

Noise and vibration control on construction and open sites

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

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Committees responsible for this British Standard

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- British Aggregate Construction Materials Industries
- British Coal Corporation
- British Compressed Air Society
- Building Employers' Confederation
- Chartered Institute of Environmental Health
- Concrete Society
- Construction Health and Safety Group
- Construction Plant-Hire Association
- Department of the Environment (Building Research Establishment)
- Department of the Environment (Pollution Control and Waste Directorate)
- Federation of Civil Engineering Contractors
- Federation of Dredging Contractors
- Federation of Piling Specialists
- Institution of Civil Engineers
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Foreword

This Part of BS 5228, which has been prepared by Subcommittee B/209/17, covers the control of noise and vibration from construction and open sites. It supersedes BS 5228 : Part 1 : 1984, which is withdrawn.

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

Noise and vibration can cause disturbance to processes and activities in neighbouring buildings, and in certain extreme circumstances vibration can cause or contribute to building damage.

Noise and vibration can be the cause of serious disturbance and inconvenience to anyone exposed to it and in certain circumstances noise and vibration can be a hazard to health. The Environmental Protection Act 1990 [1] in England and Wales (and Scotland by virtue of the Environment Act 1995 [2]) contains provisions for the abatement of nuisances caused by noise and vibration. The provisions of the Environmental Protection Act 1990 are extended to vehicles and equipment in streets and public open spaces by the Noise and Statutory Nuisance Act 1993 [3], the Control of Pollution Act 1974 [4] in England, Wales and Scotland, and the Pollution Control and Local Government (Northern Ireland) Order 1978 [5] in Northern Ireland. The 1974 and 1990 Acts (Sections 73(1) and 79(7), respectively) and the 1978 Order (Article 53(1)) define 'noise' as including 'vibration'. Insulation against noise is addressed in the Noise Insulation Regulations 1975 [6] and (Amendment) Regulations 1988 [7], the Noise Insulation (Scotland) Regulations 1975 [8] in Scotland and the Noise Insulation (Northern Ireland) Regulations 1995 [9] in Northern Ireland.

It should be noted that BS 6472 covers the human response to vibration in structures and BS 7385 : Part 1 covers the measurement and evaluation of structural vibration. BS 7385 : Part 2 contains guidance on damage levels from groundborne vibration.

An item dealing with the vibratory loading of structures is being processed within ISO Technical Committee ISO/TC 98/SC/2, Safety of structures. This is being monitored by BSI.

This Part of BS 5228 is common to all the types of work covered by the other Parts of BS 5228, which should be read in conjunction with this Part.

BS 5228 consists of the following Parts:

- | | |
|--------|--|
| Part 1 | <i>Code of practice for basic information and procedures for noise and vibration control</i> |
| Part 2 | <i>Guide to noise and vibration control legislation for construction and demolition, including road construction and maintenance</i> |
| Part 3 | <i>Code of practice applicable to surface coal extraction by opencast methods</i> |
| Part 4 | <i>Code of practice for noise and vibration control applicable to piling operations</i> |
| Part 5 | <i>Code of practice applicable to surface mineral (excluding coal) extraction¹⁾</i> |

¹⁾In preparation.

Other Parts will be published in due course as and when required by industry.

Attention is drawn to the Control of Pollution Act 1974 [4] (Part III (Noise)), the Environmental Protection Act 1990 [5] (Part III (Statutory Nuisances and Clean Air)) the Noise and Statutory Nuisance Act 1993 [3], the Health and Safety at Work etc. Act 1974 [10] (in Northern Ireland, the Pollution Control and Local Government (Northern Ireland) Order 1978 [5] and the Health and Safety at Work (Northern Ireland) Order 1978 [11]), and to the Noise at Work Regulations, 1989 SI 1790 [12] and the Noise at Work Regulations (Northern Ireland), 1990 Statutory Rules 147 [13].

As a code of practice, this Part of BS 5228 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.

Code of practice

1 Scope

This Part of BS 5228 gives recommendations for basic methods of noise and vibration control relating to construction and open sites where work activities/operations generate significant noise and/or vibration levels.

The legislative background to noise and vibration 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.

It also provides guidance, including, where appropriate, reference to other British Standards, concerning methods of measuring vibration and assessing its effects on the environment.

2 References

2.1 Normative references

This Part of BS 5228 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 page 70. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this Part of BS 5228 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 Part of BS 5228 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 page 70, but reference should be made to the latest editions.

3 Definitions

For the purposes of this Part of BS 5228, the definitions given in BS 3015 and BS 4727 : Part 3 : Group 08 apply together with the following.

NOTE 1. Where applicable, the definitions are consistent with those given in BS 7445 : Parts 1, 2 and 3.

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

3.1 ambient noise

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

3.2 site noise

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

3.3 A-weighted sound pressure level

The level of the A-weighted sound pressure, calculated as follows:

$$L_{pA} = 20 \log_{10} \left(\frac{p_A}{p_0} \right)$$

where

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

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

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

For correctness, the time weighting used to determine the r.m.s. value of the sound pressure should be specified.

NOTE. The time weightings 'S' and 'F' are standardized in BS EN 60651. The symbols are L_{pAS} and L_{pAF} , respectively.

3.4 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.

NOTE. The maximum sound level is represented by $L_{pA(max)}$.

3.5 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 .

NOTE. The one percentile level is represented by $L_{A01(T)}$.

3.6 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.

NOTE. The equivalent continuous A-weighted sound pressure level 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).

3.7 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.

NOTE. The activity may involve the operation of more than one item of plant.

3.8 sound exposure level

The constant level which, if maintained for a period of 1 s, would have the same acoustic energy as the measured noise event.

NOTE. The sound exposure level may be calculated as follows:

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

where

- 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).

3.9 A-weighted sound power level

The level of the A-weighted sound power, calculated as follows:

$$L_{WA} = 10 \log_{10} \left(\frac{P_A}{P_0} \right)$$

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_0 is the reference sound power (10^{-12} W).

3.10 noise-sensitive premises

Any occupied premises outside the site used as a dwelling (including gardens), place of worship, educational establishment, hospital or similar institution, or any other property likely to be adversely affected by an increase in noise level.

NOTE. Due consideration should be given to national parks, areas of outstanding natural beauty or other outdoor spaces where members of the public might reasonably expect quiet enjoyment of the area.

3.11 open site

A site where there is significant outdoor excavation, levelling or deposition of material (e.g. quarries, mineral extraction sites, an opencast coal site or other site where an operator is involved in the outdoor winning or working of minerals).

NOTE. Waste disposal sites and long term construction projects may, in most cases, be treated as open sites.

3.12 peak particle velocity (p.p.v.)

The instantaneous maximum velocity reached by the vibrating element as it oscillates about its rest position.

3.13 vibration dose value (v.d.v.)

A function of the weighted vibration acceleration level integrated over time.

4 Legislative background

4.1 General

This standard provides a framework for 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. The other Parts of BS 5228, which cover a range of industrial methods and operations, provide further information about the legal controls affecting industry-generated noise and vibration.

Attention is drawn to the following legislation dealing with control of environmental noise and vibration, which was current at the date of publication of this Part of this standard.

4.2 Statutory controls over noise and vibration

Citizens have a right to seek redress through common law action in the courts against the intrusion of unreasonable levels of noise or vibration which may affect their premises. In addition, there are two significant statutory remedies which enforcing authorities may employ to achieve the following two similar objectives:

- a) enforcement action to prevent or secure the abatement of a statutory nuisance; and
- b) use of specific national legislation to control noise and vibration from construction sites and other similar works.

Part III of the Environmental Protection Act 1990 [1] contains the mandatory powers available to local authorities within England and Wales in respect of any noise or vibration which either constitutes or is likely to cause a statutory nuisance. Section 79 of this Act defines statutory nuisance and places a duty on a local authority to inspect the area to detect any statutory nuisances which ought to be dealt with under section 80. Under this section, where a local authority is satisfied of the existence, recurrence or likely occurrence of a statutory nuisance it has to serve an abatement notice on the appropriate person or persons. Failure to comply with the terms of this notice is an offence which may result in proceedings in a Court of Summary Jurisdiction.

Section 82 of the Environmental Protection Act permits the court to act on a complaint by any person who may be aggrieved by the existence of a statutory nuisance and in these circumstances the court may follow the procedures described in the previous paragraph. Similar procedures to the above, for the control, in Scotland, of statutory nuisances caused by noise or vibration, are found under sections 58 and 59 of the Control of Pollution Act 1974 [4]. In Northern Ireland the relevant equivalent provisions are contained in the Pollution Control and Local Government (Northern Ireland) Order 1978 [5].

Sections 60 and 61 of the Control of Pollution Act 1974 [4] give local authorities in England, Scotland and Wales special powers for controlling noise and vibration arising from construction and demolition works on any building or civil engineering sites. In Northern Ireland, equivalent powers are contained in the Pollution Control and Local Government (Northern Ireland) Order 1978 [5]. Powers under sections 60 and 61 and their equivalent in Northern Ireland are confined to construction, including maintenance and repair, and to demolition works carried out on all building structures and roads. They are described in detail in Part 2 of BS 5228.

In section 71 of the Control of Pollution Act 1974 [4], it is stated that:

'1) For the purpose of giving guidance on appropriate methods (including the use of specified types of plant or machinery) for minimizing noise, the Secretary of State may —

- a) prepare and approve and issue such codes of practice as in his opinion are suitable for the purpose; and
- b) approve such codes of practice issued or proposed to be issued otherwise than by the Secretary of State as in the opinion of the Secretary of State are suitable for the purpose.

2) The Secretary of State shall under paragraph a) or paragraph b) of the preceding sub-section approve a code of practice for the carrying out of works to which section 60 of this Act applies.

3) The powers conferred by this section on the Secretary of State shall be exercisable by order, and shall include power to vary or revoke a previous order under this section.'

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.

4.3 European Commission (EC) Directives

As part of its programme for the removal of barriers to trade (Article 100 of the Treaty of Rome) the EC has prepared directives which set noise emission levels for new items of construction equipment. These directives have been implemented by regulations. Details of the directives and corresponding regulations are given in annex A.

Article 118A requires harmonization of existing health and safety laws. The Council of the European Communities Directive of 12 May 1986 (86/188/EEC) on the protection of workers from the risks related to exposure to noise at work [14] is implemented by the Noise at Work Regulations, 1989 SI 1790 [12].

Proposals are in hand for a new directive on physical agents. Several action levels for noise are expected to be included. Vibration will also be covered.

4.4 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 3 concerns employers' duties to persons not in their employment who may be exposed to health and safety risks. 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 articles is made available.

Section 7 places a duty on employees to take reasonable care for the health and safety of themselves and of other persons who may be affected and to co-operate with their employers, so far as is necessary to enable any duty or requirement to be performed or complied with. In Northern Ireland, equivalent powers are contained in the Health and Safety at Work (Northern Ireland) Order 1978 [11].

4.5 Noise at Work Regulations 1989

The Noise at Work Regulations, 1989 SI 1790 [12] implements the Council of the European Communities Directive of 12 May 1986 on the protection of workers from the risks related to the exposure to noise at work, 86/188/EEC [14]. The main requirements are triggered by three 'action levels': daily personal noise exposures of 85 dB(A) and 90 dB(A) (the first and second action levels respectively), and 200 Pa (the peak action level). These Regulations are concerned with the protection of people at work, and do not, therefore, deal with exposure to noise for the public.

Regulation 4 places a duty upon employers to carry out an assessment where exposures are at or above the first action level. Such assessments should identify which employees are exposed and provide enough information to facilitate compliance with duties under Regulations 7, 8, 9 and 11. Attention is drawn to Regulation 7, which states that, when any employee is exposed to levels at or above the second action level or peak action level, the employer shall reduce so far as is reasonably practicable, other than by the use of personal ear protection, the exposure to noise of that employee.

The provision of personal ear protection is covered by Regulation 8, and Regulation 9 concerns ear protection zones.

Under Regulation 11, the employer has a duty to each employee who is likely to be exposed to the first action level and above, or to the peak action level or above, to provide adequate information, instruction and training on:

- a) the risks to that employee's hearing that such exposure may cause;
- b) what steps the employee can take to minimize that risk;
- c) the steps that the employee has to take in order to obtain personal ear protectors; and
- d) the employee's obligations under the Noise at Work Regulations 1989 [12].

Regulation 12 modifies the section 6 duties of the Health and Safety at Work etc. Act 1974 [10] on manufacturers, suppliers, etc., to include specific requirements for provision of information on noise transmission. These duties include that, if a machine is likely to produce noise capable of harming health, action will need to be taken to reduce the noise to a reasonably practicable extent and to provide information on any measures needed to keep the noise under control when the machine is used.

In Northern Ireland, equivalent powers are contained in the Noise at Work Regulations (Northern Ireland) 1990 [13].

4.6 Local authorities

The local authorities exercising powers under Part III of the Control of Pollution Act 1974 [4] and Part III of the Environmental Protection Act 1990 [1] are as follows: in England and Wales, the council of a district or of 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. In Northern Ireland, district councils exercise similar functions under the Pollution Control and Local Government (Northern Ireland) Order 1978 [5].

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

For the winning and working of minerals, the relevant authority should be consulted as follows:

England: county councils, metropolitan boroughs, unitary authorities and national park planning boards where appropriate;

Wales: the unitary planning authorities and national park planning boards where appropriate;

Scotland: unitary planning authorities;

Northern Ireland: Department of the Environment for Northern Ireland.

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.

5 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 relations 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 and can under some circumstances 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, individually if necessary, is important.

NOTE. The Department of the Environment has commissioned research on the environmental effects of noise and vibration from blasting and may issue appropriate guidance.

6 Training

Under Regulation 11 of the Noise at Work Regulations 1989 [12], all employees 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 regularly of 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 on 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 employees can help themselves to protect their hearing, for example:

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

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

7 Noise and vibration and persons on site

7.1 Protection from noise-induced hearing loss

Exposure to high noise levels 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 specified levels for unprotected exposure as stated in the Noise at Work Regulations 1989 [12].

The use of plant and/or power tools on site can create areas of potential noise hazard. These areas should be identified by displaying warning signs. Such measures will be included in the assessment carried out under Regulation 4 of the Noise at Work Regulations 1989 [12]. The ear protection zones should be clearly identified with notices displayed in prominent positions, indicating that ear protectors are required to be worn inside the specified areas.

Noise exposure 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 levels 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 annex B.) 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 annex B.)

Account should always be taken of the need to minimize noise and to protect quiet areas from its impact when the layout of plant and the phasing of operations are being considered. (See also annex C.)

7.2 Ear protectors

Effective noise control at source should always be regarded as the prime means of affording proper protection to employees from risks to hearing. Circumstances may arise, however, where this is not reasonably practicable. On such occasions, employees should be provided with, and should wear, personal ear protectors. This will be necessary when all reasonably practicable means of reducing noise at source have been applied but occupational noise exposure still exceeds the levels stated in the Noise at Work Regulations 1989 [12].

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 to alert employees 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 employees wearing ear protectors.

It is important that ear protectors are reliable and capable of producing the necessary degree of noise attenuation. BS EN 24869-1 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 EN 24869-1 and to provide the resultant attenuation values. Noise Guide 5, *Types and selection of personal ear protectors* [15], describes the most commonly available forms of ear protector and provides information on suitability and efficiency of protection.

The following points relate to the introduction of ear protectors.

- a) The type of ear protector provided should be appropriate to the particular noise conditions to which the wearer will be subjected. (See Regulation 8, Noise at Work Regulations 1989 [12].)
- b) Employees required to wear ear protectors, should, where this is practicable, be able to choose the type of protector to be worn. The final choice will be dictated by the consideration outlined in item a).
- c) Ear protectors should be regularly inspected for damage and deterioration, by a competent person. (See Regulation 10, Noise at Work Regulations 1989 [12].)
- d) Facilities for the cleaning and the clean storage of ear protectors should be provided.
- e) Safety training programmes should include information on the proper use of control measures and instruction on the need for and the use, care and maintenance of ear protectors. (See Regulation 11, Noise at Work Regulations 1989 [12].)

Management should demonstrate by example its commitment to the protection of hearing.

7.3 Noise and vibration-induced stress

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

7.4 Protection from vibration exposure

Exposure to prolonged and regular work with high-vibration hand held tools can be a serious hazard to health. Workers using such equipment may suffer various forms of adverse effects, collectively known as 'hand-arm vibration syndrome' (HAVS). The best known effect is 'vibration white finger' (VWF) which is a prescribed industrial disease.

Whilst there are no specific legal duties or measures which are required to be taken to reduce the risk of HAVS, if workers are at risk employers need to consider what action should be taken to reduce the risk so far as is reasonably practicable in order to meet the requirements of general legislation, including the Health and Safety etc. at Work Act 1974 and the Management of Health and Safety at Work Regulations 1992.

Useful guidance on this matter is contained within the Health & Safety Executive booklet HS(G)88 [16]. Applying the advice given in this guidance should, in the view of HSE, ensure that the risks from HAVS are properly controlled.

8 Noise and vibration neighbourhood nuisance

8.1 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.

8.2 Disturbing effects of vibration

Vibrations, even of very low magnitude, may be perceptible to people and can interfere with the satisfactory conduct of certain activities, e.g. delicate procedures in hospital operating theatres, use of very sensitive laboratory weighing equipment. Vibration nuisance is frequently associated with the assumption that, if vibrations can be felt, then damage is inevitable; however, considerably greater levels of vibration are required to cause damage to buildings and structures (see, for example, BS 7385 : Part 2) or to cause computers and similar electronic equipment to malfunction. Vibrations transmitted from site activities to the neighbourhood may, therefore, cause anxiety as well as annoyance, and can disturb sleep, work or leisure activities. As with noise, in any neighbourhood some individuals will be more sensitive to vibration than others.

8.3 Site noise descriptor

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 8.1 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} . The time period, T , (e.g. 1 h, 12 h) involved (see 3.6) 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.

Annex D deals with the estimation of site noise and annex E is concerned with noise measurement and monitoring.

8.4 Site vibration descriptor

The peak particle velocity (p.p.v.) is the simplest indicator of both perceptibility and the risk of damage to structures. In order to obtain a typical value of p.p.v. a representative number of cycles or operations should be monitored.

The vibration dose value (VDV) is recommended in BS 6472 as the appropriate measure of nuisance from vibration.

As for noise, whichever measure is used to describe vibration from the site it should always be made clear to which period of time any particular value applies.

NOTE. BS 7385 : Part 1 is concerned with vibration measurement and monitoring in buildings.

8.5 Criteria for setting noise and vibration control targets

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

a) *Site location.* The location of a site in relation to noise or vibration sensitive development will be a major factor. The nearer a site is to sensitive premises, the more stringent should be restrictions upon noise or vibration emanating from the site.

b) *Existing ambient noise and vibration 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 the noise originating from construction and open sites since the noise will, in general, be more noticeable in quieter areas. However, the relationship between response and noise level difference may well be different. For example, a greater difference may be tolerated when it is known that the operations are of short duration.

There is no known relationship between response and levels when comparing newly intruding and ambient vibrations.

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

d) *Hours of work.* For any noise sensitive premises 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 $L_{Aeq}(1\text{ h})$ at the facade of noise-sensitive premises may need to be as low as 40 dB(A) to avoid sleep disturbance.

Sensitivity to vibration at different times of the day is far more complex than sensitivity to noise. The sensitivity of the human frame to vibration varies according to the axis of vibration relative to the human body (e.g. x , y or z axis) and to the frequency of vibration. In general, except at very low frequencies, sensitivity is greater in the z axis (i.e. head to foot). When setting vibration control targets it is reasonable to assume that people will normally be sitting or standing (i.e. vertical) during the day and lying down (i.e. horizontal) during the night. The guidance given in BS 6472 is useful but it should be remembered that when construction activities are of a temporary nature situations will exist, both during the day and night, where vibration magnitudes above those generally corresponding to minimal adverse comment level can be tolerated.

e) *Attitude to the site operator.* It is well established that people's attitudes to noise can be influenced by their attitudes to the source itself. 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 or she can to avoid unnecessary noise. The acceptability of the project itself may also be a factor in determining community reaction. People's attitudes to vibration may be similarly influenced.

f) *Noise and vibration 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} . In certain circumstances it may be appropriate to apply a weighting, or character correction, of 5 dB(A) to the source of intermittent, tonal or impulsive noise, as specified in the assessment of industrial noise in BS 4142 : 1990.

Similarly, the characteristics of vibration, e.g. whether it is continuous, intermittent or impulsive, may influence its acceptability.

g) *Effect on buildings.* Consideration should be given to the effect of vibration on buildings adjacent to the site. Guidance on the evaluation of these effects may be obtained in BS 7385 : Part 1 and guidance on damage levels from groundborne vibration may be found in Part 2 of the same standard or in BS 5228 : Part 1 : 1997.

Both operators and local authorities can assist their decision making in this area by maintaining records of situations where site noise or vibration has caused problems.

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

9 Project supervision

9.1 General

The intention at each stage of a project should be to minimize levels of site noise and vibration whilst having due regard to the practicability and economic implication of any proposed control or mitigation measures.

Planners, developers, architects, engineers and environmental health officers can all play a part in avoiding potentially excessive noise and vibration 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. Attention is drawn to the Construction (Design and Management) Regulations and Approved Code of Practice [16].

Developers, architects and engineers will need to know whether the processes 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 seeking consultation, they may find it useful to determine the expected levels of site noise in accordance with annex D. Annex C gives typical noise levels created by site plant and activities. Some guidance on levels of vibration from piling is given in BS 5228 : Part 4 and on levels of vibration from blasting in BS 5228 : Part 5.

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

9.2 Works preparation

A project design should be so arranged that the number of operations likely to be particularly disturbing is kept to a minimum. Designers should also remember that project designs can have considerable influence upon operators' use of sites. Project designs should include 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 problems.

A survey of the immediate neighbourhood surrounding a site will indicate the location of sensitive areas.

Guidance should be sought concerning recommended noise and vibration 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 consents or other restrictions should be given to tenderers as early as possible.

When a number of site operators will be working on one site, overall site operations should be coordinated. 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 sensitive premises.

Additional guidance on planning site operations may be found in CIRIA Report 120 *A guide to reducing the exposure of construction workers to noise* [18].²⁾

Tenderers will need to select the most appropriate plant for a job in order that limits will not be exceeded. They will also need to know the extent of 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 of the following before tendering:

- a) site layout, e.g. location of static noise and vibration 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 disturbance.

9.3 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.

NOTE. In practice, a balance may need to be struck between the requirement to use all available techniques and the resulting costs of so doing. The use of 'best practicable means' (BPM) to control emissions constitutes a ground of defence against charges that a nuisance is being caused under Part III of the Control of Pollution Act 1974 [4] or Part III of the Environmental Protection Act 1990 [1]. The newer concept of using 'best available techniques not entailing excessive cost' (BATNEEC) features in the integrated pollution control system set up under Part I of the Environmental Protection Act 1990 [1] and also in EC Directives on pollution control issues.

²⁾Available from the Construction Industry Research and Information Association, 6 Storey's Gate, Westminster, London SW1P 3QU

Measures which could be taken include the following.

- a) Planning the hours of working and considering the effects of noise and vibration 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.
 - b) Where reasonably practicable, 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 haulage vehicles will not arrive at or leave the site between 19.00 h and 07.00 h. On tunnel sites, for example, it is common practice to provide night-time storage areas for soil and debris.
 - c) Controlling noise and vibration at source and limiting the spread of noise, using the recommendations given in clause 10 of this standard.
 - 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 annex E.
- e) Where construction site processes are likely to give rise to significant levels of vibration, appropriate monitoring should be undertaken. A method of vibration measurement should be agreed prior to commencement of site works. If this is not specified, reference can be made to BS 7385 : Part 1 or BS 5228 : Part 4, as appropriate.
 - f) 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 clause 7).

When potential noise or vibration problems have been identified by the application of procedures referred to earlier in this standard, or when 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 or vibration control measures necessary to prevent the occurrence of significant 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 or vibration 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.

10 Control of noise and vibration

10.1 Control of noise at source

10.1.1 *Substitution*

Where reasonably practicable, noisy plant or processes should be replaced by less noisy alternatives. Annex B gives some examples.

10.1.2 *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.

10.1.3 *Enclosures*

As far as reasonably practicable sources of significant 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 (see annex B).

Tools should be sound-reduced and the operator should be supplied with the appropriate ear protection equipment (see 7.2).

Materials suitable for constructing machine enclosures are listed in annex B, 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 reduced 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.

10.1.4 Use and siting of equipment

Plant should always be used in accordance with manufacturers' instructions. Care should be taken to site equipment away from noise-sensitive areas. Where 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 occupants of nearby premises.

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 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.

10.1.5 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.

10.2 Control of vibration at source

10.2.1 General

Vibration can be more difficult to control than noise, and there are few generalizations which can be made about its control. It should be borne in mind that vibration may cause disturbance by causing structures to vibrate and radiate noise in addition to perceptible movement.

10.2.2 Substitution

Where reasonably practicable, plant and/or methods of work causing significant levels of vibration at sensitive premises should be replaced by other less intrusive plant and/or methods of working.

10.2.3 Vibration isolation of plant at source

Vibration from stationary plant (e.g. generators, pumps, compressors) may, in some instances, prove disturbing when located close to sensitive premises or when operating on connected structures. In these instances, equipment should be relocated or isolated using resilient mountings.

10.3 Controlling the spread of noise

10.3.1 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.

10.3.2 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 or fixed structures, e.g. railway tracks. The effect of distance on noise attenuation is explained in annex D.

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.

10.3.3 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. Annex D 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. Safety issues should be taken into account.

Earth bunds can be built to provide screening for major earth-moving operations and can be subsequently landscaped to become permanent features of the environment when works have 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 on this is given in annex B.

10.4 Controlling the spread of vibration

Where reasonably practicable, vibrating equipment should be located as far from sensitive premises as possible, and if on a structure, not on one which is continuous with that of the sensitive premises. In some instances it may be possible to reduce transmitted vibration by cutting a structure to separate site work from sensitive premises. Clearly, it is important to take account of safety and structural issues before carrying out any work of this nature.

NOTE. The use of trenches to reduce transmitted vibration through the ground is described in 9.2.3 of BS 5228 : Part 4 : 1992.

Annexes

Annex A (informative)

EC and UK noise legislation

A.1 Relevant Community Directives

- a) Council Directive 79/113/EEC on the approximation of the laws of the Member States relating to the determination of the noise emission of construction plant and equipment (OJ No L33, 8.2.1979, p 15).
- b) Council Directive 81/1051/EEC amending Directive 79/113/EEC on the approximation of the laws of the Member States relating to the determination of the noise emission of construction plant and equipment (OJ No L376, 30.12.1981, p 49).
- c) Council Directive 84/532/EEC on the approximation of the laws of the Member States relating to common provisions for construction plant and equipment (OJ No L300, 19.11.1984, p 111).
- d) Council Directive 84/533/EEC on the approximation of the laws of the Member States relating to the permissible sound power level of compressors (OJ No L300, 19.11.1984, p 123).
- e) Council Directive 84/534/EEC on the approximation of the laws of the Member States relating to the permissible sound power level of tower cranes (OJ No L300, 19.11.1984, p 130).
- f) Council Directive 84/535/EEC on the approximation of the laws of the Member States relating to the permissible sound power level of welding generators (OJ No L300, 19.11.1984, p 142).
- g) Council Directive 84/536/EEC on the approximation of the laws of the Member States relating to the permissible sound power level of power generators (OJ No L300, 19.11.1984, p 149).
- h) Council Directive 84/537/EEC on the approximation of the laws of the Member States relating to the permissible sound power level of powered hand-held concrete-breakers and picks (OJ No L300, 19.11.1984, p 156).
- i) Council Directive 84/538/EEC on the approximation of the laws of the Member States relating to the permissible sound power level of lawnmowers (OJ No L300, 19.11.1984, p 171).
- j) Commission Directive 84/405/EEC adapting to technical progress Council Directive 79/113/EEC on the approximation of the laws of the Member States relating to the determination of the noise emission of construction plant and equipment (OJ No L233, 30.8.1985, p 9).
- k) Commission Directive 85/406/EEC adapting to technical progress Council Directive 84/533/EEC on the approximation of the laws of the Member States relating to the permissible sound power level of compressors (OJ No L233, 30.8.1985, p 11).
- l) Commission Directive 85/407/EEC adapting to technical progress Council Directive 84/535/EEC on the approximation of the laws of the Member States relating to the permissible sound power level of welding generators (OJ No L233, 30.8.1985, p 16).
- m) Commission Directive 85/408/EEC adapting to technical progress Council Directive 84/536/EEC on the approximation of the laws of the Member States relating to the permissible sound power level of power generators (OJ No L233, 30.8.1985, p 18).
- n) Commission Directive 85/409/EEC adapting to technical progress Council Directive 84/537/EEC on the approximation of the laws of the Member States relating to the permissible sound power level of powered hand-held concrete-breakers and picks (OJ No L233, 30.8.1985, p 20).
- o) Commission Directive 87/252/EEC adapting to technical progress Council Directive 84/538/EEC on the approximation of the laws of the Member States relating to the permissible sound power level of lawn mowers (OJ No L117, 5.5.1987, p 22 with corrigenda at OJ No L158, 18.6.1987, p 31).
- p) Council Directive 87/405/EEC amending Directive 84/534/EEC on the laws of the Member States relating to the permissible sound power level of tower cranes (OJ No L220, 8.8.1987, p 60).
- q) Council Directive 88/180/EEC amending Directive 84/538/EEC on the approximation of the laws of the Member States relating to the permissible sound power level of lawnmowers (OJ No L81, 26.3.1988, p 69).
- r) Council Directive 88/181/EEC amending Directive 84/538/EEC on the approximation of the laws of the Member States relating to the permissible sound power level of lawnmowers (OJ No L81, 26.3.1988, p 71).
- s) Council Directive 86/662/EEC on the limitation of noise emitted by hydraulic excavators, rope-operated excavators, dozers, loaders and excavator-loaders (OJ No L384, 31.12.1986, p 1).
- t) Council Directive 89/392/EEC on the approximation of the laws of the Member States relating to machinery (OJ No L183, 29.6.1989, p 9).
- u) Commission Directive 89/514/EEC adapting to technical progress Council Directive 86/662/EEC on the limitation of noise emitted by hydraulic excavators, rope-operated excavators, dozers, loaders and excavator-loaders (OJ No L253, 30.8.1989, p 35).
- v) Council Directive 91/368/EEC amending Directive 89/392/EEC on the approximation of the laws of the Member States relating to machinery (OJ No L198, 22.7.1991, p 16).
- w) Council Directive 95/27/EC amending Directive 86/662/EEC on the limitation of noise emitted by hydraulic excavators, rope-operated excavators, dozers, loaders and excavator-loaders (OJ No L168, 18.7.1995, p 14).

A.2 Corresponding UK Regulations

Listed below are the implementing Regulations for each relevant Community Directive. The Regulations are listed in the same order as the Directives listed in A.1.

a) Construction Plant and Equipment (Harmonization of Noise Emission Standards) Regulations, 1985 SI 1968. London: The Stationery Office. ISBN 0 11 057968 2.

Construction Plant and Equipment (Harmonization of Noise Emission Standards) Regulations, 1988 SI 361. London: The Stationery Office. ISBN 0 11 086361 5.

Construction Plant and Equipment (Harmonisation of Noise Emission Standards) (Amendment) Regulations 1989, SI 1127. London: The Stationery Office. ISBN 0 11 097127 2.

Construction Plant and Equipment (Harmonization of Noise Emission Standards) (Amendment) Regulations, 1992 SI 488. London: The Stationery Office. ISBN 0 11 023488 X.

b) As item a).

c) As item a).

d) Construction Plant and Equipment (Harmonisation of Noise Emission Standards) Regulations, 1985 SI 1968. London: The Stationery Office. ISBN 0 11 057968 2.

e) Construction Plant and Equipment (Harmonisation of Noise Emission Standards) Regulations, 1985 SI 1968. London: The Stationery Office. ISBN 0 11 057968 2.

Construction Plant and Equipment (Harmonization of Noise Emission Standards) (Amendment) Regulations 1989, SI 1127. London: The Stationery Office. ISBN 0 11 097127 2.

f) As item d).

g) As item d).

h) As item d).

i) Lawnmowers (Harmonization of Noise Emission Standards) Regulations, 1986 SI 1795. London: The Stationery Office. ISBN 0 11 067795 1.

j) As item a).

k) As item d).

l) As item d).

m) As item d).

n) As item d).

o) Lawnmowers (Harmonization of Noise Emission Standards) (Amendment) Regulations, 1987 SI 876. London: The Stationery Office. ISBN 0 11 076876 0.

p) As item e).

q) Lawnmowers (Harmonization of Noise Emission Standards) Regulations, 1992 SI 168. London: The Stationery Office. ISBN 0 11 023168 6.

r) As item q).

s) Construction Plant and Equipment (Harmonization of Noise Emission Standards) Regulations, 1988 SI 361. London: The Stationery Office. ISBN 0 11 086361 5.

t) Construction Plant and Equipment (Harmonization of Noise Emission Standards) (Amendment) Regulations, 1992 SI 488. London: The Stationery Office. ISBN 0 11 023488 X.

u) Machinery (Safety) Regulations, 1992 SI 3073.

v) As item s).

w) Construction Plant and Equipment (Harmonization of Noise Emission Standards) (Amendment) Regulations, 1995 SI 2357. London: The Stationery Office.

Annex B (informative)

Noise sources, remedies and their effectiveness

B.1 The effectiveness of noise control at source

Examples of typical attenuations afforded to various noise sources by equipment modifications, the use of acoustic enclosures and sheds (see B.2 and B.3) or the replacement of inherently noisy plant by less noisy alternatives are given in table B.1 together with resulting L_{Aeq} sound levels, in decibels, at 10 m. It should be noted that the degree of attenuation achieved will vary from the typical value quoted depending on such parameters as source size, orientation and noise spectrum characteristics. Furthermore, the effectiveness of any given measure in controlling noise will depend very much on the prevailing circumstances. For example, noise from hammer-driven piling operations can be controlled to a limited extent by the use of the various methods described in table B.1. However, the attenuations provided are not likely to alleviate totally any disturbance from such high intensity sources. Alternative methods of piling, where practicable, can provide more beneficial reductions in sound levels. Other simple noise control measures can provide useful reductions in overall site sound levels. These include the use of screws as opposed to nails, the use of sharp saws and drills, and good practice when handling materials, for example, lowering, rather than dropping, materials such as scaffold poles.

B.2 Machinery enclosure design

The principles governing the design of covers for machinery are simple, for example, covers should enclose machines as fully as possible (at least the noisy part), they should possess adequate insulation so that noise energy does not readily pass through them, and they should be lined inside with an efficient sound absorbent so that noise is not built up within them or reflected out through openings. Because a certain number of openings are nearly always necessary, either for access or for ventilation, it is usually sufficient if the insulation value of the structure forming a cover is about 25 dB; a sheet material mass of 10 kg/m² should give this insulation. See table B.2 for details of methods.

The effective insulation value allowing for openings is unlikely to be more than 20 dB, but this is a useful reduction of machinery noise. If a machine produces predominantly low-frequency noise, a heavier cover than that suggested should be provided.

The sound-absorbent lining inside covers should normally be at least 25 mm thick, unless the noise is almost entirely high frequency when 12 mm thickness may be sufficient. Useful inexpensive materials for the purpose are mineral wool or woodwool, though proprietary absorbent tiles, etc., can be used if preferred. See table B.3 for a list of materials. Mineral wool should be contained behind some sort of perforated facing, which can take the form of wire netting, expanded metal perforated sheet or perforated boards, etc. The degree of perforation should normally be not less than 10 %. The usual method of construction for machinery covers is timber or metal framing with an absorbent material placed between the frame members, an external insulating cover and an internal protective mesh or perforated lining. The possible existence of a fire hazard should be borne in mind, whatever absorbent material is chosen; particularly if the absorbent material can become contaminated with oil.

The enclosure of compressors, generators, etc., can pose cooling and ventilation problems. Such problems can sometimes be solved by using the radiator cooling fan to induce a flow of air through the enclosure as a whole by placing a baffle in the plane of the radiator, as shown in figure B.1. The advice of the manufacturer (of the machinery to be enclosed) should be obtained to ensure that adequate ventilation is provided by the enclosure and that there is sufficient access for maintenance.

B.3 Acoustic shed design

Effective screening depends on the extent to which the noise source can be enclosed without the operation of the equipment being adversely affected or the operator being exposed to additional occupational health and safety hazards such as:

- a) increased noise levels inside through reflection;
- b) excessive heat;
- c) increased dust exposure;
- d) exacerbated effects of flash-over should an electric cable strike occur;
- e) increased risk of dangerous accumulations of gas from a leak;
- f) poor lighting.

Acoustic sheds can also be a traffic hazard, especially during erection and dismantling.

An acoustic shed designed by the Building Research Establishment is shown in figure B.2. Performance characteristics are given in table B.4.

An acoustic shed can be made of 9 mm plywood or other solid material weighing about 5 kg/m², on simple timber framing. There should be no gaps at joints or corners. There is no worthwhile advantage in using a

heavier construction for portable sheds. The inside should be lined with 50 mm of sound-absorbent material, or with 25 mm of similar material if mounted on battens. Such linings should not constitute a fire hazard. Mineral wool blankets used as sound-absorbent material will usually need to be protected by wire mesh or perforated sheets. Sheet coverings should have at least 10 % of their surface area perforated and the distance between perforations should not exceed 13 mm. The lining prevents a build up of noise inside the enclosure and improves conditions for the operator. It does not reduce the noise transmitted through the screen or shed. Gaps between the sides and the ground should be closed with a flap of a special tough grade of polyethylene sheeting or other similar flexible material. An extractor fan may be required to prevent a build-up of dust. Artificial lighting may also be necessary.

For more permanent enclosures, blockwork is a useful form of construction.

Open-textured lightweight aggregate blocks provide a useful degree of sound absorption and breeze blocks, which can be used for robust enclosures, are durable, relatively inexpensive and quick to assemble, and their rough surface texture provides a degree of sound absorption. Joints should be properly made.

B.4 Acoustic screens

Care is needed in the design, siting and construction of a barrier for screening purposes if it is to be effective. It should be noted also that a barrier may, by reflecting sound, simply transfer a problem from one receiving position to another. On level sites, for maximum effectiveness, a barrier should be brought as close as possible to either the noise source or the receiving positions. In addition, there should be no gaps or openings at joints in the barrier material.

In design it may be necessary for sound transmitted both through and around the barrier to be considered. However, in most practical situations the overall attenuation will be limited by transmission over and around the barrier, provided that the barrier material has a mass per unit of surface area in excess of about 7 kg/m² and there are no gaps at the joints. When equipment is to be screened for many months, sand bags can be useful as they are durable, easy to erect and easy to remove. Ordinary building materials normally stored on site (e.g. bricks, aggregate, timber or top soil) can, if carefully sited, provide noise screening without additional cost. Woodwool slabs are also effective when fixed to posts. Plywood sheets can be fixed to a scaffold support frame and if constructed in sections provide a portable barrier.

Some sound will pass round the ends of short straight barriers. As a rough guide, the length of a barrier should be at least five times greater than its height. A shorter barrier should be bent round the noise source. The minimum height of barriers should be such that no part of the noise source will be visible from the receiving point.

Table B.1 Methods of reducing sound levels from construction plant

Plant	Typical ¹⁾ standard plant L_{Aeq} sound level at 10 m dB	Sound reduction of plant			Alternative plant	
		Source of noise	Possible remedies (to be discussed with machine manufacturers)	A-weighted sound reduction dB	Plant description	Typical L_{Aeq} sound level at 10 m dB
Hammer drive piling equipment	100	Pneumatic/diesel hammer or steam winch vibrator driver	Enclose hammer head and top of pile in acoustic screen	5 to 10	Bored piling using crane or lorry mounted auger or tripod winch	85
		Sheet pile	Acoustically dampen sheet steel piles to reduce levels of resonant vibration		Vibratory system	90
		Impact on pile	Use resilient pad (dolly) between pile and hammer head. Packing should be kept in good condition		Drop hammer completely enclosed in box with opening at top for crane access	75
		Cranes cables, pile guides and attachments	Careful alignment of pile and rig		Steel jacket completely enclosing drop hammer with dolly and polystyrene chips fed to impact surface to dissipate energy	80
		Power units or base machine	Fix more efficient sound reduction equipment or exhaust. Acoustically dampen panels and covers. When intended by the manufacturer, engine panels should be kept closed. Use acoustic screens when possible		Oil hydraulic pile driver which generates its driving force from the frictional restraint of other piles	70
Earth-moving plant: – bulldozer – compactor – crane – dump truck – dumper – excavator – grader – loader – scraper	72 to 92	Engine	Fit more efficient exhaust sound reduction equipment Manufacturers' enclosure panels should be kept closed	5 to 10	Alternative super silenced plant may be available. Consult manufacturers for details	—

Table B.1 Methods of reducing sound levels from construction plant (*continued*)

Plant	Typical ¹⁾ standard plant L_{Aeq} sound level at 10 m dB	Sound reduction of plant			Alternative plant	
		Source of noise	Possible remedies (to be discussed with machine manufacturers)	A-weighted sound reduction dB	Plant description	Typical L_{Aeq} sound level at 10 m dB
Compressors and generators	82	Engine	Fit more efficient sound reduction equipment	Up to 10	Super silenced plant is available. Consult manufacturers for details Electric-powered compressors are available as opposed to diesel or petrol Sound-reduced compressor or generator can be used to supply several pieces of plant. Use centralized generator system	67
		Compressor or generator body shell	Acoustically dampen metal casing Manufacturers' enclosure panels should be kept closed			62
		Total machine	Erect acoustic screen between compressor or generator and noise-sensitive area. When possible, line of sight between top of machine and reception point should be obscured	Up to 10		
Pneumatic concrete breaker, rock drills and tools	102	Tool	Fit suitably designed muffler or sound reduction equipment to reduce noise without impairing machine efficiency Ensure all leaks in air line are sealed	Up to 15	Hydraulic and electric tools are available For large areas of concrete, machine designed to break concrete in bending can be used Thermic lance	82
			Bit			82
		Total machine	Erect acoustic screen between compressor or generator and noise-sensitive area. When possible, line of sight between top of machine and reception point should be obscured	Up to 10		66
			Enclose breaker or rock drill in portable or fixed acoustic enclosure with suitable ventilation	Up to 20		