

Noise control on construction and open sites —

Part 4: Code of practice for noise and vibration control applicable to piling operations

Committees responsible for this British Standard

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Arboricultural Association	Association of County Councils
Association of District Councils	Association of Metropolitan Authorities
Building Employers Confederation	Construction Health and Safety Group
Department of the Environment (Property Services Agency)	Federation of Civil Engineering Contractors
Federation of Piling Specialists	Health and Safety Executive
Incorporated Association of Architects and Surveyors	Institute of Building Control
Institute of Clerks of Works of Great Britain Incorporated	Institution of Civil Engineers
Institution of Environmental Health Officers	Institution of Structural Engineers
Landscape Institute	National Council of Building Material Producers
Royal Institute of British Architects	Royal Institution of Chartered Surveyors
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Association of Consulting Engineers	British Aggregate Construction Materials Industries
British Coal Corporation	British Compressed Air Society
Concrete Society	
Construction Plant (Hire Association)	Department of the Environment (Building Research Establishment)
Federation of Dredging Contractors	Institution of Highways and Transportation
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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 Policy Committee, covers the control of noise and vibration from piling sites, and is a revision of BS 5228-4:1986, which is withdrawn.

The 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 and vibration. It recommends procedures for noise and vibration control in respect of piling 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 and vibration.

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

Vibration can be the cause of serious disturbance and inconvenience to anyone exposed to it. The Control of Pollution Act 1974, the Environmental Protection Act 1990 and, in Northern Ireland, the Pollution Control and Local Government (Northern Ireland) Order 1978, which define “noise” as including “vibration” (Section 73(1) of the 1974 Act, Section 79(7) of the 1990 Act and Article 53(1) of the 1978 Order), contain provisions for the abatement of nuisances caused by noise and vibration.

It should be noted that BS 6472 covers the human response to vibration in structures and BS 7385-1 covers the measurement and evaluation of structural vibration. An item dealing with the vibratory loading of structures is being processed within ISO/TC 98/SC 2 “Safety of Structures”. This is being monitored by BSI.

BS 5228 consists of the following Parts:

- *Part 1: Code of practice for basic information and procedures for noise control;*
- *Part 2: Guide to noise control legislation for 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 and vibration control applicable to piling operations.*

BS 5228-1 is common to all the types of work covered by the other Parts of BS 5228, which should be read in conjunction with Part 1.

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

Attention is drawn to the Control of Pollution Act 1974 (Part III) (Noise), the Environmental Protection Act 1990 (Part III) (Statutory Nuisances and Clean Air), 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), and to the Noise at Work Regulations 1989, Statutory Instrument 1989 No. 1790.

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.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 62, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

0 Introduction

This Part of BS 5228 is concerned with all works associated with piling operations on sites where temporary or permanent foundation or ground stability requirements are to be met by the installation of piles by any of the recognized techniques (see 7.2). In common with other mechanized construction activities, piling works pose different problems of noise and vibration control from those associated with most types of factory-based industry for the following reasons:

- a) they are mainly carried out in the open;
- b) they are of temporary duration, although they may cause great disturbance while they last;
- c) the noise and vibration they cause arise from many different activities and kinds of plant, and their intensity and character may vary greatly at different phases of the work;
- d) the sites cannot be excluded by planning control, as factories can, from areas that are sensitive to noise.

Increased mechanization has meant the use of more powerful and potentially noisier machines. It is now widely recognized that noise levels that can be generated are unacceptable in many instances and that reductions are desirable for the benefit of both the industry and the public. Piling works frequently form one of the noisier aspects of construction. The trend towards medium and high rise structures, particularly in urban areas, coupled with the necessity to develop land which was hitherto regarded as unfit to support structures, has led to increasing use of piled foundations. Piling is usually one of the first activities to be carried out on site, and special precautions should be taken to mitigate the disturbance created, particularly in sensitive areas.

If a site upon which construction or demolition work will be carried out involves an existing operational railway, special features that are significant in relation to noise and vibration control have to be taken into account. Advice should be sought in such cases from the appropriate railway authorities.

Because of the variable nature of vibration transmission characteristic of soils, rocks and structure, the prediction of vibration levels is a less precise science than the corresponding prediction of air-borne noise levels. Whilst data obtained from various sources are included for illustrative purposes, any predictions based thereon for specific circumstances should ideally be verified by appropriate field measurements.

1 Scope

This part of BS 5228 supplements the information given in BS 5228-1, with information especially relevant to piling works. It sets out recommendations for noise and vibration control measures which can be adopted to ensure good practice and enable piling to be carried out economically with as little disturbance to the community as is practicable.

Section 2 contains recommendations relating to noise control. Section 3 contains recommendations for the mitigating of the effects of ground-borne vibration.

NOTE 1 This Part of BS 5228 should be read in conjunction with BS 5228-1.

NOTE 2 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 5228-1 apply together with the following.

2.1

amplification factor

the motion measured at a given point (usually on the structure) divided, by the motion measured at a reference point (usually at the base of the structure or on the foundation)

2.2

peak particle velocity (p.p.v.)

the maximum value of particle velocity obtained during a given interval

2.3

piling

the installation of bored and driven piles and the effecting of ground treatments by vibratory, dynamic and other methods of ground stabilization

3 Legislative background

Attention is drawn to the following legislation, current at the date of publication of this Part of BS 5228.

- a) Control of Noise (Appeals) (Scotland) Regulations 1983.
- b) Control of Noise (Appeals) Regulations 1975.
- c) Statutory Nuisance (Appeals) Regulations (as amended) 1990.
- d) Control of Noise (Appeals) Regulations (Northern Ireland) 1978.
- e) Control of Pollution Act 1974.
- f) Environmental Protection Act 1990.
- g) Health and Safety at Work etc. Act 1974.

h) Health and Safety at Work (Northern Ireland) Order 1978.

i) Land Compensation Act 1973.

j) Land Compensation (Scotland) Act 1973 (in Northern Ireland, the Land Acquisition and Compensation (Northern Ireland) Order, 1973).

k) Noise Insulation Regulations 1975 (in Scotland, the Noise Insulation (Scotland) Regulations 1975).

l) Pollution Control and Local Government (Northern Ireland) Order 1978.

m) Public Health Act 1961.

The Control of Pollution Act 1974, the Environmental Protection Act 1990 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, Section 79(7) of the 1990 Act and Article 53(1) of the 1978 Order) contain provisions for the abatement or cessation of nuisances caused by noise and vibration.

4 Guidance notes on legislation

4.1 General

This information on procedures is given for guidance purposes only and attention is drawn to the relevant Acts.

4.2 The Control of Pollution Act 1974

The Control of Pollution Act 1974 gives local authorities powers for controlling noise and/or vibration from construction sites and other similar works. These powers may be exercised either before works start or after they have started. In Northern Ireland, similar provision is made in the Pollution Control and Local Government (Northern Ireland) Order 1978. Contractors, or persons arranging for works to be carried out, also have the opportunity to take the initiative and ask local authorities to make their noise and/or vibration requirements known. Because of an emphasis upon getting noise and/or vibration questions settled before work starts, implications exist for traditional tender and contract procedures (see 4.5).

4.3 Notices under Section 60 of the Control of Pollution Act 1974

Section 60 enables a local authority, in whose area work is going to be carried out, or is being carried out, to serve a notice of its requirements for the control of site noise and/or vibration on the person who appears to the local authority to be carrying out the works and on such other persons appearing to the local authority to be responsible for, or to have control over, the carrying out of the works.

This notice can perform the following.

a) Specify the plant or machinery that is or is not to be used. However, before specifying any particular methods or plant or machinery a local authority has to consider the desirability, in the interests of the recipient of the notice in question, of specifying other methods or plant or machinery that will be substantially as effective in minimizing noise and/or vibration and that will be more acceptable to the recipient.

b) Specify the hours during which the construction work can be carried out.

c) Specify the level of noise and/or vibration that can be emitted from the premises in question or at any specified point on those premises or that can be emitted during the specified hours.

d) Provide for any change of circumstances. An example of such a provision might be that if ground conditions change and do not allow the present method of working to be continued then alternative methods of working should be discussed with the local authority.

In serving such a notice a local authority takes account of:

- 1) the relevant provisions of any code of practice issued and/or approved under Part III of the Control of Pollution Act 1974;
- 2) the need for ensuring that the best practicable means are employed to minimize noise and/or vibration;
- 3) other methods, plant or machinery that might be equally effective in minimizing noise and/or vibration, and be more acceptable to the recipient of the notice;
- 4) the need to protect people in the neighbourhood of the site from the effects of noise and/or vibration.

A person served with such a notice can appeal to a magistrates' court or in Scotland to the Sheriff or in Northern Ireland to a court of summary jurisdiction, within 21 days from the date of serving of the notice. Normally the notice is not suspended pending an appeal unless it requires some expenditure on works and/or the noise or vibration in question arises or would arise in the course of the performance of a duty imposed by law on the appellant. The regulations governing appeals (the Control of Noise (Appeals) Regulations 1975; in Northern Ireland, the Control of Noise (Appeals) Regulations (Northern Ireland) 1978; and in Scotland, the Control of Noise (Appeals) (Scotland) Regulations 1983) also give local authorities discretion not to suspend a notice even when one or other of these conditions is met, if the noise and/or vibration is injurious to health, or is of such limited duration that a suspension would render the notice of no practical effect; or if the expenditure necessary on works is trivial compared to the public benefit expected.

4.4 Consents under Section 61 of the Control of Pollution Act 1974

This subclause concerns the procedure adopted when a contractor (or developer) takes the initiative and approaches the local authority to ascertain its noise and/or vibration requirements before construction work starts (see also 4.3).

It is not mandatory for applications for consents to be made, but it will often be in the interest of a contractor or an employer or their agents to apply for a consent, because once a consent has been granted a local authority cannot take action under Section 58 or Section 60 of the Control of Pollution Act 1974 or Section 80 of the Environmental Protection Act 1990, so long as the consent remains in force and the contractor complies with its terms. Compliance with a consent does not, however, exempt the person holding that consent against action by a private individual under Section 59 of the 1974 Act, under Section 82 of the 1990 Act, or under common law.

It is essential that an application for a consent is made at the same time as, or later than, any request for approval under Building Regulations or for a warrant under Section 6 of the Building (Scotland) Act 1959, when this is relevant. Subject to this constraint, there are obvious advantages in making any application at the earliest possible date. There may be advantages in having informal discussions before formal applications are made.

It is essential that an applicant for a consent gives the local authority as much detail as possible about the construction work to which the application relates and about the method or methods by which the work is to be carried out. It is also essential that information be given about the steps that will be taken to minimize noise and/or vibration resulting from the construction work.

Provided that a local authority is satisfied that proposals (accompanying an application) for the minimizing of noise and/or vibration are adequate (and in deciding this it may have regard, among other things, to the provisions of this standard), it will give its consent to the application. It can however attach conditions to the consent, or limit or qualify the consent, to allow for any change in circumstances and to limit the duration of the consent. If a local authority fails to give its consent within 28 days of the lodging of an application, or if it attaches any conditions or qualification to the consent that are considered unnecessary or unreasonable, the applicant concerned can appeal to a magistrates' court or in Scotland to the Sheriff or in Northern Ireland to a court of summary jurisdiction, within 21 days from the end of that period.

When a consent has been given and the construction work is to be carried out by a person other than the applicant for the consent, it is essential that the applicant takes all reasonable steps to bring the terms of consent to the notice of that other person; failure to do so or failure to observe the terms of a consent are offences under the Act.

4.5 Contractual procedures

It is likely to be to the advantage of a developer or contractor, or an employer or his agent, who intends to carry out construction work, to take the initiative and apply to the local authority for consents under the Control of Pollution Act. This will have implications for traditional tender and contract procedures because the local authority's noise and/or vibration requirements may well affect both the tender and contract price. It is therefore preferable that the local authority's requirements are made known before tenders are submitted. The best way of achieving this is for the person for whom the work is to be carried out to make the application to the local authority for a consent, before inviting tenders. As much detailed information as possible should be given concerning the methods by which the construction work is to be carried out, and concerning also the proposed noise abatement and/or vibration control measures to enable the local authority to give a consent (see also 4.4).

When a person for whom construction work is to be carried out has sought and obtained consent from the local authority, the local authority's requirements should be incorporated in the tender documents so that tenderers do not base their tenders on the use of unacceptable work methods and plant.

As far as possible, a contractor should be allowed freedom of choice regarding plant and methods to be used but a local authority can, in consultation with the recipient of a consent, specify the type of plant or methods to be used with its consent. In addition to any approach made by a person responsible for construction work, a tenderer may also wish to apply to a local authority in order either to seek consent for the use of methods or plant in place of those specified in an earlier consent (or notice), or to satisfy himself that the detailed methods and plant that he had planned to use meet the conditions laid down.

4.6 Emergencies

In the event of any emergency or unforeseen circumstances arising that cause safety to be put at risk, it is important that every effort should be made to ensure that the work in question is completed as quickly and as quietly as possible and with minimum practical disturbance to people living or working nearby. The local authority should be informed as soon as possible, should it be found necessary to exceed permitted noise and/or vibration limits because of an emergency.

4.7 Flow diagram

The procedures available under the Control of Pollution Act 1974 for the control of construction noise and/or vibration are illustrated by the flow diagram shown in Figure 1.

4.8 Land Compensation Act 1973 (as amended), Highways Act 1980 and Land Compensation (Scotland) Act 1973

The Noise Insulation Regulations 1975 and Noise Insulation (Scotland) Regulation 1975, made under the powers contained respectively in the Land Compensation Act 1973 and the Land

Compensation (Scotland) Act 1973, allow a highway authority to provide insulation for dwellings and other buildings used for residential purposes by means of double glazing and special ventilation when highway works are expected to cause serious noise effects for a substantial period of time.

The 1973 Acts also contain provisions that enable a highway authority to pay the reasonable expenses of residents who, with the agreement of the authority, have to find suitable alternative accommodation for the period during which construction work makes continued occupation of an adjacent dwelling impracticable.

The Highways Act 1980 and the Land Compensation (Scotland) Act 1973 enable highway authorities to acquire land by agreement when its enjoyment is seriously affected by works of highway construction or improvement. In addition, these Acts give the highway authority power to carry out works, for example the installation of noise barriers, to mitigate the adverse effects of works of construction or improvement on the surroundings of a highway.

5 Project supervision

5.1 Project programme

Piling programmes should be arranged so as to control the amount of disturbance in noise and vibration sensitive areas at times that are considered to be of greatest sensitivity. If piling works are in progress on a site at the same time as other works of construction and demolition that themselves may generate significant noise and vibration, the working programme should be phased so as to prevent unacceptable disturbance at any time.

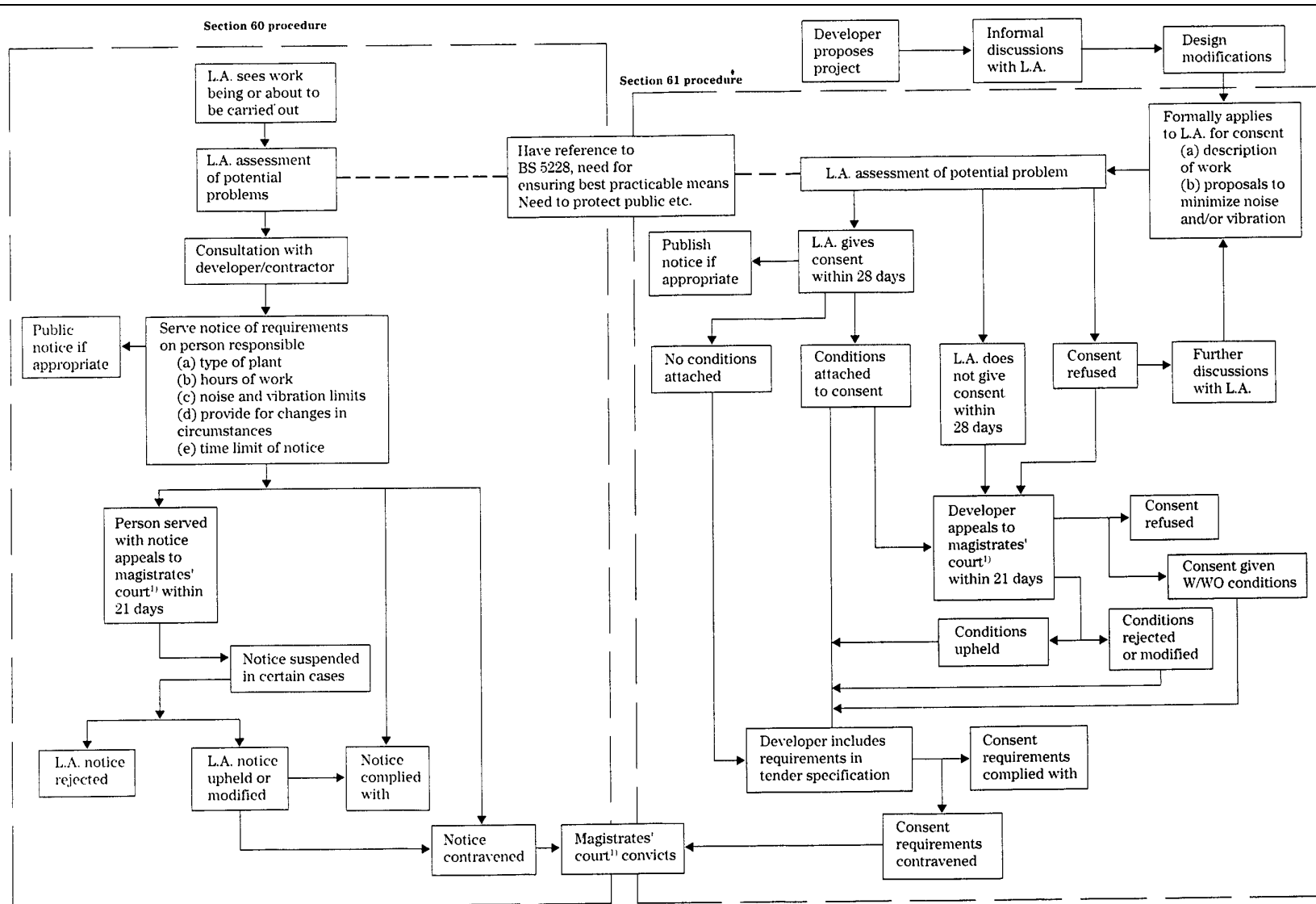
5.2 Piling subcontracts: consents and notices

When piling works are to form a subcontract to the main construction and demolition works on a site, copies of noise and/or vibration consents and details of other noise and/or vibration restrictions should be included in the tender documents for the piling subcontract. Any such noise and/or vibration restrictions, limitations on hours of work, etc., may be at variance with conditions with which the piling tenderer may otherwise be expected to comply. Provision should therefore be made for further consultations with the local authority that could in turn lead to a special consent or variation in restrictions for the duration of the piling works.

During such a consultation the planner, developer, architect and engineer, as well as the local authority, should be made aware of the proposed method of working of the piling subcontractor, who in turn should have evaluated any practicable and more acceptable alternatives that would economically achieve, in the given ground conditions, equivalent structural results.

Information relating to the mechanical equipment and plant to be used (see BS 5228-1) should be supplied in support of the proposed method of working. An indication of the intended programme of works should be given, but the piling subcontractor will wish to retain as much flexibility as possible in order to combat unexpected ground conditions or other problems, and it should be recognized that substantial deviations from a detailed programme of works could be made in practice. Due attention should be paid to safe working practices and to emergency procedures.

The developer, as the person ultimately responsible for a project, will need to instigate a check that the proposals suggested by those tendering for piling works are likely to be acceptable to the local authority.



¹⁾ In Scotland, the Sheriff; in Northern Ireland, the court of summary jurisdiction.

NOTE. The following abbreviations have been used:

L.A. local authority; W/WO with or without.

Figure 1 — Procedures to control construction noise and/or vibration under the Control of Pollution Act 1974

Section 2. Noise

6 Factors to be considered when setting noise control targets

6.1 Selection of piling method

6.1.1 The selection of a method to be used for the installation of piles will depend on many factors, some of which are outlined in **6.1.2** (see **7.2** for types of piling).

6.1.2 It should be remembered that a decision regarding the type of pile to be used on a site will normally be governed by such criteria as loads to be carried, strata to be penetrated and the economics of the system, for example the time it will take to complete the installation and other associated operations such as soil removal.

6.1.3 It may not be possible for technical reasons to replace a noisy process by one of the “quieter piling” alternatives. Even if it is possible, the adoption of a quieter method may prolong the piling operation; the net result being that the overall disturbance to the community, not only that caused by noise, will not necessarily be reduced.

6.1.4 Examples of typical noise levels associated with the different methods of piling are given in Table 1 which is an extension to the data given in Table 8 of BS 5228-1:1984.

6.2 Types of noise

On typical piling sites the major sources of noise are essentially mobile and the noise received at any control points will, therefore, vary from day to day as work proceeds.

The type of noise associated with piling works depends on the method of piling employed. For example, pile driving using a drop hammer results in a well defined, impulsive type of noise. Air and diesel hammers also produce impulsive noise although their striking rates can be much higher than with drop hammers. With auger-bored piling the impulsive characteristic is virtually absent. With bored or jacked piling methods the resultant noise is steady.

Highly impulsive noise is generally less acceptable than steady noise. However, other characteristics of the noise source play an important part in determining the acceptability of piling noise, e.g. cable slap, screeching of pulleys and guides and ringing of piles.

6.3 Duration of piling works

The duration of piling work is usually short in relation to the length of construction work as a whole, and the amount of time spent working near to noise-sensitive areas can represent only a part of the piling period.

6.4 Hours of working

When a local authority intends to control noise by imposing restrictions on working hours it should have regard to the specialized nature of some piling works, which may necessitate a longer working day. A local authority should also bear in mind the acceptable hours for the residents and occupiers of a particular area.

6.5 Methods of monitoring and control

Whatever method is appropriate for the specifying of a noise target, there should be agreement between the piling contractor concerned and the controlling authority.

It is essential that a noise target is appropriate to the type of noise, and is practical and enforceable. It should adequately protect the community but allow work to proceed as near normally as possible.

Steady noise levels should normally be expressed in terms of the L_{Aeq} over a period of several hours or for a working day. Impulsive noise levels cannot always be controlled effectively using this measure alone. The specification of a higher short term limit is often found useful. This can be achieved by specifying a short period L_{Aeq} or the one percentile exceedance level L_{A01} over one driving cycle. Where L_{A01} is specified the F time weighting should be used and measurements should be made with a sampling rate of at least five samples per second. Noise limits should not be set in terms of $L_{pA,max}$ when the noise is impulsive.

The difference between limits set in terms of L_{A01} and L_{Aeq} will depend on the striking rate of the pile driver.

Those who wish to use the data for L_{Aeq} in Table 1 to estimate the corresponding value of L_{A01} should note the following approximate relationships [all measurements in dB(A)]:

- | | |
|------------------------|--------------------------|
| a) L_{A01} | for pile drivers such as |
| $\approx L_{Aeq} + 11$ | drop hammers with a slow |
| | striking rate; and |
| b) L_{A01} | for air hammers with a |
| $\approx L_{Aeq} + 5$ | fast striking rate. |

Table 1 — Sound level data on piling

Ref no. ^a	Pile		Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level L_{Aeq} at 10 m (1 cycle)
	Depth	Width								
	m	m				dB			%	dB
SHEET STEEL PILING										
50	12	0.4	Double acting diesel hammer	3 790 kgf m	Steel on fibrous material	135	—	—	100	107
51				16 500 kgf m	Not known	140	—	—	100	112
52	12	0.4	Double acting air hammer	560 kgf m	Steel on fibrous material	134	—	—	100	106
53	12	0.4	Hydraulic vibratory driver	20.7 kg m eccentric moment; 26 Hz	None	118	Sand and gravel	—	100	90
54	8	0.508	Air hammer	415 kgf m	None	131	Sandy clay overlying boulder clay	—	100	103
55	8	0.508		415 kgf m	None	134	Sandy clay overlying boulder clay	—	100	106
56	8	0.508	Drop hammer (hammer and pile enclosed acoustically)	3 t	150 mm greenheart timber plus rope	94	Sandy clay overlying boulder clay	—	100	66
57	8	0.508		3 t	150 mm greenheart timber plus rope	98	Sandy clay overlying boulder clay	—	100	70

^a See reference numbers 1 to 49, in Table 8 of BS 5228-1:1984 for further information concerning sound level data on piling.

Table 1 — Sound level data on piling

Ref no.	Pile		Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level L_{Aeq} at 10 m (1 cycle)	
	Depth	Width									
58	m 10 (4 m exposed)	m 0.96	Double acting air impulse hammer	15 kN m	Air cushion	dB 111	—	—	% 100	dB 83	
59	15 (5 m exposed)	1.05	Hydraulic hammer, enclosed acoustically	60 kN m	Steel on fibrous material	121	Gravel overlying stiff clay	—	100	93	
60	15	1.05	Hydraulic drop hammer, enclosed acoustically	60 kN m	Steel on fibrous material	113	Gravel overlying stiff clay	—	100	85	
	TUBULAR CASING										
61	23	1.07 dia. }	Double acting	{ 6 219 kgf m 16 000 kgf m	Not known	122	Silt overlying chalk	—	100	94	
62	23		diesel hammer		Not known	132	Silt overlying chalk	—	100	104	
	TUBULAR STEEL CASING/PILE CAST IN PLACE										
63(a)	13	0.35 dia. }	Drop hammer	{ 3.3 t, 1.2 m drop 3.3 t, 1.2 m drop	Resilient composite pad	130	Estuarial alluvia	20 min	20	95	}
63(b)	13				0.35 dia.	Resilient composite pad	126	Estuarial alluvia	20 min	30	
63(c)	13	0.35 dia.	Drop hammer, extracting casing	3.3 t	Resilient composite pad	120	Estuarial alluvia	20 min	10	82	
64(a)	14	0.4 dia. }	Drop hammer	{ 4 t, 1.2 m drop 4 t, 1.2 m drop	Resilient composite pad	132	Dense sand	45 min	40	100	}
64(b)	14				0.4 dia.	Resilient composite pad	125	Dense sand	45 min	20	
64(c)	14	0.4 dia.	Drop hammer, extracting casing	4 t	Resilient composite pad	118	Dense sand	45 min	5	77	

Table 1 — Sound level data on piling

Ref no.	Pile		Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level L_{Aeq} at 10 m (1 cycle)
	Depth	Width								
	m	m				dB			%	dB
65(a)	8	0.35 dia.	Drop hammer, partially enclosed acoustically	3.3 t, 1.2 m drop	Resilient composite pad	117	Silt/peat/shale/sandstone	25 min	15	81
65(b)	8	0.35 dia.		3.3 t, 1.2 m drop	Resilient composite pad	122	Silt/peat/shale/sandstone	25 min	35	89
65(c)	8	0.35 dia.		3.3 t, 1.2 m drop	Resilient composite pad	121	Silt/peat/shale/sandstone	25 min	8	82
66(a)	8	0.4 dia.	Drop hammer, partially enclosed acoustically	4 t, 1.6 m drop	None	129	Stiff to hard sandy clay	30 min	35	96
66(b)	8	0.4 dia.		4 t, 1.6 m drop	None	125	Stiff to hard sandy clay	30 min	30	92
67(a)	5	0.45 dia.	Internal drop hammer	3 t, 4 m drop	Dry mix aggregate plug	113	Made ground overlying clay	40 min	50	82
67(b)	5	0.45 dia.		3 t, 4 m drop	Dry mix aggregate plug	115	Made ground overlying clay	40 min	50	84
68(a)	14	0.4 dia.		3 t, 4 m drop	Dry mix aggregate plug	111	Ballast	—	50	80
68(b)	14	0.4 dia.		3 t, 4 m drop	Dry mix aggregate plug	116	Ballast	—	25	82

Table 1 — Sound level data on piling

Ref no. ^a	Pile		Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level L_{Aeq} at 10 m (1 cycle)	
	Depth	Width									
	m	m				dB			%	dB	
	IMPACT BORED/PILE CAST IN PLACE										
69(a)	20	0.5 dia.	Tripod winch	{ 20 kW	None	106	Fill/ballast/stiff clay	6 h	30	73	} 83
69(b)	20	0.5 dia.			{ 20 kW	None	108	Fill/ballast/stiff clay	6 h	60	
69(c)	20	0.5 dia.	Tripod winch, driving casing	{ 3/4 t, 1 m drop	Steel	118	Fill/ballast/stiff clay	6 h	2.5	74	
69(d)	20	0.5 dia.			{ 3/4 t, 1 m drop	Steel	122	Fill/ballast/stiff clay	6 h	2.5	
70(a)	25	0.6 dia.	Tripod winch	{ 20 kW	None	108	Fill/sand/ballast/stiff clay	10 h	30	75	} 88
70(b)	25	0.6 dia.			{ 20 kW	None	113	Fill/sand/ballast/stiff clay	10 h	60	
70(c)	25	0.6 dia.	Tripod winch, driving casing	{ 3/4 t, 1 m drop		127	Fill/sand/ballast/stiff clay	10 h	2	82	
70(d)	25	0.6 dia.			{ 3/4 t, 1 m drop	Steel	129	Fill/sand/ballast/stiff clay	10 h	2	
	H SECTION STEEL PILING										
71	22.5	0.31 × 0.31 × 0.11	Double acting diesel hammer	3 703 kgf m	Steel on fibrous material	127	Sand and silt overlying stiff clay	—	100	99	
72	—	0.35 × 0.37 × 0.089	Diesel hammer	6 219 kgf m	Not known	122	Rock fill	—	100	94	
73	75	0.3 × 0.3	Hydraulic drop hammer, enclosed acoustically	{ 36 kN m	Hardwood	113	Chalk	—	100	85	
74	75	0.3 × 0.3			{ 36 kN m	Hardwood	116	Chalk	—	100	88
75	75	0.3 × 0.3	Hydraulic drop hammer	84 kN m	Steel on fibrous material	124	Chalk	—	100	96	

^a See reference numbers 1 to 49, in Table 8 of BS 5228-1:1984 for further information concerning sound level data on piling.

Table 1 — Sound level data on piling

Ref no.	Pile		Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level L_{Aeq} at 10 m (1 cycle)
	Depth	Width								
	m	m				dB			%	dB
PRECAST CONCRETE PILES										
76	—	—	Drop hammer	5 t, 0.75 m drop	Not known	114	Fill	—	100	86
77	50	0.29 × 0.29 square section modular (joined)	Hydraulic drop hammer, enclosed acoustically	60 kN m	Hardwood	107	Chalk	—	100	79
78	50				Hardwood	111	Chalk	—	100	83
79	20	0.275 × 0.275 square section modular (joined)	Hydraulic hammer	3 t, 0.3 m drop	Hardwood	111	Stiff clay overlying mudstone	—	100	83
80	20				Hardwood	119	Stiff clay overlying mudstone	—	100	91

Table 1 — Sound level data on piling

Ref no.	Pile		Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level L_{Aeq} at 10 m (1 cycle)
	Depth	Width								
81	10	0.275 × 0.275 square section modular (joined)	Hydraulic hammer, partially enclosed acoustically	4 t, 0.3 m drop	Hardwood	109	Clay/gravel overlying mudstone	—	100	81
82	10	0.275 × 0.275 square section modular (joined)		4 t, 0.3 m drop	Hardwood	106	Clay/gravel overlying mudstone	—	100	78
83	17	0.285 × 0.285 square section modular (joined)	Drop hammer	5 t, 1 m drop	Wood	114	Silt/sand/gravel	55 min	80	85
84	20	0.08 m ² hexagonal section modular (joined)	Drop hammer, hanging leaders: soft driving	4 t, 0.6 m drop	Wood	114	Alluvium	—	100	86
85	20	0.08 m ² hexagonal section modular (joined)	Drop hammer, hanging leaders: medium/hard driving	4 t, 0.75 m drop	Wood	121	Stiff clays and gravels	—	100	93

Table 1 — Sound level data on piling

Ref no.	Pile		Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level L_{Aeq} at 10 m (1 cycle)
	Depth	Width								
86	m	m	Drop hammer driving on mandrel/pile cast in place	5 t, 0.75 m drop	Wood/sisal	dB	Fill overlying chalk	41 min	%	dB
87	20	0.406 dia. modular shell		6 t, 1 m drop	Wood	114	Sand/clay/chalk	57 min	30	82
88	28	0.444 dia. modular shell				121			30	89
BORED PILING/PILE CAST IN PLACE										
88	10	0.45 dia.	Crane-mounted auger: donkey engine in acoustic enclosure	65 kW	None	108	Fill overlying stiff clay	45 min	100	80
89(a)	25	0.6 dia.		90 kW	None	110	Sand/gravel/stiff clay	90 min	85	81
89(b)	7	0.6 dia.	Driving temporary casing to support upper strata in prebored hole by drop hammer	2.5 t, 0.6 m drop	Steel	128	Sand/gravel/stiff clay	90 min	1.5	82
90	15	0.45 dia.	Lorry-mounted auger: donkey engine in acoustic enclosure	90 kW	None	109	Sand/gravel/clay	55 min	100	81
91	20	0.6 dia.		90 kW	None	113	Fill/clay	75 min	100	85
92(a)	25	0.9 dia.	Crane-mounted auger	90 kW	None	114	Fill/clay	3 h	95	86
92(b)	25	0.9 dia.	Crane-mounted auger: kelly bar clanging	90 kW	None	122	Fill/clay	3 h	3	79
93	30	1.05 dia.	Crane-mounted auger	120 kW	None	117	Ballast/clay	5 h	100	89

Table 1 — Sound level data on piling

Ref no.	Pile		Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level L_{Aeq} at 10 m (1 cycle)	
	Depth	Width									
	m	m				dB			%		dB
94(a)	24	2.1 dia.	Crane-mounted auger and drilling bucket: pile bored under bentonite	110 kW	None	112	Alluvia/sands/clay	2 days	50	81	82
94(b)	24	2.1 dia.	Crane-mounted auger and drilling bucket: kelly bar clanging	110 kW	None	121	Alluvia/sands/clay	2 days	2	76	
95	40	1.2 dia.	Crane-mounted auger and drilling bucket: pile bored under bentonite	120 kW	None	117	Sand/boulder clay/marl	2 days	50	86	
96	20	0.9 dia.	Lorry-mounted auger	110 kW	None	115	Fill/sand/gravel/clay	3 h	100	87	
97	20	1.2 dia.		110 kW	None	112	Fill/ballast/clay	6 h	100	84	
CONTINUOUS FLIGHT AUGER INJECTED PILING											
98	11	0.45 dia.	Crane-mounted leaders with continuous flight auger; cement grout injected through hollow stem of auger. Engine/power pack partially enclosed acoustically	90 kW	None	111	Alluvium	30 min	50	80	
99	15	0.35 dia.		90 kW	None	108	Sand and silts	30 min	50	77	
100	12	0.45 dia.	Crane-mounted continuous flight auger rig; concrete injected through hollow stem of auger. Engine/power pack partially enclosed acoustically	100 kW	None	109	Gravels overlying chalk	30 min	50	78	