roadworks	42
Section two. Noise and persons on site		12. Sound level data on motorway construction	44
6. Protection from noise-induced hearing loss	4	13. Sound level data on opencast coal sites	46
7. Ear protectors	5	14. Sound level data on dredging	52
8. Noise-induced stress	5	15. Methods of reducing sound levels from construction plant	54
Section three. Noise and neighbourhood nuisance		16. Sound insulation characteristics of common building materials	56
9. Disturbing effects of noise	5	17. Sound-absorbing materials for lining of covers and enclosures	56
10. Description of site noise	5	18. Measured sound reduction given by types of partial enclosure	57
11. Criteria for setting noise control targets	5		
Section four. Project supervision		Figures	
12. General	6	1. Flow chart for the prediction of site noise	10
13. Works preparation	6	2. Distance adjustment K_d for activity L_{Aeq} method	11
14. Execution of works	7	3. Distance adjustment K for plant sound power method	12
Section five. Control of noise		4. Adjustment to sound level to give resulting L_{Aeq} (plant sound power method)	13
15. Control of noise at source	7	5. Nomograph: combined L_{Aeq} from activity L_{Aeq} values and their respective durations	15
16. Controlling the spread of noise	8	6. Office development site showing plant locations in relation to the nearest affected facade	16
Appendices		7. Spoil movement on a haul road showing location of the nearest affected property	18
A. Estimating noise from sites	9	8. Example of machine enclosure	56
B. Noise monitoring	19	9. Typical acoustic shed	57
C. Guide to sound level data on site equipment and site activities	21	10. Examples of acoustic open-sided sheds	58
D. Noise sources, remedies and their effectiveness, and acoustic screens	52		
E. Bibliography	59		
Tables			
1. Relationship of distance ratio and equivalent on-time for slow moving plant	13		
2. Addition of steady sound levels	14		

Foreword

This Part of BS 5228, which has been prepared under the direction of the Basic Data and Performance Criteria for Civil Engineering and Building Structures Standards Committee, covers the control of noise from construction sites and from other open sites. This Part of BS 5228 supersedes BS 5228 : 1975 which is now withdrawn.

BS 5228 has been revised to include the considerable amount of research and experience which has accumulated since BS 5228 : 1975 was published, together with the need for wider guidance on noise control both for specialist operations within the construction industry and from open sites other than construction sites.

This standard refers to the need for the protection of persons living and working in the vicinity of such sites and those working on the sites, from noise. It recommends procedures for noise control in respect of construction and open site operations and aims to assist architects, contractors and site operatives, designers, developers, engineers, local authority environmental health officers and planners, regarding the control of noise.

The recommendations of this standard do not cover vibration, but it should be borne in mind that vibration can be the cause of serious disturbance and inconvenience to anyone exposed to it. The Control of Pollution Act 1974 and, in Northern Ireland, the Pollution Control and Local Government (Northern Ireland) Order 1978 SI 1049, which define noise as including vibration (Section 73(1) of the 1974 Act and Article 53 of the 1978 Order), contain provisions for the abatement of nuisances caused by noise and vibration.

It should be noted that BSI has published a British Standard, BS 6472, covering the human response to vibration in structures. BSI has commenced drafting work

for a new British Standard covering the measurement and evaluation of vibration shock in stationary structures. Work is also proceeding within BSI upon the subject of the vibration loading of building structures.

This standard consists of the following Parts.

- Part 1. Code of practice for basic information and procedures for noise control.
- Part 2. Guide to legislation for noise control applicable to construction and demolition, including road construction and maintenance.
- Part 3. Code of practice for noise control applicable to surface coal extraction by opencast methods.
- Part 4. Code of practice for noise control applicable to piling operations.*

This Part of this standard is common to all the types of work covered by the other Parts of this standard which should be read in conjunction with this Part. Other Parts will be published in due course as and when required by industry.

Attention is drawn to the Health and Safety Executive's 'Code of Practice for reducing the exposure of employed persons to noise'† and to the following British Standards:

BS 5930, BS 6031, BS 6187 and CP 3 : Chapter III.

Compliance with a British Standard does not of itself confer immunity from legal obligations. In particular, attention is drawn to the Control of Pollution Act 1974 (Part III) (Noise) and to the Health and Safety at Work etc. Act 1974 (in Northern Ireland, the Pollution Control and Local Government (Northern Ireland) Order 1978 and the Health and Safety at Work (Northern Ireland) Order 1978).

* In course of preparation.

† Available from HMSO.

British Standard

Noise control on construction and open sites

Part 1. Code of practice for basic information and procedures for noise control

Section one. General

1. Scope

This Part of this standard gives recommendations for basic methods of noise control relating to construction sites and other open sites where noisy work activities and operations are carried out.

The legislative background to noise control is described and recommendations are given regarding procedures for the establishment of effective liaison between developers, site operators and local authorities.

This standard provides guidance concerning methods of predicting and measuring noise and assessing its impact on those exposed to it. Recommendations are given on how the impact of noise from sites on people living nearby and on site workers can be minimized.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2. Definitions

For the purposes of this Part of BS 5228, the definitions given in BS 661 and BS 3015 apply together with the following.

NOTE 1. Where applicable, the definitions are consistent with those given in ISO 1996/1-1982.

NOTE 2. The term 'noise level' is sometimes used in place of 'sound level'.

2.1 ambient noise. The total sound in a given situation at a given time usually composed of sound from many sources near and far.

2.2 site noise. That component of the ambient noise in the neighbourhood of a site that originates from the site.

2.3 A-weighted sound pressure level. The level of the A-weighted sound pressure is calculated as follows:

$$L_{pA} = 20 \log_{10} (p_A / p_0)$$

where

L_{pA} is the A-weighted sound pressure level (in dB);

p_A is the root mean square sound pressure determined using frequency weighting A (in Pa);

p_0 is the reference sound pressure (i.e. 20 μ Pa).

NOTE. For correctness, the time weighting used to determine the r.m.s. value of the sound pressure should be specified. The time-weightings 'S' and 'F' are standardized in BS 5969 (the symbols are L_{pAS} and L_{pAF} respectively).

2.4 maximum sound level. The highest value of the A-weighted sound pressure level that occurs during a given event or time period. The time-weighting should be specified. The symbol used is $L_{pA, \max}$.

2.5 one percentile level. The A-weighted sound pressure level (obtained by using the time weighting F) that is exceeded for 1 % of the time interval T. The symbol used is $L_{A01, T}$.

2.6 equivalent continuous A-weighted sound pressure level. The value of the A-weighted sound pressure level of a continuous, steady sound that, within a specified time interval T, has the same mean square sound pressure as a sound under consideration whose level varies with time. It is calculated as follows:

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

where

$L_{Aeq, T}$ is the equivalent continuous A-weighted sound pressure level (in dB), determined over a time interval T;

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

p_0 is the reference sound pressure (i.e. 20 μ Pa).

2.7 activity L_{Aeq} . The value of the equivalent continuous A-weighted sound pressure level determined at a distance of 10 m from and over the period of a given activity. The activity may involve the operation of more than one item of plant.

2.8 sound exposure level. The level of sound exposure of a discrete noise event is calculated as follows:

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

where

L_{AE} is the sound exposure level (in dB);

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

$t_2 - t_1$ is a stated time interval long enough to encompass all significant sound of a stated event (in s);

p_0 is the reference sound pressure (i.e. 20 μ Pa);

t_0 is the reference duration (i.e. 1 s).

2.9 A-weighted sound power level. The level of the A-weighted sound power is calculated as follows:

$$L_{WA} = 10 \log_{10} \left(\frac{P_A}{P_o} \right)$$

where

L_{WA} is the A-weighted sound power level (in dB);

P_A is the sound power of the source determined using the frequency weighting A (in W);

P_o is the reference sound power '10⁻¹² W'.

2.10 noise-sensitive premises. Any premises outside the site used as a dwelling, hospital, school, place of worship, or for any other purpose likely to be affected by site noise.

3. Legislative background

3.1 General. This standard represents a standard of good practice. Compliance with it does not confer immunity from relevant legal requirements including those imposed by regulations, byelaws and conditions attached to planning permissions. Further information about the legal controls affecting noise from the industries covered by this standard is given in the specialized Parts of this standard dealing with each industry.

3.2 Control of Pollution Act Part III. Attention is drawn to the following legislation dealing with control of environmental noise, which was current at the date of publication of this Part of this standard.

The Control of Pollution Act 1974, which provides general powers for the control of noise arising from premises, including land. Under Sections 58 and 59 of the Act, local authorities and magistrates courts' (in Scotland, the Sheriff and, in Northern Ireland, the Court of Summary Jurisdiction) may lay down the requirements designed to abate a noise which they are satisfied amounts to a statutory nuisance. Section 60 and 61 give local authorities special powers for controlling noise arising from construction and demolition works, regardless of whether a statutory nuisance has been caused or is likely to be caused. Works within the scope of the special powers include repair and maintenance work and road works. In Northern Ireland, equivalent powers are contained in the Pollution Control and Local Government (Northern Ireland) Order 1978. Powers under Sections 60 and 61 are confined to construction and demolition works comprising building structures and roads and are described in detail in Part 2 of this standard.

The statutory powers of local authorities to require the implementation of noise control measures remain the same whatever the character of the area within which the works are taking place, although the requirements will vary according to local circumstances.

3.3 EEC directives. As part of its programme for the removal of barriers to trade (Article 100 of the Treaty of Rome) the EEC is preparing directives which will set noise emission limits for new items of construction equipment. The implementation of adopted directives will be through UK legislation to which attention is drawn.

Directives adopted on permissible noise from plant and equipment will generally define a noise performance

standard and contain provision for the free circulation within the European Community of new machines complying with the directives. Conditions relating to the operation of the machines (e.g. the hours during which they may be used) will generally be governed by national legislation.

NOTE. An EEC document covering the control of noise and vibration from sites is being discussed. This standard covering noise control on construction and open sites is being used as the basis for the EEC document.

3.4 Health and Safety at Work etc. Act 1974. The protection of employed persons is covered by the Health and Safety at Work etc. Act 1974. Section 2 of the Act requires all employers to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all their employees. Section 6 requires designers, manufacturers, importers or suppliers to ensure, so far as is reasonably practicable, that articles for use at work are so designed and constructed as to be safe and without risks to health when properly used, that any necessary research to this end is carried out and that adequate information on the safe use of the article is made available. In Northern Ireland, equivalent powers are contained in the Health and Safety at Work (Northern Ireland) Order 1978.

Attention is drawn to the guidance given in the Health and Safety Executive's 'Code of Practice for reducing the exposure of employed persons to noise'* on levels of exposure that are regarded as a serious hazard to hearing and on action that should be taken to protect workers.

The current position regarding the formulation by the Commission of proposals concerning occupational noise may be ascertained from the Health and Safety Commission.

3.5 The Woodworking Machines Regulations 1974.

The Woodworking Machines Regulations 1974 made under the Factories Act 1961, contains a Regulation (No. 44) on occupational noise exposure for workers in the woodworking industry. No corresponding provision is in force in Northern Ireland.

3.6 Local authorities. The local authorities exercising powers under Part III of the Control of Pollution Act 1974 are, in England and Wales, the council of a district or a London borough, the Common Council of the City of London, the Sub-Treasurer of the Inner Temple and the Under Treasurer of the Middle Temple; and in Scotland, District or Islands Councils; and in Northern Ireland, district councils exercise similar functions under the Pollution Control and Local Government (Northern Ireland) Order 1978.

The local authorities exercising planning powers may, according to the circumstances, be County Councils or District Councils; in Scotland, the Regional Council in Borders, Highland and Dumfries and Galloway Regions and District or Islands Council elsewhere; and, in Northern Ireland, planning control is a function of the Department of the Environment (Northern Ireland).

* Available from HMSO.

For the winning and working of minerals, the relevant planning authority in England and Wales, outside Greater London, is the county planning authority (including the National Park Joint Planning Boards). Within Greater London, the relevant authority is the Greater London Council or the London borough depending on the size of the development. In Scotland and Northern Ireland the relevant authority is the planning authority.

In the case of uncertainty as to which local authority or local authority department to consult about a noise problem, a good starting point will often be the environmental health department of the district or London borough council or in Scotland, the District or Islands Council, or in Northern Ireland, the Department of Environment (Northern Ireland) in Belfast.

4. Community relations

Good relations with people living and working in the vicinity of site operations are of paramount importance. Early establishment and maintenance of these relations throughout the carrying out of site operations will go some way towards allaying people's fears.

It is suggested that good relationships can be developed by keeping people informed of progress and by treating complaints fairly and expeditiously. The person, company or organization carrying out work on site should appoint a responsible person to liaise with the public. The formation of liaison committees with members of the public can be considered for longer term projects when relatively large numbers of people are involved.

Noise from blasting operations is a special case. The sharp report often associated with blasting can give rise to concern or even alarm to persons unaccustomed to it. The adoption of good blasting practices will reduce the inherent and associated impulsive noise: prior warning to members of the public, if necessary individually, is important.

5. Training

Site personnel should be informed about the need to minimize noise and about the health hazards of exposure to excessive noise. As part of their training, they should be advised regarding the following:

- (a) the proper use and maintenance of tools and equipment;
- (b) the positioning of machinery on site to reduce the emission of noise to the neighbourhood and to site personnel;
- (c) avoidance of unnecessary noise when carrying out manual operations and when operating plant and equipment;
- (d) protection of persons against noise;
- (e) the operation of sound measuring equipment (selected personnel).

Special attention should be given to the use and maintenance of sound reduction equipment fitted to power tools and machines.

Persons issued with ear protection equipment should be instructed in its use, care and maintenance.

Education programmes should draw attention to the harmful effects of noise and make it clear that there are several ways in which operators can help themselves to protect their hearing. For example:

- (1) by using and maintaining measures adopted for noise control;
- (2) by reporting defective noise control equipment to their superiors;
- (3) by not damaging or misusing ear protectors provided and by immediately reporting damage to or loss of such items to their superiors.

Supervisors can help by recognizing the need for operators to make proper use of equipment so that noise emission will be minimized and to make proper use of ear protectors when required.

Section two. Noise and persons on site

6. Protection from noise-induced hearing loss

Noise in excess of the Health and Safety Executive's recommended limit for unprotected ears can be a serious hazard to health, causing permanent damage to hearing.

The risk can be reduced by limiting the exposure (i.e. the combination of the quantity of noise and the duration of exposure) to ensure that it does not exceed the maximum acceptable levels for unprotected exposure recommended in the Health and Safety Executive's 'Code of Practice for reducing the exposure of employed persons to noise'.*

The use of plant and/or power tools on site can create areas of potential noise hazard. These areas should be identified by carrying out a noise survey and by displaying warning signs. A notice should be displayed in a prominent position on the noise source, whether fixed, portable or mobile, advising the use of ear protection equipment within given distances. Occupational noise calculated on the basis of equivalent noise exposure should be checked periodically.

Noise can be increased to a hazardous level by reverberation from reflecting surfaces and special care should be exercised when using equipment in confined spaces, e.g. in basements and between reflecting walls. Steps should be taken to reduce noise when several items of equipment, that may be relatively quiet when in use singly, are to be used simultaneously; to avoid hazard to the users and to persons working in the vicinity.

If persons that are on site but not engaged in noisy operations cannot be given quiet areas in which to work and noise from machines cannot be properly silenced, then noise screens should, whenever possible, be erected having due regard for safety considerations. (See also appendix D.) Certain operations, e.g. mechanical crushing, may necessitate the use of purpose-made acoustic cabins to afford proper protection to the operators.

Screens and barriers themselves reflect noise which can be reduced by covering their inner surfaces with noise-absorbent material to protect persons required to work on the noisy side. (See also appendix D.)

Account should always be taken of the need for the minimizing of noise and the protection of quiet areas from its impact, when the layout of plant and the phasing of operations are being considered. (See also appendix C.)

* Available from HMSO.

7. Ear protectors

Effective noise control at source should always be regarded as the prime means of affording proper protection to operatives from risk to their hearing. Circumstances will arise however when this is not reasonably practicable. On such occasions, operatives should be supplied with, and should wear, personal ear protectors. This will be necessary when all practicable means of reducing noise at source have been applied but occupational noise still exceeds that recommended in the Health and Safety Executive's 'Code of Practice for reducing the exposure of employed persons to noise'.*

A method of test for estimating the risk of hearing handicap due to noise exposure is described in BS 5330.

It may be necessary for the tone and/or volume of warning signals to be modified or for additional steps to be taken for the alerting of operatives to hazards, in areas where personal ear protectors are used. Checks will be necessary, when sound warning signals are used, to ensure that the signals can be heard and orientated by operatives wearing ear protectors.

It is important that ear protectors are reliable and capable of producing the necessary degree of noise attenuation. BS 5108 describes methods of measurement of attenuation of hearing protectors. The protectors to be used should be selected from suppliers able to certify that their product has been tested in accordance with BS 5108, with the resultant attenuation values given. The Health and Safety Executive's 'Code of Practice for reducing the exposure of employed persons to noise'* describes the most commonly available forms of ear protection aids.

The following points relate to the introduction of ear protectors.

- (a) The types of ear protector provided should be appropriate to the particular noise conditions to which the wearers will be subjected.
- (b) An operator should be encouraged to use an ear protector and, when this is practicable, to choose the type of protector to be worn. The final choice will be dictated by the consideration outlined in (a).
- (c) Ear protectors should be regularly inspected for damage and deterioration, by a competent person.
- (d) Facilities for the cleaning and clean storage of ear protectors should be provided.
- (e) Safety training programmes should include instruction on the need for and the use, care and maintenance of ear protectors. Management should demonstrate, by example, its commitment to the protection of hearing.

8. Noise-induced stress

Noise can interfere with working efficiency by inducing stress, by disturbing concentration and by increasing accident risk. The effects of noise on persons on site are similar to the effects on nearby residents and the benefits of good noise control measures will apply equally on and off site.

Section three. Noise and neighbourhood nuisance

9. Disturbing effects of noise

The effects of noise on the neighbourhood are varied and complicated. They include loudness sensation, interference with speech communication, disturbance of work or leisure, disturbance of sleep, annoyance and possible effects on mental and physical health. A complicating factor is that in any neighbourhood some individuals will be more sensitive to noise than others.

10. Description of site noise

The A-weighted sound pressure level L_{pA} will give an indication of the loudness of, and degree of speech interference from, noise. Some of the other effects mentioned in clause 9 are less clearly dependent upon a simple measure of the noise.

A measure that is in general use and is recommended internationally for the description of environmental noise is the equivalent continuous A-weighted sound pressure level L_{Aeq} . This can be considered as the level of a continuous steady sound that would, over a given time period, result in the same acoustic energy being received as that from the actual fluctuating sound experience. The time period (e.g. 1 h, 12 h) should always be stated.

When describing noise from isolated events that may not always be apparent from a longer period L_{Aeq} , it can be useful to use a short period (e.g. 5 min) L_{Aeq} . Alternatively, the maximum sound level $L_{pA, max}$ or the one percentile level L_{A01} can be used.

Whichever measure is used to describe site noise, it should always be made clear to which period of the day any particular value of the measure applies.

Appendix A deals with the estimation of site noise and appendix B is concerned with noise measurement and monitoring.

11. Criteria for setting noise control targets

It is not possible to provide detailed guidance for determining whether or not noise from a site will constitute a problem in a particular situation. However, a number of factors are likely to affect considerations of the acceptability of site noise and the degree of control necessary.

- (a) *Site location.* The location of a site in relation to noise-sensitive development will be a major factor. The nearer a site is to noise-sensitive premises, the more stringent should restrictions be upon noise emanating from the site.
- (b) *Existing ambient noise levels.* Experience of complaints about noise that has originated from new industrial sources indicates that the likelihood of complaint increases as the difference between the industrial noise and existing background noise increases. It is possible that a similar effect occurs with open site noise since the noise will, in general, be more noticeable in quieter areas. However, the relationship between response and noise level difference may well

* Available from HMSO.

be different. For example, a greater difference may be tolerated when it is known that the operations are of short duration.

(c) *Duration of site operations.* In general, the longer the duration of noisy site operations, the more likely it is that the site noise will prove unsatisfactory. In this context, good public relations are important. Local residents may be willing to accept higher levels of noise if they know that such levels will only last for a short time. It is then important that noisy site operations are carried out according to a stated schedule.

(d) *Hours of work.* For any noise-sensitive building, some periods of the day will be more sensitive than others. For example levels of noise that would cause speech interference in an office during the day would cause no problem in the same office at night. For dwellings, times of site operation outside normal weekday working hours will need special consideration. Noise control targets for the evening period in such cases will need to be stricter than those for the daytime and when noise limits are set the evening limit may have to be as much as 10 dB(A) below the daytime limit. Very strict noise control targets should be applied to any site which is to operate at night. The periods when people are getting to sleep and just before they wake appear to be particularly sensitive. Site noise expressed as L_{Aeq} over 1 h at the facade of noise-sensitive premises may need to be as low as 40 dB(A) to 45 dB(A) to avoid sleep disturbance.

(e) *Attitude to the site operator.* It is well established that people's attitude to noise can be influenced by their attitude to the source itself. Therefore noise from a site will tend to be accepted more readily by local residents if they consider that the site operator is doing all that he can to avoid unnecessary noise. The acceptability of the project itself may also be a factor in determining community reaction.

(f) *Noise characteristics.* In some cases a particular characteristic of the noise, for example the presence of impulses or tones, may make it less acceptable than might be concluded from the level expressed in terms of L_{Aeq} .

Until such time as more detailed information on assessing the acceptability of site noise levels is generally available, both operators and local authorities can assist their decision-making in this area by maintaining records of situations where site noise has caused problems.

In addition to the factors that affect community response, described in (a) to (f), the feasibility of noise control in a particular situation, including type of work to be carried out, will influence the final choice of noise control targets.

Section four. Project supervision

12. General

The intention at each stage of a project should be to minimize levels of site noise.

Planners, developers, architects, engineers and environmental health officers can all play a part in avoiding potentially excessive noise levels. This can be achieved by giving careful consideration to the design of a proposed project, the processes and equipment implied by the design and the phasing of operations.

Developers, architects and engineers will need to know whether the processes which they intend using are likely to be permitted. Therefore an early consultation should be made with local authorities in order to ascertain the limits or restrictions, if any, likely to be imposed. Before doing so they may find it useful to determine the expected levels of site noise by referring to appendix A.

Local authorities should ensure that any noise level limits or restrictions being imposed are necessary and practicable.

13. Works preparation

A project design should be so arranged that the number of operations likely to be particularly noisy will be kept to a minimum. Designers should also remember that project designs can have considerable influence upon operators' use of sites. Project designs will influence decisions regarding the location of items such as haulage roads, batching plants and generators.

Appropriate investigations into ground conditions should be made when preliminary surveys are being carried out, in order that consideration may be given to methods of working which could avoid noise problems. A survey of the immediate neighbourhood surrounding a site will indicate the location of noise-sensitive areas.

Guidance should be sought concerning recommended noise levels for the neighbourhood surrounding a site, and concerning acceptance of the proposed methods of working, in very general terms, from the relevant authorities at the same time as approvals are being requested for the commencement of work. This procedure should enable work to proceed smoothly.

When works involve a tender stage, details of noise consents or other noise restrictions should be given to tenderers as early as possible.

Overall site operations should be planned when a number of site operators will be working on one site. Preferred routes for off-site movement of vehicles should be established with the local highway authority and the police. Access traffic should be routed away from noise-sensitive premises such as dwellings, hospitals and schools.

Tenderers will need to select the most appropriate plant for a job in order that noise limits will be maintained. They will also need to know the extent of noise control measures that will be necessary so that appropriate cost allowances can be made.

Tenderers for a project should satisfy themselves that proposed methods of working and phasing of operations will meet the local authority's requirements. They should be clear about this before submitting their tenders.

Tenderers should take due regard, before tendering, of the following:

- (a) site layout, e.g. location of static noise sources and use of site buildings, material dumps, etc., as *ad hoc* barriers;
- (b) types of machinery likely to be used and whether alternative types or techniques would achieve less noisy operations.

14. Execution of works

All available techniques should be used to minimize, as far as is necessary, the level of noise to which operators and others in the neighbourhood of site operations will be exposed. Measures which could be taken include the following.

(a) Planning the hours of working and considering the effects of noise upon persons in areas surrounding site operations and upon persons working on site, taking into account the nature of land use in the areas concerned, the duration of work and the likely consequence of any lengthening of work periods, and other problems affecting surrounding areas such as severance, dust, etc.

(b) Ensuring the use of quiet working methods, the use of the most suitable plant, reasonable hours of working for noisy operations, and economy and speed of operations. Site work continuing throughout 24 h of a day should be programmed, when appropriate, so that off-site vehicles will not arrive on-site between 19.00 hours and 07.00 hours. On tunnel sites, for example, it is common practice to provide night-time storage areas for soil and debris.

(c) Controlling noise at source and the spread of noise, using the recommendations given in section five of this code.

(d) On-site noise levels should be monitored regularly, particularly if changes in machinery or project designs are introduced, by a suitably qualified person appointed specifically for the purpose.

A method of noise measurement should be agreed prior to commencement of site works. If this is not specified, the method used should be one of those described in appendix B.

Appendix C* gives typical noise levels created by site plant and activities.

(e) On those parts of a site where high levels of noise are likely to be a hazard to persons working on the site, prominent warning notices should be displayed and, where necessary, ear protectors should be provided. (See also section two.)

When potential noise problems have been identified by the application of procedures referred to in previous sections of this code, or when noise problems have already occurred, consideration will have to be given to the implementation of practicable measures to avoid or minimize those problems. Local authorities, consulting with developers and their professional advisers or with site operators, will need to consider the extent of noise control measures necessary to prevent the occurrence of significant noise problems and will also need to consider whether the implementation of those measures will be practicable. Local authorities may wish to consider whether to specify quantified limits on site noise and whether, additionally or instead, to lay down requirements relating to work programmes, plant to be used, siting of plant, periods of use, working hours, access points, etc.

The latter approach will often be preferable in that it facilitates the monitoring of formally or informally specified requirements, both for the authorities and for the site operators.

* Much of the information given in appendix C is reproduced by permission of the Director of the Construction Industry Research and Information Association (CIRIA). More detailed information is included in CIRIA Report 64, 'Noise from construction and demolition sites — measured levels and their prediction', available from CIRIA, 6 Storey's Gate, Westminster SW11 3AU.

Section five. Control of noise

15. Control of noise at source

15.1 General. Some ways of controlling noise at source are given in 15.2 to 15.6.

15.2 Substitution. When reasonably practicable, noisy plant or processes should be replaced by less noisy alternatives. Appendix D gives some examples.

15.3 Modification of existing plant and equipment. Noise from existing plant and equipment can often be reduced by modification or by the application of improved sound-reduction methods, but this should only be carried out after consultation with the manufacturer.

Noise caused by resonance of body panels and cover plates can be reduced by stiffening with additional ribs or by increasing the damping effect with a surface coating of special resonance damping material. Rattling noises can be controlled by tightening loose parts and by fixing resilient materials between the surfaces in contact.

15.4 Enclosures. As far as reasonably practicable, sources of noise should be enclosed. The extent to which this can be done depends on the nature of the machines to be enclosed and their ventilation requirements.

When it is necessary to enclose a machine and its operator in an acoustic shed, precautions should be taken to protect the operator from any consequential hazard. Tools should be sound-reduced and the operator should be supplied with the appropriate ear protection equipment (see clause 7).

Materials suitable for constructing machine enclosures are listed in appendix D which also includes a design for an acoustic shed.

Noise in the cabs of machines may be reduced by damping of the cab walls, provision of a sound-absorbing lining and a well sealed floor cover, as appropriate.

The effectiveness of partial noise enclosures and of screens can be partially lost if they are used incorrectly, e.g. the noise being enclosed should be directed into and not out of enclosures. There should not be a reflecting surface, such as a parked lorry, opposite the open side of noise enclosures. Any openings in complete enclosures, e.g. for ventilation, should be effectively sound-reduced.

15.5 Use and siting of equipment. Plant should always be used in accordance with manufacturers' instructions. Care should be taken to site noisy equipment away from noise-sensitive areas. When possible, loading and unloading should also be carried out away from such areas. Special care will be necessary when work has to be carried out at night.

Circumstances can arise when night-time working is unavoidable. Bearing in mind the special constraints under which such work has to be carried out, steps should be taken to minimize disturbance to those living nearby.

Machines such as cranes that may be in intermittent use should be shut down between work periods or should be throttled down to a minimum. Machines should not be left running unnecessarily, as this can be noisy and waste energy.

Plant known to emit noise strongly in one direction should, when possible, be orientated so that the noise is directed away from noise-sensitive areas. Attendant operators of the plant can also benefit from this acoustical phenomenon by sheltering, when possible, in the area with reduced noise levels.

Acoustic covers to engines should be kept closed when the engines are in use and when idling. The use of compressors that have effective acoustic enclosures and are designed to operate when their access panels are closed, is recommended.

Materials should be lowered whenever practicable and should not be dropped. The surfaces on to which the materials are being moved could be covered by resilient material.

15.6 Maintenance. Regular and effective maintenance by trained personnel is essential and will do much to reduce noise from machinery. Increases in plant noise are often indicative of future mechanical failure. Sound-reducing equipment may lose its effectiveness before failure is indicated by visual inspection.

Noise caused by vibrating machinery having rotating parts can be reduced by attention to proper balancing. Frictional noise from the cutting action of tools and saws can be reduced if the tools are kept sharp. Noises caused by friction in conveyor rollers, trolleys and other machines can be reduced by proper lubrication.

16. Controlling the spread of noise

16.1 Methods of control. If noisy processes can be avoided, then the amount of noise reaching the neighbourhood should be limited. Alternative ways of doing this are either to increase the distance between the noise source and the listener or to introduce noise reduction screens.

16.2 Distance. Increasing the distance is often the most effective method of controlling noise. This may not be possible when work takes place on a restricted site on fixed structures, e.g. railway tracks. The effect of distance on noise attenuation is explained in appendix A.

Stationary plant such as compressors and generators can be located away from the work area so as to avoid being close to any noise-sensitive area.

16.3 Screening. On sites where it is not possible to reduce a noise problem by increasing the distance between the source and receiver, screening may have to be considered. Appendix A gives information on the noise attenuation to be expected from typical barriers. If possible, decisions as to the most suitable types of screening should be made at project planning stages, because it will often be found that a site layout can itself contribute quite effectively towards the provision of useful screening.

Site buildings such as offices and stores can be grouped together to form a substantial barrier separating site operations and nearby noise-sensitive premises. On some sites, stacks of certain materials such as bricks, aggregate, timber or top soil can be strategically placed to provide a barrier. Areas which have been excavated below ground level such as basements or river works can be used to position static plant such as generators, compressors and pumps. This is a useful and often necessary method of reducing noise from plant that is required to operate continually day and night. Mechanical plant operating in confined spaces should be adequately ventilated, to allow for fume dispersal and to provide cooling air. Nevertheless, adequate precautions should be taken to minimize noise emission.

Earth bunds can be built to provide screening for major earthmoving operations and can be subsequently landscaped to become permanent features of the environment when work has been completed. When earth barriers are not practicable due to lack of space, it may be possible for protective features ultimately needed as permanent noise screening to be built in during the early stages of site work. Such an approach is particularly pertinent to major road construction works.

The effectiveness of a noise barrier will depend upon its length, effective height, its position relative to the noise source and to the listener and the material from which it is made. Further guidance relating to this is given in appendix D.

Appendix A

Estimating noise from sites

A.1 Introduction. Some means of predicting expected levels of noise from sites are useful whether or not noise limits are to be imposed.

Before work starts the following should be considered.

- (a) Local authorities need to know the expected levels of site noise in order that assessments may be made as to whether potential problems exist and whether controls are necessary. They also need to ensure that any noise limits proposed are practicable for the developments concerned and that they are capable of protecting the community from excessive noise.
- (b) Developers, architects and engineers need to know whether their intended site operations will cause noise problems and, if so, whether the operations will be able to comply with the specified noise limits.
- (c) Contractors need to select the most appropriate plant in conformity with any specified limits. They also need to know at the tender stage what noise controls are necessary so that they can make appropriate cost allowances.

A.2 General noise assessment. As explained in clause 10, site noise can be assessed in terms of the equivalent continuous sound level and/or in terms of the maximum level. The level of sound in the neighbourhood that arises from a site will depend on a number of factors. The estimation procedures described here take into account the more significant factors, these being:

- (a) the sound power outputs of processes and plant;
- (b) the periods of operation of processes and plant;
- (c) the distances from sources to receiver;
- (d) the presence of screening by barriers;
- (e) the reflection of sound.

Other factors such as meteorological conditions (particularly wind speed and direction), ground absorption and atmospheric absorption may also influence the level of noise received. The estimation of the effects of these factors is complicated, not least because of interaction, and is beyond the scope of this standard. In general, at short distances (say less than 50 m), the size of any effects arising from these factors will be small while at longer distances there will be a tendency towards an increase in sound attenuation. Exceptionally, however, meteorological conditions can result in higher than expected noise levels due to focusing of the sound and this may be important when blasting is taking place. So far as is known, the estimating procedures described are applicable also to sound travelling over areas of water (wide rivers, harbours, lakes, etc.).

A.3 Methods of calculation

A.3.1 General. Site noise is produced by many different activities and types of plant, the noise from which not only varies in intensity and character but also in location and over time. There may also be many combinations of these activities both of a static and a mobile nature. However, reasonably accurate predictions can be made by approaching the problem in a logical way and by analysing all activities involved.

No one prediction model can conveniently describe the noise from both stationary and mobile activities and each should be dealt with separately. A general approach to the prediction of site noise is shown in figure 1 where four methods of calculating L_{Aeq} noise levels are indicated. The following are examples of methods that can be used. They do not preclude the use of other similarly appropriate methods. In practice noise prediction at a point of interest could involve a combination of all four methods.

- (a) The activity L_{Aeq} method (see A.3.2) can be used for stationary and quasi-stationary activities and is the method which should be used when these activities and their locations are clearly defined.

The method is based upon the use of the measured L_{Aeq} values given in appendix C and the application of various allowances for differences in source-receiver distance, screening and reflections. The advantages of this method are that the variations in plant cycle times, interactions between various items of plant during the activity and the consequent overall variation of noise level with time are automatically taken into account. Provided that the plant in the sample is similar to that for which the calculations are being carried out, this method provides a reasonably accurate prediction.

For continuous plant, it is necessary to determine the proportion of the assessment period during which the plant is operating and to adjust the L_{Aeq} for periods of non-operation. For cyclic or intermittent plant, the number of complete sequences that will occur within the working day should be estimated and the L_{Aeq} should be adjusted, if necessary, for standing or idling time. A.3.5 covers the making of these allowances.

- (b) The plant sound power method (see A.3.3) should be used in the absence of sufficient data for the activity L_{Aeq} method but it should be recognized that the on-time of the plant should be known in order that a comparable accuracy of site noise prediction can be obtained

The method involves the calculation of L_{Aeq} from the plant sound power levels given in appendix C, typical percentage on-times and various allowances for distance, screening and reflection. The percentage on-time is taken as the duration of the activity for which the sound level is within 3 dB(A) of the maximum. Typical percentage on-times are given in appendix C. Since this method necessitates the introduction into the calculation of the additional variable of percentage on-time, the method should be reserved for situations where an L_{Aeq} for a similar activity is not available.

Neither this method nor the activity L_{Aeq} method is suitable for predicting the L_{Aeq} of mobile plant operating either on site in close proximity to the point of interest or on haul roads. Techniques for the estimation of noise of such mobile plant are given in A.3.4. The technique for plant operating over short traverses is similar to the sound power method, but is modified for equivalent on-time related to traverse length and minimum distance to the point of interest.

- (c) The prediction of the L_{Aeq} from mobile plant operating over a small area or on site (see A.3.4.1) can be used for other activities when items of mobile plant are operating in close proximity to the point of interest, taking into account the adjustment of the predicted L_{Aeq} for standing and idling time of the plant.

(d) The prediction of L_{Aeq} from mobile plant using a regular route (see A.3.4.2) should be used when items of mobile plant pass by at a known rate per hour.

In the absence of data measured directly for items of plant to be used on the site under assessment, appendix C contains examples of noise levels for a variety of plant and activities that can be used as a guide.

The general methods of calculation given in A.3.2 to A.3.4 will be suitable for many situations. Nevertheless, it

should be remembered that they have been developed in relation to construction sites and have only been tested on such sites. They do not preclude the use of more precise methods when such methods are considered necessary in particular situations and when more detailed information is available. More detailed calculation procedures can take into account factors not covered in this standard, e.g. ground attenuation, or can deal with factors that have been covered, e.g. screening, in a more precise way.

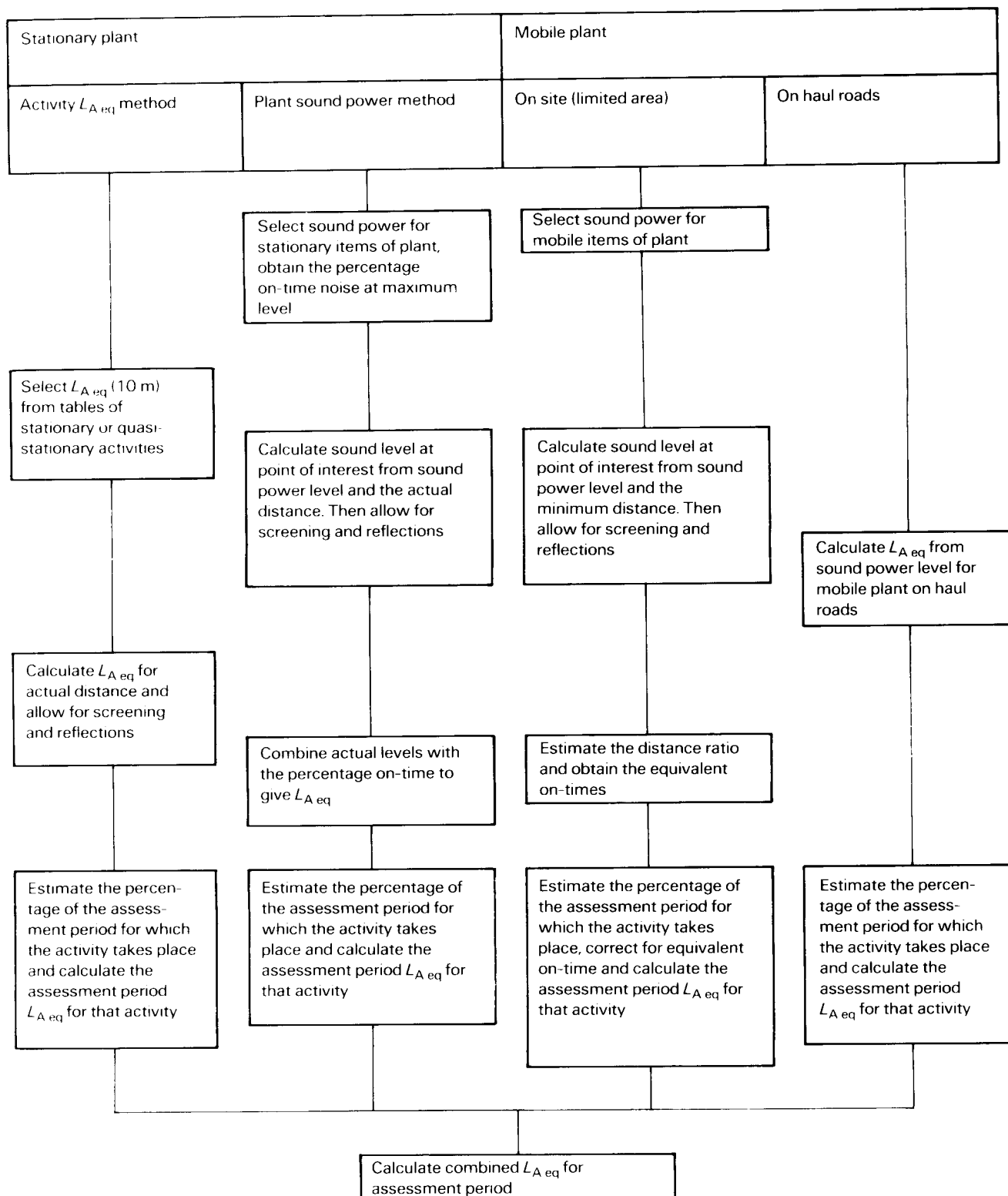


Figure 1. Flow chart for the prediction of site noise

A.3.2 Activity L_{Aeq} method. Use the following procedure.

Stage 1. Select an activity equivalent to the situation being assessed from appendix C, making sure that the plant numbers, types and sizes are similar. From this entry extract the L_{Aeq} values at 10 m. When there is more than one entry of the same or similar activities, list all the L_{Aeq} values and take the arithmetic average. When the size of plant required is not listed, take the average value of L_{Aeq} of the sizes above and below that required.

Stage 2. If the distance, R (in m), from the point of interest to the geometric centre of the plant or activity is other than 10 m, add (algebraically) to the L_{Aeq} obtained in stage 1 a distance adjustment, K_d (in dB(A)), obtained either:

(a) from the following equation:

$$K_d = -20 \log_{10} \frac{R}{10} ; \text{ or} \quad (1)$$

(b) from figure 2, which is based on equation (1).

Both methods give the same result. It is a matter of personal preference which method is used.

Stage 3. Make allowances for screening and/or reflections (see also 16.3 and appendix D).

The accurate determination of the effectiveness of a barrier is a complex process. A knowledge of sound pressure levels at separate frequencies and also of the geometry of the receiving position in relation to the source and the barrier are required. As a working approximation, if there is a barrier or other topographic feature between the source and the receiving position, assume an approximate attenuation of 5 dB(A) when the top of the plant is just visible to the receiver over the noise barrier, and 10 dB(A) when the noise screen completely hides the source from the receiver. High topographical features and specifically designed and positioned noise barriers could provide significantly greater attenuation. Subtract the attenuation from the L_{Aeq} calculated at the point of interest.

If the point of interest is within 1 m of the facade of a building, add an allowance for reflection of 3 dB(A) to the calculated levels.

Stage 4. Repeat stages 1 to 3 for each activity.

Stage 5. Estimate the percentage of the assessment period for which each activity takes place. Then use one of the methods outlined in A.3.5 to predict the assessment period L_{Aeq} from the individual activity L_{Aeq} values obtained in stage 3, which may be on a shorter time-basis.

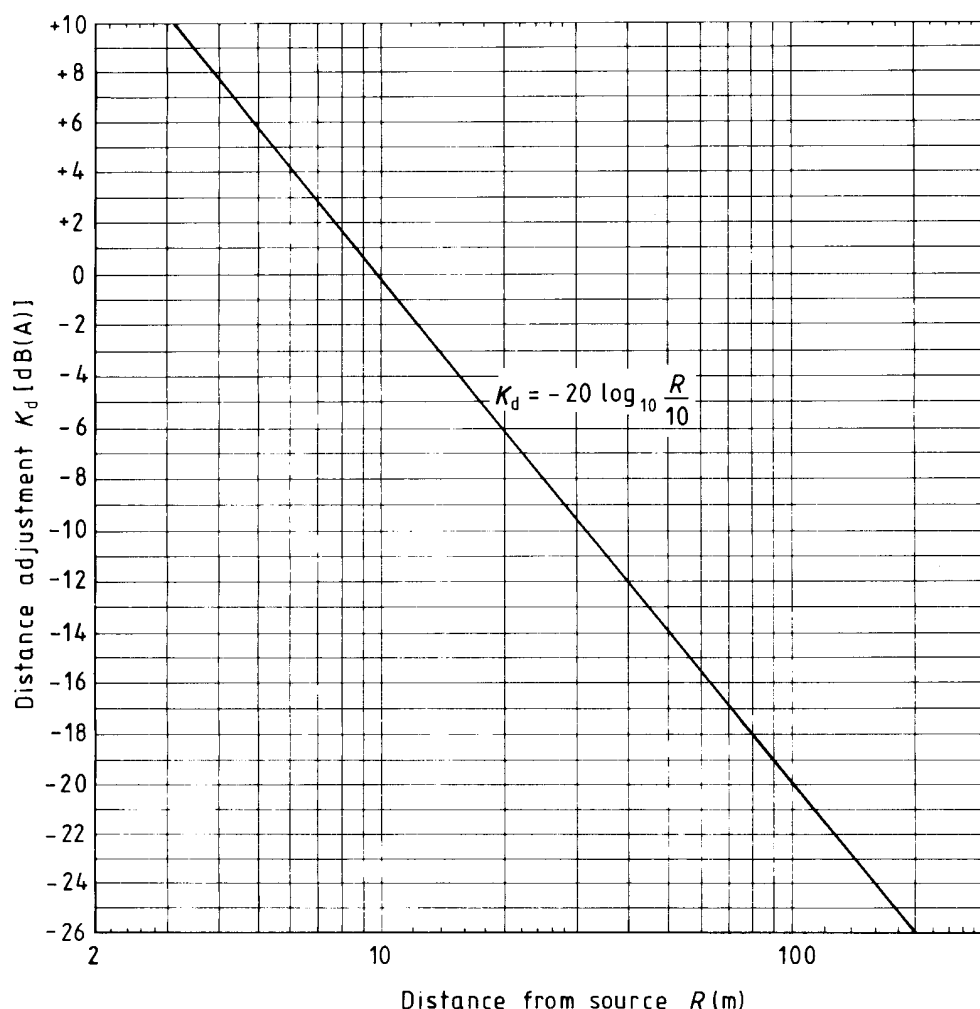


Figure 2. Distance adjustment K_d for activity L_{Aeq} method

A.3.3 Plant sound power method. Use the following procedure.

Stage 1. Select the sound power levels L_{WA} from appendix C for the stationary items or quasi-stationary items of plant associated with a particular activity. When there is more than one entry for the same size plant, list all the L_{WA} values and take the arithmetic average. When the size of plant required is not listed, take the average sound power level of the sizes above and below that required.

Stage 2. Obtain the average percentage on-time from the tables and note the value for use in stage 5. This value is the percentage time that the noise levels of the individual items of plant are at or within 3 dB(A) of the maximum.

Stage 3. Calculate the sound levels at the point of interest for each item of plant or operation taking part in the activity, from their sound power levels and their distances, as follows. If the plant moves about a limited area on site, then take a time-weighted average distance to the point of interest.

From the distance, R (in m), from the points of interest to the source, calculate the sound level L_{pA} at the point of interest by subtracting from the sound power level L_{WA} obtained in stage 1 a distance allowance K (in dB(A)) obtained *either*:

- (a) from the following equation:
$$K = 20 \log_{10} R + 8; \text{ or} \tag{2}$$
- (b) from figure 3 which is based on equation (2).

Both methods give the same result.

In practice, sources of sound such as construction site equipment do not radiate sound uniformly in all directions. Equation (2) can be adapted to allow for this directivity effect. However, for the purposes of calculations in this standard the effect is ignored.

The calculation of sound level can be made for various conditions of operation, such as working and idling, by either of the two methods.

Stage 4. If necessary, make allowances to each sound level for screening effects and for reflections if the receiving position is within 1 m of the facade of a building, as detailed in stage 3 of **A.3.2**, adding or subtracting the allowances from the sound level L_{pA} obtained in stage 3.

Stage 5. Calculate the activity L_{Aeq} at the point of interest for the period of that activity by subtracting from the modified L_{pA} obtained in stage 4 the adjustment K_T obtained from figure 4 for the on-time obtained in stage 2.

Stage 6. Repeat stages 1 to 5 for each activity.

Stage 7. Estimate the percentage of the assessment period for which each activity takes place, then use one of the methods outlined in **A.3.5** to predict the assessment period L_{Aeq} from the individual activity L_{Aeq} values calculated in stage 5, which may be on a shorter time-base. If only the maximum sound level is required, stages 4 to 6 can be omitted.

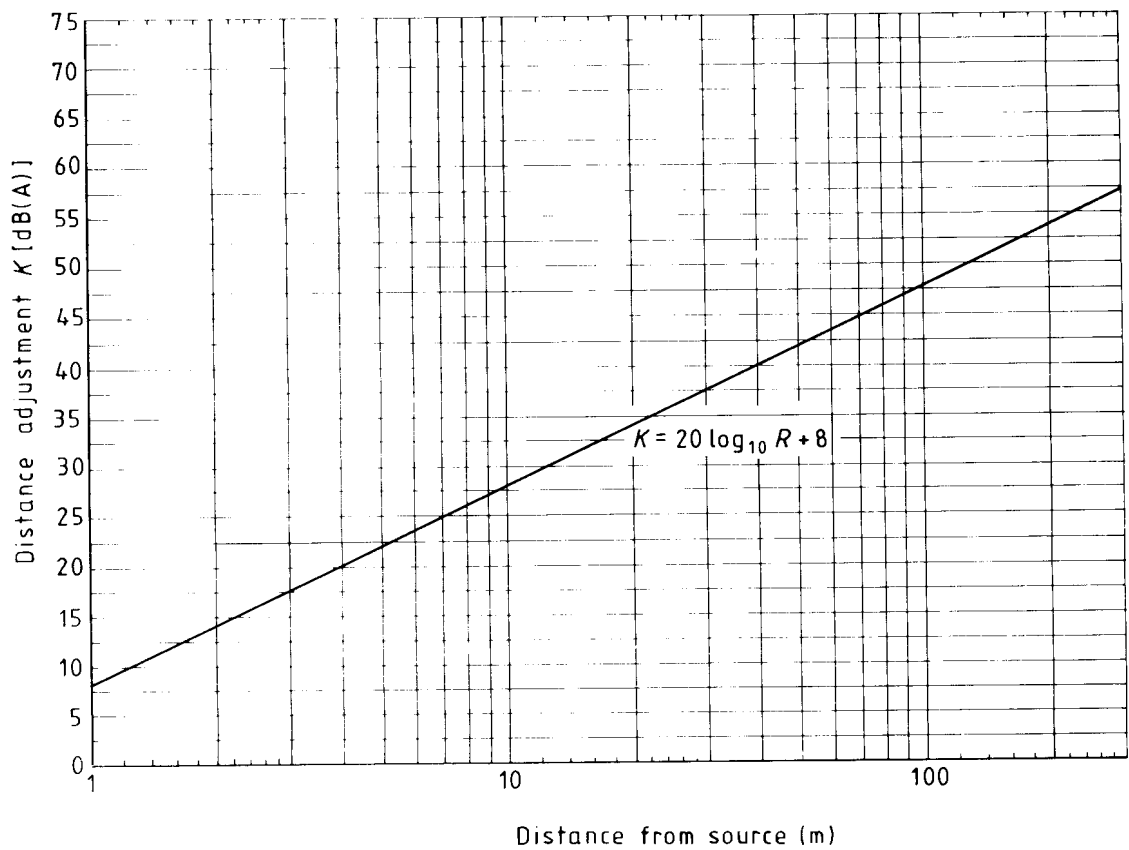


Figure 3. Distance adjustment K for plant sound power method

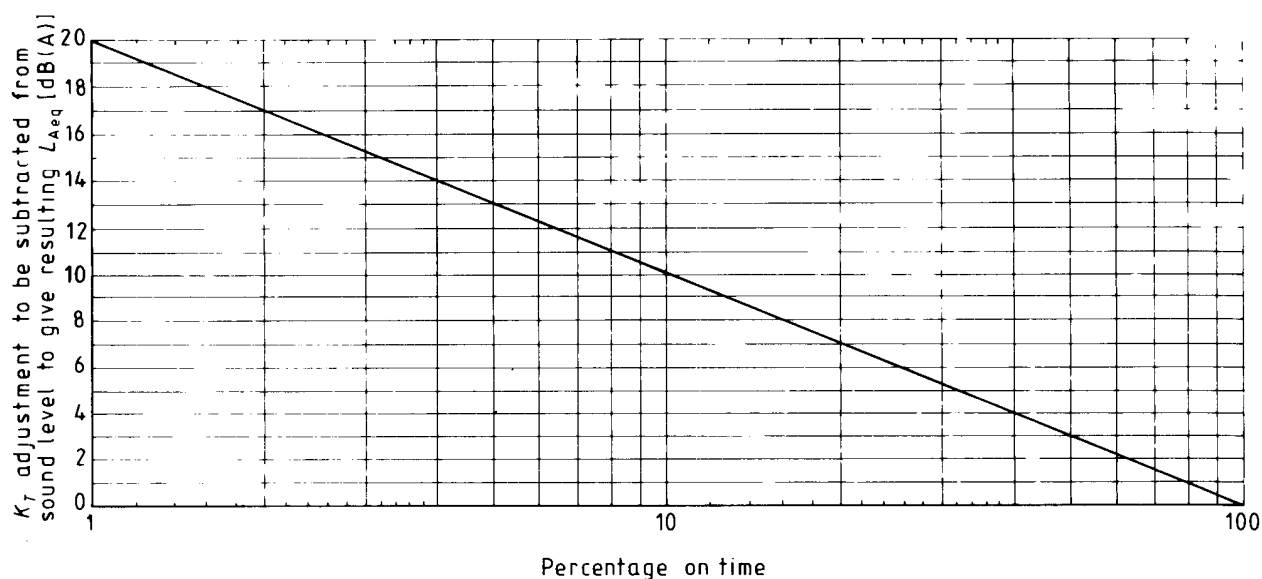


Figure 4. Adjustment to sound level to give resulting L_{Aeq} (plant sound power method)

A.3.4 Mobile plant

A.3.4.1 Method when working over a limited area. The tabulated sound power levels and the equivalent continuous sound levels for mobile plant working over a limited area were measured in the same way as the values for stationary plant. Therefore these results can be used in calculations in the same way as those given in A.3.2 or A.3.3. The sound power level data for these operations are given in appendix C.

Estimates of the L_{Aeq} from mobile plant working in a limited area made using the methods described in A.3.2 or A.3.3 tend to err on the high side because the orientation of the plant varies relative to the point of interest. The errors for estimates of sound level at some distance from the site can be neglected, but when the point of interest is close to the site, i.e. the ratio of traverse length to minimum distance is greater than 0.5, a further refinement is necessary to minimize errors.

To estimate the noise level of slow moving plant typically of speeds of 5 km/h to 10 km/h working over short traverses, the following procedure can be adopted.

Stage 1. Select the sound power level given in appendix C for mobile plant. When there is more than one entry for the same size of plant, list all the L_{WA} values and take the arithmetic average. When the size of plant is not listed, take the average sound power level for the sizes above and below that required.

Stage 2. Calculate the sound level at the receiving position for the plant from the sound power level when the plant is at its closest proximity to the receiving position, as detailed in stage 3 of A.3.3.

Stage 3. If necessary, make allowances for screening effects and for reflections if the receiving position is within 1 m of the facade of a building, as detailed in stage 3 of A.3.2, adding or subtracting the allowances from the sound level L_{pA} .

Stage 4. Estimate the distance ratio (traverse length/minimum distance to receiving position) and obtain the equivalent on-time from table 1.

Stage 5. Estimate the percentage of the assessment period for which the activity takes place. Then correct the on-time for the period of the activity using equation (3) (see stage 6).

Stage 6. Repeat stages 1 to 4 for each activity of this type where:

$$t_c = T_t \times t_o \quad (3)$$

where

t_c is the corrected on-time;

T_t is the total time for which the plant is likely to work during the period of interest;

t_o is the equivalent on-time.

Stage 7. Use one of the methods outlined in A.3.5 to predict the assessment period L_{Aeq} from the sound level L_{pA} and the corrected on-times.

Table 1. Relationship of distance ratio and equivalent on-time for slow moving plant

Distance ratio, D (traverse length/ minimum distance)	Equivalent on-time
0.5	1.00
0.7	0.80
1	0.63
1.5	0.50
2	0.40
3	0.32
4	0.20
5	0.16
6	0.13
7	0.10
8	0.10
9	0.08
10	0.08
10	0.06

A.3.4.2 Method for mobile plant on haul roads or in similar situations where they take regular well defined routes. For mobile items of plant that pass by at intervals (such as earthmoving machinery passing along a haul road), it is possible to predict an equivalent continuous sound level.

Stage 1. The general expression for predicting the L_{Aeq} alongside a haul road used by single engined items of mobile plant is:

$$L_{Aeq} = L_{WA} - 33 + 10 \log_{10} Q - 10 \log_{10} V - 10 \log_{10} d \quad (4)$$

where

L_{WA} is the sound power level of the plant (in dB);

Q is the number of vehicles per hour;

V is the average vehicle speed (km/h);

d is the distance of receiving position from the centre of haul road (in m).

Estimates of the L_{Aeq} from a haul road used by other types of mobile plant with twin engines can be made by adding a further 3 dB(A) to the L_{Aeq} calculated using equation (4).

Stage 2. If necessary, make allowances to the equivalent sound level for screening effects and for reflections if the receiving position is within 1 m of a building facade, as detailed in stage 3 of A.3.2, adding or subtracting the allowances from the L_{Aeq} obtained in stage 1.

Stage 3. Repeat stages 1 and 2 for each activity.

Stage 4. Estimate the percentage of the assessment period for which each activity takes place then use one of the methods outlined in A.3.5 to predict the assessment period L_{Aeq} from the individual activity L_{Aeq} values obtained in stage 3, which may be on a shorter time-base.

A.3.5 Summation of sound levels

A.3.5.1 Conditions constant. When conditions on site are such that all activities affecting the noise level at the point of interest are carried out continuously for any assessment period, the activity L_{Aeq} values obtained from A.3.2, A.3.3 and/or A.3.4 can be combined in the same way as actual continuous sound levels. It is possible to combine the separate sound levels in pairs. This is done by obtaining the difference between them and adding a correction to the higher level; the appropriate corrections are given in table 2. For a number of activities, this process can be repeated by combining two levels at a time until a single value is obtained, starting with the lowest pair of levels and working upwards in sequence.

Table 2 shows that if the difference between the two levels is equal to, or greater than, 10 dB(A), the influence of the lower level on the higher level would be zero.

Table 2. Addition of steady sound levels

Difference between the two levels	Addition to higher level
dB(A)	
0	3
1	3
2	2
3	2
4	1
5	1
6	1
7	1
8	1
9	1
10 and over	0

As this method is used when the activity L_{Aeq} values are appropriate for a complete assessment period, the calculated sound level will be the combined equivalent continuous sound level L_{Aeq} , for that period only.

For other periods it is necessary to use the method described in A.3.5.2.

A.3.5.2 Conditions varying during the assessment period.

When conditions on site are such that some or all of the activities affecting the noise level at the point of interest continue for less than the assessment period, the values of L_{Aeq} obtained from A.3.2, A.3.3 and/or A.3.4 may be combined as in equation (5).

$$L_{Aeq,T} = 10 \log_{10} \frac{1}{T} \sum t_i 10^{0.1 L_{Aeq,i}} \quad (5)$$

where

$L_{Aeq,T}$ is the combined equivalent continuous A-weighted sound pressure level over a given period T ;

$L_{Aeq,i}$ is the individual equivalent continuous A-weighted sound pressure level for an item of plant or activity during a period t_i .

Alternatively, the combined equivalent continuous sound level can be obtained from the nomograph (figure 5), details of which are given in A.3.5.3.

A.3.5.3 Equivalent continuous sound level (nomograph). ¹⁺ It is possible to calculate the combined equivalent continuous sound level by use of the nomograph shown in figure 5 which is based on equation (5).

To obtain the combined equivalent continuous sound level of a number of items of plant operating for times $t_1, t_2 \dots t_n$ within the total time period T and producing sound levels of $L_1, L_2 \dots L_n$ dB(A) at the point of interest, the following procedure should be carried out:

(a) Calculate the percentage times of each activity within total time period T , i.e.:

$$P_1 = \frac{t_1 \times 100}{T}, P_2 = \frac{t_2 \times 100}{T} \dots P_n = \frac{t_n \times 100}{T}$$

(b) Enter the nomograph from the left-hand ordinate at the first sound level L_1 and move across to the corresponding percentage P_1 then move vertically

down to the partial noise exposure index value of E_1 and record E_1 .

(c) Repeat step (b) for each sound level, $L_1, L_2 \dots L_n$.

(d) The partial noise exposure values $E_1, E_2 \dots E_n$ are then added to give E_T , i.e.:

$$E_1 + E_2 \dots + E_n = E_T$$

(e) Re-enter the nomograph on the horizontal axis at the value of E_T on the partial noise exposure index scale and move vertically upwards to the 100 %, then horizontally across the right-hand ordinate to read the combined equivalent continuous sound level.

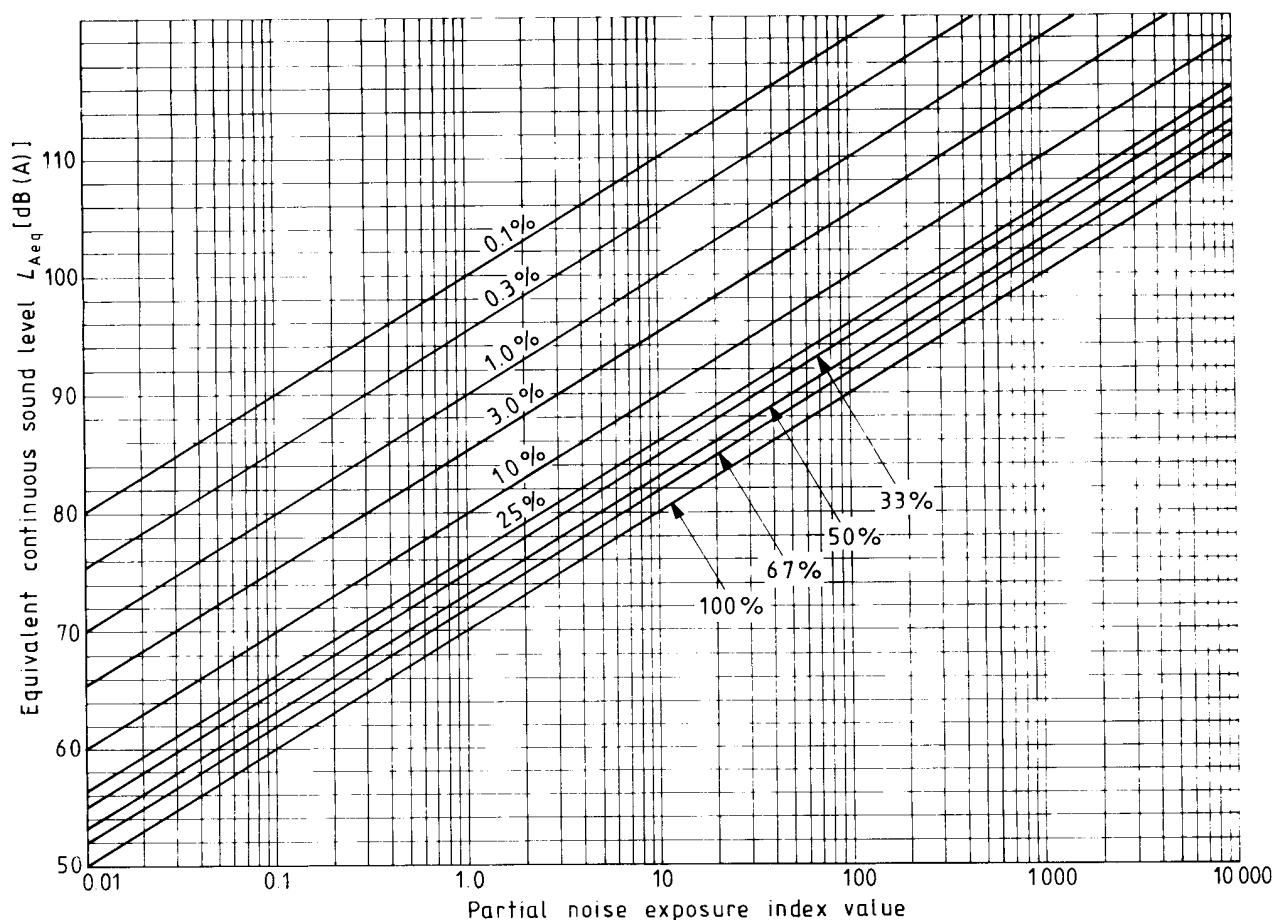


Figure 5. Nomograph: combined L_{Aeq} from activity L_{Aeq} values and their respective durations

A.3.6 Example calculations

A.3.6.1 Example 1. Building, office development

A.3.6.1.1 General. This example is shown in figure 6.

Excavations are in progress for foundations of an office block, including breaking out of some old concrete bases, at a site next to existing offices. A tracked excavator (72 kW) is digging out spoil, placing it on a temporary tip which partially screens the machine from the offices. A wheeled loader (52 kW) is backfilling part of the excavated area with spoil from a nearby pile. Two hand-held breakers (35 kg) are being used to break out old concrete and are powered from a compressor (3.5 m³/min) fitted with standard sound-reducing equipment.

During the working day the plant is in use for the following periods:

- (a) excavator: 8 h;
- (b) loader: 4 h;
- (c) breakers: 3 h.

The example predicts the 12 h L_{Aeq} at the northern facade of the office which is closest to the site activities.

Consider the plant that is operating and select the methods to be used for the plant types. The excavator, compressor and breakers can be treated by the activity L_{Aeq} method (see A.3.2) whereas the wheeled loader which is mobile in operation should be treated by the method for mobile plant on site (see A.3.4.1).

The example calculation is shown in table 3 and described in A.3.6.1.2 and A.3.6.1.3.

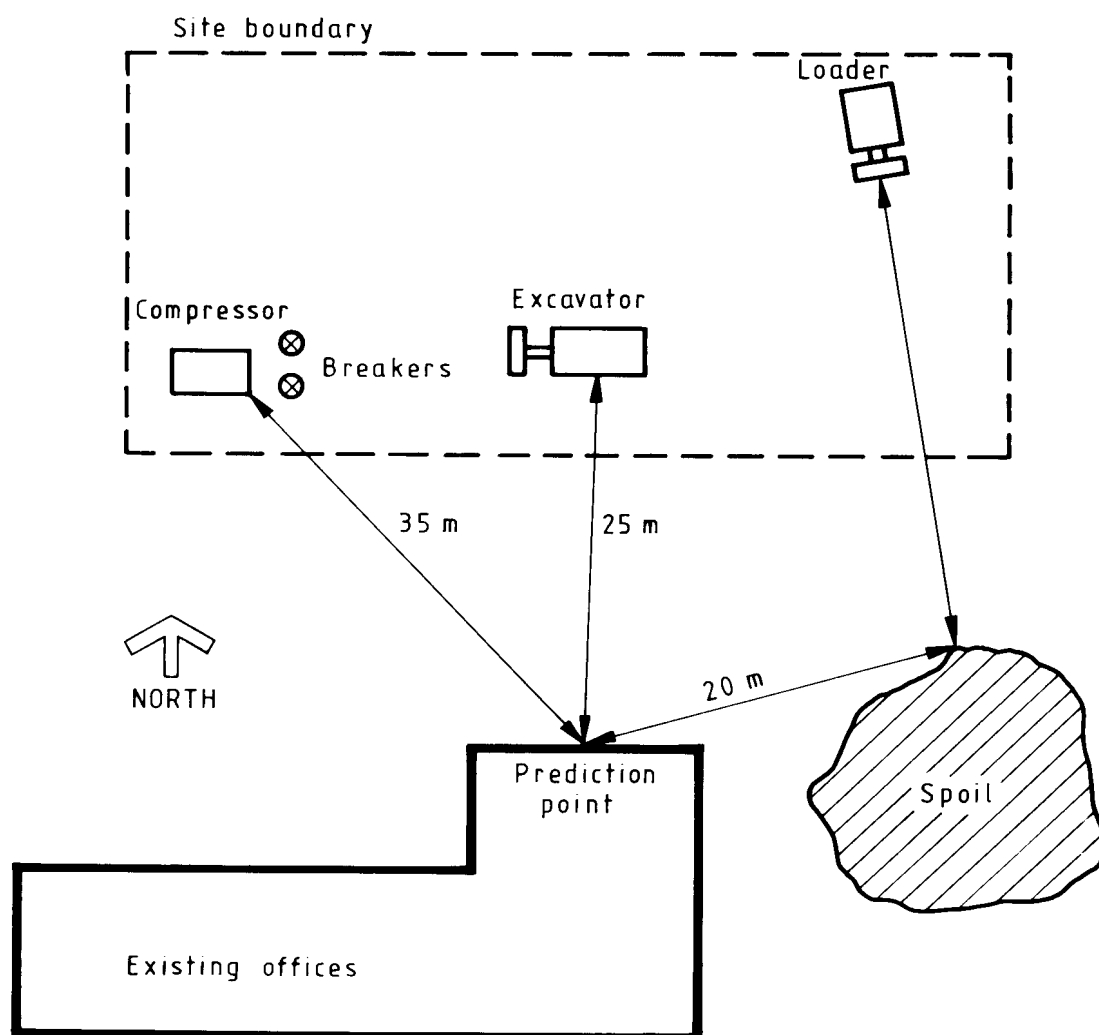


Figure 6. Office development site showing plant locations in relation to the nearest affected facade

A.3.6.1.2 Activity L_{Aeq} method. Calculate the estimated noise using the method described in **A.3.2** as follows.

NOTE. Step numbers refer to table 3.

- (a) Tabulate the activities of items of plant (step 1).
- (b) Select the L_{Aeq} at 10 m from the item of plant or activity (step 2). For the excavator refer to table 7 reference number 40 and for the compressor and two breakers refer to table 11, reference numbers 5, 6 and 7.
- (c) Take the distance from the drawing of the plant or activity to the point of interest (step 3) and obtain the corresponding allowance in dB(A) from figure 2 (step 4).
- (d) Include allowances for screening (step 5) and reflections (step 6) from which the L_{Aeq} of each activity is obtained (step 7).
- (e) The duration of each activity in hours as the percentage of the 12 h period is then tabulated (steps 8 and 9) and used with each activity L_{Aeq} to obtain the partial noise exposure index from figure 5 (step 10).

A.3.6.1.3 Mobile plant on site. Calculate the estimated noise using the method described in **A.3.4** as follows.

NOTE. Step numbers refer to table 3.

- (a) Tabulate the item of plant (step 1).

(b) Select the sound power level L_{WA} for the item of plant (step 2). For the loader refer to table 7, reference numbers 2, 3 and 4, and take the average of all three.

(c) Take the distance from the drawing of the plant from the point of interest (step 3) and the corresponding adjustments to correct to sound level at that distance from figure 3 (step 4).

(d) Include allowances for screening (step 5) and reflections (step 6) from which the resultant sound level can be calculated (step 7).

(e) Estimate the distance ratio, traverse length/minimum distance ($30/20 = 1.5$) (step 8) and obtain the equivalent on-time from table 2 (step 9).

(f) Use the equivalent on-time, duration of activity (step 10) and equation 3 to obtain the corrected on-time (step 11).

(g) Use the corrected on-time as a percentage of 12 h period (step 11) and the resultant sound level (step 7) to obtain the partial noise exposure index from figure 5 (step 12).

The partial noise exposure indices from all the activities, the activity L_{Aeq} and mobile plant on site methods are then added together and, referring again to figure 5, the combined L_{Aeq} (12 h) is predicted at 75 dB(A) to the nearest whole number.

Table 3. Example of prediction of noise from a building site

(a) Activity L_{Aeq} method

Plant type	L_{Aeq} at 10 m	Distance	Adjustments			Resultant L_{Aeq}	Duration of activity	Duration of activity as percentage of 12 h	Partial noise exposure index
			Distance	Screening	Reflection				
Excavator	80	25	-8	-5	+3	70	8	67	0.7
Compressor + 2 breakers	88	35	-11	0	+3	80	3	25	2.5
Step 1	2	3	4	5	6	7	8	9	10

(b) Mobile plant on site method

Plant type	Average L_{WA}	Distance	Adjustments			Resultant L_{pA}	Distance ratio	Equivalent on-time	Duration of activity	Corrected percentage on-time	Partial noise exposure index
			Distance	Screening	Reflection						
Loader	104	20	-34	0	+3	73	$30/20 = 1.5$	0.5	4	16.7	0.33
Step 1	2	3	4	5	6	7	8	9	10	11	12

Total noise exposure index = 3.53

Combined L_{Aeq} (12 h) = 75 dB(A)

A.3.6.2 Example 2. Civil engineering: spoil movement on a haul road**A.3.6.2.1 General.** This example is shown in figure 7.

Spoil is being taken from civil engineering works along a haul road which passes 50 m from a farm house. The loads are carried in scrapers (475 kW) and dump trucks (310 kW). The condition of the haul road is maintained by a grader (150 kW). Details of the journeys made are as follows.

- (a) Scrapers: 8 journeys each way per hour at 15 km/h;
- (b) Dump trucks: 12 journeys each way per hour at 25 km/h;
- (c) Grader: 1 journey each way per hour at 7 km/h.

Operations are continuous for the 12 h day.

The method to be adopted for predicting the noise is that for mobile plant on haul roads (see **A.3.4.2**).

The prediction method is based on equation (4).

$$L_{Aeq} = L_{WA} - 33 + 10 \log_{10} Q - 10 \log_{10} V - 10 \log_{10} d \quad (4)$$

A.3.6.2.2 Sound level of plant. Calculate the sound level as follows.

- (a) *Scrapers.* Select the sound power level from the tables. Refer to table 12, reference numbers 13 and 14.

For loaded scraper:

$$L_{WA} = 123 \text{ dB(A)}.$$

Using equation (4) and substituting for $Q = 8$:

$$V = 15 \text{ km/h and } d = 50 \text{ m}.$$

The $L_{Aeq} = 70 \text{ dB(A)}$.

For empty scraper:

$$L_{WA} = 120 \text{ dB(A)}.$$

Using equation (4) and substituting for $Q = 8$:

$$\text{The } L_{Aeq} = 67 \text{ dB(A)}.$$

- (b) *Dump trucks.* Assume an average sound power level for trucks travelling at similar speed. Refer to table 12, reference numbers 29, 30, 32, 35 and 37.

$$L_{WA} = 112 \text{ dB(A)}.$$

Using equation (4) and substituting for $Q = 24$ (12 journeys):

$$V = 25 \text{ km/h and } d = 50 \text{ m}.$$

$$\text{The } L_{Aeq} = 62 \text{ dB(A)}.$$

- (c) *Grader.* Select the sound power level from the tables. Refer to table 12, item 7.

$$L_{WA} = 111 \text{ dB(A)}.$$

Using equation (4) and substituting for $Q = 2$ (1 journey):

$$V = 7 \text{ km/h and } d = 50 \text{ m}.$$

$$\text{The } L_{Aeq} = 56 \text{ dB(A)}.$$

A.3.6.2.3 Combined sound levels. The total L_{Aeq} from the three types of plant is obtained by combining these levels using table 2 as follows:

- (a) combine 56 to 62, the difference is 6 so add 1 to the higher sound level = 63 dB(A);
- (b) combine 63 and 67, the difference is 4 so add 1 to the higher sound level = 68 dB(A);
- (c) combine 68 and 70, the difference is 2 so add 2 to the higher sound level = 72 dB(A).

As the point of interest is at the building facade an allowance for reflections of +3 dB(A) is made; there is no allowance for screening as there is direct line of sight. As operations are continuous over the 12 h day there is no correction necessary for duration of activity.

Hence the resultant facade level = $72 + 3 = 75 \text{ dB(A)}$ L_{Aeq} (12 h).

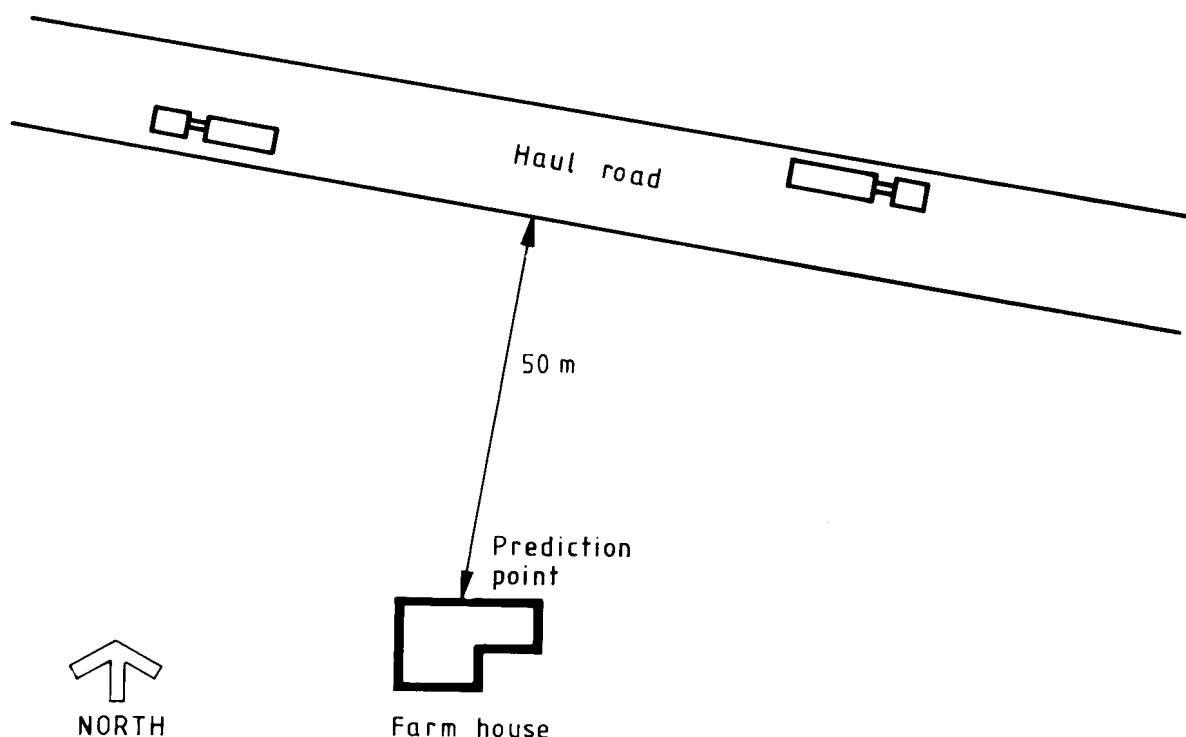


Figure 7. Spoil movement on a haul road showing location of the nearest affected property