AP2

THE OXFORDSHIRE COUNTY COUNCIL (DIDCOT GARDEN TOWN HIGHWAYS INFRASTRUCTURE – A4130 IMPROVEMENT (MILTON GATE TO COLLETT ROUNDABOUT), A4197 DIDCOT TO CULHAM LINK ROAD, AND A415 CLIFTON HAMPDEN BYPASS) COMPULSORY PURCHASE ORDER 2022

THE OXFORDSHIRE COUNTY COUNCIL (DIDCOT TO CULHAM THAMES BRIDGE) SCHEME 2022

THE OXFORDSHIRE COUNTY COUNCIL (DIDCOT GARDEN TOWN HIGHWAYS INFRASTRUCTURE – A4130 IMPROVEMENT (MILTON GATE TO COLLETT ROUNDABOUT), A4197 DIDCOT TO CULHAM LINK ROAD, AND A415 CLIFTON HAMPDEN BYPASS) (SIDE ROADS) ORDER 2022

THE CALLED-IN PLANNING APPLICATION BY OXFORDSHIRE COUNTY COUNCIL FOR THE DUALLING OF THE A4130 CARRIAGEWAY, CONSTRUCTION OF THE DIDCOT SCIENCE BRIDGE, ROAD BRIDGE OVER THE APPLEFORD RAILWAY SIDINGS AND ROAD BRIDGE OVER THE RIVER THAMES, AND ASSOCIATED WORKS BETWEEN THE A34 MILTON INTERCHANGE AND THE B4015 NORTH OF CLIFTON HAMPDEN, OXFORDSHIRE (APPLICATION NO: R3.0138/21

PLANNING INSPECTORATE REFERENCE:

APP/U3100/V/23/3326625 and NATTRAN/SE/HAO/286 (DPI/U3100/23/12)

Appendices to the Proof of Evidence of

ANDREW JOHN PAGETT

(Noise and Vibration)

CONTENTS

Appendix AP2.1

DMRB LA 111 Noise and vibration

Design Manual for Roads and Bridges

Sustainability & Environment
Appraisal

LA 111
Noise and vibration

(formerly HD 213/11, IAN 185/15)

Revision 2

Summary
This document sets out the requirements for assessing and reporting the effects of highways noise and vibration from construction, operation and maintenance projects. The document has been updated to correct time periods in Tables 3.12 and 3.49.1, update the references for speed pivoting requirements in Appendix A2, and to clarify other requirements following feedback received.

Application by Overseeing Organisations
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
2	May 2020	Revison 2 (May 2020) The document has been updated to correct time periods in Tables 3.12 and 3.49.1, update the references for speed pivoting requirements in Appendix A2, and to clarify other requirements following feedback received. Revision 1 (February 2020) Update to Wales National Application Annex. Revision 0 (November 2019) LA 111 replaces HD 213/11 and IAN 185/15. This full document has been re-written to make it compliant with the new Highways England drafting rules.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes HD 213/11, which is withdrawn. This document supersedes the noise advice within IAN 185/15 on the assessment of link speeds and generation of vehicle data into 'speed-bands'.

This document also makes provision for requirements outlined within EU Directive 2011/92/EU as amended by 2014/52/EU [Ref 1.N].

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

The construction, operation and maintenance of highway projects can lead to changes in noise and vibration levels in the surrounding environment.

Environmental assessment provides a framework for assessing and managing the noise and vibration effects associated with construction, improvement, use and maintenance of motorways and all purpose trunk roads.

This document aligns with Directive 2011/92/EU as amended by 2014/52/EU [Ref 1.N].

This document sets out the requirements for noise and vibration assessments from road projects, applying a proportionate and consistent approach using best practice and ensuring compliance with relevant legislation.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 15.N] apply to this document.

Abbreviations and symbols

Abbreviations

Abbreviation	Definition
BNL	Basic noise level
CRTN	Calculation of road traffic noise
DMFY	Do-minimum future year scenario
DMOY	Do-minimum opening year scenario
DSFY	Do-something future year scenario
DSOY	Do-something opening year scenario
EMP	Environmental management plan
END	Environmental Noise Directive
HDV	Heavy duty vehicles
HGV	Heavy goods vehicles
km/h	Kilometres per hour
LOAEL	Lowest observed adverse effect level
m	Metres
m/s	Metres per second
PPV	Peak particle velocity
RSI	Road surface influence
SOAEL	Significant observed adverse effect level

Symbols

Symbol	Definition
dB	Decibels
dB(A)	A-weighted noise levels

Terms and definitions

Terms and definitions

Term	Definition
Absorptive noise barrier	A noise barrier that has an absorptive lining.
Ambient noise	Ambient noise is the total sound in a given situation at a given time usually composed of sound from many sources, near and far.
A-weighting	In addition to its non-linear amplitude response, the human ear has a non-linear frequency response; it is less sensitive at low and high frequencies and most sensitive in the mid range frequencies. NOTE 1: The A-weighting is applied to measured sound pressure levels so that these levels correspond more closely to the subjective response. NOTE 2: A-weighted noise levels are often expressed in dB(A).
Baseline scenario	A description of the state of the environment without implementation of the project.
Basic noise level	The basic noise level (BNL) is a measure of source noise as defined in Appendix A.
Calculation of road traffic noise	The technical memorandum that describes the procedures for calculating noise from road traffic CRTN [Ref 3.N].
Construction noise assessment	An assessment which compares predicted noise levels from construction tasks to ambient noise levels at nearby noise sensitive receptors.
Construction vibration assessment	An assessment of magnitude of predicted vibration from construction activities.
Decibel	The unit of measurement used for sound pressure levels and noise levels quoted in decibels (dB). NOTE 1: The decibel scale is logarithmic rather than linear; the threshold of hearing is zero decibels while, at the other extreme, the threshold of pain is about 130 decibels. NOTE 2: These limits are seldom experienced and typical levels lie within the range of 30 dB(A) (a quiet night time level in a bedroom) to 90 dB(A) (at the kerbside of a busy road).
Diversion route	A set of approved routes to follow in case of closure of motorway / major A-roads.
Do-minimum	Scenario without the project.
Do-something	Scenario with the project.
Environmental Noise Directive quiet area	A location formally designated as an 2002/49/EC [Ref 10.N] (END) quiet area.
Facade sound level	Sound level that is determined 1 metre (m) in front of a window or door in a facade.

Terms and definitions (continued)

Term	Definition
Free-field sound level	The sound level which is measured or calculated, in the open, without any reflections from nearby surfaces except the ground.
Future year	The 15th year after opening.
Insertion loss	A measure of the effectiveness of noise control devices such as silencers and enclosures. NOTE: The insertion loss of a device is the difference, in dB, between the noise level with and without the device present.
L_{A10}	The A-weighted sound level, in dB, that is exceeded 10% of the measurement period. NOTE: This is the standard index used within the UK to describe traffic noise.
$L_{A10,18hr}$	The noise level, in dB, that is exceeded 10% of the time between 0600 and 2400.
L_{Aeq}	The equivalent continuous sound level (L_{Aeq}) is the level of a notional steady sound, which at a given position and over a defined period of time, would have the same A-weighted acoustic energy as the fluctuating noise.
L_{Amax}	The maximum A-weighted level measured during a given time period.
L_{night}	A facade noise index derived from the $L_{A10,18hr}$ using the TRL conversion method TRL PR/SE/451/02 [Ref 7.N].
$L_{night,outside}$	For the purpose of night-time noise assessment, the $L_{night,outside}$ is the equivalent continuous sound level $L_{Aeq,8hr}$ for the period 23:00 to 07:00 hours assessed outside a dwelling and is free-field.
Long-term	Noise change based on the +15 year assessment (for example Do-minimum opening year scenario (DMOY) against Do-minimum future year scenario (DMFY) and DMOY against Do-something future year scenario (DSFY)).
Lowest observed adverse effect level	Level above which adverse effects on health and quality of life can be detected.
Noise	Unwanted sound.
Noise mapping	The production of computer software generated maps showing how the predicted levels of outdoor noise vary with location.
Noise modelling	Software to predict noise levels. NOTE: This can be undertaken either by specialist software to provide a 3D representation of the project and nearby noise sensitive receptors or a simple spreadsheet.
Noise monitoring	Measurement of noise levels.

Terms and definitions (continued)

Term	Definition
Noise sensitive receptor	Receptors which are potentially sensitive to noise. NOTE: Examples include dwellings, hospitals, healthcare facilities, education facilities, community facilities, END quiet areas or potential END quiet areas, international and national or statutorily designated sites, public rights of way and cultural heritage assets.
Non-project noise change	Noise change based on the DMOY against DMFY scenario, with no project implementation.
Point source attenuation	A source of noise/sound that radiates from a single point, decreasing by 6dB every time the distance between the source and receiver is doubled.
Sensitive buildings	Dwellings, including those that are listed, hospitals, healthcare facilities, education facilities or other buildings where noise or vibration can cause disturbance to people using the buildings.
Opening year	The first year of operation.
Operational noise assessment	An assessment to determine the operational noise impacts and effects of a road project.
Potential END quiet area	A location with potential to be formally designated as a END quiet area, but not officially designated as such.
Reflective noise barrier	A noise barrier that reflects noise.
Short-term	Noise change based on parallel assessment year (for example DMOY against Do-something opening year scenario (DSOY)).
Significant observed adverse effect level	The level above which significant adverse effects on health and quality of life occur.
Vibration	A to-and-fro motion which oscillates about a fixed equilibrium position.
Vibration sensitive receptor	Receptors which are potentially sensitive to vibration. NOTE: Examples include dwellings, hospitals, healthcare facilities, education facilities, community facilities, buildings containing vibration sensitive equipment and cultural heritage assets.

1. Scope

Aspects covered

1.1 The requirements in this document shall be applied to the assessment, reporting and management of environmental effects, specifically changes in noise and vibration emissions, from the delivery of projects.

1.2 Environmental assessments shall describe the effects of changes in noise and vibration emissions in accordance with the wider requirements and advice provided in:

1) LA 101 [Ref 14.N] Introduction to environmental assessment;
2) LA 102 [Ref 19.N] Screening projects for Environmental Impact Assessment;
3) LA 103 [Ref 18.N] Scoping projects for environmental assessment; and
4) LA 104 [Ref 12.N] Environmental assessment and monitoring

1.3 The environmental assessment must, in line with the 2014/52/EU [Ref 1.N] describe the likely significant effects of proposed projects on the environment resulting from the emissions of noise and vibration.

1.4 Environmental assessment of noise and vibration emissions shall include likely significant effects from:

1) construction noise;
2) construction vibration; and
3) operational noise.

NOTE Operational vibration is scoped out of the assessment methodology as a maintained road surface will be free of irregularities as part of project design and under general maintenance, so operational vibration will not have the potential to lead to significant adverse effects.

1.5 The assessment of noise and vibration shall inform the assessment of other environmental factors, where appropriate.

Implementation

1.6 This document shall be implemented forthwith on all projects involving construction, improvement and maintenance of motorways and all purpose trunk roads on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 15.N].

Use of GG 101

1.7 The requirements contained in GG 101 [GG 101 [Ref 15.N] shall be followed in respect of activities covered by this document.

2. Principles and purpose

2.1 During options identification, the level of detail of a noise and vibration assessment shall be proportionate to the quality of data available and the risk of likely significant effects occurring.

NOTE Scoping assessments can identify and focus the assessment on the risk of likely significant environmental effects occurring for route options.

2.2 The assessment shall determine and report likely significant effects on sensitive buildings within the relevant study areas.

2.2.1 For cultural heritage resources, the impact of noise and or vibration on the people living in buildings should be included within the noise and vibration assessment.

2.3 The assessment of whether noise and/or vibration levels generated by the project gives rise to, or contributes to, a likely significant effect shall be undertaken and reported within the following documents:

1) LA 108 [Ref 2.N] for receptors containing biodiversity resources;
2) LA 107 [Ref 16.N] for receptors containing landscape resources;
3) LA 106 [Ref 8.N] for receptors containing cultural heritage resources;
4) LA 112 [Ref 17.N] for receptors containing community recreational facilities.

2.3.1 For cultural heritage resources the impact of noise and vibration on the building itself, or its setting, should be included within the cultural heritage assessment - see LA 106 [Ref 8.N].

Baseline scenario

2.4 The baseline scenario shall be defined and described in accordance with LA 104 [Ref 12.N].

2.5 The assessment shall predict:

1) construction noise levels and comparison with the baseline at noise sensitive receptors within the construction noise study area;
2) construction vibration levels and comparison with the baseline at vibration sensitive receptors within the construction vibration study area;
3) operational noise levels and changes from the baseline at noise sensitive receptors within the operational noise study area.

3. Assessment methodology

Construction noise assessment

Scoping

3.1 The scoping assessment shall report on the following questions to gain an understanding of the need to undertake further assessment:

1) does construction noise generated by the project have the potential to adversely affect any noise sensitive receptors?;
2) are there any noise receptors where there would be a reasonable stakeholder expectation that a construction noise assessment would be undertaken?

NOTE An example of reasonable stakeholder expectation that a construction noise assessment would be required is where works are not noisy enough to give rise to adverse effects at the noise sensitive receptors, but will be visible from the receptor and/or last for many weeks.

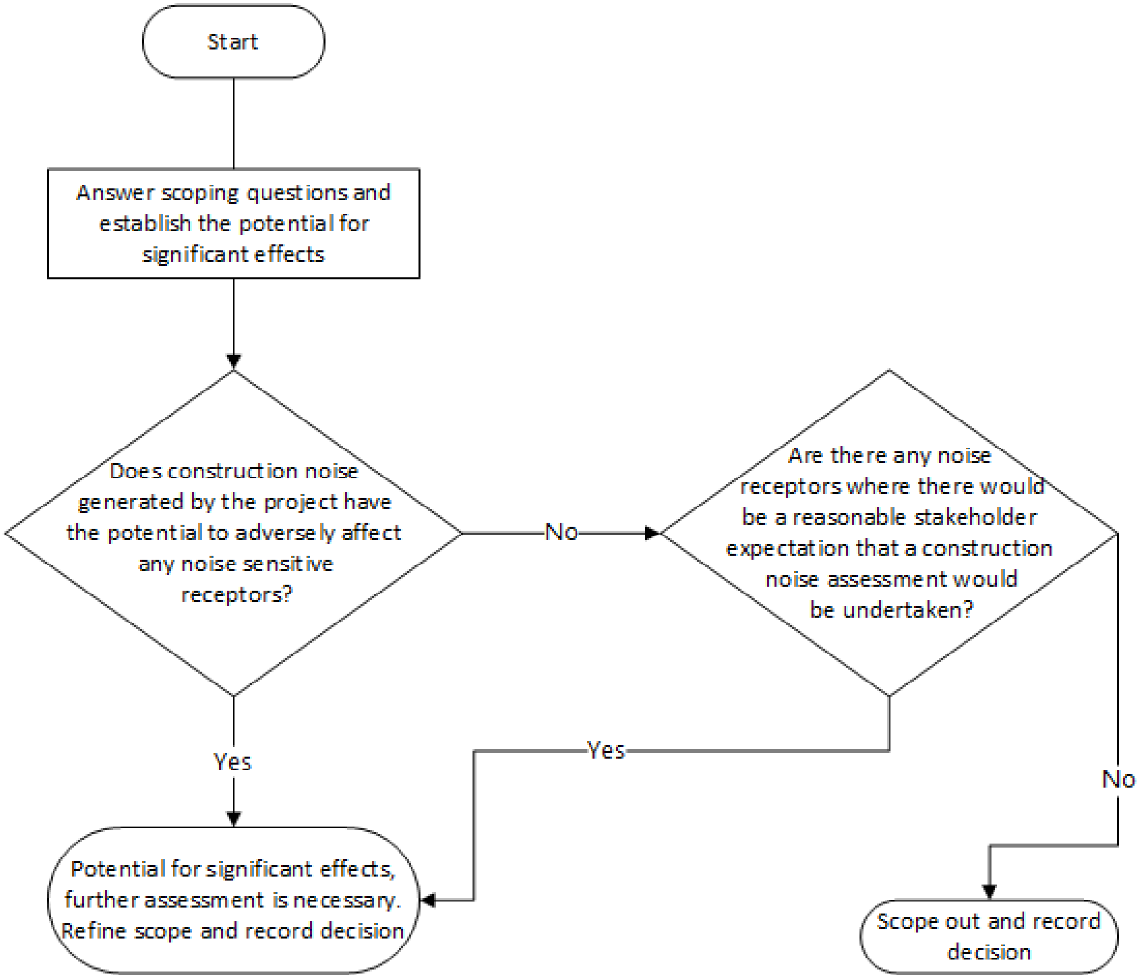
3.2 Scoping assessments shall be based on existing available information.

3.3 Where the response to one or more of the scoping assessment questions is 'yes', further assessment shall be undertaken.

3.4 The scoping assessment shall follow the process illustrated in Figure 3.4N.

NOTE The flow diagram in Figure 3.4N illustrates the scoping process for construction noise.

Figure 3.4N Scoping process for construction noise



Study areas

3.5 A construction noise study area shall be defined, where the need for further assessment has been established to include all noise sensitive receptors:

1) that are potentially affected by construction noise;
2) in areas where there is a reasonable stakeholder expectation that a construction noise assessment will be undertaken.

NOTE 1 A study area of 300m from the closest construction activity is normally sufficient to encompass noise sensitive receptors.

NOTE 2 Variations in the study area can be defined for individual projects.

3.6 A diversion route study area shall be defined where a project requires full carriageway closures during the night (23:00-07:00) to enable construction works to take place.

3.7 A diversion route study area shall be defined to include a 25m width from the kerb line of the diversion route.

NOTE 1 When full carriageway closures are implemented at night on major roads, traffic using those roads is diverted onto local roads that normally experience lower traffic levels at night.

NOTE 2 The sudden change of traffic levels on diversion routes, as a result of night time closures, is highly likely to cause disturbance to receptors next to (within 25m of) the road.

NOTE 3 It is possible to calculate changes in noise levels due to diversion routes, but it is not a proportionate approach, as it would require significant work in additional traffic modelling and noise calculations that would be highly likely to confirm that disturbance would occur.

3.8 A construction traffic study area shall be defined to include a 50m width from the kerb line of public roads with the potential for a increase in baseline noise level (BNL) of 1 dB(A) or more as a result of the addition of construction traffic to existing traffic levels.

Baseline

3.9 Construction noise baseline shall be determined via one or more of the following methods:

1) noise measurements, based upon actual survey data;
2) predicted noise levels (noise model outputs);
3) existing noise mapping undertaken by public bodies or as part of other developments.

3.10 The scope of the assessment of the extent and quality of data required to determine the baseline noise environment shall be proportionate and include:

1) the risk of a likely significant effect occurring;
2) the stage of development of the project;
3) the availability of previously collected data.

3.10.1 Noise monitoring, specifically for the purposes of construction noise baseline data collection, should only be undertaken where data from other sources is not sufficient to enable production of a proportionate construction noise assessment.

NOTE Additional methodology on predicting construction noise can be found in BS 5228-1 [Ref 5.N].

Determining significance

3.11 Lowest observable adverse effect level (LOAEL) and significant observable adverse effect level (SOAEL) shall be established and reported within the environmental assessment for all noise sensitive receptors within the construction activity study area, with reference to baseline noise levels.

3.12 The LOAEL and SOAEL shall be established in accordance with Table 3.12:

Table 3.12 Construction time period - LOAEL and SOAEL

Time period	LOAEL	SOAEL
Day (0700-1900 weekday and 0700-1300 Saturdays)	Baseline noise levels $L_{Aeq,T}$	Threshold level determined as per BS 5228-1 [Ref 5.N] Section E3.2 and Table E.1 BS 5228-1 [Ref 5.N]
Night (2300-0700)	Baseline noise levels $L_{Aeq,T}$	Threshold level determined as per BS 5228-1 [Ref 5.N] Section E3.2 and Table E.1 BS 5228-1 [Ref 5.N]
Evening and weekends (time periods not covered above)	Baseline noise levels $L_{Aeq,T}$	Threshold level determined as per BS 5228-1 [Ref 5.N] Section E3.2 and Table E.1 BS 5228-1 [Ref 5.N]

NOTE Where specific local circumstances mean that an alternative method of setting LOAEL and SOAEL for noise sensitive receptors is more appropriate, the alternative method can be submitted as a departure from standards to the Overseeing Organisation for approval.

3.13 Construction noise levels shall be calculated at selected locations which are representative of all noise sensitive receptors in the study area.

3.13.1 Calculations may be undertaken at a selection of noise sensitive receptors, or at varying distances from each activity, to represent all receptors in the study area.

3.14 The calculation of construction noise levels shall follow the methodology in BS 5228-1 [Ref 5.N] and include the following sources where they are present:

1) construction plant in use on the project;
2) construction compounds;
3) traffic on haul roads not part of the public highway;

3.15 Construction traffic BNL increases shall be calculated for roads within the construction traffic study area.

3.16 Magnitude of impact of construction noise, shall be determined in accordance with Table 3.16:

Table 3.16 Magnitude of impact and construction noise descriptions

Magnitude of impact	Construction noise level
Major	Above or equal to SOAEL +5dB
Moderate	Above or equal to SOAEL and below SOAEL +5dB
Minor	Above or equal to LOAEL and below SOAEL
Negligible	Below LOAEL

3.17 Magnitude of impact at noise sensitive receptors of construction traffic shall be determined in accordance with Table 3.17.

Table 3.17 Magnitude of impact at receptors

Magnitude of impact	Increase in BNL of closest public road used for construction traffic (dB)
Major	Greater than or equal to 5.0
Moderate	Greater than or equal to 3.0 and less than 5.0
Minor	Greater than or equal to 1.0 and less than 3.0
Negligible	Less than 1.0

3.18 For diversion routes used at night, a major magnitude of impact for construction noise impact shall be determined at any noise sensitive receptors within the diversion route study area.

3.19 Construction noise and construction traffic noise shall constitute a significant effect where it is determined that a major or moderate magnitude of impact will occur for a duration exceeding:

1) 10 or more days or nights in any 15 consecutive days or nights;
2) a total number of days exceeding 40 in any 6 consecutive months.

NOTE 1 It is more appropriate to use the specified timescales for highway construction, which are taken from BS 5228-1 [Ref 5.N] section E.4, rather than the '1 month or more' timescale included within E.3.3 of BS 5228-1 [Ref 5.N] due to the transient nature of most highway construction work.

NOTE 2 Where specific local circumstances mean that an alternative method for determining significance is more appropriate, the alternative method can be submitted as a departure from standards to the Overseeing Organisation for approval.

3.20 The following shall be reported in the environmental assessment:

1) data sources used;
2) assumptions applied during use of data;
3) the risk of any inaccuracies or errors within the data, or any modifications or assumptions made, leading to the assessment drawing incorrect conclusion;.
4) locations of noise sources and noise sensitive receptors.

NOTE Instruction on allowing for uncertainty in Environmental Impact Assessment is provided in LA 104 [Ref 12.N].

Design and mitigation

3.21 Two types of construction noise mitigation shall be incorporated into the design of the construction of the project as follows:

1) best practice noise mitigation techniques to minimise the generation and impact of noise applied to all construction activities;
2) specific noise mitigation measures to reduce the noise impact from activities which result in moderate or major magnitude of effect.

3.21.1 Best practice noise mitigation techniques should include the following measures:

1) training of site personnel to raise awareness of noise and nearby noise sensitive receptors;
2) provision of information to the public on expected construction noise, including duration, especially to those likely to be exposed to moderate and major magnitude of effect.

NOTE Examples of best practice construction noise techniques are presented in the following references:

1) best practicable means as defined in BS 5228-1 [Ref 5.N];
2) guidance presented in BS 5228-1 [Ref 5.N];

3) information within industry specific schemes such as: Considerate Constructors Scheme Best Practice Hub Considerate Contractor (Website) [Ref 1.I].

3.22 The implications of the use of specific mitigation measures on cost and construction timescales shall be determined and reported to the Overseeing Organisation.

3.22.1 Specific noise mitigation measures for sources other than diversion routes may include:

1) specification of the use of noise reduction construction methods, for example: specifying the use of rotary rather than driven piling;
2) provision of measures to reduce the noise reaching noise sensitive receptors, for example: installation of temporary barriers;
3) restriction of some activities to less sensitive times, for example: restricting piling activity to the daytime only;
4) providing noise insulation to houses, or temporarily rehousing local residents.

3.22.2 Specific noise mitigation measures for diversion routes may include:

1) use of more than one diversion route for different closures, to reduce the exposure of individual noise sensitive receptors;
2) providing noise insulation to residents along the diversion routes.

3.23 Specific noise mitigation measures shall only be included within the project if they are practicable as defined in BS 5228-1 [Ref 5.N].

NOTE Advice relating to the practicability of specific mitigation measures can be sought from project sponsors and or those responsible for determining the construction methodology for the project.

3.24 Where a specific noise mitigation measure is not practicable, as defined in BS 5228-1 [Ref 5.N], the measure shall not be included within the project design for the purposes of the construction noise assessment.

3.25 Specific noise mitigation measures included within the project shall be listed in the assessment and included within the construction stage of the environment management plan for the project.

Construction vibration assessment

Scoping

3.26 The scoping assessment shall report on the following scoping assessment questions to gain an understanding of the need to undertake further assessment:

1) does vibration from construction have the potential to adversely affect any vibration sensitive receptors?;
2) does the scale of the development or type of construction mean that there will be a reasonable stakeholder expectation that a construction vibration assessment would be undertaken at any vibration sensitive receptors?

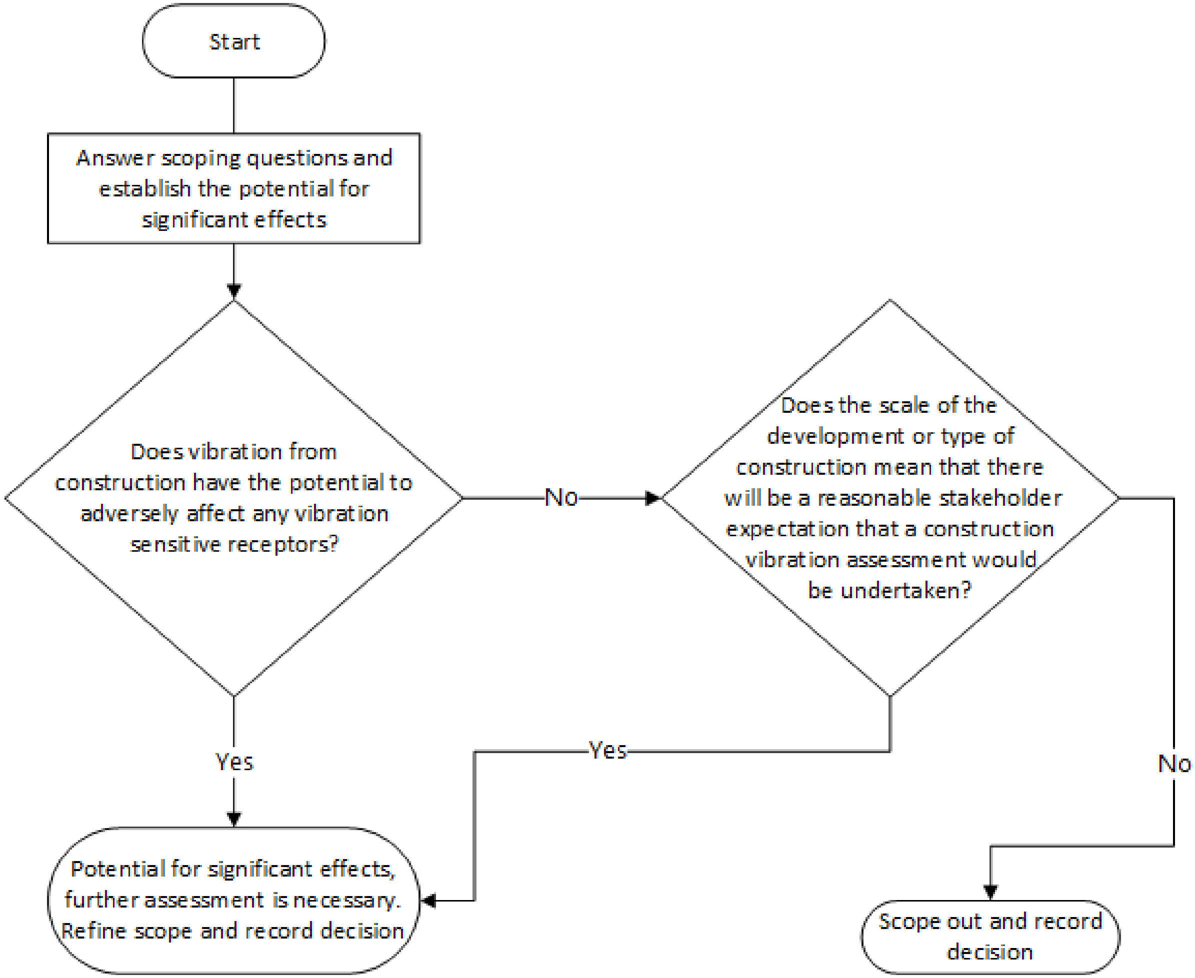
NOTE An example of reasonable stakeholder expectation that a construction vibration assessment would be required is where works are unlikely to generate enough vibration to give rise to adverse effects at the vibration sensitive receptors, but be visible and/or audible from the receptor and/or last for many weeks.

3.27 Where the response to one or more of the scoping assessment questions is 'yes', the scoping assessment shall make a recommendation on the scope of further assessment.

3.28 Scoping assessments shall be based on reasonably available information.

NOTE The flow diagram in Figure 3.28N illustrates the scoping process for construction vibration.

Figure 3.28N Scoping process for construction vibration



Study area

3.29 Where the need for further assessment has been established, a vibration study area shall be defined to include all:

1) vibration sensitive receptors that are potentially affected by construction vibration;
2) vibration sensitive receptors in areas where there is a reasonable stakeholder expectation that a construction vibration assessment will be undertaken.

NOTE 1 *A study area of 100m from the closest construction activity with the potential to generate vibration is normally sufficient to encompass vibration sensitive receptors.*

NOTE 2 *Variations in the study area can be defined for individual projects.*

Baseline

3.30 The construction vibration baseline shall be assumed to be zero due to the absence of construction work prior to project commencement.

Determining significance

3.31 Where the need for further assessment has been established, the LOAEL and SOAEL for construction vibration shall be set as follows:

Table 3.31 Construction vibration LOAELs and SOAELs for all receptors

Time period	LOAEL	SOAEL
All time periods	0.3mm/s PPV	1.0mm/s PPV

NOTE *Where specific local circumstances mean that an alternative method of setting LOAEL and SOAEL for vibration sensitive receptors is more appropriate,the alternative method can be submitted as a departure from standards to the Overseeing Organisation for approval.*

3.32 Where the need for further assessment has been established, the prediction methodology presented in BS 5228-2 [Ref 6.N] shall be used to to calculate construction vibration levels for all activities with the potential to adversely affect vibration sensitive receptors.

3.33 Magnitude of impact shall be determined in accordance with Table 3.33:

Table 3.33 Vibration level - magnitude of impact

Magnitude	Vibration level
Major	Above or equal to 10 mm/s PPV
Moderate	Above or equal to SOAEL and below 10 mm/s PPV
Minor	Above or equal to LOAEL and below SOAEL
Negligible	Below LOAEL

3.34 Construction vibration shall constitute a likely significant effect where it is determined that a major or moderate magnitude of impact will occur for a duration exceeding:

1) 10 or more days or nights in any 15 consecutive days or nights; or
2) a total number of days exceeding 40 in any 6 consecutive months.

NOTE *The duration timescales are used to retain consistency with those used in the construction noise assessment.*

3.35 The following shall be reported in the environmental assessment:

1) data sources used;

2) assumptions applied during use of data;
3) vibration levels at source - in line with the methodology provided in BS 5228-2 [Ref 6.N];
4) the risk of any inaccuracies or errors within the data, or any modifications or assumptions made, leading to the assessment drawing incorrect conclusions;
5) locations of vibration sources and vibration sensitive receptors;
6) the risk of structural damage due to construction vibration, with reference to criteria set out in BS 7385-2 [Ref 13.N].

NOTE 1 Instruction on allowing for uncertainty in Environmental Impact Assessment is provided in LA 104 [Ref 12.N].

NOTE 2 Human response to vibration occurs at much lower vibration levels than would be required to cause damage to buildings.

Design and mitigation

3.36 Two types of construction vibration mitigation shall be incorporated into the design of the construction of the project as follows:

1) best practice vibration mitigation techniques to minimise the generation and impact of vibration applied to all construction activities;
2) specific vibration mitigation measures to reduce the vibration impact from activities which result in major or moderate impacts.

3.36.1 Best practice should include the following measures:

1) selection of construction method and plant to minimise vibration generated;
2) training of site personnel to raise awareness of vibration and nearby vibration sensitive receptors;
3) provision of information to the public on expected construction vibration, including duration, especially to those likely to be exposed to moderate and major impacts.

NOTE Examples of best practice construction vibration techniques are presented in the following references:

1) best practicable means as defined in BS 5228-2 [Ref 6.N];
2) guidance presented in BS 5228-2 [Ref 6.N];
3) information within industry specific schemes such as Considerate Constructors Scheme Best Practice Hub Considerate Contractor (Website) [Ref 1.I].

3.37 The implications of the use of specific mitigation measures on cost and construction timescales shall be determined and provided to the Overseeing Organisation.

3.37.1 Specific vibration mitigation measures may include:

1) restrictions on construction method to reduce vibration;
2) restrictions of some activities to less sensitive times, for example, restricting piling activity to the daytime only;
3) temporarily rehousing local residents.

3.38 Specific vibration mitigation measures shall only be included within the project if they are practicable as defined in BS 5228-2 [Ref 6.N].

3.39 Where a specific mitigation measure is not practicable as defined in BS 5228-2 [Ref 6.N], the measure shall not be included within the project design for the purposes of the construction vibration assessment.

NOTE Advice relating to the practicality of specific mitigation measures can be sought from project sponsors and or those responsible for determining the construction methodology for the project.

3.40 Specific vibration mitigation measures shall be listed in the assessment and included within the construction part of the environmental management plan (EMP) for the project.

Operational noise assessment

Scoping

3.41 The scoping assessment shall report on the following scoping assessment questions to gain an understanding of the need to undertake a further noise assessment:

1) is the project likely to cause a change in the BNL of 1dB $L_{A10,18hr}$ in the do-minimum opening year (DMOY) compared to the do-something opening year (DSOY)?;
2) is the project likely to cause a change in the BNL of 3dB $L_{A10,18hr}$ in the do-something future year (DSFY) compared to the DMOY?;
3) does the project involve the construction of new road links within 600m of noise sensitive receptors?;
4) would there be a reasonable stakeholder expectation that an assessment would be undertaken?

NOTE An example of reasonable stakeholder expectation that an operational noise assessment would be required is where works involve changes to infrastructure but are not expected to give rise to significant environment effect, such as smart motorway projects.

3.42 Where the response to one or more of the scoping assessment questions is 'yes', the scoping assessment shall make a recommendation on the scope of further assessment.

3.43 Scoping assessments shall be based on available information.

Study area

3.44 Where the need for further assessment has been established, an operational study area shall be defined within the scoping assessment to include:

1) noise sensitive receptors that are potentially affected by operational noise changes generated by the project, either on the route of the project or other roads not physically changed by the project;
2) noise sensitive receptors in areas where there is a reasonable stakeholder expectation that noise assessment is undertaken.

NOTE 1 An operational study area defined as the following can be sufficient for most projects, but it can be reduced or extended to ensure it is proportionate to the risk of likely significant effects:

1) the area within 600m of new road links or road links physically changed or bypassed by the project;
2) the area within 50m of other road links with potential to experience a short term BNL change of more than 1.0dB(A) as a result of the project.

NOTE 2 Variations in the study area can be defined for individual projects.

Baseline

3.45 The operational noise baseline shall be determined from do-minimum noise levels in each assessment year.

3.45.1 Noise monitoring should be used to inform baseline noise modelling results and to provide data for public consultation purposes.

NOTE Validation of baseline can be undertaken by comparing modelled noise levels to measured noise levels, using corrections to take account of expected changes in traffic levels between the date of monitoring and the date of the baseline.

3.46 Where noise monitoring is undertaken, it shall follow the procedures set out in BS 7445-1 [Ref 9.N].

3.47 Noise monitoring data shall only be valid when it is undertaken during periods when:

1) wind speed is less than 5m/s;

2) there is no precipitation and road surfaces are dry.

3.48 Noise equipment used for monitoring shall be class 1 following the specification in IEC 61672 [Ref 11.N].

Determining significance

3.49 LOAELs and SOAELs shall be set for all noise sensitive receptors within the study area, for time periods when they are in use.

NOTE For example, schools are typically not in use at night when they are closed, so only daytime LOAELs and SOAELs are required to be set for typical schools.

3.49.1 LOAELs and SOAELs should be set out in accordance with Table 3.49.1 for all noise sensitive receptors:

Table 3.49.1 Operational noise LOAELs and SOAELs for all receptors

Time Period	LOAEL	SOAEL
Day (06:00-24:00)	55dB $L_{A10,18hr}$ facade	68dB $L_{A10,18hr}$ facade
Night (23:00-07:00)	40dB $L_{night, outside}$ (free-field)	55dB $L_{night, outside}$ (free-field)

3.50 LOAELs and SOAELs shall be modified where it is proportionate and merited by local circumstances which can include, but are not limited to:

1) noise sensitive receptors that have reduced sensitivity to noise or vibration e.g., sensitivity to noise is reduced if receptors have good noise insulation;
2) noise sensitive receptors that have an increased sensitivity to noise or vibration e.g., if a building is regularly used by people with hearing impairments, it is likely to be more sensitive to the users, as noise affects speech intelligibility at lower levels than it would for those with non-impaired hearing.

NOTE 1 Modification can be proportionate where it has the potential to change the assessment of likely significant effects.

NOTE 2 Examples of receptors with good noise insulation can include properties that have been included within Highway Authority insulation schemes, or newer properties that have noise insulation to reduce road noise incorporated into their design (evidence to support the latter can be found in planning application documents for developments).

3.51 Noise change due to the project shall be determined at noise sensitive receptors within the study area, during the periods for which LOAELs and SOAELs have been set, for:

1) Short term: DMOY compared against the DSOY;
2) Long-term: DMOY compared against the DSFY;
3) Non-project noise change: do-minimum future year (DMFY) compared against the DMOY.

3.51.1 Noise level changes may be determined through:

1) calculation of noise levels at each individual noise sensitive receptor; or
2) calculation of noise levels at a sample of noise sensitive receptors representative of all noise sensitive receptors.

3.51.2 Noise level changes may be determined by:

1) comparing noise levels calculated at noise sensitive receptors using CRTN [Ref 3.N] calculations as modified by Appendix A;
2) Comparing of BNL change of road links using the methodology in Appendix A.

NOTE 1 CRTN [Ref 3.N] calculations of noise levels change at noise sensitive receptors are likely to be required within 600m of new road links or roads physically changed by the project.

NOTE 2 *Calculations of BNL change are likely to be required for noise sensitive receptors not covered by calculations of noise level change, and within 50m of road links where noise levels change by 1dB(A) in the short term or 3dB(A) in the long term.*

NOTE 3 *Where BNL changes show likely significant effects for noise sensitive receptors along road links, it can be appropriate to extend CRTN [Ref 3.N] calculations to include these road links.*

3.52 Traffic data used for noise calculations shall be subject to the speed pivoting process set out in Appendix A.

NOTE *The speed pivoting process is normally undertaken by traffic engineers who are responsible for preparing traffic models for road projects.*

3.53 Where the noise sensitive receptor is a building, the facade used to calculate noise change shall be chosen as follows:

1) the facade with the greatest magnitude of noise change;
2) where the greatest magnitude of noise change is equal on more than one facade, the facade experiencing the greatest magnitude of noise change and highest do-something noise level.

NOTE *The greatest magnitude of change is likely to occur on the facade facing the new or changed stretch of road, or facades facing road links leading directly to major junctions, but this is not always the case, particularly at buildings close to junctions.*

3.54 The magnitude of change shall be defined in accordance with Table 3.54a for short term and Table 3.54b for long term:

Table 3.54a Magnitude of change - short term

Short term magnitude	Short term noise change (dB $L_{A10,18hr}$ or L_{night})
Major	Greater than or equal to 5.0
Moderate	3.0 to 4.9
Minor	1.0 to 2.9
Negligible	less than 1.0

Table 3.54b Magnitude of change - long term

Long term magnitude	Long term noise change (dB $L_{A10,18hr}$ or L_{night})
Major	Greater than or equal to 10.0
Moderate	5.0 to 9.9
Minor	3.0 to 4.9
Negligible	less than 3.0

3.55 A summary of noise level changes shall be presented as Table 3.55a and 3.55b.

Table 3.55a Operational noise reporting table for noise assessment - short-term

Project:					
Scenario/Comparison:					
		Daytime		Night-time	
Change in noise level dB(A)		Number of dwellings	Number of other noise sensitive receptors	Number of dwellings	Number of other noise sensitive receptors
Increase in noise level dB $L_{A10,18hr}$ / L_{night}	<1.0				
	1.0 - 2.9				
	3 - 4.9				
	>5				
No Change	0				
Decrease in noise level dB $L_{A10,18hr}$ / L_{night}	<1.0				
	1.0 - 2.9				
	3 - 4.9				
	>5				

Table 3.55b Operational noise reporting table for noise assessment - long-term

Project:					
Scenario/Comparison:					
		Daytime		Night-time	
Change in noise level		Number of dwellings	Number of other noise sensitive receptors	Number of dwellings	Number of other noise sensitive receptors
Increase in noise level dB $L_{A10,18hr}$ / L_{night}	<3				
	3.0 - 4.9				
	5 - 9.9				
	>10+				
No Change	0				
Decrease in noise level dB $L_{A10,18hr}$ / L_{night}	<3				
	3.0 - 4.9				
	5 - 9.9				
	>10+				

3.56 Noise level changes at each noise sensitive receptor within the study area (including any BNL calculations) shall be reported.

3.56.1 Noise level changes should be reported using one or more of the following methods:

1) tables of results;
2) noise contour maps;
3) other mapping methods, for example, assigning colours to noise sensitive receptors.

3.57 It shall be determined whether the operational noise changes constitute a likely significant effect on noise sensitive buildings as defined by the 2014/52/EU [Ref 1.N].

3.58 The initial assessment of likely significant effect on noise sensitive buildings shall be determined using Table 3.58.

Table 3.58 Initial assessment of operational noise significance

Significance	Short term magnitude of change
Significant	Major
Significant	Moderate
Not significant	Minor
Not significant	Negligible

3.59 Where the magnitude of change in the short term is negligible at noise sensitive buildings, it shall be concluded that the noise change will not cause changes to behaviour or response to noise and as such, will not give rise to a likely significant effect.

3.60 For noise sensitive receptors where the magnitude of change in the short term is minor, moderate or major at noise sensitive buildings, Table 3.60 shall be used, together with the output of Table 3.58 to determine final significance.

Table 3.60 Determining final operational significance on noise sensitive buildngs

Local circumstance	Influence on significance judgement
Noise level change (is the magnitude of change close to the minor/moderate boundary?)	1) Noise level changes within 1 dB of the top of the 'minor' range can indicate that it is more appropriate to determine a likely significant effect. Noise level changes within 1 dB of the bottom of a 'moderate' range can indicate that it is more appropriate to consider a change is not a likely significant effect.
Differing magnitude of impact in the long term to magnitude of impact in the short term	1) Where the long term impact is predicted to be greater than the short term impact, it can be appropriate to conclude that a minor change in the short term is a likely significant effect. Where the long term impact is predicted to be less than the short term it can be appropriate to conclude that a moderate or major change in the short term is not significant. 2) A similar change in the long term and non-project noise change can indicate that the change is not due to the project and not an indication of a likely significant effect.

Table 3.60 Determining final operational significance on noise sensitive buildngs (continued)

Local circumstance	Influence on significance judgement
Absolute noise level with reference to LOAEL and SOAEL (by design this includes sensitivity of receptor)	1) A noise change where all do-something absolute noise levels are below SOAEL requires no modification of the initial assessment. 2) Where any do-something absolute noise levels are above the SOAEL, a noise change in the short term of 1.0dB or over results in a likely significant effect.
Location of noise sensitive parts of a receptor	1) If the sensitive parts of a receptor are protected from the noise source, it can be appropriate to conclude a moderate or major magnitude change in the short term and/or long term is not a likely significant effect. 2) Conversely, if the sensitive parts of the receptor are exposed to the noise source, it can be more appropriate to conclude a minor change in the short term and/or long term is a likely significant effect. 3) It is only necessary to look in detail at individual receptors in terms of this circumstance where the decision on whether the noise change gives rise to a significant environmental effect is marginal.
Acoustic context	1) If a project changes the acoustic character of an area, it can be appropriate to conclude a minor magnitude of change in the short term and/or long term is a likely significant effect.
Likely perception of change by residents	1) If the project results in obvious changes to the landscape or setting of a receptor, it is likely that noise level changes will be more acutely perceived by the noise sensitive receptors. In these cases it can be appropriate to conclude that a minor change in the short term and/or long term is a likely significant effect. 2) Conversely, if the project results in no obvious changes for the landscape, particularly if the road is not visible from the receptor, it can be appropriate to conclude that a moderate change in the short term and/or long term is not a likely significant effect.

NOTE 1 In relation to the location of sensitive parts of the receptor, an example of a situation where sensitive parts of a receptor would be protected from the noise source would include a house with no, or very

few, windows of sensitive rooms facing the road, and its outdoor spaces are protected from the road by buildings.

NOTE 2 *In relation to the location of sensitive parts of the receptor, an example of a situation where sensitive parts of a receptor would be exposed to the noise source would include a house with most windows of sensitive rooms facing the road, and/or outdoor spaces facing the road.*

3.61 The number of properties affected shall not be used to justify change between the initial operational significance and the final operational significance.

3.62 The following shall be reported in the assessment:

1) data sources used;
2) assumptions applied during use of data;
3) the risk of any inaccuracies or errors within the data, or any modifications or assumptions made, leading to the assessment drawing incorrect conclusions; and
4) locations of noise sources and noise sensitive receptors.

3.63 The assessment report shall include justification for determination of significance for each noise sensitive receptor in the study area.

3.63.1 Presentation of the conclusions to determine likely significant effects on noise sensitive receptors should:

1) be succinct;
2) be grouped to aid presentation; and,
3) present clear justification if likely significant effect exists.

NOTE *There are many options for grouping noise sensitive receptors to aid presentation, these can include location, setting, similarity of noise change or other criteria.*

Operational noise management

3.64 Any mitigation measure that has the potential to mitigate or manage existing operational noise, and/or operational noise generated by a project, within a project area, shall be identified and reported within the assessment.

3.64.1 Measures to mitigate and manage operational noise may include, but are not limited to:

1) vertical or horizontal alignment of the road;
2) earth bunds to act as a noise barrier;
3) noise barriers;
4) low noise road surfacing;
5) speed limits;
6) restrictions on noisy vehicle types.

NOTE *Speed limits or restrictions on noisy vehicle types are not normally practical for use on motorways and all purpose trunk roads, as they can encourage drivers to take alternative routes, which can be less safe and result in higher noise levels for populations along the alternative routes.*

3.65 The suitability of each potential mitigation measure for use within the project area shall be determined based on the following criteria:

1) for residential noise receptors only, a comparison of the monetised noise benefit of a mitigation measure against the cost of the measure over the anticipated design life of the project;
2) the likely perceived benefit of the measure at any noise sensitive receptors;
3) the benefit of a measure in terms of elimination of likely significant effects;

4) practicality of the measure, for example, in terms of safety considerations and engineering constraints;
5) the impact of the measure across other environmental factors, for example the visual impact of a noise barrier.

NOTE Information received at project consultation events can help to determine the likely perceived benefit of a potential mitigation measure.

3.65.1 The cost of mitigation measures should be determined with reference to previously installed similar measures, and include costs of installation and maintenance through its life.

3.65.2 Where the life of a mitigation measure is shorter than the assessment period, costs for replacement at the relevant intervals should be included.

3.65.3 Detailed analysis of all of the criteria should only be undertaken where it is considered that that a mitigation measure has the potential to be suitable based on all of the criteria.

NOTE For example, where it was determined at the outset that a barrier would not be practical as there was insufficient space, there would be no requirement to undertake detailed analysis on other criteria such as value for money.

3.66 Mitigation measures that are deemed suitable for use shall be included within the project design.

3.67 The insertion loss for each noise barrier included within the project shall be reported.

3.68 Individual noise barriers included within the project shall be designated as either:

1) reflective, where there is no potential for increased noise levels at any noise sensitive receptors due to reflections of noise from the road facing surfaces of the barrier; or
2) absorptive, where there is potential for increased noise levels at any noise sensitive receptors due to reflections of noise from the road facing surfaces of the barrier.

3.69 Where barriers included within the project are required to be absorptive, each of the absorptive barriers shall be designated as either:

1) a single barrier, where there are barriers on one side of the road; or
2) a parallel barrier, where there are barriers on both sides of the road.

4. Monitoring and evaluation

Construction

4.1 Likely significant environmental effects from noise and/or vibration during construction shall be monitored.

4.1.1 Monitoring of likely significant effects should include one or more of the following:

1) verification that specific noise and vibration mitigation measures are in place for activities where there is potential for likely significant effects to occur in their absence;
2) measurement of noise and/or vibration;
3) checking that noise and vibration management procedures and practices are sufficient to ensure that adverse effects are no worse than set out in the assessment report.

Operation phase

4.2 Likely significant environmental effects from noise during operation shall be monitored and include:

1) ensuring mitigation measures included with the project design are incorporated with the as-built project. Where they are not included, ensuring resultant noise levels, taking account of any additional mitigation installed but not included in the assessed design, are no higher than set out in the project assessment;
2) ensuring specifications of noise mitigation measures, including barriers and low noise surfaces, meet design specifications.

NOTE Post construction noise monitoring cannot provide a reliable gauge for whether the predicted magnitude and extent of operational adverse impacts are greater or less than those predicted in the assessment, this is due to the following reasons:

1) *the assessment is based on annual average conditions with and without the project to ensure a like-for-like comparison, which is not possible to replicate through monitoring within a reasonable timescales;*
2) *monitoring in the absence of the project would need to be completed before the start of the construction works, and would therefore be a number of years before the with-scheme monitoring and the assessment completed for the environmental statement is based on calculated road traffic noise levels, whereas ambient noise monitoring can be affected by other noise sources such as people, agricultural activities, military activities, aircraft etc.*

5. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	2014/52/EU, 'Assessment of the effects of certain public and private projects on the environment'
Ref 2.N	Highways England. LA 108, 'Biodiversity'
Ref 3.N	HMSO. Department of Transport and Welsh Office. CRTN, 'Calculation of Road Traffic Noise '
Ref 4.N	Transport Research Laboratory. Abbott, P.G. TRL PR/SE/611/99, 'Calculation of road traffic noise - Extending the range of propagation.'
Ref 5.N	BSI. BS 5228-1, 'Code of practice for noise and vibration control on construction and open sites - Part 1: Noise'
Ref 6.N	BSI. BS 5228-2, 'Code of practice for noise and vibration control on construction and open sites. Vibration '
Ref 7.N	Transport Research Laboratory. P G Abbott and P M Nelson. TRL PR/SE/451/02, 'Converting the UK traffic noise index LA10,18h to EU noise indices for noise mapping'
Ref 8.N	Highways England. LA 106, 'Cultural heritage assessment'
Ref 9.N	BSI. BS 7445-1, 'Description and measurement of environmental noise. Guide to quantities and procedures'
Ref 10.N	2002/49/EC, 'Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise - Declaration by the Commission in the Conciliation Committee on the Directive relating to the assessment and management of environmental noise'
Ref 11.N	International Electrotechnical Commission . International Electrotechnical Commission. IEC 61672, 'Electroacoustics - Sound level meters - Part 1: Specifications'
Ref 12.N	Highways England. LA 104, 'Environmental assessment and monitoring'
Ref 13.N	BSI. BS 7385-2, 'Evaluation and measurement for vibration in buildings' - Part 2: Guide to damage levels from groundborne vibration'
Ref 14.N	Highways England. LA 101, 'Introduction to environmental assessment'
Ref 15.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 16.N	Highways England. LA 107, 'Landscape and visual effects'
Ref 17.N	Highways England. LA 112, 'Population and human health'
Ref 18.N	Highways England. LA 103, 'Scoping projects for environmental assessment'
Ref 19.N	Highways England. LA 102, 'Screening projects for Environmental Impact Assessment'

6. Informative references

The following documents are informative references for this document and provide supporting information.

Ref 1.I	Considerate Constructors Scheme. Considerate Contractor (Website), 'Considerate Constructors Scheme Best Practice Hub ccsbestpractice.org.uk'

Appendix A. Operation noise calculations

A1 BNL Calculations

BNL calculations are undertaken by using traffic flow, speed and HGV percentage to calculate a reference noise emission from the road link, as set out in CRTN [Ref 3.N].

A2 CRTN Modifications

Modifications to CRTN [Ref 3.N] methodology are listed as follows:

1) adopt dual source lines for all dual carriageways;
2) include reflection and screening of barriers located in the central reservation within the noise model if they equal to or more than 1.5m in height;
3) classify all vehicles with an unladen weight of less than 3.5 tonnes as light vehicles, and all vehicles with an unladen weight of greater than 3.5 tonnes as heavy vehicles;
4) use pivoted speeds, as defined below, for road links within the noise model.
5) for thin surfacing with speeds of greater than 75km/h, adopt a surface correction of the RSI, or if RSI data is not available assume an upper limit correction of -3.5dB;
6) Where speed changes from below or equal to 75km/h to above 75km/h (or vice versa) do not occur:
    a) for hot rolled asphalt surfaces, a correction of -0.5dB should be used for speeds greater than 75km/h;
    b) for brushed concrete surfacing, with speeds greater than 75km/h adopt a surface correction of: +3.5dB;
    c) for all roads with speeds of less than or equal to 75 km/h, adopt a surface correction of -1.0 dB for all surfaces;
7) Where speed changes from below or equal to 75km/h to above 75km/h (or vice versa) do occur:
    a) where the speed change is less than 15 km/h, adopt surface correction set out in modification 8 based on the DM speed in both scenarios;
    b) where the speed change is more than 15km/h, adopt the surface correction set out in modification 8 based on the speed for each scenario;
8) for roads with mixed surfaces, apply the surface correction applicable to the surface type covering the largest proportion of the road, or if two surface types cover equal proportions of the road, apply the surface correction that results in the highest magnitude of change;
9) use the equations set out in Charts 7 and 8 of CRTN [Ref 3.N] to calculate noise to a distance of 600m TRL PR/SE/611/99 [Ref 4.N] from the road. Assume distance attenuation of 3dB per doubling of distance for distances in excess of 600m;
10) where purpose built noise barriers are classed as absorptive, a reflection correction is not needed;
11) apply correction for reflection effects from opposite facades when the horizontal distance between the calculation point and the nearside kerb (d) and the horizontal distance between the source line and the opposite facade (D) meet either of the following conditions, with reference to the limits of application set out in CRTN paragraph 26.2:
    a) $d < 12m$ and $D <= 20m$;
    b) $12m<d<=300m$ and $D<=10^{(0.825+0.4\log(d+3.5))}$.

Best available information should be used to determine where existing barriers are absorptive or reflective for the purposes of CRTN calculations.

TRL research TRL PR/SE/451/02 [Ref 7.N] provides methods to convert $L_{A10,18hr}$ to other indices. 'Method 1' requires hourly traffic flows but gives reliable results. TRL 'Method 2' has been shown in some circumstances to give large step changes and thus unreliable results.

TRL 'Method 3' provides reliable results for most UK roads. Exceptions to this can include roads where the proportion of night time traffic to day time traffic is atypical, which can occur on roads serving facilities that operate 24 hours per day, for example airports or ports.

If TRL Method 3 is used with do-something traffic data on congestion relief projects, it has the potential to over predict increases in night-time traffic.

A3 Speed pivoting process

Speed pivoting ensures that modelled speeds from the the traffic model are consistent with observed speeds. The process can be applicable to all roads within the operational noise study area, and is implemented by the project's traffic modelling team.

The implementation of speed pivoting process should be proportionate to the stage of the assessment, e.g. it is not necessary to undertake the full speed pivoting process at early stages of a scheme, particularly where the traffic models are likely to be updated.

The speed pivoting process is set out as follows:

1) observed vehicle speeds at a link level are obtained for the traffic model base year from data sets such as TrafficMaster, GPS, mobile phone data, etc;
2) the observed speed is divided by the modelled speeds for the time period(s) considered by the noise assessment, to generate the speed pivot factor.
3) modelled link speeds in each assessment scenario are multiplied by the speed pivot factor;
4) apply pivot factor.

Where observed speeds are not available for individual links and/or particular time periods, the speed pivot factor can be estimated using the following information: the speed pivoting performance on adjacent links, the speed pivoting performance on roads with similar characteristics either in the local area or across the study area e.g. motorways, urban centre roads, single carriageways, rural roads.

Design Manual for Roads and Bridges

highways england

Sustainability & Environment
Appraisal

LA 111
England National Application Annex to LA 111 Noise and vibration

(formerly HD 213/11, IAN 185/15)

Revision 0

Summary
This National Application Annex sets out the Highways England specific requirements for noise and vibration.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
0	Nov 2019	Highways England National Application Annex to LA 111.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes HD 213/11 and IAN 185/15, which are withdrawn.

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

This National Application Annex sets out the Highways England specific requirements relating to the compliance with the National Networks National Policy Statement NN NPS 2014 [Ref 3.N] and the Noise Insulation Regulations [Ref 5.N] which are reported as part of the environmental assessment of noise and vibration.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 2.N] apply to this document.

Abbreviations

Abbreviations

Abbreviation	Definition
LOAEL	Lowest observed adverse effect level
NN-NPS	National Policy Statement for National Networks
NPPF	National Planning Policy Framework
NPSE	Noise Policy Statement for England
SOAEL	Significant observed adverse effect level

Terms and definitions

Terms and defintions

Term	Definition
Indicative forecast eligibility	Dwellings where changes in noise levels due to a project are forecast to result in eligibility under the Noise Insulation Regulations [Ref 5.N], that apply 1 year after the opening of a project.
Lowest observed adverse effect level	Level above which adverse effects on health and quality of life can be detected.
Noise Important Areas	Important Areas identified in the NAP(Roads) [Ref 4.N] as at risk of experiencing a significant adverse impact to health and quality of life as a result of their exposure to road traffic noise.
Significant observed adverse effect level	The level above which significant adverse effects on health and quality of life occur.

E/1. English noise policy

E/1.1 The requirements within this National Application Annex shall apply to all projects, irrespective of the planning route.

E/1.2 The environmental assessment shall determine compliance with the relevant sections of the Noise Policy Statement for England (NPSE) NPS(E) [Ref 6.N], National Planning Policy Framework (NPPF) NPPF [Ref 1.N] and the Government's associated planning guidance on noise.

E/1.3 The environmental assessment shall report against the three aims within the National Policy Statement for National Networks (NN-NPS) NN NPS 2014 [Ref 3.N] (presented in the Table E/1.3), and demonstrate the actions taken to support delivery of each aim.

Table E/1.3 NN-NPS Aims and associated actions

NN-NPS Aim	Action	Action applicable to all three aims
Aim 1: Avoid significant adverse impacts on health and quality of life from noise as a result of the new development. NOTE: Significant adverse noise effects occur when noise levels are above SOAEL.	1) For each receptor or group of receptors, set out the mitigation measures used to reduce noise exposure to below SOAEL; 2) Where project noise levels are not predicted to be below the SOAEL, report the reasons why noise levels could not be reduced below the SOAEL, in terms of Government policy on sustainable development.	Mitigation measures include the following: 1) measures incorporated into a project to reduce overall environmental impact, which can include, but are not limited to: project alignment, project design; and, 2) measures used solely to mitigate noise, which can include, but are not limited to, noise barriers, restrictions on the use of plant during the construction phase, or quieter road surfaces.
Aim 2: Mitigate and minimise other adverse impacts on health and quality of life from noise from the new development. NOTE: Other adverse impacts occur when noise levels are between LOAEL and SOAEL.	1) Set out measures used to mitigate and minimise other adverse impacts for all receptors or groups of receptors where project noise levels are above LOAEL; 2) Where project noise levels are not predicted to be below the LOAEL, report the reasons why noise levels could not be reduced below the LOAEL, in terms of Government policy on sustainable development.	
Aim 3: Contribute to improvements to health and quality of life through the effective management and control of noise, where possible. NOTE: Applies to all noise levels.	1) Set out mitigation measures used to improve the noise environment. 2) Where it has not been possible to contribute to improvements to health and quality of life through management of project noise levels, report the reasons why it is not possible in terms of Government policy on sustainable development.	

NOTE 1 It is not normally possible to contribute to improvements to health and quality of life during a construction phase.

NOTE 2 NN-NPS states that the Secretary of State "....should not grant development consent unless satisfied that the proposals will meet the three aims [set out in requirement E/1.1], within the context of Government policy on sustainable development".

E/1.4 The environmental assessment report shall include a list of noise mitigation that the project will deliver in Noise Important Areas.

E/2. Noise Insulation Regulations

E/2.1 The environmental assessment shall report on the properties which are forecast to be eligible for insulation under the Noise Insulation Regulations [Ref 5.N].

E/2.1.1 An assessment of indicative forecast eligibility may be undertaken at options identification stage where routes pass through urban areas.

NOTE *The assessment of indicative forecast eligibility sets out which buildings are forecast to be eligible for either statutory or discretionary noise insulation, and in urban areas it can be appropriate to complete this at an early project stage to estimate costs of insulation, if there is potential for it to be required for large numbers of dwellings.*

E/3. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	Department of Housing. NPPF, 'Communities and Local Government: National Planning Policy Framework'
Ref 2.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 3.N	NN NPS, 'National Networks National Policy Statement (NN NPS)' , 2014
Ref 4.N	Defra. NAP(Roads), 'Noise Action Plan: Roads'
Ref 5.N	Noise Insulation Regulations, 'Noise Insulation Regulations 1975, as amended 1988'
Ref 6.N	Defra. NPS(E), 'Noise Policy Statement for England'

Design Manual for Roads and Bridges

Department for
Infrastructure
An Roinn Bonneagair

Sustainability & Environment
Appraisal

LA 111
Northern Ireland National Application Annex to LA 111 Noise and vibration

(formerly HD 213/11, IAN 185/15)

Revision 0

Summary
There are no specific requirements for Department for Infrastructure, Northern Ireland supplementary or alternative to those given in LA 111.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated team in the Department for Infrastructure, Northern Ireland. The email address for all enquiries and feedback is: dcu@infrastructure-ni.gov.uk

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Appraisal

LA 111
Scotland National Application Annex to LA 111 Noise and vibration

(formerly HD 213/11 and IAN 185/15)

Revision 0

Summary
This National Application Annex sets out Transport Scotland specific requirements for noise and vibration.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Transport Scotland team. The email address for all enquiries and feedback is: TSStandardsBranch@transport.gov.scot

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
0	Nov 2019	Transport Scotland National Application Annex to LA 111.

Foreword

Publishing information

This document is published by Highways England on behalf of Transport Scotland.

This document supersedes HD 213/11 and IAN 185/15, which are withdrawn.

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

This National Application Annex sets out Transport Scotland specific requirements for noise and vibration.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 1.N] apply to this document.

S/1. Applicability of this document

S/1.1 Transport Scotland shall be contacted for the application of LA 111 in Scotland.

NOTE The email address is:TSStandardsBranch@transport.gov.scot.

S/2. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'

Design Manual for Roads and Bridges

Llywodraeth Cymru
Welsh Government

Sustainability & Environment
Appraisal

LA 111
Wales National Application Annex to LA 111
Noise and vibration

(formerly HD 213/11, IAN 185/15)

Revision 1

Summary
This National Application Annex contains the Welsh Government specific requirements related to noise and vibration.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Welsh Government team. The email address for all enquiries and feedback is: Standards_Feedback_and_Enquiries@gov.wales

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
1	Feb 2020	Revision 1 (February 2020) Creation of clause W/1.1 to contact Welsh Government for requirements related to noise and vibration. Revision 0 (November 2019) Welsh Government National Application Annex to LA 111.

Foreword

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Introduction

Background

This National Application Annex sets out Welsh Government specific requirements for noise and vibration.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 1.N] apply to this document.

W/1. Applicability of this document

W/1.1 Welsh Government shall be contacted for the application of LA 111 in Wales.

NOTE The email address is: standards_feedback_and_enquiries@gov.wales

W/2. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'

Appendix AP2.2

BS 5228-1:2009+A1:2014

Code of practice for noise and vibration control on open sites – Part 1: Noise

BS 5228-1:2009+A1:2014

BSI Standards Publication

Code of practice for noise and vibration control on construction and open sites –

Part 1: Noise

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Publishing and copyright information

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Amendments issued since publication

Date	Text affected
February 2014	A1. See Foreword

Contents

Tables

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 158, an inside back cover and a back cover.

Foreword

Publishing information

This part of BS 5228 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 1 January 2009. It was prepared by Subcommittee B/564/1, *Noise control working group*, under the authority of Technical Committee B/564, *Noise control on construction and open sites*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

Together with BS 5228-2:2009, this part of BS 5228 supersedes BS 5228-1:1997, BS 5228-2:1997, BS 5228-3:1997, BS 5228-4:1992 and BS 5228-5:1997, which are withdrawn.

BS 5228-1:2009+A1:2014 supersedes BS 5228-1:2009, which is withdrawn.

Relationship with other publications

BS 5228 is published in two parts:

- Part 1: *Noise*;
- Part 2: *Vibration*.

BS 6164 gives guidance on occupational health issues relevant to tunnelling.

Information about this document

This British 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, construction and open 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. Attention is drawn to the legislation summarized in Annex A.

BS 5228-1:2009 was a full revision of this part of BS 5228, and introduced the following principal changes:

- restructuring of the standard into two parts, one dealing with noise and one with vibration;
- updating of information relating to legislative requirements;
- updating of information relating to methods and equipment.

Text introduced or altered by Amendment No.1 is indicated in the text by tags [A1⟩ ⟨A1]. Minor editorial changes are not tagged.

NOTE Copyright is claimed in Tables C.1 to C.11. The copyright holder is the Department for Environment, Food and Rural Affairs (Defra), Nobel House, 17 Smith Square, London SW1P 3JR.

Use of this document

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.

Any user claiming compliance with this part of BS 5228 is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This part of BS 5228 gives recommendations for basic methods of noise control [A1) relating to construction sites, including sites where demolition, remediation, ground treatment or related civil engineering works are being carried out, and open sites, (A1] where work activities/operations generate significant noise levels, including industry-specific guidance.

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

This part of BS 5228 provides guidance concerning methods of predicting and measuring noise and assessing its impact on those exposed to it.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 4727-3:Group 08, *Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms – Part 3: Terms particular to telecommunications and electronics – Group 08: Acoustics and electroacoustics*

BS 7580-1:1997, *Specification for the verification of sound level meters – Part 1: Comprehensive procedure*

BS 7580-2:1997, *Specification for the verification of sound level meters – Part 2: Shortened procedure for type 2 sound level meters*

[A1) BS EN 60942:2003, *Electroacoustics – Sound calibrators*

BS EN 61672-1:2013, *Electroacoustics – Sound level meters – Part 1: Specifications*

BS EN 61672-3:2013, *Electroacoustics – Sound level meters – Part 3: Periodic tests* (A1]

3 Terms and definitions

For the purposes of this part of BS 5228, the definitions given in BS 4727-3:Group 08 and the following apply.

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

3.1 activity [A1) $L_{Aeq,\,T}$ (A1]

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 might involve the operation of more than one item of plant.

3.2 air overpressure

airborne pressure waves generated by blasting, produced over a range of frequencies including those which are audible and those which are below the lower end of the audible spectrum

NOTE Air overpressure can be quantified either as a pressure or as a level in linear (unweighted) decibels (dB).

3.3 ambient noise

NOTE 1 Ambient noise is normally expressed as the equivalent continuous A-weighted sound pressure level A1⟩ ($L_{Aeq, T}$) ⟨A1.

A1⟩ noise in a given situation at a given time, usually composed of sound from many sources near and far, but excluding site noise

NOTE 2 Ambient noise plus site noise gives total noise. ⟨A1

3.4 A-weighted sound pressure level, L_{pA}

NOTE The reference sound pressure is 20 μPa (2×10^{-5} Pa).

ten times the logarithm to the base 10 of the ratio of the square of the sound pressure to the square of the reference sound pressure, determined by use of frequency-weighting network "A" and time-weighting "S" or "F" (see BS EN 61672-1), expressed in decibels

3.5 background noise

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

3.6 baffle mound

temporary dump usually formed from topsoil or subsoil, for the purpose of reducing noise from the site and to provide a visual screen

3.7 equivalent continuous A-weighted sound pressure level

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:

A1⟩ $$L_{Aeq, T} = 10\log_{10}\left[\frac{1}{T}\int_0^T \frac{p_A{}^2(t)}{p_0{}^2}\,dt\right]$$ ⟨A1

where:

A1⟩ $L_{Aeq, T}$ ⟨A1 *is the equivalent continuous A-weighted sound pressure level, in decibels (dB), determined over a time interval T;*

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

p_o *is the reference sound pressure* A1⟩ *(i.e. 20 μPa)* ⟨A1.

3.8 maximum sound level

NOTE The maximum sound level is represented by L_{Amax}.

highest value of the A-weighted sound pressure level with a specified time weighting that occurs during a given event

3.9 noise-sensitive premises (NSPs)

NOTE This can include national parks, areas of outstanding natural beauty or other outdoor spaces where members of the public might reasonably expect quiet enjoyment of the area.

any occupied premises outside a 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

3.10 one percentile level

NOTE The one percentile level is represented by A1⟩ $L_{A01, T}$ ⟨A1.

A-weighted sound pressure level (obtained by using the time weighting F) that is exceeded for 1% of the time interval *T*

3.11 open site

site where there is significant outdoor excavation, levelling or deposition of material

NOTE 1 Examples include 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 2 Waste disposal sites and long term construction projects can, in most cases, be treated as open sites.

3.12 overburden

material overlying the coal, or mineral or minerals to be extracted, including topsoil and subsoil

NOTE Economic deposits of other minerals can occur in the overburden.

3.13 piling

installation or removal of bored, driven and pressed-in piles and the effecting of ground treatments by vibratory, dynamic or other methods of ground stabilization

3.14 residual noise

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

NOTE Ambient noise is normally expressed as the equivalent continuous A-weighted sound pressure level [A1⟩ ($L_{Aeq,\,T}$) ⟨A1].

3.15 site noise

[A1⟩ noise in the neighbourhood of a site that originates from the site

NOTE Ambient noise plus site noise gives total noise. ⟨A1]

3.16 sound power level, L_{WA}

ten times the logarithm to the base 10 of the ratio of the sound power radiated by a sound source to the reference sound power, determined by use of frequency-weighting network "A" (see BS EN 61672-1), expressed in decibels

NOTE The reference sound power is 1 pW (10^{-12} W).

3.17 traverse length

length of travel of a mobile item of plant operating on a repetitive cycle

4 Community relations

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

It is suggested that good 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 government has published research on the environmental effects of noise from blasting [1].

5 Noise and persons on site

5.1 Training

NOTE Attention is drawn to Regulation 10 of the Control of Noise at Work Regulations 2005 [2], which requires all employees to be informed about the need to minimize noise and about the health hazards of exposure to excessive noise.

Operatives should be trained to employ appropriate techniques to keep site noise to a minimum, and should be effectively supervised to ensure that best working practice in respect of noise reduction is followed. All employees should be advised regularly of the following, as part of their training:

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) the avoidance of unnecessary noise when carrying out manual operations and when operating plant and equipment;

d) the 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 be provided which 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.

A programme of monitoring should be implemented to ensure that condition limits are not exceeded and that all the relevant recommendations are met.

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.

5.2 Protection from noise-induced hearing loss

NOTE Attention is drawn to the Control of Noise at Work Regulations 2005 [2].

Exposure to high noise levels for unprotected ears can be a serious hazard to health, causing permanent damage to hearing. The use of plant and/or power tools on site can create areas of potential noise hazard. The risk can be reduced by limiting the exposure (i.e. the combination of the quantity of noise and the duration of exposure).

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 might 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, might 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.)

Plant from which the noise generated is known to be particularly directional should, wherever practicable, be orientated so that attendant operators of the plant can benefit from this acoustical phenomenon by sheltering, when possible, in the area with reduced noise levels.

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 and Annex D.)

Tools should be sound-reduced and the operator should be supplied with the appropriate hearing protection (see **5.3**).

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

5.3 Ear protectors

NOTE Attention is drawn to the Control of Noise at Work Regulations 2005 [2] and their accompanying guidance [3]. The legislation requires that exposure with hearing protection is not to exceed the limit levels.

Effective noise control at source should always be regarded as the prime means of affording proper protection to employees from risks to hearing. Circumstances might arise, however, where this is not reasonably practicable. On such occasions, employees should be provided with, and should wear, personal ear protectors.

It might 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.

5.4 Noise-induced stress

Noise can interfere with working efficiency by inducing stress, by disturbing concentration and by increasing accident risk. Effects of noise 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.

6 Neighbourhood nuisance

NOTE Example criteria for the assessment of the [A1⟩] *potential significance* ⟨[A1] *of noise effects are given in Annex E.*

6.1 Disturbing effects of noise

The effects of noise on noise-sensitive premises (NSPs) are varied and complicated. They include interference with speech communication, disturbance of work or leisure activities, disturbance of sleep, annoyance and possible effects on mental and physical health. In any neighbourhood, some individuals will be more sensitive to noise than others.

6.2 Environmental noise descriptor

The A-weighted sound pressure level, L_{pA}, will give an indication of the loudness of noise at a NSP. However, some of the effects mentioned in **6.1** are dependent not only upon loudness; attitudinal and other factors are also important.

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, [A1⟩] $L_{Aeq, T}$ ⟨[A1]. The time period, *T* (e.g. 1 h, 12 h), involved (see **3.7**) should always be stated.

When describing noise from isolated events that might not always be apparent from a longer period [A1⟩] $L_{Aeq, T}$ ⟨[A1], it can be useful to use a short period (e.g. 5 min) [A1⟩] $L_{Aeq, T}$ ⟨[A1]. Alternatively, the maximum sound level, [A1⟩] L_{Amax} ⟨[A1], or the one percentile level, [A1⟩] $L_{A01, T}$ ⟨[A1], can be used.

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

Annex F deals with the estimation of site noise and Annex G is concerned with noise measurement and monitoring.

6.3 Issues associated with noise effects and community reaction

A number of factors are likely to affect the acceptability of noise arising from [A1⟩] construction and open sites ⟨[A1] and the degree of control necessary. These are described as follows.

a) *Site location*. The location of a site in relation to NSPs will be a major factor. The nearer a site is to NSPs, the more control that might be required upon noise emanating from the site.

b) *Existing ambient noise levels*. Experience of complaints associated with industrial noise sources indicates that the likelihood of complaint increases as the difference between the industrial noise and the existing background noise increases. Some types of open sites, such as quarries and landfill sites, are usually assessed in this manner. For some large infrastructure projects that require an environmental statement to be prepared, construction noise is sometimes assessed by comparing the predicted construction noise (plus ambient noise) with the pre-construction ambient noise.

However, it is generally assumed that a greater difference might be tolerated, than for an industrial source, when it is known that the operations are of short or limited duration, and the critical issues are likely to include interference with speech communication and/or sleep disturbance.

c) *Duration of site operations*. In general, the longer the duration of activities on a site, the more likely it is that noise from the site will prove to be an issue, assuming NSPs are likely to be significantly affected. In this context, good public relations and communication are important. Local residents might be willing to accept higher levels of noise if they know that such levels will only last for a short time. It is then important that construction activities are carried out in accordance with the stated schedule and that the community is informed of their likely durations. (See also **8.5.2.3**.)

d) *Hours of work*. For any NSP, 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 activity outside normal weekday and Saturday morning 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 might have to be as much as 10 dB(A) below the daytime limit. Very strict noise control targets might need be applied to any site which is to operate at night; this will depend on existing ambient noise levels. The periods when people are getting to sleep and just before they wake are particularly sensitive. (See also **8.5.2.4**.)

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 or activity itself. Noise from a site will tend to be accepted more readily by local residents, if they consider that the contractor is taking all possible measures to avoid unnecessary noise. The attitude to the contractor can also be improved through good community liaison and information distribution and the provision of a helpline to respond to queries or complaints. The acceptability of the project itself can also be a factor in determining community reaction.

f) *Noise characteristics*. In some cases a particular characteristic of the noise, e.g. the presence of impulses or tones, can make it less acceptable than might be concluded from the level expressed in terms of [A1⟩ $L_{Aeq,\,T}$ ⟨A1]. This is because these characteristics are likely to make the noise more disturbing than a noise with the same [A1⟩ $L_{Aeq,\,T}$ ⟨A1] level that does not have these characteristics. Examples would be impulsive noise from driven piling, rattling type noise from vibratory rollers, machine reversing alarms, etc.

[A1⟩ *List item g) deleted* ⟨A1]

[A1⟩ *NOTE Information regarding the provision of mitigation is given in Annex E.* ⟨A1]

7 Project supervision

7.1 General

The intention throughout any construction programme should be to minimize levels of site noise 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 assist in preventing excessive noise levels. Prevention can be achieved by giving careful consideration to the plant, processes, activities and programme associated with any construction project.

NOTE The Construction (Design and Management) Regulations 2007 [4] came into effect on 6 April 2007. They replaced the Construction (Design and Management) Regulations 1994 [5] and the Construction (Health, Safety and Welfare) Regulations 1996 [6]. An Approved Code of Practice [7] provides practical guidance on complying with the duties set out in the Regulations.

The key aim of these are to integrate health and safety into the management of the project and to encourage everyone involved to work together to:

a) improve the planning and management of projects from the very start;

b) identify risks early on so that they can be eliminated or reduced at the design or planning stage and the remaining risks can be properly managed;

c) target effort where it can do the most good in terms of health and safety; and

d) discourage bureaucracy.

Developers, architects and engineers will need to know whether the processes they intend using are likely to result in excessive noise and/or vibration levels. Therefore 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, the expected levels of site noise should be determined. Annexes C and D give typical noise levels created by site plant and activities, and Annex F gives guidance on estimating noise from sites.

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

7.2 Works preparation

NOTE Additional guidance on planning site operations is given in CIRIA Report 120 [8].

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 can be given to methods of working which could avoid problems.

A survey of the immediate neighbourhood surrounding a site should be undertaken to indicate the location of sensitive areas.

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

Tenderers for a project should select the most appropriate plant in order that limits will not be exceeded. They should also be aware of the extent of control measures that will be necessary so that appropriate cost allowances can be made.

Tenderers 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 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.

7.3 Execution of works

NOTE The use of "best practicable means" (BPM) to control emissions can constitute a ground of defence against charges that a nuisance is being caused under Part III of the Control of Pollution Act 1974 [9] or Part III of the Environmental Protection Act 1990 [10].

All available techniques should be used to minimize, as far as is appropriate, the level of noise to which operators and others in the neighbourhood of site operations will be exposed.

Measures which should be taken include the following.

a) The hours of working should be planned and account should be taken of the effects of noise upon persons in areas surrounding site operations and upon persons working on site, taking into account the nature of land use in the areas concerned, the duration of work and the likely consequence of any lengthening of work periods.

b) Where reasonably practicable, quiet working methods should be employed, including 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) Noise should be controlled at source and the spread of noise should be limited, in accordance with Clause **8**.

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 G.

e) On those parts of a site where high levels of noise are likely to be a hazard to persons working on the site, prominent warning notices should be displayed and, where necessary, ear protectors should be provided (see also Clause **5**).

When potential noise problems have been identified, or when problems have already occurred, consideration should be given to the implementation of practicable measures to avoid or minimize those problems. Local authorities, consulting with developers and their professional advisers or with site operators, will need to consider the extent of noise control measures necessary to prevent the occurrence of significant problems, and will also need to consider whether the implementation of those measures will be practicable. Local authorities might wish to consider whether to specify quantified limits on site noise and whether, additionally or instead, to lay down requirements relating to work programmes, plant to be used, siting of plant, periods of use, working hours, access points, etc. The latter approach will often be preferable in that it facilitates the monitoring of formally or informally specified requirements, both for the authorities and for the site operators.

7.4 Emergencies

*NOTE Attention is drawn to Section 61 of the Control of Pollution Act 1974 [9], which requires provision to be made for emergencies (see **A.3.3.3**).*

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

8 Control of noise

8.1 General

*NOTE 1 Guidance on groundborne noise from sub-surface construction activities is given in BS 5228-2:2009, **8.7**.*

Construction and demolition works can pose different noise control problems compared with most other types of industrial activity for the following reasons:

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

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 control have to be taken into account. Advice should be sought in such cases from the appropriate railway authorities.

NOTE 2 EC Directive 2000/14/EC [11] deals with noise from particular sources, for example, many categories of construction plant and equipment.

Much of the noise from construction and demolition sites is generated by plant and machinery. The noise levels so generated are unacceptable in many instances and reductions are necessary for the benefit of both the industry and the public.

8.2 Control of noise at source

8.2.1 General

NOTE Attention is drawn to regulatory requirements contained within the Health and Safety at Work etc Act 1974 [12], the Workplace (Health, Safety and Welfare) Regulations 1992 [13] and the Management of Health and Safety at Work Regulations 1992 [14] in respect of reversing warning systems.

There are many general measures that can reduce noise levels at source such as:

a) avoid unnecessary revving of engines and switch off equipment when not required;

b) keep internal haul routes well maintained and avoid steep gradients;

c) use rubber linings in, for example, chutes and dumpers to reduce impact noise;

d) minimize drop height of materials;

e) start up plant and vehicles sequentially rather than all together.

The movement of plant onto and around the site should have regard to the normal operating hours of the site and the location of any NSPs as far as is reasonably practicable.

The use of conventional audible reversing alarms has caused problems on some sites and alternatives are available. Audible reversing warning systems on mobile plant and vehicles should be of a type which, whilst ensuring that they give proper warning, have a minimum noise impact on persons outside sites. When reversing, mobile plant and vehicles should travel in a direction away from NSPs whenever possible. Where practicable, alternative reversing warning systems should be employed to reduce the impact of noise outside sites.

8.2.2 Specification and substitution

Where a construction site is within a noise-sensitive area, the plant and activities to be employed on that site should be reviewed to ensure that they are the quietest available for the required purpose; this is in accordance with best practicable means. For an existing operational site, where reasonably practicable, noisy plant or activities should be replaced by less noisy alternatives (see Annex B for examples) if noise problems are occurring.

8.2.3 Modification of existing plant and equipment

Noise from existing plant and equipment can often be reduced by modification or by the application of improved sound reduction methods, but this should only be carried out after consultation with the manufacturer. Suppliers of plant will often have ready-made kits available and will often have experience of reducing noise from their plant.

For steady continuous noise, such as that caused by diesel engines, it might be possible to reduce the noise emitted by fitting a more effective exhaust silencer system or by designing an acoustic canopy to replace the normal engine cover. Any such project should be carried out in consultation with the original equipment manufacturer and with a specialist in noise reduction techniques. The replacement canopy should not cause the engine to overheat nor interfere excessively with routine maintenance operations.

It might be possible in certain circumstances to substitute electric motors for diesel engines, with consequent reduction in noise. On-site generators supplying electricity for electric motors should be suitably enclosed and appropriately located.

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; this is generally a maintenance issue.

Impact noise during steel construction can be a nuisance. Direct metal-to-metal contact should be minimized.

8.2.4 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 machine or process to be enclosed and their ventilation requirements.

Materials suitable for constructing enclosures are listed in Annex B, which also includes a design for an acoustic shed. When it is necessary to enclose a machine or process and its operator(s) in an acoustic enclosure or building, precautions should be taken to protect the operator(s) from any consequential hazard.

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.

8.2.5 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 is necessary when work has to be carried out at night but it might be possible to carry out quiet activities during that time.

Machines such as cranes that might 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 wastes energy.

Plant from which the noise generated is known to be particularly directional should, wherever practicable, be orientated so that the noise is directed away from noise-sensitive areas. Acoustic covers to engines should be kept closed when the engines are in use and idling. If compressors are used, they should have effective acoustic enclosures and be designed to operate when their access panels are closed.

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

When a site is in a residential environment, lorries should not arrive at or depart from the site at a time inconvenient to residents.

In certain types of piling works there will be ancillary mechanical plant and equipment that might be stationary, in which case care should be taken in location, having due regard also for access routes. Stationary or quasi-stationary plant might include, for example, support fluid preparation equipment, grout or concrete mixing and batching machinery, lighting generators, compressors, welding sets and pumps. When appropriate, screens or enclosures should be provided for such equipment. Additional mitigation might be required at night, e.g. by moving plant away from sensitive areas to minimize disturbance to occupants of nearby premises.

8.2.6 Maintenance

Regular and effective maintenance by trained personnel is essential and will do much to reduce noise from plant and machinery. Increases in plant noise are often indicative of future mechanical failure.

Sound-reducing equipment can 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.

8.3 Controlling the spread of noise

8.3.1 General

If noisy processes can be avoided, then the amount of noise reaching the noise-sensitive area will be reduced. Alternative ways of doing this are either to increase the distance between the noise source and the sensitive area or to introduce noise reduction screens, barriers or bunds.

8.3.2 Distance

Increasing the distance from NSPs is often the most effective method of controlling noise. This might 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 F.

Stationary plant such as compressors and generators should be located away from any noise-sensitive area.

8.3.3 Screening

On sites where it is not possible to reduce a noise problem by increasing the distance between the source and receiver, screening might have to be considered. For maximum benefit, screens should be close either to the source of noise (as with stationary plant) or to the listener. Careful positioning of noise barriers, such as bunds or noise screens, can bring about significant reductions in noise levels, although account should be taken of the visual impact of such barriers. Planting of shrubs or trees can have a beneficial psychological effect but will do little to reduce noise levels unless the planting covers an extensive area. Annex F 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. It might be necessary for safety reasons to place a hoarding around the site, in which case it should be designed taking into consideration its potential use as a noise screen. Removal of a direct line of sight between source and listener can be advantageous both physically and psychologically.

Site buildings such as offices and stores can be grouped together to form a substantial barrier separating site operations and nearby NSPs. 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. The construction of a bund can be a noisy activity and should be planned carefully, e.g. it might be possible to construct the outer side of the bund first so that remaining work on the bund is shielded from NSPs. When earth barriers are not practicable due to lack of space, it might 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, position relative to the noise source and to the sensitive area, and the material from which it is constructed. Further guidance on this is given in Annex B.

8.4 Noise control targets

All reasonably practicable means should be employed to ensure the protection of local communities and of people on construction sites, from detrimental effects of the noise generated by construction operations. The means employed should be determined by local circumstances and can include the methods described in **8.2** and **8.3**.

NOTE 1 Section 60 of the Control of Pollution Act 1974 [9] specifies the matters to which local authorities will have regard when serving a notice imposing requirements to limit noise and vibration emission from sites.

NOTE 2 Annexes C and D give guidance on noise levels produced by site equipment and activities, and Annex F describes methods of estimating noise from construction sites. The information contained in these annexes is intended to assist with the prediction of the levels of noise likely to emanate from a proposed construction site and to provide a useful reference when the setting of noise limits is being considered.

NOTE 3 [A1) Specific limits for noise from surface mineral extraction and production for England are detailed in the Technical Guidance to the National Planning Policy Framework [15]; there are no similarly defined limits for Scotland or Wales. (A1]

Those seeking to determine suitable noise control targets for construction operations should be aware of the particular noise problem that can occur when such operations take place in existing buildings that are either occupied or contiguous with occupied buildings. Vibration introduced directly into the structure by equipment such as breakers, hammers and drills might attenuate only slowly as it is transmitted through the structure and might therefore produce unacceptable levels of noise in rooms remote from the source. In particularly sensitive situations, it might be necessary to use alternative techniques and equipment. (See also **6.3**.)

Monitoring of noise at sites where noise is an issue should be regarded as essential. Measurement may be carried out for a number of reasons, including the following:

a) to allow the performance of noise control measures to be assessed;
b) to ascertain noise from items of plant for planning purposes;
c) to provide confirmation that planning requirements have been complied with.

Monitoring positions should reflect the purpose for which monitoring is carried out.

Monitoring to ascertain whether an item of plant or particular process is meeting an anticipated noise criterion or if noise control methods are working, might require measurements to be carried out close to the plant or process to avoid undue interference from other noise sources.

Monitoring to confirm that planning conditions imposed to protect local occupants have been met may be undertaken at NSPs or at the site boundary, with a correction applied. The choice of noise measurement locations to be included in the planning conditions should reflect the requirement to accurately assess the noise.

Monitoring is the responsibility of the site operator and should be carried out by suitably trained personnel.

NOTE 4 Joint monitoring between the site operator and the local authority is possible.

8.5 Noise control from piling sites

8.5.1 General

Increased mechanization has meant the use of more powerful and potentially noisier machines. Noise levels can be unacceptable in many instances, and reductions in noise level 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 noise-sensitive areas.

Guidance on types of piling is given in Annex H.

Those undertaking piling works should endeavour to ascertain the nature and levels of noise produced by the mechanical equipment and plant that will be used (see Tables C.3, C.12, D.4 and D.5). They should then take appropriate steps to reduce either the level or the annoying characteristics, or both, of the noise, following the recommendations given in **8.3.3**.

Impact noise when piling is being driven can be reduced by introducing a non-metallic dolly between the hammer and the driving helmet. This will prevent direct metal-to-metal contact, but will also modify the stress wave transmitted to the pile, possibly affecting the driving efficiency. The energy absorbed by the dolly will appear as heat. Further noise reduction can be achieved by enclosing the driving system in an acoustic shroud. Several commercially available systems employ a partial enclosure arrangement around the hammer. It is also possible to use pile driving equipment that encloses the hammer and the complete length of pile being driven, within an acoustic enclosure.

8.5.2 Factors to be considered when setting noise control targets

NOTE 1 The construction industry is generally innovative and constantly developing, and there might be proprietary systems available at the time of tender that were not known or available at the planning stage.

*NOTE 2 Factors that can affect the acceptability of noise and the degree of mitigation required are described in **6.3**. The present subclause provides information specifically related to piling works and should be read in conjunction with **6.3**.*

8.5.2.1 Selection of piling method

NOTE Examples of typical noise levels associated with the different methods of piling are given in Tables C.3, C.12, D.4 and D.5.

The selection of a method to be used for the installation of piles will depend on many factors (see Annex H for types of piling). A decision regarding the type of pile to be used on a site should not be governed solely by noise, but should also take into account criteria such as loads to be carried, strata to be penetrated and the economics of the system, e.g. the time it will take to complete the installation and other associated operations such as soil removal. In some cases, adjacent land uses can play a significant role in the choice of piling technique, e.g. due to the effects of noise.

It might not be possible for technical reasons to replace a noisy process by a quieter alternative. Even if it is possible, the adoption of a quieter method might 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.

8.5.2.2 Types of noise

On typical piling sites the major sources of noise are mobile. Therefore, the noise received at any control points will 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 noise. Air and diesel hammers also produce impulsive noise although their striking rates can be much higher than with drop hammers. With bored or pressed-in piling methods the resultant noise is continuous rather than impulsive.

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, clanking of locking kelly bars, and ringing of piles.

8.5.2.3 Duration of piling works

*NOTE See also **6.3**c).*

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 might represent only a part of the piling period. Furthermore, the noisiest part of the pile construction process might occur at each individual pile location only for a short period of time.

8.5.2.4 Hours of work

*NOTE See also **6.3**d).*

When noise impacts are to be controlled by imposing restrictions on working hours the specialized nature of some piling works should be considered, which might necessitate a longer working day. This is especially necessary for large diameter concrete bored piles and diaphragm walls.

Additionally, the acceptable hours for the residents and occupiers of a particular area should also be considered.

Developers should have regard to likely restrictions to be placed on them when considering piling techniques, and should liaise with local authorities at an early stage.

8.5.2.5 Methods of monitoring and control on piling sites

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 without placing undue restriction on the activities.

Steady noise levels should normally be expressed in terms of the [A1] $L_{\mathrm{Aeq},\,T}$ [/A1] 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 [A1] $L_{\mathrm{Aeq},\,T}$ [/A1] or the one percentile exceedance level [A1] $L_{\mathrm{A01},\,T}$ [/A1] over one driving cycle or the [A1] L_{Amax} [/A1]. Where [A1] $L_{\mathrm{A01},\,T}$ [/A1] or [A1] L_{Amax} [/A1] is specified, the F time weighting should be used.

The difference between limits set in terms of [A1] $L_{\mathrm{A01},\,T}$ [/A1] and [A1] $L_{\mathrm{Aeq},\,T}$ [/A1] will depend on the striking rate of the pile driver.

Those who wish to use the data for [A1⟩ $L_{Aeq,\,T}$ ⟨A1] in Annexes C and D to estimate the corresponding value of [A1⟩ $L_{A01,\,T}$ ⟨A1] should note the following approximate relationships [all measurements in dB(A)]:

a) [A1⟩ $L_{A01,\,T}$ ⟨A1] = [A1⟩ $L_{Aeq,\,T}$ ⟨A1] + 11 for pile drivers such as drop hammers with a slow striking rate (typically 20 to 25 blows per minute);

b) [A1⟩ $L_{A01,\,T}$ ⟨A1] = [A1⟩ $L_{Aeq,\,T}$ ⟨A1] + 9 for pile drivers using hydraulic hammers with an intermediate striking rate (typically 40 to 50 blows per minute);

   and

c) [A1⟩ $L_{A01,\,T}$ ⟨A1] = [A1⟩ $L_{Aeq,\,T}$ ⟨A1] + 5 for air hammers with a fast striking rate (typically more than 80 blows per minute).

There are no general empirical relationships between [A1⟩ L_{Amax} ⟨A1] and [A1⟩ $L_{Aeq,\,T}$ ⟨A1].

The monitoring of noise might not be required if it can be demonstrated by calculation or manufacturer's data that the chosen method of pile installation will not exceed the noise target. Annexes C and D provide guidance of measured noise levels for different piling methods. Annex C gives up-to-date guidance, whereas Annex D gives historic data tables taken from the 1997 edition of BS 5228-1 and the 1992 edition of BS 5228-4. The tables in Annex D are intended for use where no equivalent data exists in Annex C.

8.6 Noise control from surface coal extraction

8.6.1 General

Opencast coal sites can pose a greater diversity of problems of noise control compared with most other types of industrial activity for the following reasons.

a) Apart from some ancillary operations, they are carried out entirely in the open and can extend over a wide area.

b) They are of variable duration from a few months to several years, and in some cases sites in adjacent areas can follow one another in succession over a prolonged period.

c) A wide variety of activities are carried out involving the following phases:

   1) geological and geotechnical exploration;
   2) preliminary operations to establish the site;
   3) soil stripping and removal of overburden;
   4) coaling, coal preparation, storage and dispatch;
   5) backfilling and final site restoration;
   6) rehabilitation of final land form to public amenity, agriculture or other subsequent development.

d) A wide range of earth-moving and specialized plant is employed, the use of which varies significantly at different phases and times and at different heights and depths within the site.

Prior to making an application for planning permission, an applicant should discuss with the Mineral Planning Authority (MPA) and the appropriate department of the local authority (see Annex A) the predicted noise levels from the proposed site and the control measures to be implemented. This will highlight at an early stage any noise and vibration issues that need to be addressed. The predicted noise levels and proposed control measures should be included in the application documentation.

Local residents and other interested parties should also be consulted at this stage.

8.6.2 Site planning

In planning the working of the site, account should be taken of the effect of the proposed working method and site layout on adjacent NSPs. Where necessary, alternative methods or arrangements which have the least noise impact should be employed if economically viable.

8.6.3 Location of site elements

With due consideration of the topography of the area and natural screening effects, care should be taken in the siting of the following:

a) access points;

b) limit of excavation;

c) baffle mounds;

d) acoustic fences;

e) overburden mounds;

f) internal haul roads;

g) plant yards and maintenance facilities;

h) coal screening and washing plants;

i) pumps, generators and static plant;

j) stocking areas and loading facilities;

k) off-site coal haulage routes; and

l) site amenities and car parking.

NOTE The location and design of access points have to be agreed with the highway authority and the Mineral Planning Authority.

Access points should be located with due regard to the proximity of NSPs.

The limit of excavation is determined by a wide range of geological and engineering constraints such as the location, nature and quality of the coal, the characteristics and stability of the strata and the existence of faults and other features. In addition to these constraints, further reductions to the limit of excavation should be considered where necessary, e.g. to provide additional space around the excavation area for baffle mounds or other screening methods or to utilize fully the natural screening effects of the existing topography.

Baffle mounds should be sited so as to provide protection to NSPs and should be extended in length beyond the limits of the premises to be protected. To obtain the best protection, they should be sited to obscure the line of sight to the noise sources and to maximize the path differences. Guidance on the noise reduction to be expected from baffle mounds and similar barriers is given in Annex F.

Where protection to NSPs is required, and where construction of a baffle mound is impracticable, the provision of another type of acoustic barrier should be considered where appropriate. Visual considerations should be taken into account.

Due to the highly visible and intrusive nature of operations involved in the construction and removal of overburden mounds, they should always be sited as far from NSPs as possible unless they provide acoustic benefits that are necessary. Their height should be restricted where necessary to avoid visual issues.

During construction of an overburden mound, the faces nearest to NSPs should be progressively raised to form an effective baffle so that the bulk of tipping is carried out behind those faces. Similarly, those faces should be retained for as long as practicable during removal of the mounds to provide screening for the bulk of the removal operations.

Internal haul roads should be located as far as practicable from NSPs and should be appropriately screened. The roads should have easy gradients and gradual turns to reduce noise emission from vehicles and mobile plant.

Overburden mounds should be located as far from NSPs as is reasonably practicable, except where they are used as baffle mounds.

Site amenities, plant yards, maintenance areas, coal screening/washing plants, stocking and loading facilities should be sited as far from NSPs as practicable and should be screened from NSPs.

Where coal is to be transported from the site by road, the route should be carefully selected to minimize the impact on NSPs even if this results in an increased haulage distance.

8.6.4 Working methods

The phasing of the works and the working methods will have a major bearing on the control of noise. The following factors will have a particularly significant effect:

a) depth of the coal seams;

b) direction of working;

c) height, method of construction and location of overburden mounds;

d) location, gradient and screening of site roads;

e) plant to be employed;

f) working hours;

g) rate of production;

h) use and control of blasting.

Working methods should be adopted that allow for early screening of NSPs from the subsequent operations. Where practicable, noisy static site elements should be located to take advantage of the screening effects of overburden and soil mounds.

Once the limit of excavation and the maximum depth of the coal seams to be extracted have been determined (see **8.6.3**), a direction of working and phasing of operations should be deployed that reduces the transmission of noise from the site.

There is a wide range of variables that influence these activities, therefore it is not possible to be prescriptive for individual sites and a common sense approach should be adopted. For example, it might be useful to retain an area of high ground within an excavation area of a site to screen other site activities until the latter stages of a particular phase of an operation, whereas in other cases the material from the high ground might be more effectively utilized as screening material in an earlier phase of the operation.

8.6.5 Selection of plant

The characteristics of noise emissions from each item of plant, and their collective effect, should be assessed during the selection process for the acquisition of plant. Where practicable, plant should be selected which will have the least impact in terms of noise. For example, where electric plant is to be deployed on site, a mains supply is likely to produce less noise than on-site generators. Information concerning sound power levels for specific items of plant is given in Tables C.6, D.10 and D.11.

8.6.6 Deployment of plant

The movement of plant on and off the site should be restricted as far as practicable to within the agreed working hours for the site.

The time taken to carry out noisy operations near occupied properties outside the site should be reduced to as short a period as possible.

8.6.7 Hours of work

*NOTE See also **6.3**d).*

The restriction of working hours for any operation where emissions of noise might have an adverse effect on the occupants of NSPs should be considered in preference to the sterilization of coal reserves. Coal haulage by road from such sites should be limited to between 07.00 h and 19.00 h, unless local circumstances require otherwise. However, working hours both for coal production and HGV activity on site are likely to be defined through conditions attached to the planning consent for the coal site.

8.6.8 Noise reduction

Noise sources likely to be encountered on site include trucks, loaders, dozers, excavators, sirens, screening and crushing plant, pumps, draglines, dumpers, drills and dredgers. Each site has its own particular characteristics so appropriate methods of noise reduction should be determined for each individual site. The general guidance on noise control given in **8.2** and **8.3** is applicable to surface coal extraction sites.

8.6.9 Blasting

Blasting can be an emotive issue for residents around an opencast site. Good liaison between operator and residents is essential to prevent unnecessary anxiety. Wherever possible, the operator should inform each resident of the proposed times of blasting and of any deviation from this programme in advance of the operations.

On each day that blasting takes place it should be restricted as far as practicable to regular periods.

Blasthole drilling can cause excessive noise emissions, particularly when carried out at or near ground level and close to the site boundary. The choice of appropriate drilling rigs, such as down-the-hole hammers or hydraulic drifters as opposed to compressed air drifters, will reduce the impact of noise emissions from this activity.

Each blast should be carefully designed to maximize its efficiency and reduce the transmission of noise.

Initiation using detonating fuse on the surface can cause problems associated with air overpressure (see Annex **I**).

8.6.10 Coal disposal sites

After coal is excavated from an opencast site, it is sometimes taken to a coal disposal site. This can be located within an opencast site, adjacent to an opencast site or at some distance, near main line rail and road facilities, and can serve more than one site. At a coal disposal site any, all or a combination of the following can take place: coal washing, crushing, screening, blending, storage in hoppers or on the ground in bunds and dispatch from the disposal point by rail or road vehicles.

All of these activities generate noise. The major sources are the crushing and screening processes, the reception and disposal hoppers, mobile site plant and road and rail traffic.

Coal disposal sites are areas of major industrial activity and should be located at distance from noise-sensitive areas.

If there are any NSPs in close proximity, effective screening of mobile plant and traffic by baffle mounds is likely to be required, and appropriate provision should be made for the effective insulation of fixed plant and equipment, such as the use of lined chutes and properly designed acoustic enclosures.

8.6.11 Limitations on emissions of noise from sites

Opencast coal extraction and associated works can take place in remote to semi-urban areas. Each site and situation should be assessed for noise mitigation and control requirements based upon the specifics of the activity and the surrounding area. When the site is adjacent to NSPs, the MPA or Secretary of State can impose conditions including specific noise limits.

Guidance on criteria for the setting of noise control targets is given in Clause **6**.

Limitations on working hours for the site, or part of it, and the restriction of the noisier activities to less sensitive times or days, can be employed as a means of limiting the impact of noise and vibration from opencast coal sites.

8.7 Noise control from surface mineral (except coal) extraction sites

Although there are some similarities with opencast coal extraction (see **8.6**), surface mineral extraction sites can present different problems of noise control compared with most other industrial activity for the following reasons.

a) Operations are to a large extent carried out entirely in the open.

b) Activities are of variable duration, varying from a few months to many decades.

c) On completion, surface mineral extraction sites are restored either to their original condition or to an appropriate state after use.

d) A wide variety of activities, employing different types of plant, are carried out on surface mineral extraction sites. The intensity and character of any noise can vary at different phases of work, at different times and under differing conditions of, for example, topography, geology, climate and methods of operation. Particular problems have been encountered with audible warning signal devices such as sirens and audible reversing alarms.

e) Minerals can only be worked where suitable resources exist. Resources might be present in close proximity to NSPs. Under these circumstances, such premises should be protected as far as is practicable from the adverse effects of noise.

A wide variety of different minerals is produced in Britain by surface extraction methods. These include natural and crushed sand, gravel and rock (sedimentary, igneous and metamorphic) produced as aggregates and building stone for the construction industry. In addition to some of the foregoing, slate, chalk, china clay, ball clay, fuller's earth, silica sands and various other minerals are essential raw materials to other British industries and world markets. The methods of working of each of these different materials vary greatly according to its type, the geology and location and the end uses for which the material is intended. The nature of any impacts from noise therefore need to be considered in the context of the relevant site-specific factors, bearing in mind the general advice contained in this clause.

NOTE 1 Further government guidance on these aspects is provided in [A1⟩ the Technical Guidance to the National Planning Policy Framework [15] ⟨A1].

As with coal sites, most of the noise from surface mineral extraction sites is generated by excavating plant, earth-moving plant, blasting activities, processing plant and other heavy traffic. Much of this plant is large and powerful but not necessarily noisy. Measures to control noise are generally necessary where sites are located in the vicinity of NSPs, for the benefit of both the public and the industry.

NOTE 2 Guidance on noise from blasting is given in Annex I.

Blasting only occurs at a proportion of surface mineral extraction sites; generally only hard rock quarries. There are particular characteristics of blasting which require specific consideration of noise issues. Whilst drilling blast holes is associated with intermittent noise, blasting creates noise which is of very short duration, with a frequency of events varying from a small number per year to several times per day, depending on the nature and size of the extraction operation. Blasting results in airborne noise and groundborne vibration and both effects have more familiar parallels, for example, wind and thunder and pneumatic drills.

As with coal sites, typical mineral extraction operation involves stripping of topsoil and removal of overburden, excavation and processing of the material to be extracted, transportation of material within the site and to markets and subsequent restoration of the land. To allow specific work, e.g. soil stripping and baffle mound construction, to be carried out, higher noise level limits for short periods of time might need to be agreed. Guidance is given in [A1⟩ the Technical Guidance to the National Planning Policy Framework [15] ⟨A1]. It might be preferable for occupants of NSPs to have a shorter, higher level of noise exposure than a longer term lower level noise exposure. The discussion and agreement of this with the Mineral Planning Authority (MPA) and local residents might be required.

Criteria can be set from one or more of the following:

1) individual items of plant;
2) at the site boundary;
3) at local NSPs; and/or
4) at mutually agreed monitoring positions.

A correction factor (subtraction of 3 dB) is necessary to convert a measurement at a façade if the measurement is to be interpreted for the free field.

Annex A (informative) Legislative background

A.1 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 might affect their premises. In addition, there are two significant statutory remedies which enforcing authorities can 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 [10] contains the mandatory powers available to local authorities within England and Wales in respect of any noise 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 can 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 might be aggrieved by the existence of a statutory nuisance and in these circumstances the court might follow the procedures described in the previous paragraph. Similar procedures to the above, for the control, in Scotland, of statutory nuisances caused by noise, are found under Sections 58 and 59 of the Control of Pollution Act 1974 [9]. In Northern Ireland the relevant equivalent provisions are contained in the Pollution Control and Local Government (Northern Ireland) Order 1978 [17].

Sections 60 and 61 of the Control of Pollution Act 1974 [9] give local authorities in England, Scotland and Wales special powers for controlling noise 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 [17]. 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 **A.3.3**.

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.

Under Part III of the Control of Pollution Act 1974 [9], Section 71 requires the Secretary of State to approve a code of practice for the execution of works which come within the scope of Section 60.

A.2 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. The most recent of these, Directive 2000/14/EC [11] and Amending Directive 2005/88/EC [18], replaced a number of earlier directives, and have been implemented by regulations in the UK. Details of the directives and corresponding regulations are given in **A.3**.

A.3 UK Acts and Regulations

A.3.1 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 [12].

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 might 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 might 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 [19].

A.3.2 Control of Noise at Work Regulations 2005

NOTE These regulations were made under the Health and Safety at Work etc Act 1974 [12].

The Control of Noise at Work Regulations 2005 [2] implement Directive 2003/10/EC [20].

The main requirements are triggered by four "action levels": daily personal noise exposures of 80 dB(A) and 85 dB(A) (the lower and upper exposure action levels respectively), and 135 dB(C) and 137 dB(C) (the lower and upper peak action levels respectively). There are also daily exposure and peak exposure limits of 87 dB(A) and 140 dB(C) respectively, which take into account the effect of wearing hearing protection and which the regulations do not allow to be exceeded. These regulations are concerned with the protection of people at work, and do not, therefore, deal with exposure to noise for the public.

Regulation 5 places a duty upon employers to carry out an assessment in the workplace to ascertain whether exposures are at or above the first action level. Such assessments are expected to identify which employees are exposed, and to provide enough information to facilitate compliance with duties under Regulations 6, 7 and 10. Under Regulation 6, when any employee is exposed to levels at or above the upper daily exposure action level or upper peak exposure action level, the employer is required to 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 and the demarcation of hearing protection zones are covered by Regulation 7, and Regulation 9 introduces a specific duty on employers to carry out health surveillance including audiometric testing, where there is a risk to health.

Under Regulation 10, 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 might 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 Control of Noise at Work Regulations 2005 [2].

In Northern Ireland, equivalent powers are contained in the Control of Noise at Work Regulations (Northern Ireland) 2006 [21].

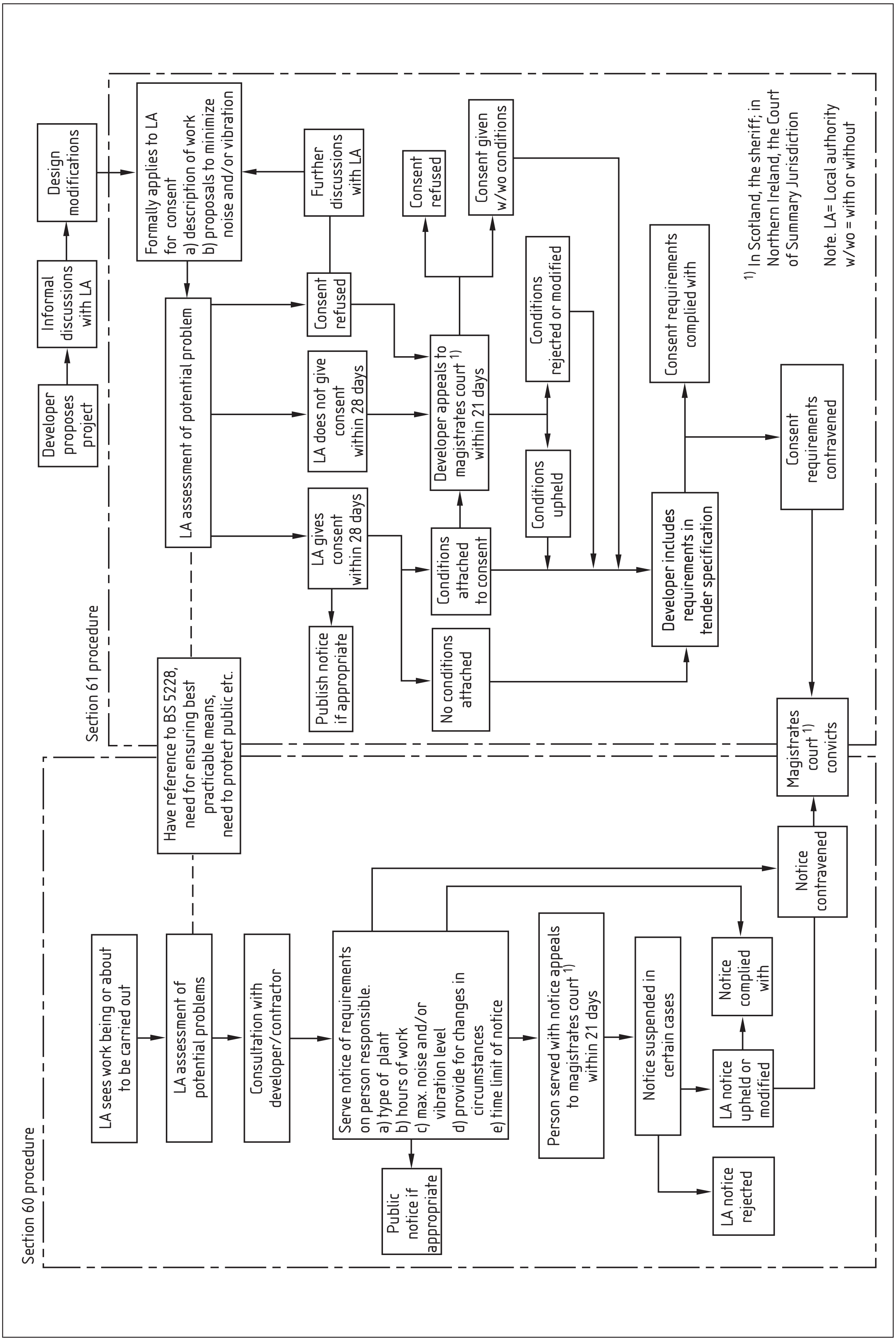
A.3.3 Control of Pollution Act 1974 and Environmental Protection Act 1990

A.3.3.1 General

The Control of Pollution Act 1974 [9] and the Environmental Protection Act 1990 [10] give local authorities powers for controlling noise and vibration from construction sites and other similar works. These powers can 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 [17]. Under the 1974 Act, 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 vibration control requirements known. Because of an emphasis upon answering noise and vibration questions before work starts, implications exist for traditional tender and contract procedures (see **A.3.3.4**).

The procedures available under the Control of Pollution Act 1974 [9] for the control of construction noise are illustrated in the flow diagram shown in Figure A.1.

Figure A.1 **Procedures to control construction noise under the Control of Pollution Act 1974**



A.3.3.2 Notice under Section 60 of the Control of Pollution Act 1974

Section 60 of the Control of Pollution Act 1974 [9] 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 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 functions.

a) Specify the plant or machinery that is or is not to be used. However, before specifying any particular methods or plant or machinery, the 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 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 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 the following:

1) the relevant provisions of any code of practice issued and/or approved under Part III of the Control of Pollution Act 1974 [9];

2) the need for ensuring that the best practicable means are employed to minimize noise and vibration. "Best practicable means" recognizes that there are technical and financial limits on action that might reasonably be required to abate a nuisance;

3) other methods, plant or machinery that might be equally effective in minimizing noise and 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 vibration.

A person served with such a notice can appeal to a magistrates court or, in Scotland, a Sheriff or, in Northern Ireland, 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 also give local authorities discretion not to suspend a notice even when one or other of these conditions is met, if the noise 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.

The regulations governing appeals are:

- the Control of Noise (Appeals) Regulations 1975 [22];
- the Statutory Nuisance (Appeals) Regulations 1990 [23] as amended;
- in Northern Ireland, the Control of Noise (Appeals) Regulations (Northern Ireland) 1978 [24];
- in Scotland, the Control of Noise (Appeals) (Scotland) Regulations 1983 [25].

A.3.3.3 Consents under Section 61 of the Control of Pollution Act 1974

Section 61 of the Control of Pollution Act 1974 [9] concerns the procedure adopted when a contractor (or developer) takes the initiative and approaches the local authority to ascertain its noise and vibration requirements before construction work starts. (See also **A.3.3.2**.)

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 60 of the Control of Pollution Act 1974 [9] or Section 80 of the Environmental Protection Act 1990 [10], so long as the consent remains in force and the contractor complies with its terms. Compliance with a consent does not, however, mean that nuisance action cannot be taken under Section 82 of the Environmental Protection Act 1990 or under common law. A consent can be used as a defence in appeals against an abatement notice [Statutory Nuisance (Appeals) Regulations 1990 [23] as amended].

An application for a consent has to be made at the same time as, or later than, any request for approval under the Building Regulations 2000 [26], the Building Standards (Scotland) Regulations 1990 [27] or the Building Regulations (Northern Ireland) 2000 [28], or for a warrant under Section 6 of the Building (Scotland) Act 2003 [29], when this is relevant. Subject to this constraint, there are obvious advantages in making any application at the earliest possible date. There might be advantages in having informal discussions before formal applications are made.

An applicant for a consent is expected to give the local authority as much detail as possible about the works to which the application relates and about the method or methods by which the work is to be carried out. Information also has to be given about the steps that will be taken to minimize noise and vibration resulting from the works.

Provided that a local authority is satisfied that proposals (accompanying an application) for minimizing noise and vibration are adequate, 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 an application being lodged, 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 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, applicant is required to take all reasonable steps to bring the terms of consent to the notice of that other person; failure to observe the terms of a consent is deemed to be an offence under the Control of Pollution Act 1974 [9].

Section 61 also requires provision to be made for emergencies.

A.3.3.4 Contractual procedures

It is likely to be to the advantage of a developer or contractor, or an employer or its agent, who intends to carry out construction or demolition work, to take the initiative and apply to the local authority for consents under the Control of Pollution Act 1974 [9].

An employer or its agent can choose to place the responsibility on the contractor to secure the necessary consents and can impose this requirement through formal contractual arrangements.

This could have implications for traditional tender and contract procedures because the local authority's noise and vibration requirements (in addition to any separate requirements defined by the employer) can be ill-defined at tendering and contract award stage. In these circumstances, any tendering contractor needs to endeavour to identify, quantify and accommodate the level of risk (in terms of both construction methodology and cost) prior to participating in the tendering process.

When a person for whom construction work is to be carried out has already sought and obtained consent from the local authority, the local authority's requirements need to be incorporated in the tender documents so that tenderers are aware of any apparent constraints arising from the consent.

A.3.4 Land Compensation Act 1973 (as amended), Highways Act 1980, Land Compensation, (Scotland) Act 1973, Land Acquisition and Compensation (Northern Ireland) Order 1973

The Noise Insulation Regulations 1975 [30], Noise Insulation (Scotland) Regulations 1975 [31] and Noise Insulation (Northern Ireland) Regulations 1995 [32], made under the powers contained respectively in the Land Compensation Act 1973 [33], the Land Compensation (Scotland) Act 1973 [34] and the Land Acquisition and Compensation (Northern Ireland) Order 1973 [35], allow a highway authority to provide insulation for dwellings and other buildings used for residential purposes by means of secondary 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 [36] and the Land Compensation (Scotland) Act 1973 [34] 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, e.g. the installation of noise barriers, to mitigate the adverse effects of works of construction or improvement on the surroundings of a highway.

A.3.5 The Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1995

The Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1995 [37] give a discretionary power to railway authorities to provide insulation or grant for insulation where noise from the construction of a new or altered railway is expected seriously to affect residential and other buildings for a substantial time.

A.3.6 Other relevant UK legislation

A.3.6.1 Surface coal extraction by opencast methods

[A1] Opencast coal mining is governed by legislative instruments and government policy. With regard to policy, guidance is contained in MPG 9 [40] on noise, blasting and vibration limits for blasting (as example conditions) and in the Technical Guidance to the National Planning Policy Framework [15] on noise limits for general minerals extraction and production. [/A1]

The legislative framework consists of several elements, the most important of which is the Coal Industry Act 1994 [41]. Other key legislation includes the Coal Industry Nationalisation Act 1946 [42], the Opencast Coal Act 1958 [43], the Town and Country Planning Act 1990 [44] and the Planning and Compulsory Purchase Act 2004 [45].

Before 1984 the British Coal Corporation's sites were authorized by the Secretary of State for Energy. Since then for all opencast sites a planning permission has been required from the appropriate Mineral Planning Authority (MPA) or, on appeal or in respect of a call-in, from the Secretary of State for Communities and Local Government in England or the Scottish Minister for Scotland or the Minister for Environment, Planning and Countryside for Wales as appropriate.

Before making a planning application, the operator often undertakes extensive drilling and other explorations to prove the coal reserves. These operations are now governed by Clause **18** of the Town and Country Planning (General Development Procedure) Order 1995 [46]. Coal operators also require a licence from the Coal Authority if they wish to explore for coal.

NOTE Almost all coal in Great Britain is vested in the Coal Authority, a non-departmental public body created by the Coal Industry Act 1994 [41]. The authority is responsible for managing the non-operational aspects of the UK coal industry.

Since July 1988 almost all the British Coal Corporation's site applications and many larger sites applied for by other operators have been accompanied by an Environmental Statement. These are required under the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 [47]. The Environmental Statement examines the environmental implications of the proposed operations (noise, dust, visual impact, traffic, etc.) on the local community as well as the impact on the ecology and landscape of the site.

The MPA considers the application and, if satisfied that the proposals are acceptable in planning and environmental terms, approves it subject to conditions governing the site operations and restoration.

If the planning application is refused or not determined by the MPA, the operator can appeal to the Secretary of State for Communities and Local Government in England, the Minister for Environment, Planning and Countryside in Wales, or the Scottish Minister in Scotland, as appropriate. A public inquiry is held under an Inspector, and following the Inspector's report the Secretary of State in England or relevant Minister in Wales or Scotland, as appropriate, grants or refuses permission.

After an opencast site receives planning permission, an authorization from the local authority is also needed for the coal loading operations, which are Part B processes in accordance with the Regulations under Part 1 of the Environmental Protection Act 1990 [10].

All future coal mining operations will require a lease and licence from the Coal Authority under Part II of the Coal Industry Act 1994 [41]. Sites licensed by the British Coal Corporation before 31 October 1994 under Section 36 (2) of the Coal Industry Nationalisation Act 1946 [42] (as amended by the Coal Industry Act 1994), can, however, continue operations during the validity of those licences. Sites contained in the 1994 privatization packages have licences granted by the Government.

The previous limitation of 250 000 t on the amount of coal extracted from any one licensed opencast site was removed by the Coal Industry Act 1994.

Applicants for licences are responsible for securing the planning permission and other consents needed to work the coal, including rights to occupy the land and to disturb other minerals. Many opencast sites win significant quantities of other minerals, principally seams of fireclay beneath the coal seams. These operations also require planning permission.

A.3.6.2 Surface mineral extraction (except coal) sites

The principal legislation controlling the use of land for surface mineral extraction in Great Britain is provided by the Town and Country Planning Act 1990 [44] and the Town and Country Planning (Scotland) Act 1972 [48], both of which have been amended by the Planning and Compensation Act 1991 [49].

The primary planning legislation in Northern Ireland is the Planning (Northern Ireland) Order 1991 [50]. Acts of Parliament, rules and orders which are of relevance include the Environment Act 1995 [51] and the Planning and Compulsory Purchase Act 2004 [45]. There is also separate legislation controlling pollution, waste and statutory nuisance, much of which is now contained in the Environmental Protection Act 1990 [10].

The relevant planning authorities are as follows:

a) England: county councils, metropolitan borough councils, unitary authorities, the national park authorities and the broads authority, where appropriate;

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

c) Scotland: the local authority;

d) Northern Ireland: Department of the Environment for Northern Ireland.

In England, the Secretary of State for Communities and Local Government is responsible for setting out government policy on [A1) noise from mineral extraction and production, which is contained in the Technical Guidance to the National Planning Policy Framework [15] (A1].

In Wales, general policy is supplemented by Welsh Office guidance. Policy guidance in Scotland is provided by the Scottish Office in National Planning Policy Guidelines (NPPGs) and circulars, and advice on best practice in Planning Advice Notes (PANs). NPPG 4 [53], PAN 50 [54] and the associated PAN 50 Annex A [16], are of particular relevance to this standard. The Secretary of State for Communities and Local Government in England, the Scottish Minister for Scotland, and the Minister for Environment, Planning and Countryside in Wales, all have powers as defined by the legislation in relation to the submission of planning applications, determination of appeals and in respect of development plans.

Most minerals in Britain are privately owned and are worked by commercial operating companies. Sometimes, however, ownership of the land is divorced from the rights to extract the mineral. Mineral extraction, as a form of development, requires planning permission in order to be undertaken; guidance on the procedures being contained within MPG 2 [55], MPG 8 [56] and MPG 9 [40]. The Mineral Planning Authorities (MPAs), or on appeal the Secretary of State, will consider and either approve or refuse mineral planning applications according to their decision as to the acceptability of the proposals. In the case of an appeal, a public inquiry might be held and the Inspector (Reporter in Scotland) might determine the appeal or make a recommendation to the Secretary of State. All planning permissions are subject to conditions controlling relevant aspects of the development, including noise and vibration.

A.4 Local authorities

The local authorities exercising powers under Part III of the Control of Pollution Act 1974 [9] and Part III of the Environmental Protection Act 1990 [10] are as follows:

a) in England, the council of a district or a district or a London borough, the Common Council of the City of London, the Sub-Treasurer of the inner temple and the Under Treasurer of the Middle Temple;

b) in Wales, the council of a county or a county borough;

c) in Scotland, an islands or district council.

In Northern Ireland, district councils exercise similar functions under the Pollution Control and Local Government (Northern Ireland) Order 1978 [17].

The local authorities exercising planning powers are, 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 needs to 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 is often the environmental health department of the district or London borough council; in Scotland, the district or islands council; or in Northern Ireland, the Department of Environment (Northern Ireland) in Belfast.

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.

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 noise levels. Other simple noise control measures can provide useful reductions in overall site noise levels.

Table B.1 **Methods of reducing noise levels from construction plant**

Plant	**Noise reduction of plant**			**Alternative plant**
	Source of noise	**Possible remedies** (to be discussed with machine manufacturers)	**A-weighted sound reduction** dB	
Hammer drive piling equipment	Pneumatic/diesel hammer or steam winch vibrator driver	Enclose hammer head and top of pile in acoustic screen	5 to 10	Bored piling Vibratory system Drop hammer completely enclosed in box with opening at top for crane access Steel jacket completely enclosing drop hammer with dolly and polystyrene chips fed to impact surface to dissipate energy Pressed-in piling which generates its driving force from the frictional restraint of other piles
	Sheet pile	Acoustically dampen sheet steel piles to reduce levels of resonant vibration		
	Impact on pile	Use resilient pad (dolly) between pile and hammer head. Packing needs to be kept in good condition		
	Cranes cables, pile guides and attachments	Careful alignment of pile and rig		
	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 need to be kept closed. Use acoustic screens when possible		
Earth-moving plant: • bulldozer • compactor • crane • dump truck • dumper • excavator • grader • loader • scraper	Engine	Fit more efficient exhaust sound reduction equipment Manufacturers' enclosure panels need to be kept closed	5 to 10	Alternative super silenced plant might be available. Consult manufacturers for details

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

Plant	Noise reduction of plant			Alternative plant
	Source of noise	**Possible remedies** (to be discussed with machine manufacturers)	**A-weighted sound reduction** dB	
Compressors and generators	Engine Compressor or generator body shell	Fit more efficient sound reduction equipment Acoustically dampen metal casing Manufacturers' enclosure panels need to be kept closed	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
	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 needs to be obscured	Up to 10	
		Enclose compressor or generator in ventilated acoustic enclosure	Up to 20	
Pneumatic concrete breaker, rock drills and tools	Tool	Fit suitably designed muffler or sound reduction equipment to reduce noise without impairing machine efficiency	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
		Ensure all leaks in air line are sealed		
	Bit	Use dampened bit to eliminate ringing		
	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 needs to be obscured	Up to 10	
		Enclose breaker or rock drill in portable or fixed acoustic enclosure with suitable ventilation	Up to 20	
Rotary drills, diamond drilling and boring	Drive motor and bit	Use machine inside acoustic shed with adequate ventilation	Up to 15	Thermic lance

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

Plant	**Noise reduction of plant**			**Alternative plant**
	Source of noise	**Possible remedies** (to be discussed with machine manufacturers)	**A-weighted sound reduction** dB	
Riveters	Impact on rivet	Enclose work area in acoustic shed	Up to 15	Design for high tensile steel bolts instead of rivets
Pumps	Engine pulsing	Use machine inside acoustic enclosure with allowance for engine cooling and exhaust	Up to 20	
Batching plant	Engine	Fit more efficient sound reduction equipment on diesel or petrol engines Enclose the engine	5 to 10	Use electric motor in preference to diesel or petrol engine
	Filling	Do not let aggregate fall from an excessive height		
Concrete mixers	Cleaning	Do not hammer the drum		
Materials handling	Impact of material	Do not drop materials from excessive heights. Screen dropping zones, especially on conveyor systems. Line chutes and dump trucks with a resilient material	Up to 15	

B.2 Machinery enclosure design

The principles governing the design of covers for machinery are simple: for example, covers need to enclose machines as fully as possible (at least the noisy part), they need to possess adequate insulation so that noise energy does not readily pass through them, and they need to 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/m^2 is expected to give this insulation. See Table B.2 for a list of materials.

Table B.2 **Sound insulation characteristics of common building materials**

Material	**Thickness**	**Surface mass**	**Mean sound reduction index** (100 Hz to 3 150 Hz)
	mm	kg/m^2	dB
Fibre cement boards	6	12	26
Brickwork	113	220	35 to 40
Chipboard	18	12	26
Clinker blocks	75	100	23
Fibreboard (insulation board)	12	4	18
Compressed straw	50	17	28
Plasterboard	13	12	26
Plywood	9	4.5	24
Woodwool/cement slabs 50 mm thick, each face with 13 mm thick plaster	76	70	35

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 needs to be provided.

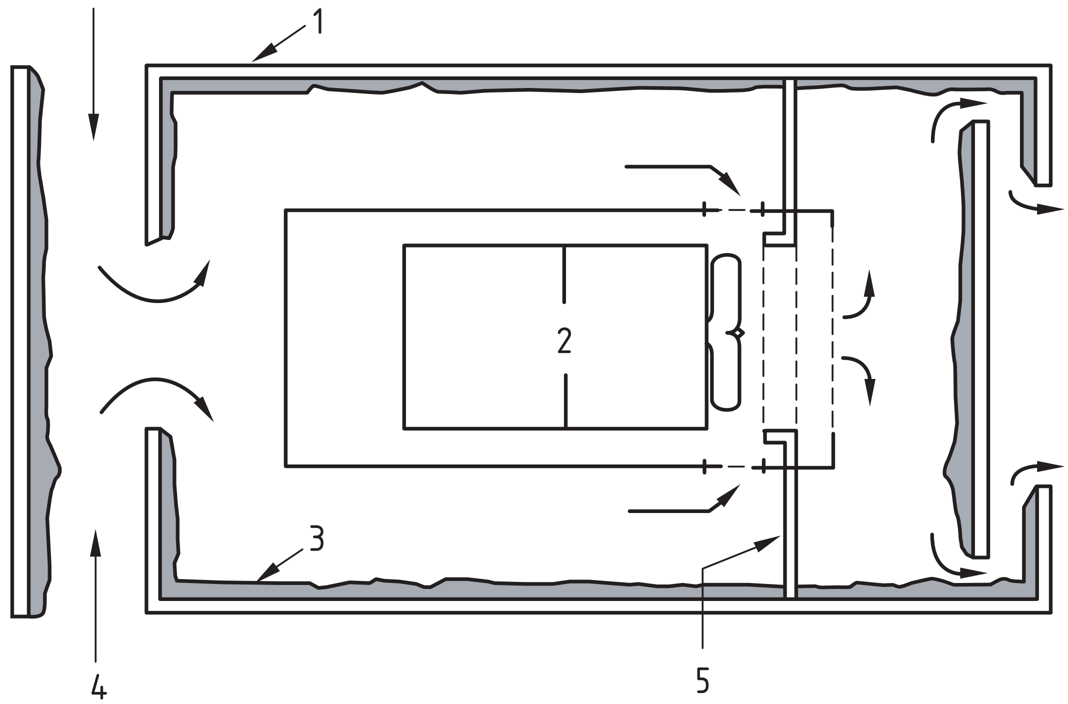
The sound-absorbent lining inside covers normally need to be at least 25 mm thick, unless the noise is almost entirely high frequency when 12 mm thickness might be sufficient. Useful inexpensive materials for the purpose are mineral wool or woodwool, though proprietary absorbent tiles, etc., can be used if preferred. See Table B.3 for a list of materials. Mineral wool needs to 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 normally needs to 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 has to 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. It is advisable to obtain advice from the manufacturer (of the machinery to be enclosed), to ensure that adequate ventilation is provided by the enclosure and that there is sufficient access for maintenance.

Table B.3 **Sound-absorbing materials for lining covers and enclosures**

Material	Thickness mm	Average absorption coefficient between 125 Hz and 4 000 Hz
Mineral wool	50	0.7 to 0.8
Straw slabs	50	0.4
Woodwool slabs	50	0.6

Figure B.1 **Example of machine enclosure**



Key

1 Enclosure
2 Machine
3 Sound-absorbent material
4 Air flow
5 Baffle

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 in the event of an electric cable strike occurring;

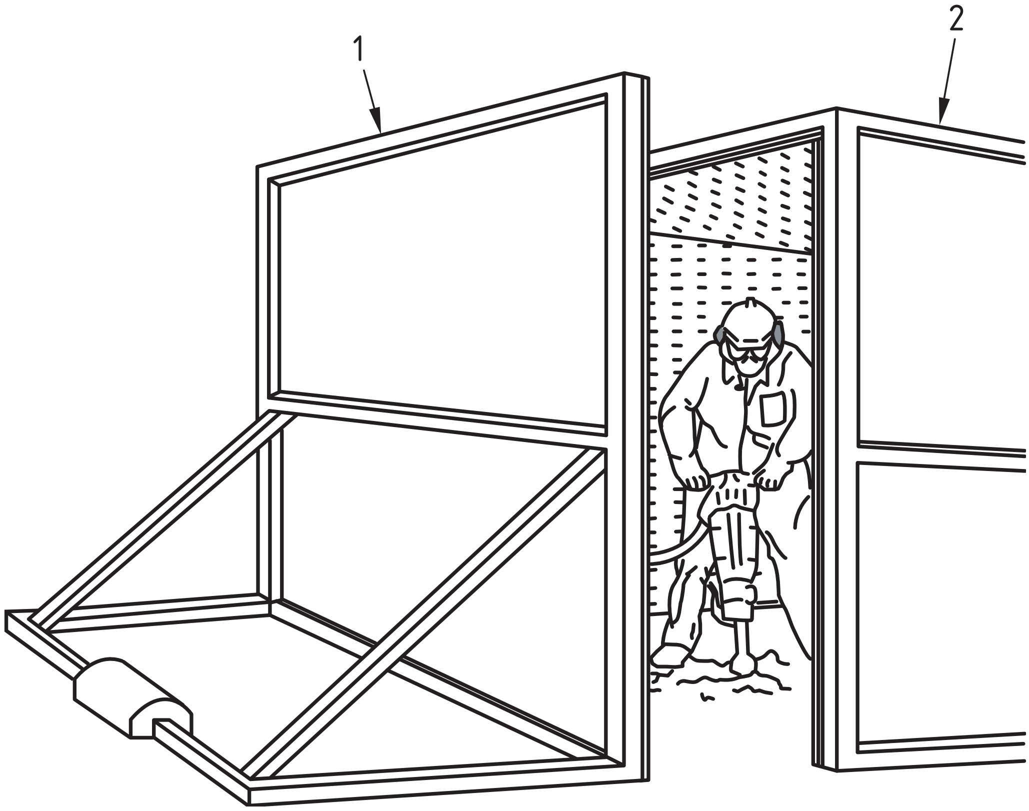
e) increased risk of dangerous accumulations of gas from a leak;

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 for the types of enclosure illustrated in Figure B.3.

Figure B.2 **Typical acoustic shed**



Key

1 Acoustic screen 2 m wide and 2.7 m high

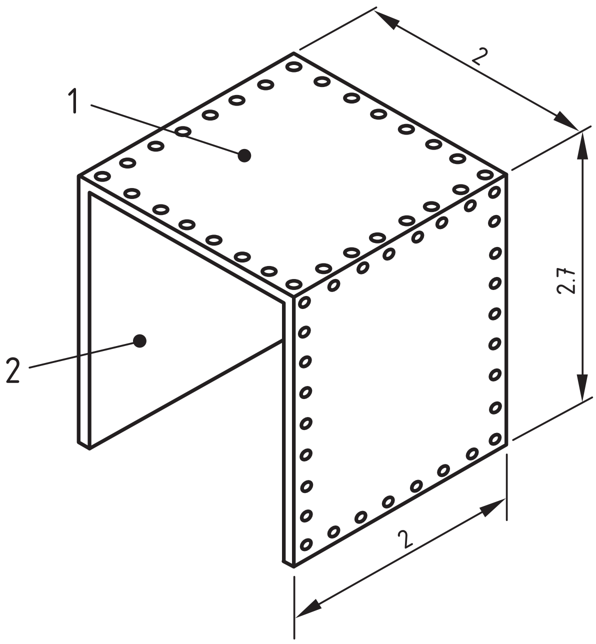
2 Acoustic shed 2 m square and 2.7 m high

Table B.4 **Measured sound reduction given by types of partial enclosure**

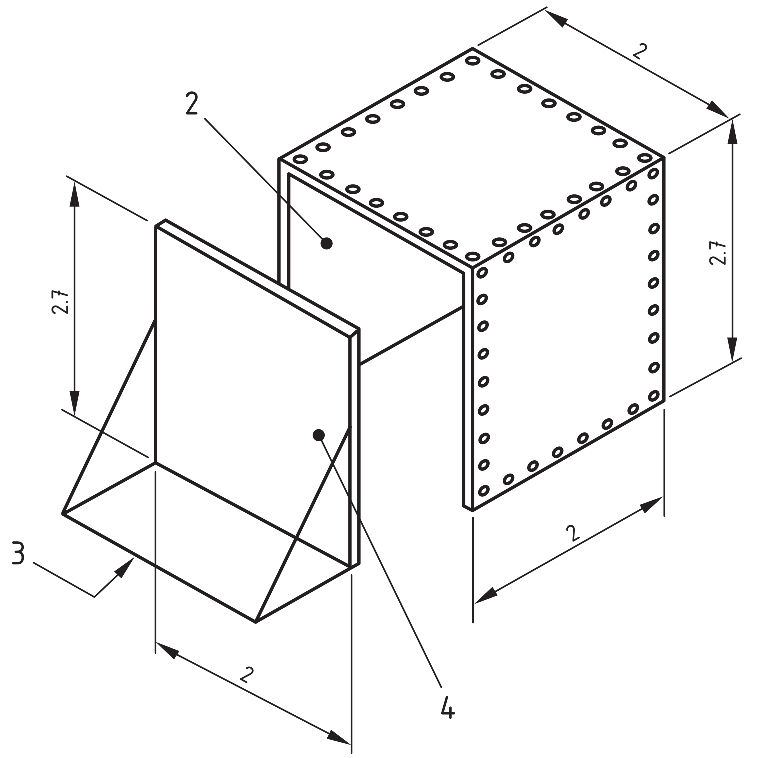
Type of enclosure (see Figure B.3)	**Reduction dB**(A)		
	Facing the opening(s)	**Sideways**	**Facing rear of shed**
Open-sided shed lined with absorbent material; no screen	1	9	14
Open-sided shed lined with absorbent material; with reflecting screen in front	10	6	8
Open-sided shed lined with absorbent material; with absorbent screen in front	10	10	10

Figure B.3 **Examples of acoustic open-sided sheds**

Unless otherwise stated, dimensions are in metres



a) Open-sided shed



b) Open-sided shed with screen

Key

1 9 mm plywood outer covering on wood framework

2 Inner lining of 50 mm sound-absorbent material (see **B.3**)

3 Weighted or tied down

4 9 mm plywood screen

An acoustic shed can be made of 9 mm plywood or other solid material weighing about 5 kg/m^2, on simple timber framing, with no gaps at joints or corners. There is no worthwhile advantage in using a heavier construction for portable sheds. The inside is typically lined with 50 mm of sound-absorbent material, or with 25 mm of similar material if mounted on battens. Such linings are not expected to 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 typically have at least 10% of their surface area perforated, with the distance between perforations not exceeding 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 are typically closed with a flap of a special tough grade of polyethylene sheeting or other similar flexible material. An extractor fan might be required to prevent a build-up of dust. Artificial lighting might 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 need to 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. A barrier can, by reflecting sound, simply transfer a problem from one receiving position to another. On level sites, for maximum effectiveness, a barrier needs to be brought as close as possible to either the noise source or the receiving positions, with no gaps or openings at joints in the barrier material.

In design it might 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/m^2 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, can provide a portable barrier.

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

Annex C (informative) Current sound level data on site equipment and site activities

C.1 General

NOTE The information given in Tables C.1 to C.11 is reproduced by permission of the Department for Environment, Food and Rural Affairs (Defra). The levels recorded represent individual measurements on specific items of plant.

The data listed in Tables C.1 to C.11 are taken from tables published by Defra in 2005. They are supplemented by Table C.12, which contains additional, recently acquired, information on piling and ancillary operations, supplied by the Federation of Piling Specialists and the Steel Piling Group. Table C.12, unlike Tables C.1 to C.11 inclusive, does not include octave band information.

Historic data tables taken from the 1997 edition of BS 5228-1 and the 1992 edition of BS 5228-4 are included in Annex D. The tables in Annex D are intended for use only when no appropriate data exists in the tables in Annex C.

C.2 Presentation of data

The lists of site equipment and activities given in Tables C.1 to C.12 do not cover the complete range of equipment used or all the activities undertaken during the various stages of site work. Users of this part of BS 5228 need to be aware of the processes involved in the development of a site and of the equipment that can be used. When necessary, the tables can be extended to include additional information concerning site equipment and activities, and their sound levels, for future reference.

Values of the sound power levels for a particular type and size of machine and the equivalent continuous sound pressure levels for the site activities given in Tables C.1 to C.12 will apply in the majority of cases, but can be lower or higher due to the make and maintenance of the machines, their operation and the procedures adopted when work is carried out.

An estimate can be made of site noise by averaging the sound levels of equipment of similar type and size, and of site activities as discussed in Annex F.

In Tables C.1 to C.11 inclusive, the broad band data relate to the activity [A1] $L_{Aeq,T}$ [A1] at a standard distance of 10 m, except for entries marked with an asterisk *, which show the L_{Amax} measured during drive by of mobile plant at a distance of 10 m. Except where otherwise shown, e.g. in Table C.12, the L_{WA}, which is to be used in certain of the prediction procedures described in Annex F, may be obtained by adding 28 dB(A) to the broad band [A1] $L_{Aeq,T}$ [A1] or L_{Amax} as appropriate (for further details, refer to Annex D, **D.1**, paragraph 3).

Table C.1 **Sound level data on demolition**

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1] $L_{Aeq,T}$, [A1] dB at 10 m
				63	125	250	500	1k	2k	4k	8k	
	Breaking up concrete											
1	Breaker mounted on wheeled backhoe	59	(7.4 t) 380 kg / 1 700 mm tool / 74 mm dia. / 125 bar	79	82	81	82	86	86	86	85	92
2	Breaker mounted on wheeled backhoe	—	380 kg / 1 700 mm tool / 74 mm dia. / 125 bar	79	84	82	84	88	85	84	82	92
3	Pulverizer mounted on excavator	—	—	85	76	74	75	74	75	70	65	80
4	Pulverizer mounted on excavator	147	30 t	75	72	71	73	70	69	66	59	76
5	Pulverizer mounted on excavator	143	29 t	73	73	69	70	67	64	58	51	72
6	Hand-held pneumatic breaker	—	—	83	83	81	74	73	76	78	77	83
7	Hand-held hydraulic breaker	—	20 kg / 69 bar	82	81	87	87	88	86	83	87	93
8	Hydraulic breaker power pack	6	63 kg/ 138 bar	77	72	73	69	68	66	64	60	74
	Breaking up brick foundations											
9	Breaker mounted on excavator	121	(15 t) 1 650 kg breaker	88	88	86	89	83	83	80	76	90
	Dumping brick rubble											
10	Tracked excavator (loading dump truck)	228	44 t	82	78	82	81	81	78	72	64	85
11	Articulated dump truck (dumping rubble)	250	28 t	94	76	77	75	76	73	68	63	80
	Breaking and spreading rubble											
12	Tracked excavator	228	44 t	79	81	83	79	77	75	70	62	82
13	Tracked excavator	205	40 t	81	80	80	83	82	79	76	73	86
	Crushing concrete/rubble											
14	Tracked crusher	172	47 t	93	86	79	81	75	71	66	59	82
15	Tracked crusher	—	—	86	84	84	81	78	75	71	66	84
	Breaking up/cutting steel											
16	Tracked excavator	205	40 t	75	74	77	80	78	74	67	61	82
17	Tracked excavator	74	14 t	79	77	76	77	78	78	73	66	83
18	Gas cutter	—	—	72	72	69	72	73	72	71	71	79
	Breaking stud partition											
19	Lump hammer	—	—	66	66	68	68	63	57	55	51	69
	Breaking windows											
20	Lump hammer	—	—	77	75	71	72	74	74	75	73	81

Table C.2 **Sound level data on site preparation**

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1] $L_{Aeq,T}$, [/A1] dB at 10 m
				63	125	250	500	1k	2k	4k	8k	
	Clearing site											
1	Dozer ж	142	20 t	79	77	76	74	68	67	60	59	75 ж
2	Tracked excavator	301	71 t	75	84	78	74	70	68	64	61	77
3	Tracked excavator	102	22 t	80	83	76	73	72	70	69	66	78
4	Tracked excavator (idling)	102	22 t	59	49	45	45	49	46	39	31	52
5	Tracked excavator	72	16 t	78	70	72	68	67	66	73	65	76
6	Tracked excavator (idling)	72	16 t	64	62	64	62	56	53	47	39	63
7	Tracked excavator	69	14 t	74	70	68	67	64	62	58	50	70
8	Wheeled backhoe loader	62	8 t	74	66	64	64	63	60	59	50	68
9	Wheeled backhoe loader (idling)	62	8 t	60	53	49	52	51	48	43	33	55
	Ground excavation/earthworks											
10	Dozer	239	41 t	89	90	81	73	74	70	68	64	80
11	Dozer	179	28 t	75	79	77	77	74	71	65	57	79
12	Dozer	142	20 t	85	74	76	73	72	78	62	56	81
13	Dozer	82	11 t	74	83	78	74	74	70	67	62	78
14	Tracked excavator	226	40 t	85	78	77	77	73	71	68	63	79
15	Tracked excavator	173	32 t	77	85	70	73	70	68	63	57	76
16	Tracked excavator	170	30 t	72	71	74	73	69	66	63	58	75
17	Tracked excavator	162	28 t	78	78	75	71	72	68	63	55	76
18	Tracked excavator	134	27 t	81	77	74	70	70	66	60	56	75
19	Tracked excavator	125	25 t	95	84	79	73	70	68	64	57	77
20	Tracked excavator (idling)	125	25 t	80	76	65	65	63	58	53	49	68
21	Tracked excavator	107	22 t	75	76	72	68	65	63	57	49	71
22	Tracked excavator	96	—	78	74	68	68	67	66	61	53	72
23	Tracked excavator	92	—	79	81	68	69	66	65	61	52	73
24	Tracked excavator	71	15 t	77	74	71	70	68	66	60	54	73
25	Tracked excavator	66	14 t	77	65	67	67	63	61	57	47	69

Table C.2 **Sound level data on site preparation** *(continued)*

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1] $L_{Aeq,T}$ [A1] dB at 10 m	
				63	125	250	500	1k	2k	4k	8k		
	Loading lorries												
26	Wheeled loader	209	—	87	82	77	78	73	70	64	57	79	
27	Wheeled loader	193	—	85	83	76	75	75	72	72	61	80	
28	Wheeled loader	170	—	86	82	77	74	70	66	62	55	76	
29	Tracked excavator	75	15 t	80	79	76	77	73	70	66	59	79	
	Distribution of material												
30	Dump truck (tipping fill)	306	29 t	85	74	78	73	73	74	67	63	79	
31	Dump truck (empty) ж	306	29 t	86	79	79	79	79	84	69	60	87	ж
32	Articulated dump truck (tipping fill)	187	23 t	80	76	73	70	69	66	63	58	74	
33	Articulated dump truck ж	187	23 t	85	87	77	75	76	73	69	62	81	ж
34	Lorry ж	—	4-axle wagon	73	78	78	78	74	73	68	66	80	ж
35	Telescopic handler	60	10 t	85	79	69	67	64	62	56	47	71	
	Rolling and compaction												
36	Dozer (towing roller)	142	20 t	83	77	77	76	76	75	68	56	81	
37	Roller (rolling fill) ж	145	18 t	72	75	81	78	74	70	63	55	79	ж
38	Roller ж	145	18 t	80	75	77	72	67	62	54	46	73	ж
39	Vibratory roller ж	29	4 t	88	83	69	68	67	65	62	59	74	ж
40	Vibratory roller ж	20	3 t	82	78	67	71	67	64	60	57	73	ж
41	Vibratory plate (petrol)	3	62 kg	70	74	71	78	74	75	63	58	80	
42	Hydraulic vibratory compactor (tracked excavator)	—	225 kg / 193 bar / 17 500 N	81	76	72	73	72	72	68	63	78	
	Ground investigation drilling												
43	Cable percussion drilling rig	18	2 t / 150 mm diameter / 75 m depth	77	77	67	66	70	68	62	56	74	
	Directional drilling												
44	Directional drill (generator)	106	—	67	80	74	72	72	72	68	61	77	
	Pumping water												
45	Water pump	20	6 in	73	68	62	62	61	56	53	41	65	
46	Water pump	—	4 in	75	74	60	54	54	53	48	46	62	

ж Drive-by maximum sound pressure level in L_{max} (octave bands) and L_{Amax} (overall level)

Table C.3 **Sound level data on piling and ancillary operations**

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, (A1) $L_{Aeq, T}$, (A1) dB at 10 m
				63	125	250	500	1k	2k	4k	8k	
	Pre-cast concrete piling – hydraulic hammer											
1	Hydraulic hammer rig	145	16 m length / 5 t hammer / plywood dolly	82	82	82	89	83	78	75	70	89
	Tubular steel piling – hydraulic hammer											
2	Hydraulic hammer rig	186	4 t hammer	80	87	88	84	83	78	74	65	87
3	Hydraulic hammer rig	—	240 mm diameter	87	93	85	87	83	80	75	72	88
4	Hydraulic hammer rig	—	(1 t) 2 m length / 300 mm diameter	73	65	65	64	70	72	72	68	77
5	Drop hammer pile rig power pack	23	—	79	65	60	59	66	63	53	46	69
	Tubular steel piling – hydraulic jacking											
6	Piling	2800 kN	10 t / 13 m length / 900 mm width / soil	80	74	70	65	61	57	49	43	68
7	Power pack	147	6 t	77	78	73	66	63	57	50	42	70
	Sheet steel piling – vibratory											
8	Vibratory piling rig	—	52 t / 14 m length / soft clay	83	82	79	82	84	82	77	67	88
	Sheet steel piling – hydraulic jacking											
9	Piling	1500 kN	10 t / 7.4 m length / 600 mm width / sandy clay	74	71	63	60	56	54	50	44	63
10	Power pack	147	6 t	80	75	69	67	61	55	49	43	68
11	Piling	980 kN	7.4 t / 12 m length / 500 mm width	68	60	59	57	51	50	45	44	59
12	Rig power pack	—	5 t	74	70	66	60	54	51	46	42	63
13	Water jet pump	—	—	75	75	62	58	55	54	48	40	63
	Rotary bored piling – cast in situ											
14	Large rotary bored piling rig	—	110 t / 20 m deep / 1.2 m diameter	84	92	81	80	78	76	68	61	83
15	Tracked drilling rig with hydraulic drifter	104	12.5 t	75	79	76	73	74	79	74	69	82
16	Crane mounted auger	—	—	87	86	77	73	75	72	67	59	79
17	Mini piling rig	29	5.4 t / auger 10 m deep × 450 mm diameter piles	87	77	72	73	71	69	65	57	76
18	Mini piling rig	—	Auger 12 m deep × 250 mm diameter piles	74	72	65	71	70	68	63	57	75
19	Compressor for mini piling	45	1 t	75	71	65	70	71	69	62	57	75
20	Mini tracked excavator	17	2.8 t	76	73	62	66	62	59	54	49	68

Table C.3 **Sound level data on piling and ancillary operations** *(continued)*

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1] $L_{Aeq,T}$, [A1] dB at 10 m
				63	125	250	500	1k	2k	4k	8k	
	Continuous flight auger piling – cast in situ											
21	Crawler mounted rig	150	35 t	81	81	78	76	74	72	68	63	79
22	Crawler mounted rig	126	33 t	79	79	78	78	75	71	66	56	80
23	Tracked excavator	—	—	84	76	67	64	62	59	53	43	68
24	Tracked excavator (inserting cylindrical metal cage)	—	20 t	79	75	73	69	69	67	60	52	74
25	Concrete pump	59	2.8 t / 180 mm diameter / 59 bar	84	76	70	71	73	73	66	58	78
26	Concrete pump	25	120 mm diameter / 50 bar	82	82	72	71	69	68	62	54	75
	Vibro stone columns											
27	Vibrodisplacement and compaction of stone columns	60	17 t	91	84	79	77	74	69	70	59	80
	Craneage for piling (lifting piles, casings, etc)											
28	Tracked mobile crane	184	110 t	81	77	66	62	59	57	51	46	67
29	Tracked mobile crane	132	55 t	81	77	69	67	62	60	61	51	70
30	Wheeled mobile crane	—	70 t	80	72	71	67	65	62	57	49	70
	Welding / cutting steel piles											
31	Hand-held welder (welding piles)	—	—	67	68	69	68	69	66	61	56	73
32	Generator for welding	—	—	75	72	67	68	70	66	62	60	73
33	Generator for welding	6	508 kg	75	67	59	52	48	44	41	33	57
34	Gas cutter (cutting top of pile)	—	230 bar	74	74	72	61	60	58	56	56	68
35	Hand-held gas cutter	—	230 bar	74	76	66	58	56	56	55	55	65

Table C.4 **Sound level data on general site activities**

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1) $L_{Aeq,\,T}$, (A1] dB at 10 m	
				63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**		
	Distribution of materials												
1	Articulated dump truck ж	194	25 t	90	87	77	79	75	73	67	63	81	ж
2	Articulated dump truck ж	187	23 t	85	80	77	72	74	70	65	58	78	ж
3	Dumper ж	81	7 t	84	81	74	73	72	68	61	53	76	ж
4	Dumper ж	75	9 t	82	76	75	74	68	68	64	55	76	ж
5	Dumper (idling)	75	9 t	73	64	55	55	60	56	50	43	63	
6	Dumper ж	60	6 t	89	86	77	74	72	72	66	62	79	ж
7	Dumper ж	56	5 t	90	86	72	71	71	71	66	59	78	ж
8	Dumper (idling)	56	5 t	68	56	47	49	52	50	41	32	56	
9	Dumper ж	32	3 t	82	82	78	77	69	67	61	53	77	ж
10	Wheeled excavator	90	18 t	64	60	63	64	62	57	51	45	66	
11	Wheeled excavator (idling)	90	18 t	61	59	57	57	58	52	42	34	61	
12	Wheeled excavator ж	63	14 t	84	82	77	75	72	68	60	52	77	ж
13	Wheeled loader ж	75	37 t	83	72	70	69	65	64	57	49	71	ж
14	Wheeled backhoe loader	62	9 t	68	67	63	62	62	61	54	47	67	
15	Fuel tanker lorry ж	—	11 t	79	73	71	75	72	67	59	50	76	ж
16	Fuel tanker pumping	—	25 000 L	75	70	67	67	69	66	60	53	72	
17	Tracked excavator	41	8 t	81	72	68	68	66	64	60	55	71	
	Mixing concrete												
18	Cement mixer truck (discharging)	—	—	80	69	66	70	71	69	64	58	75	
19	Cement mixer truck (idling)	—	—	77	71	65	65	66	66	60	51	71	
20	Concrete mixer truck	—	—	83	74	66	69	70	78	60	55	80	
21	Large lorry concrete mixer	216	—	80	71	65	72	71	72	68	56	77	
22	Large concrete mixer	167	26 t	72	73	79	72	69	67	63	60	76	
23	Small cement mixer	2	—	61	65	58	58	57	53	51	49	61	

Table C.4 **Sound level data on general site activities** *(continued)*

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1] $L_{Aeq, T}$ [A1] dB at 10 m
				63	125	250	500	1k	2k	4k	8k	
	Pumping concrete											
24	Concrete pump + cement mixer truck (discharging)	223	8 t / 350 bar	69	64	64	66	63	59	53	47	67
25	Concrete pump + concrete mixer truck (pumping to 5th floor)	171	6 t / 350 bar / 150 mm diameter	83	81	78	79	77	74	71	66	82
26	Concrete pump + concrete mixer truck (idling)	171	6 t / 350 bar / 150 mm diameter	75	76	71	70	71	68	64	60	75
27	Concrete mixer truck	—	—	84	74	74	73	73	75	65	59	79
28	Concrete mixer truck (discharging) & concrete pump (pumping)	—	26 t (capacity) / 7 m^3 + 22 m boom	79	80	73	72	69	68	59	53	75
29	Truck mounted concrete pump + boom arm	—	26 t	83	77	75	75	74	75	67	63	80
30	Truck mounted concrete pump + boom arm	—	17 t	71	76	71	76	76	72	66	62	79
31	Truck mounted concrete pump + boom arm (idling)	—	22 m boom	84	75	71	70	70	69	61	52	75
32	Concrete mixer truck + truck mounted concrete pump + boom arm	—	—	73	73	77	76	72	70	65	62	78
	Concreting other											
33	Poker vibrator	—	—	82	80	80	73	69	72	70	65	78
34	Poker vibrator	2.2	—	62	70	70	64	62	61	59	56	69
35	Vibratory tamper	1.1	15 kg	59	71	54	56	57	55	55	49	63
36	Pump boom + vibrating poker	—	—	71	68	68	67	65	64	59	56	71
37	Concrete placing boom	—	142 mm diameter / 24 m reach	63	68	65	62	59	53	53	49	65

Table C.4 **Sound level data on general site activities** *(continued)*

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1] $L_{Aeq,T}$, [A1] dB at 10 m
				63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	
	Lifting											
38	Wheeled mobile telescopic crane	610	400 t	80	79	73	74	73	73	64	55	78
39	Mobile telescopic crane	315	80 t	87	82	78	74	71	67	60	52	77
40	Mobile telescopic crane (idling)	315	80 t	75	72	65	62	61	60	52	45	66
41	Mobile telescopic crane	280	100 t	73	71	68	70	66	63	54	49	71
42	Mobile telescopic crane (idling)	280	100 t	71	67	64	61	60	56	50	41	64
43	Wheeled mobile crane	275	35 t	80	76	71	63	64	63	56	50	70
44	Wheeled mobile crane (idling)	275	35 t	73	66	55	56	56	53	45	36	60
45	Mobile telescopic crane	260	55 t	90	81	78	74	77	76	69	61	82
46	Mobile telescopic crane	240	50 t	78	69	67	64	62	57	49	40	67
47	Mobile telescopic crane (idling)	240	50 t	67	66	59	58	56	53	44	35	61
48	Tower crane	88	22 t	82	77	80	76	66	66	56	50	76
49	Tower crane	51	12 t	84	79	80	76	70	63	57	51	77
50	Tracked mobile crane	390	600 t / 125 m	68	71	68	62	66	66	55	46	71
51	Tracked mobile crane (idling)	390	600 t / 125 m	66	67	60	61	62	61	50	40	66
52	Tracked mobile crane	240	105 t	73	71	66	67	74	66	58	49	75
53	Lorry with lifting boom	50	6 t	81	78	76	74	72	69	64	56	77
54	Telescopic handler	76	4 t	79	73	66	65	78	66	54	47	79
55	Telescopic handler	75	3.7 t	82	72	63	65	67	64	56	49	70
56	Wheeled excavator	63	14 t	87	84	80	81	78	75	69	67	83
57	Lifting platform	35	8 t	78	76	62	63	60	59	58	49	67
58	Lifting platform (idling)	35	8 t	72	71	59	59	56	56	52	45	63
59	Diesel scissor lift	24	6 t	80	77	74	74	74	71	65	63	78
60	Diesel scissor lift (idling)	24	6 t	74	72	68	68	64	61	57	56	70
61	Caged material hoist (electric)	—	500 kg	64	64	65	65	63	61	59	52	68
62	Site lift for workers	—	—	68	63	64	63	59	60	58	51	66

Table C.4 **Sound level data on general site activities** *(continued)*

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1] $L_{Aeq,T}$ [A1] dB at 10 m	
				63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**		
	Trenching												
63	Tracked excavator	223	40 t	77	86	75	75	71	69	64	55	77	
64	Tracked excavator	107	22 t	74	80	75	73	69	66	60	51	75	
65	Tracked excavator	95	21 t	76	74	68	70	65	63	59	55	71	
66	Wheeled backhoe loader	63	8 t	72	63	67	67	63	62	56	50	69	
67	Mini tracked excavator	—	5 t	87	79	76	70	68	64	57	48	74	
68	Mini tracked excavator	30	5 t	71	71	66	59	59	58	54	48	65	
	Core drilling concrete												
69	Core drill (electric)	—	250 mm diameter bit	75	74	75	72	74	75	80	80	85	
	Cutting concrete floor slab												
70	Petrol hand-held circular saw	3	9 kg / 300 mm diameter	72	89	81	80	80	82	86	85	91	
	Cutting concrete blocks / paving slabs												
71	Circular bench saw (petrol-cutting concrete blocks)	—	—	85	74	72	70	72	76	82	77	85	
72	Hand-held circular saw (petrol-cutting concrete blocks)	3	9 kg	69	75	77	74	71	70	74	69	79	
73	Hand-held circular saw (cutting paving slabs)	1.5	7.6 kg / 235 mm diameter	73	67	70	68	73	78	78	77	84	
	Moving equipment												
74	Tractor (towing equipment) ж	100	—	79	71	78	75	78	70	61	55	80	ж
75	Tractor (towing trailer) ж	71	3.5 t	93	86	76	76	73	72	64	59	79	ж
	Power for site cabins												
76	Diesel generator	6.5	—	80	74	57	54	53	48	45	37	61	
77	Diesel generator	—	—	70	62	62	57	53	52	48	41	60	
78	Diesel generator	—	—	64	67	68	65	58	54	49	42	66	
79	Diesel generator	—	—	69	71	68	61	57	51	46	44	64	
80	Diesel generator	—	—	54	64	59	56	55	52	49	45	60	
81	Petrol generator	—	2 t	63	57	58	53	51	46	38	33	56	
82	Diesel generator	—	2 t	64	61	59	53	49	47	42	35	56	
83	Diesel generator	3	210 kg	57	71	65	61	60	56	52	44	65	
84	Diesel generator	—	—	75	72	76	70	69	65	56	47	74	

Table C.4 **Sound level data on general site activities** *(continued)*

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, A1 $L_{Aeq,T}$, A1 dB at 10 m
				63	125	250	500	1k	2k	4k	8k	
	Power for welder											
85	Diesel generator	4	18 kg	69	69	67	60	59	60	56	53	66
	Power for lighting											
86	Diesel generator	15	—	78	71	66	62	59	55	56	49	65
87	Diesel generator	7.5	6 kVA / 3 000 rpm	77	72	64	60	59	57	54	42	65
	Pumping water											
88	Water pump (diesel)	10	100 kg	70	65	66	64	64	63	56	46	68
89	Water tanker extracting water (vacum pump)	—	—	81	82	67	72	71	74	73	66	79
	Sweeping and dust suppression											
90	Road sweeper	70	—	80	75	69	75	71	67	61	58	76
91	Dust suppression unit trailer	—	—	78	73	74	80	70	68	60	56	78
	Miscellaneous											
92	Mounting supports for directional drill (hydraulic hammer)	—	—	77	83	73	68	73	80	84	77	87
93	Angle grinder (grinding steel)	2.3	4.7 kg	57	51	52	60	70	77	73	73	80
94	Petrol generator for hand-held grinder	3.75	105 kg	77	74	71	70	69	68	66	62	75
95	Handheld cordless nail gun	—	15 to 50 mm nails	63	65	65	66	65	69	64	61	73
96	Directional drill (generator)	106	—	67	80	74	72	72	72	68	61	77

ж Drive-by maximum sound pressure level in L_{max} (octave bands) and L_{Amax} (overall level)

Table C.5 **Sound level data on road construction works**

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1] $L_{Aeq,T}$, [A1] dB at 10 m	
				63	125	250	500	1k	2k	4k	8k		
	Breaking road surface												
1	Backhoe mounted hydraulic breaker	67	—	86	80	78	77	81	83	82	81	88	
2	Mini excavator with hydraulic breaker	—	(1.5 t) 44 mm diameter / 115 bar / 120 kg	79	75	73	74	77	77	75	70	83	
3	Road breaker (hand-held pneumatic)	—	—	82	75	73	68	63	67	80	69	82	
4	Road breaker (hand-held pneumatic)	—	—	84	84	74	75	73	77	83	81	86	
5	Compressor for hand-held pneumatic breaker	—	1 t	84	73	64	59	57	55	58	47	65	
	Breaking concrete												
6	Hand-held pneumatic breaker	—	—	90	79	75	78	78	83	91	92	95	
	Road planing												
7	Road planer	185	17 t	81	87	79	77	77	74	70	67	82	
8	Road planer (idling)	185	17 t	67	59	58	60	59	49	46	38	62	
9	Mini planer	32	3 t	72	67	70	65	62	56	53	48	68	
10	Mini planer (idling)	32	3 t	67	53	58	50	47	45	42	39	54	
	Removing broken road surface												
11	Wheeled excavator	112	17 t	78	74	68	71	68	64	59	52	73	
	Spreading chipping/fill												
12	Dozer	104	14 t	80	78	71	70	74	68	65	61	77	
13	Dozer	68	11 t	82	84	76	75	78	76	70	62	82	
	Earthworks												
14	Bulldozer ж	250	35 t	77	86	75	75	82	80	73	67	86	ж
15	Bulldozer ж	134	24 t	83	81	76	77	82	70	65	58	83	ж
16	Articulated dump truck ж	194	25 t	88	90	80	79	76	71	65	61	81	ж
17	Articulated dump truck ж	187	23 t	85	88	77	75	77	74	69	63	81	ж
18	Tracked excavator	172	35 t	76	79	75	75	76	73	70	65	80	

Table C.5 **Sound level data on road construction works** *(continued)*

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, $L_{Aeq,T}$, dB at 10 m	
				63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**		
	Rolling and compaction												
19	Road roller ж	95	22 t	87	85	75	73	75	73	69	63	80	ж
20	Vibratory roller	98	8.9 t	90	82	73	72	70	65	59	54	75	
21	Vibratory roller ж	95	12 t	90	84	77	81	73	68	65	61	80	ж
22	Vibratory roller ж	92	12 t	92	83	75	79	77	70	67	61	81	ж
23	Vibratory roller (not vibrating) ж	—	12 t	83	77	75	84	76	72	66	61	83	ж
24	Vibratory roller ж	53	12 t	89	82	76	77	72	74	81	61	84	ж
25	Vibratory roller	32	4.5 t	80	75	72	75	69	66	62	57	75	
26	Vibratory roller	—	4 t	84	84	78	70	70	70	67	61	77	
27	Vibratory roller	20	3 t	85	70	62	62	61	59	53	45	67	
28	Vibratory roller	12	1.5 t	82	80	76	73	70	70	63	59	77	
29	Vibratory compacter (asphalt)	3	60 kg	76	78	74	77	77	77	73	70	82	
	Paving												
30	Asphalt paver (+ tipper lorry)	112	12 t hopper	78	77	72	72	71	69	62	56	75	
31	Asphalt paver (+ tipper lorry)	94	18 t	72	77	74	72	71	70	67	60	77	
32	Asphalt paver (+ tipper lorry) ж	94	18 t	87	84	81	80	79	76	74	65	84	ж
33	Asphalt paver (+ tipper lorry)	78	18 t	82	82	78	72	69	67	61	54	75	
	Trenching												
34	Wheeled excavator	51	7 t	72	66	62	70	63	62	57	53	70	
35	Tracked excavator	27	—	82	72	71	69	69	70	61	54	74	
	Cutting concrete slabs												
36	Hand-held circular saw (petrol)	3	300 mm diameter / 9.2 kg	84	86	78	78	77	78	82	80	87	
	Lifting formwork for underpass												
37	Wheeled mobile crane	315	80 t	85	73	67	71	72	69	63	56	76	
38	Wheeled mobile crane (idling)	315	80 t	71	62	57	59	63	60	54	46	66	
	Pumping water												
40	Electric water pump	15	6 in	71	64	64	67	63	57	54	49	68	

ж Drive-by maximum sound pressure level in L_{max} (octave bands) and L_{Amax} (overall level)

Table C.6 **Sound level data on opencast coal sites**

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1) $L_{Aeq,T}$ (A1] dB at 10 m	
				63	125	250	500	1k	2k	4k	8k		
	Breaking out and loading												
1	Tracked excavator	1 680	505 t	91	86	80	81	80	78	77	70	85	
2	Tracked excavator	1 008	240 t	88	91	87	86	83	81	76	68	89	
3	Tracked excavator	870	213 t	89	92	83	81	82	78	73	65	86	
4	Tracked excavator	382	89 t	86	90	78	74	75	70	62	60	80	
5	Tracked excavator	380	90 t	91	92	83	84	80	78	77	70	86	
6	Tracked excavator	172	35 t	77	80	79	76	76	75	70	63	81	
7	Tracked excavator	128	35 t	84	80	75	74	70	67	64	56	76	
8	Tracked excavator	128	28 t	83	83	77	77	75	72	67	61	80	
9	Tracked excavator	128	23 t	78	85	77	72	69	68	64	61	76	
10	Tracked excavator	107	22 t	83	79	78	76	74	71	65	60	79	
11	Tracked excavator	103	19 t	82	84	75	69	69	67	62	57	75	
12	Tracked excavator	71	13 t	84	74	71	71	68	66	61	55	74	
	Haulage												
13	Dump truck ж	1 417	160 t	97	95	91	91	86	84	79	75	92	ж
14	Dump truck ж	783	158 t	89	94	89	85	83	81	76	71	89	ж
15	Dump truck ж	746	90 t	94	91	91	87	84	83	77	70	90	ж
16	Articulated dump truck (empty) ж	287	40 t	93	90	85	84	83	81	77	69	88	ж
17	Articulated dump truck ж	247	28 t	86	84	86	83	79	76	72	67	85	ж
18	Articulated dump truck ж	240	35 t	91	90	83	83	81	79	70	61	86	ж
19	Road lorry (empty) ж	320	39 t	81	79	75	70	70	70	68	65	76	ж
20	Road lorry (empty) ж	313	39 t	81	76	79	70	71	68	64	60	76	ж
21	Road lorry (full) ж	270	39 t	96	82	74	73	77	72	71	64	80	ж
22	Road lorry (empty) ж	260	39 t	97	85	81	83	76	71	69	64	83	ж
23	Rigid road lorry ж	—	—	88	86	80	78	75	73	76	68	82	ж

Table C.6 **Sound level data on opencast coal sites** *(continued)*

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1] $L_{Aeq,T}$, [A1] dB at 10 m	
				63	125	250	500	1k	2k	4k	8k		
	Dumping load												
24	Dump truck	783	158 t	79	84	81	84	81	80	75	68	86	
25	Dump truck	746	90 t	85	86	86	82	81	79	77	68	86	
26	Articulated dump truck	287	40 t	88	84	75	73	75	72	68	60	79	
27	Articulated dump truck	250	51 t	77	77	76	72	71	69	64	54	76	
	Bulldozing												
28	Crawler mounted dozer	354	48 t	80	84	76	77	79	81	69	59	85	
29	Crawler mounted dozer	250	38 t	83	84	80	77	79	76	86	75	88	
30	Crawler mounted dozer	250	35 t	79	87	79	78	82	80	73	66	86	
	Levelling haul road												
31	Grader ж	205	25 t	88	87	83	79	84	78	74	65	86	ж
	Front end loaders												
32	Wheeled loader (loading hopper)	198	23 t	83	77	70	70	70	68	64	58	75	
33	Wheeled loader (loading lorry)	190	25 t	92	84	83	77	76	74	71	62	82	
34	Wheeled loader	184	23 t	82	82	71	73	69	67	66	58	76	
	Drilling												
35	Tracked hydraulic drilling rig	—	100 mm bore	85	93	78	79	80	79	76	74	86	
	Diesel bowser												
36	Diesel bowser ж	—	—	80	81	84	81	84	85	76	66	89	ж
	Water bowser												
37	Water bowsers (discharging)	—	—	80	81	75	79	73	74	70	65	81	
38	Tractor (towing water bowser) ж	—	—	78	86	84	78	78	77	70	69	83	ж
	Power for site cabins												
39	Diesel generator	120	150 kVA, 1 500 rpm	79	74	67	64	55	51	45	40	65	
	Pumping water												
41	Diesel water pump	—	300 kPa / 1 645 rpm	83	76	70	73	74	72	65	58	78	

ж Drive-by maximum sound pressure level in L_{max} (octave bands) and L_{Amax} (overall level)

Table C.7 **Sound level data on dredging**

Ref no.	**Equipment**	**Power rating,** kW	**Equipment size, weight (mass), capacity**	**Octave band sound pressure levels** at 10 m, Hz								**A-weighted sound pressure level,** [A1] $L_{Aeq,T}$, [A1] dB at 10 m
				63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	
	Digging out river bed											
1	Long reach tracked excavator	178	21 m arm / 39 t	74	83	76	75	70	71	63	57	78
	Dredging harbour											
2	Grab hopper dredging ship	2 461	2 136 t	83	91	80	78	78	73	66	58	82

Table C.8 **Sound level data on waste disposal sites**

Ref no.	**Equipment**	**Power rating,** kW	**Equipment size, weight (mass), capacity**	**Octave band sound pressure levels** at 10 m, Hz								**A-weighted sound pressure level,** [A1] $L_{Aeq,T}$, [A1] dB at 10 m
				63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	
	Tipping area											
1	Waste compactor	392	54 t	70	78	79	72	77	68	66	62	80
2	Waste compactor	298	—	66	74	78	76	74	70	66	62	79
3	Waste compactor	283	37 t	79	83	71	75	78	70	67	67	80
4	Waste compactor	—	—	72	76	76	70	69	67	63	58	75
5	Waste compactor	226	—	73	75	70	66	68	64	58	50	71
6	Dozer	138	24 t	81	80	75	77	74	69	63	58	78
7	Dozer	138	21 t	73	79	73	72	69	67	61	57	75
8	Dozer	134	50 t	74	76	73	71	71	68	64	58	75
9	Dozer	104	20 t	76	78	71	70	71	65	60	55	74
10	Tracked excavator	96	24 t	67	70	67	65	63	62	60	55	69
	Cell excavation area											
11	Tracked excavator	228	45 t	73	81	75	76	73	70	65	60	78
12	Tracked excavator	96	24 t	78	80	71	70	68	67	63	58	74
13	Articulated dump truck ж	327	25 t	92	89	83	84	79	75	68	64	85 ж
14	Articulated dump truck ж	250	23 t	88	84	82	73	75	71	66	60	80 ж
15	Articulated dump truck ж	227	21 t	91	81	76	77	73	72	70	62	79 ж
16	Articulated dump truck ж	198	30 t	84	84	81	79	76	73	69	64	81 ж
17	Dozer	142	20 t	82	88	81	80	75	72	63	57	81

Table C.8 **Sound level data on waste disposal sites** *(continued)*

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, A1 $L_{Aeq,T}$, A1 dB at 10 m	
				63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**		
	Waste delivery vehicles												
18	Refuse wagon ж	—	—	82	79	78	75	71	72	66	62	78	ж
19	Refuse wagon ж	283	44 t	88	81	79	76	72	70	64	60	78	ж
20	Tipper lorry ж	—	—	88	82	74	74	74	73	70	67	79	ж
21	Skip wagon ж	—	—	82	84	78	75	71	70	65	59	78	ж
	Pumping water												
22	Diesel surface water pump	—	4 in	70	75	60	58	65	66	59	62	71	
23	Diesel generator for submersible pump	—	—	81	73	57	56	52	49	49	42	62	
	Power for temporary site cabin												
24	Diesel generator	—	—	82	57	63	48	45	44	40	33	59	

ж Drive-by maximum sound pressure level in L_{max} (octave bands) and L_{Amax} (overall level)

Table C.9 **Sound level data on hard rock quarries**

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, A1 $L_{Aeq,T}$ A1 dB at 10 m	
				63	125	250	500	1k	2k	4k	8k		
	Drilling blast holes												
1	Tracked mobile drilling rig	317	20 t / 125 mm dia.	86	92	85	88	84	83	78	77	90	
2	Tracked mobile drilling rig	270	23 t / 110 mm dia.	94	95	90	91	87	85	80	73	92	
3	Tracked mobile drilling rig	186	16 t	77	83	82	84	85	85	84	79	91	
4	Tracked mobile drilling rig	321	—	83	84	79	85	82	79	75	71	87	
	Face shovel loading dump trucks												
5	Tracked hydraulic excavator (mainly engine noise)	400	82 t	90	85	79	80	78	75	70	62	83	
6	Tracked hydraulic excavator	235	47 t	95	93	89	89	86	82	76	74	91	
7	Wheeled loader	597	94 t	88	88	87	85	86	83	77	70	90	
7	Wheeled loader	466	82 t	88	93	84	84	83	81	79	69	88	
8	Wheeled loader	370	50 t	89	87	84	82	81	81	72	65	86	
9	Wheeled loader	364	56 t	91	94	90	86	86	83	77	69	91	
10	Wheeled loader	325	58 t	89	87	85	83	84	80	75	71	88	
	Breaking boulders/oversized material												
11	Excavator mounted rock breaker	125	29 t	91	89	85	89	87	87	84	80	93	
12	Excavator mounted rock breaker	102	23 t	86	86	83	78	80	78	76	71	85	
13	Excavator mounted rock breaker	100	22 t	85	88	85	89	92	88	86	81	95	
14	Tracked semi-mobile crusher	310	90 t	91	91	88	87	85	83	78	68	90	
15	Tracked semi-mobile crusher	250	38 t	98	98	97	94	91	88	82	72	96	
	Dump trucks on haul roads												
16	Rigid dump truck ж	699	90 t	86	89	88	88	86	83	76	70	91	ж
17	Rigid dump truck ж	567	64 t	99	95	87	86	84	83	77	73	90	ж
18	Rigid dump truck ж	544	60 t	95	97	89	85	83	83	76	75	90	ж
19	Rigid dump truck ж	517	63 t	90	91	88	85	83	82	77	73	89	ж
20	Rigid dump truck ж	517	60 t	96	97	90	84	84	84	74	76	90	ж
21	Rigid dump truck ж	362	41 t	92	91	86	85	84	85	77	77	90	ж
22	Articulated dump truck ж	309	40 t	100	97	88	84	82	80	77	68	89	ж

Table C.9 **Sound level data on hard rock quarries** *(continued)*

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1] $L_{Aeq, T}$, [A1] dB at 10 m
				63	125	250	500	1k	2k	4k	8k	
	Dump truck discharging into hopper											
23	Rigid dump truck	544	60 t	88	82	77	79	80	79	73	67	85
24	Rigid dump truck	362	40 t	89	84	80	82	80	78	72	64	85
	Lorries being loaded from silo											
25	Lorry	310 to 350	32 t to 36 t	80	79	74	76	76	76	73	65	82
	Loading chippings into dump trucks											
26	Wheeled loader	320	45 t	89	90	86	82	83	77	75	64	87
27	Wheeled loader	221	30 t	91	81	73	71	71	72	62	59	77

ж Drive-by maximum sound pressure level in L_{max} (octave bands) and L_{Amax} (overall level)

Table C.10 **Sound level data on other quarries (i.e. sand and gravel)**

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1] $L_{Aeq, T}$, [A1] dB at 10 m
				63	125	250	500	1k	2k	4k	8k	
	Face shovel extracting/loading dump trucks											
1	Tracked hydraulic excavator	184	37 t	82	87	82	77	72	70	66	59	80
2	Tracked hydraulic excavator	74	19 t	82	75	72	73	71	70	66	58	76
3	Wheeled loader	198	29 t	88	84	81	84	76	70	68	61	83
4	Wheeled loader	193	31 t	87	87	85	75	76	74	69	62	82
	Face shovel loading hopper											
5	Wheeled loader	232	39 t	84	88	81	74	74	71	66	65	80

Table C.10 **Sound level data on other quarries (i.e. sand and gravel)** *(continued)*

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1] $L_{Aeq,T}$, [/A1] dB at 10 m
				63	125	250	500	1k	2k	4k	8k	
	General wheeled loader operations											
6	Loading sand to lorry	221	30 t	93	78	73	72	76	83	71	57	85
7	Loading sand to lorry	198	29 t	81	79	75	77	71	65	61	53	77
8	Loading sand to lorry	193	23 t	85	83	76	76	75	72	72	61	80
9	Loading sand to lorry	180	21 t	90	79	71	69	71	67	61	55	75
10	Loading gravel to lorry	193	23 t	89	86	87	77	78	77	73	68	85
11	Loading dump truck with pebbles	232	39 t	92	84	84	80	79	78	75	72	85
12	Loading dump truck with pebbles	184	23 t	87	84	82	77	76	74	70	65	82
13	Picking up sand from stockpile	175	23 t	89	80	82	73	70	69	64	57	78
	Semi-mobile screen/stockpiler											
14	Screen stockpiler	56	15 t	93	86	79	78	75	71	69	62	81
15	Screen stockpiler	51	17 t	84	82	79	79	74	74	71	64	81
	Transport of material											
16	Wheeled loader ж	193	31 t	83	89	92	80	71	69	64	58	85 ж
17	Wheeled loader ж	184	23 t	77	83	91	75	75	72	65	59	84 ж
18	Articulated dump truck ж	309	37 t	87	85	83	81	78	74	71	66	83 ж
19	Articulated dump truck ж	239	23 t	98	94	89	85	79	79	70	65	87 ж
	Field conveyor system											
20	Conveyor drive unit	42	—	71	69	68	71	75	67	63	57	77
21	Conveyor drive unit	37	—	73	75	73	73	70	68	66	59	76
22	Feed hopper conveyor drive unit	6	—	71	68	62	63	66	62	58	51	69
23	Field conveyor (rollers)	—	—	58	52	52	43	43	42	47	47	53

ж Drive-by maximum sound pressure level in L_{max} (octave bands) and L_{Amax} (overall level)

Table C.11 **General sound level data**

Ref no.	Equipment	Power rating, kW	Equipment size, weight (mass), capacity	Octave band sound pressure levels at 10 m, Hz								A-weighted sound pressure level, [A1] $L_{Aeq, T}$, [/A1] dB at 10 m	
				63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**		
	Pumping surface water												
1	Diesel water pump	136	—	81	83	77	75	76	75	69	63	81	
2	Diesel water pump	25	—	81	71	67	62	65	65	63	59	71	
3	Electric water pump	37	—	67	65	65	64	63	63	60	54	69	
	Lorry movements on access road												
4	Lorry ж	350	44 t	82	80	78	75	76	78	75	69	83	ж
5	Lorry ж	350	36 t	92	82	77	76	77	72	68	63	80	ж
6	Lorry ж	343	29 t	92	82	76	78	77	76	74	68	83	ж
7	Lorry ж	313	44 t	87	79	77	74	73	73	70	64	79	ж
8	Lorry ж	313	40 t	81	79	79	83	84	81	76	70	88	ж
9	Lorry ж	313	32 t	99	82	81	76	78	74	71	66	82	ж
10	Lorry ж	310	32 t	91	79	77	74	71	69	64	61	77	ж
11	Lorry ж	306	44 t	96	79	75	79	82	80	72	67	86	ж
12	Lorry ж	298	44 t	96	80	75	75	74	72	67	60	79	ж
13	Lorry ж	283	44 t	84	80	76	74	73	70	67	61	78	ж
14	Lorry ж	254	32 t	93	79	76	74	73	72	69	66	79	ж
15	Lorry ж	242	32 t	86	94	81	77	80	77	75	69	85	ж
16	Lorry ж	235	26 t	86	81	74	76	73	72	69	60	79	ж
17	Lorry ж	233	32 t	91	78	74	70	72	74	66	59	78	ж
18	Lorry ж	216	32 t	85	78	83	82	86	80	73	69	88	ж
19	Lorry ж	201	26 t	87	76	73	81	79	75	68	62	83	ж
20	Lorry ж	160	18 t	91	76	79	78	80	76	70	64	83	ж

ж Drive-by maximum sound pressure level in L_{max} (octave bands) and L_{Amax} (overall level)

Table C.12 **Supplementary sound level data on piling**

Ref. no	Equipment	Pile depth	Width	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$, [/A1] at 10 m (one cycle)	
		m	m			dB		[A1]min[/A1]	%	dB	
	Steel piling										
1	Pressed-in steel tubular piles; power pack pressing unit (does not include ancillary plant including mobile crane)	—	—	225 kW	—	96	—	—	—	68	68
		—	—	Available up to 4 MN pressing force	—	83	—	—	—	55	
2	Hydraulic power pack	—	—	75 kW to 900 kW	—	101 to 114	—	—	100	73 to 86	
	Driven cast in situ piling										
3	Junttan PM25, hydraulic hammer	16.75	0.38 dia.	4 t, 0.6 m drop	Sand	103 A)	12 m fill onto stiff clay	30	65	84	101
4		16.75	0.38 dia.	4 t, 0.6 m drop	Sand	103 A)		30	65	85	
5		16.75	0.38 dia.	4 t, 0.6 m drop	Sand	119 A)		30	65	101	
6		16.75	0.38 dia.	4 t, 0.6 m drop	Sand	117 A)		30	65	98	
7	Junttan PM26, hydraulic hammer	10.90	0.34 dia.	5 t, 0.6 m drop	Sand	104	6 m fill, 4 m alluvium overlying mudstone	30	65	92	
8		15.00	0.34 dia.	5 t, 0.6 m drop	Sand	108	5 m fill overlying firm to stiff clay	20	50	80	
9		11.70	0.34 dia.	5 t, 0.6 m drop	Sand	132		25	50	107	
10		10.30	0.34 dia.	5 t, 0.6 m drop	Sand	117	2 m fill, 7 m alluvium overlying medium dense gravel	20	50	98	

Table C.12 **Supplementary sound level data on piling** *(continued)*

Ref. no	Equipment	Pile depth	Width	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level $L_{Aeq, T}$, at 10 m (one cycle)
		m	m			dB		min	%	dB
11	NCK 605, hanging leaders and drop hammer	20.90	0.34 dia.	4 t, 0.9 m drop	Aluminium	121	4 m fill, 3 m v. loose sand, 2 m peat, 2 m v. soft clay, 10 m v. soft silt onto v. dense sand	30	65	93
12		20.90	0.34 dia.	4 t, 0.9 m drop	Aluminium	146		30	65	61
13		16.50	0.43 dia.	4 t, 0.9 m drop	Timber	88	1 m fill, 10 m alluvium, 2 m loose to medium dense gravel onto stiff clay	40	80	80
14		17.70	0.43 dia.	4 t, 0.9 m drop	Aluminium	103		40	80	88
15		17.70	0.43 dia.	4 t, 0.9 m drop	Aluminium	122		40	80	96
16		17.70	0.43 dia.	4 t, 0.9 m drop	Plastic	118		40	80	90
17		7.60	0.34 dia.	4 t, 0.9 m drop	Aluminium	142	4 m fill, 3 m alluvium overlying very dense sand	25	75	101
18		20.80	0.43 dia.	4 t, 0.9 m drop	Aluminium	122	3 m fill, 10 m alluvium, 5 m gravel onto mudstone	40	80	96
19		11.50	0.34 dia.	4 t, 0.9 m drop	Aluminium	116	2 m fill, 3 m alluvium overlying medium dense gravel	30	65	93
20		11.10	0.34 dia.	4 t, 0.9 m drop	Aluminium	110		30	65	91
21		14.60	0.38 dia.	4 t, 0.9 m drop	Aluminium	120	2 m fill onto firm becoming stiff clay	40	80	92
22		11.10	0.34 dia.	4 t, 0.9 m drop	Aluminium	100	2 m fill, 3 m alluvium overlying medium dense gravel	30	65	72
23		8.30	0.43 dia.	4 t, 0.9 m drop	Aluminium	112		30	65	93
24		15.00	0.38 dia.	4 t, 0.9 m drop	Aluminium	109	2 m fill, 7 m alluvium overlying chalk	30	65	90
25		15.50	0.34 dia.	4 t, 0.9 m drop	Aluminium	112	2 m fill, 6 m alluvium overlying firm to stiff clay	30	65	91

Table C.12 **Supplementary sound level data on piling** *(continued)*

Ref. no	Equipment	Pile depth (m)	Width (m)	Energy, power rating	Dolly	Sound power level L_{WA} (dB)	Soil	Cycle time (min)	On-time (%)	Activity equivalent continuous sound pressure level $L_{Aeq,T}$ at 10 m (one cycle) (dB)	
26	NCK 605, hanging leaders and drop hammer	15.50	0.38 dia.	4 t, 0.9 m drop	Timber	107	2 m fill, 13 m alluvium overlying medium dense sand	25	50	79	
27	NCK 605, hanging leaders and drop hammer	14.50	0.34 dia.	4 t, 0.9 m drop	Aluminium	115	5 m fill, 3 m alluvium, 7 m firm to stiff clay onto mudstone	30	65	87	
28	NCK 605, hanging leaders and drop hammer	16.50	0.34 dia.	4 t, 0.9 m drop	Aluminium	107	7 m fill, 1 m peat, 4 m alluvium, 8 m gravel onto chalk	40	80	79	
29	NCK 605, hanging leaders and drop hammer	16.50	0.34 dia.	4 t, 0.9 m drop	Aluminium	120	7 m fill, 1 m peat, 4 m alluvium, 8 m gravel onto chalk	40	80	92	
30	NCK 605, hanging leaders and drop hammer	19.50	0.43 dia.	4 t, 0.9 m drop	Aluminium	120	7 m fill, 1 m peat, 4 m alluvium, 8 m gravel onto chalk	40	80	92	
31	NCK 605, hanging leaders and drop hammer	19.50	0.43 dia.	4 t, 0.9 m drop	Aluminium	109	7 m fill, 1 m peat, 4 m alluvium, 8 m gravel onto chalk	40	80	81	
32	NCK 605, hanging leaders and drop hammer	11.50	0.43 dia.	4 t, 0.9 m drop	Timber	113	6 m fill, 4 m firm clay onto medium dense gravel	30	65	85	
33	NCK Atlas, hanging leaders and drop hammer	23.00	0.38 dia.	4 t, 0.9 m drop	Aluminium	106	7 m fill, 1 m peat, 4 m alluvium, 8 m gravel onto chalk	40	80	78	92
34	NCK Atlas, hanging leaders and drop hammer	23.00	0.38 dia.	4 t, 0.9 m drop	Aluminium	120	7 m fill, 1 m peat, 4 m alluvium, 8 m gravel onto chalk	40	80	92	
	Driven precast concrete piling										
35	Junttan PM25, hydraulic hammer	—	—	7 t, 0.6 m drop	Sand	103	—	—	—	94	
36	Junttan PM25, hydraulic hammer	—	—	9 t, 0.7 m drop	Polypenco	106	—	—	—	86	
37	Junttan PM25, hydraulic hammer	—	—	7 t, 0.6 m drop	Polypenco	111	—	—	—	91	
38	Junttan PM25, hydraulic hammer	—	—	7 t, 0.6 m drop	Sand	108	—	—	—	88	
39	Junttan PM25, hydraulic hammer	—	—	7 t, 0.6 m drop	Sand	111	—	—	—	93	
	Continuous flight auger piling										
40	Soilmec R622	25.00	0.9 dia.	—	None	106	7 m alluvium, 7 m firm to stiff clay, 2 m medium dense sand, 2 m clay onto sand	133		81	
41	Soilmec CM45	11.80	0.4 dia.	—	None	105	8 m fill overlying sandstone	50	95	80	
42	Soilmec CM45	17.50	0.45 dia.	—	None	108	5 m fill, 2 m sand onto firm becoming stiff clay	55	95	83	
43	Soilmec CM48	14.80	0.45 dia.	134 kW	None	102	2 m fill, 7 m soft to firm clay, 6 m medium dense clayey sand onto sandstone	80	95	77	77
44	Soilmec CM48	14.80	0.45 dia.	134 kW	None	98	2 m fill, 7 m soft to firm clay, 6 m medium dense clayey sand onto sandstone	80	95	73	

Table C.12 **Supplementary sound level data on piling** *(continued)*

Ref. no	Equipment	Pile depth	Width	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,\,T}$, [A1] at 10 m (one cycle)
		m	m			dB		[A1]min[A1]	%	dB
45		12.00	0.6 dia.	155 kW	None	100	2 m fill overlying firm to stiff becoming very stiff clay with limestone bands	55	95	75
46	Soilmec R412	7.50	0.6 dia.	155 kW	None	102	3 m fill overlying siltstone	25	90	76
47		10.00	0.45 dia.	155 kW	None	102		25	90	77
48		10.00	0.45 dia.	155 kW	None	102	5 m fill, 6 m stiff sandy clay onto sandstone	25	90	77
49		10.00	0.45 dia.	155 kW	None	101		25	90	76
	Vibroflotation									
50	Vibrocat, top-feed, electric vibrator	3.50	~0.45 dia.	50 kW	None	115	Firm to stiff clay	10	70	85
51	NCK 305, top-feed, electric vibrator	3.00	~0.45 dia.	50 kW	None	119		10	70	89
52	Vibrocat, bottom-feed, electric vibrator	3.30	~0.55 dia.	50 kW	None	96		10	70	65
53	Vibrocat, VCC, electric vibrator	8.50	0.43 dia.	50 kW	None	115	Mixed medium dense granular / firm cohesive soils	25	85	85
54	Minicat, top-feed, electric vibrator	3.40	~0.50 dia.	50 kW	None	108		20	85	77
55	Minicat, top-feed, electric vibrator	3.00	~0.50 dia.	50 kW	None	115		15	80	85
56	NCK 305, top-feed, electric vibrator	3.00	~0.50 dia.	50 kW	None	111		15	80	81
57	Vibrocat, bottom-feed, electric vibrator	3.0	~0.55 dia.	55 kW	None	102	Soft to firm clay	10	70	72
58	Vibrocat, bottom-feed, electric vibrator	3.70	~0.50 dia.	50 kW	None	119		10	70	89
59	Minicat, top-feed, electric vibrator	4.70	~0.45 dia.	55 kW	None	123	Mixed medium dense granular/ firm cohesive soils	10	70	93
60	Vibrocat, bottom-feed, electric vibrator	6.00	~0.50 dia.	55 kW	None	129		15	80	87
61	Minicat, top-feed, electric vibrator and prebore rig	3.50	~0.50 dia.	55 kW	None	115	Very loose cohesionless soils	10	70	84
62	Minicat, top-feed, electric vibrator	1.70	~0.55 dia.	55 kW	None	110	Loose cohesionless soils	10	70	79

Table C.12 **Supplementary sound level data on piling** *(continued)*

Ref. no	Equipment	Pile depth	Width	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$, [/A1] at 10 m (one cycle)	
		m	m			dB		[A1]min[/A1]	%	dB	
63	Minicat, top-feed, electric vibrator	4.30	~0.40 dia.	55 kW	Polyurethane	113		15	80	83	
64	Minicat, top-feed, electric vibrator	4.30	~0.40 dia.	55 kW	Polyurethane	105	Mixed medium dense granular/ firm cohesive soils	15	80	75	
65	NCK 305, top-feed, electric vibrator	4.00	~0.50 dia.	55 kW	None	103		15	80	73	
66		2.80	~0.55 dia.	55 kW	None	112		10	70	82	
67	Vibrocat, bottom-feed, electric vibrator	2.50	~0.55 dia.	55 kW	None	111	Loose to medium dense cohesionless soils	10	70	81	84
68		2.50	~0.55 dia.	55 kW	None	114		10	70	84	
69		3.50	~0.55 dia.	55 kW	None	113		10	70	83	
70	Vibrocat, bottom-feed, electric vibrator	—	—	55 kW	None	113		—	—	85	
71	Vibrocat, bottom-feed, electric vibrator	—	—	55 kW	None	106	Unknown	—	—	75	
72	Vibrocat, VCC, electric vibrator	—	—	55 kW	None	91		—	—	60	
	Dynamic compaction										
73	—	—	2.4 × 2.4	8 t, 8 m drop	None	102	Refuse / contaminated fill	1	80	81	
74	NCK Ajax	—	2.4 × 2.4	8 t, 8 m drop	None	101	Refuse / contaminated fill	1	80	81	
75	NCK Ajax	—	2.4 × 2.4	8 t, 12 m drop	None	105		1	80	84	
76	Supra 1100	—	2.4 × 2.4	15 t, 10 m drop	None	101	Mixed fill	1	80	81	
77	NCK Eiger C120	—	2.4 × 2.4	15 t, 10 m drop	None	102		1	80	81	

Table C.12 **Supplementary sound level data on piling** *(continued)*

Ref. no	Equipment	Pile depth	Width	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,\ T}$, [A1] at 10 m (one cycle)	
		m	m			dB		[A1]min[A1]	%	dB	
78		—	2.4 × 2.4	8 t, 12 m drop	None	102		1	80	82	
79		—	2.4 × 2.4	8 t, 12 m drop	None	105		1	80	69	
80		—	2.4 × 2.4	8 t, 12 m drop	None	105		1	80	78	
81		—	2.4 × 2.4	8 t, 12 m drop	None	99		1	80	79	
82		—	2.4 × 2.4	8 t, 12 m drop	None	99		1	80	78	
83		—	2.4 × 2.4	8 t, 12 m drop	None	102		1	80	81	
84		—	2.4 × 2.4	8 t, 12 m drop	None	110		1	80	90	
85		—	2.4 × 2.4	8 t, 12 m drop	None	109		1	80	88	
86		—	2.4 × 2.4	8 t, 12 m drop	None	109		1	80	88	
87		—	2.4 × 2.4	8 t, 12 m drop	None	107		1	80	87	
88	NCK Ajax	—	2.4 × 2.4	8 t, 12 m drop	None	106	Refuse / contaminated fill	1	80	86	91
89		—	2.4 × 2.4	8 t, 12 m drop	None	108		1	80	87	
90		—	2.4 × 2.4	8 t, 12 m drop	None	107		1	80	87	
91		—	2.4 × 2.4	8 t, 12 m drop	None	107		1	80	87	
92		—	2.4 × 2.4	8 t, 12 m drop	None	109		1	80	88	
93		—	2.4 × 2.4	8 t, 12 m drop	None	111		1	80	91	
94		—	2.4 × 2.4	8 t, 12 m drop	None	106		1	80	86	
95		—	2.4 × 2.4	8 t, 12 m drop	None	107		1	80	86	
96		—	2.4 × 2.4	8 t, 12 m drop	None	109		1	80	89	
97		—	2.4 × 2.4	8 t, 12 m drop	None	109		1	80	89	
98		—	2.4 × 2.4	8 t, 12 m drop	None	109		1	80	88	
99		—	2.4 × 2.4	8 t, 3 m drop	None	104		1	80	83	
	Coring through existing piles										
100	Bauer BG36 coring reinforced concrete pile	—	—	—	None	—	—	—	—	72 to 87	
101	Junttan PM18/30 coring reinforced concrete pile	—	—	—	None	—	—	—	—	76 to 90	

A) Owing to local circumstances the attenuation rate was not standard so propagation values have been amended.

Annex D (informative) Historic sound level data on site equipment and site activities

NOTE Much of the information given in this annex is reproduced by permission of the Director of the Construction Industry Research and Information Association (CIRIA). The levels recorded represent individual measurements on specific items of plant.

More detailed information is included in CIRIA Report 64 [57].

D.1 General

The data given in this annex are largely historical, and are taken unaltered from the tables originally provided in BS 5228-1:1997 and BS 5228-4:1992. More recent data are provided in Annex C.

Table D.1 provides an index of site equipment. The subsequent table, or tables, that contain sound level data for particular types of equipment is marked by an asterisk; a tick represents other categories of site work in which these types of equipment are also operated.

Tables D.2 to D.12 provide a guide to the sound power levels for stationary and quasi-stationary site equipment, and the equivalent continuous sound pressure levels at 10 m distance from the site activities. For a single noise source, the dimensions of which are small in relation to 10 m, generating noise at a constant level, the equivalent continuous sound pressure level at 10 m distance is 28 dB(A) below the sound power level. Maximum sound pressure levels at 10 m distance from the drive-by of mobile plant are also included.

NOTE The noise emissions of certain categories of plant are governed by regulations implementing EC Directive 2000/14/EC [11], in particular the Noise Emission in the Environment by Equipment for Use Outdoors Regulations 2001 [58] and the Noise Emission in the Environment by Equipment for Use Outdoors (Amendment) Regulations 2005 [59]. The current permissible sound power levels are given in Annex F (Table F.1).

The on-time recorded in the tables is the percentage time that the equipment was working at full power during the measurement period.

D.2 Presentation of data

For guidance on the presentation of data within Tables D.2 to D.12, refer to Annex C.

Table D.1 **Index of site equipment referred to in Tables D.2 to D.12**

Equipment	Sound level data table									
	D.2	D.3	D.4 and D.5	D.6	D.7	D.8	D.9	D.10 and D.11	D.12	
	Demolition	Site preparation	Piling	Concreting operations	General site activities	Roadworks	Motorway construction	Opencast coal sites	Dredging	Quarrying
Air hammer pile driver			*							
Asphalt melter						*	✓			
Asphalt spreader						*	✓			
Asphalt spreader and chipping hopper						*	✓			
Auger, crane mounted			*							
Auger, lorry mounted			*							
Batching plant				*						✓
Chip spreader						*	✓			
Circular saw, bench mounted					*					
Club hammer					*					
Coal lorry								*		
Compactor rammer		*								
Compressor		*		*	*	*	✓	✓		✓
Compressor, tractor mounted		✓				*	✓			
Compressor and pneumatic drilling rig								*		✓
Concrete mixer				*						
Concrete pump, lorry mounted				*						
Crane, lorry mounted				*			✓	✓		✓
Crane mounted auger			*							
Crane mounted auger, pile case vibratory driven			*							
Diesel combined rig (rotary)								*		
Diesel dragline								*		✓
Diesel face shovel								*		✓

Table D.1 **Index of site equipment referred to in Tables D.2 to D.12** *(continued)*

Equipment	**Sound level data table**									
	D.2	**D.3**	**D.4 and D.5**	**D.6**	**D.7**	**D.8**	**D.9**	**D.10 and D.11**	**D.12**	
	Demolition	**Site preparation**	**Piling**	**Concreting operations**	**General site activities**	**Roadworks**	**Motorway construction**	**Opencast coal sites**	**Dredging**	**Quarrying**
Diesel front end loader (crawler)								*		✓
Diesel front end loader (wheeled)								*		✓
Diesel hammer pile driver			*							
Diesel hoist					*					
Diesel hydraulic shovel								*		✓
Diesel tractor scraper								*		✓
Double acting air hammer pile driver			*							
Double acting air trenching hammer			*							
Dozer		*				✓	*	*		✓
Dragline excavator		*						✓		✓
Drop hammer pile driver			*							
Dump truck		*				✓	*	*		✓
Dumper		*			*					
Electric dragline								*		✓
Electric face shovel								*		✓
Electric percussion drill				*						
Electric vibratory pile extractor			*							
Enclosed drop hammer pile driver			*							
Generator (power)				*	*			✓		✓
Generator (welding)					*			✓		✓
Grader		*					*	*		
Groove cutter						*	✓			

Table D.1 **Index of site equipment referred to in Tables D.2 to D.12** *(continued)*

Equipment	Sound level data table									
	D.2	D.3	D.4 and D.5	D.6	D.7	D.8	D.9	D.10 and D.11	D.12	
	Demolition	Site preparation	Piling	Concreting operations	General site activities	Roadworks	Motorway construction	Opencast coal sites	Dredging	Quarrying
Grout mixer and pump				*						
Hand-held electric circular saw					*					
Hand-held hammer	*				✓					✓
Hydraulic pile driver			*							
Lorry		*			*	*	✓	✓		✓
Lorry mounted auger			*							
Lorry mounted concrete pump				*						
Lorry mounted crane				*		✓	✓	✓		✓
Lorry mounted road sweeper						*	✓	✓		✓
Oscillatory boring machine for bored piling			*			*	✓	✓		✓
Paving train						*	✓			
Petrol driven chainsaw	*									
Petrol driven disc cutter, hand-held				*						✓
Pneumatic breaker	*	*		*		*	✓			✓
Pneumatic chipper/drill				*						
Pneumatic chipping hammer			*	*						
Pneumatic circular saw					*					
Pneumatic concrete grinder				*						
Pneumatic drilling rig and compressor								*		✓
Pneumatic hammer						*	✓			
Pneumatic hammer fitted with attachment for pinning reinforcing				*						

Table D.1 **Index of site equipment referred to in Tables D.2 to D.12** *(continued)*

Equipment	Sound level data table									
	D.2	D.3	D.4 and D.5	D.6	D.7	D.8	D.9	D.10 and D.11	D.12	
	Demolition	Site preparation	Piling	Concreting operations	General site activities	Roadworks	Motorway construction	Opencast coal sites	Dredging	Quarrying
Pneumatic rock drill mounted on tracked excavator		*								✓
Pneumatic rock drill, hand-held					*					✓
Pneumatic spade		*								
Poker vibrator				*						
Power float				*						
Road planer						*	✓			
Road raiser and lorry						*	✓			
Road roller						*	✓			
Scaffold frames and clips					*					
Scaffold poles and clips					*					
Scraper							*	*		✓
Ship chain bucket									*	
Site fork lift truck					*			✓		✓
Tipper lorry		*				✓	✓	✓		✓
Tracked crane	*			*	*			✓	*	✓
Tracked crane fitted with excavator attachment		*						✓		✓
Tracked excavator		*		*		*	*	✓	*	✓
Tracked excavator fitted with breaker	*									
Tracked excavator fitted with hydraulic rock breaker						*	✓			✓
Tracked excavator/loader		*				✓	✓	✓		✓
Tracked loader		*				✓	✓	✓	*	✓
Tracked pneumatic rock drill		*						✓		✓

Table D.1 **Index of site equipment referred to in Tables D.2 to D.12** *(continued)*

Equipment	**Sound level data table**									
	D.2	**D.3**	**D.4 and D.5**	**D.6**	**D.7**	**D.8**	**D.9**	**D.10 and D.11**	**D.12**	
	Demolition	**Site preparation**	**Piling**	**Concreting operations**	**General site activities**	**Roadworks**	**Motorway construction**	**Opencast coal sites**	**Dredging**	**Quarrying**
Tractor		✓				✓	*	✓		
Tractor mounted compressor		✓				*	✓			
Tractor pulling dump truck						✓	*	✓		✓
Trenching machine		*								
Tripod winch			*							
Truck mixer				*						
Vibratory roller		*				✓	✓			✓
Water bowser					✓	✓	✓	*		
Water pump		*			*			✓	*	✓
Wheeled crane					*			✓		✓
Wheeled excavator/loader		*		*		*	✓	✓		✓
Wheeled excavator/loader fitted with hydraulic rock breaker						*	✓			
Wheeled loader		*				✓	✓	*	*	✓

Table D.2 **Historic sound level data on demolition**

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass), capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m dB
	Dropping ball demolition				
1	Tracked crane	123	—	121	93
	Breaking concrete below ground level				
2	Pneumatic breaker	—	20 kg	109	81
	Breaking concrete for drainage				
3	Pneumatic breakers (2)	—	35 kg	118	95
		—	35 kg	121	
	Breaking concrete foundation				
4	Tracked excavator fitted with breaker	—	200 kg·m	119	91
5	Tracked excavator fitted with breaker	—	200 kg·m	119	91
6	Tracked excavator fitted with breaker	—	200 kg·m	124	96
	Breaking concrete				
7	Pneumatic breaker	—	18 kg	120	92
8	Pneumatic breaker	—	25 kg	119	91
9	Pneumatic breaker	—	27 kg	116	88
10	Pneumatic breaker	—	35 kg	110	82
	Breaking hard ground				
11	Pneumatic breaker	—	27 kg	115	87
	Breaking brickwork				
12	Pneumatic breaker	—	35 kg	117	89
	Breaking rubble				
13	Pneumatic breaker	—	33 kg	118	90
	Sawing timber				
14	Petrol driven chain saw	—	—	114	86
	Boarding windows				
15	Hand-held hammer	—	—	112	84

Table D.3 **Historic sound level data on site preparation**

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass), capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m dB
	Clearing site				
1	Wheeled loader	41	—	103	75[A)] (15)
2	Wheeled loader	52	—	101	73[A)] (15)
3	Wheeled loader	52	—	102	74[A)] (15)
4	Wheeled loader	52	—	108	80[A)] (5)
5	Tracked loader	31	—	111	83
6	Tracked loader (idling)	37	—	101	73[A)] (—)
7	Tracked loaders	37	—	107	79[A)] (10)
8	Tracked loaders	37	—	110	82
9	Tracked loaders	37	—	110	82
10	Tracked loaders	37	—	113	85
11	Tracked loaders	37	—	118	90
12	Tracked loaders	41	—	116	88
13	Tracked loaders	45	—	113	85
14	Tracked loaders	56	—	108	80
15	Tracked loaders	56	—	112	84
16	Tracked loaders	60	—	104	76
17	Tracked loaders	60	—	113	85
18	Tracked loaders	61	—	114	86
19	Tracked loaders	67	—	112	84[A)] (10)
20	Tracked loaders	72	—	115	87
21	Tracked loaders	97	—	110	82
22	Tracked loader	60	—	110	82
	Lorry	—	—	—	82
23	Tracked loader (no exhaust silencer)	72	—	118	90
	Lorry	—	—	—	90
24	Tracked excavator/loader	46	—	108	80
25	Tracked excavator	73	—	113	85
26	Dozer	104	—	116	88
27	Dozer	239	—	109	81
	Ground excavation				
28	Dozer	201	—	115 Ripping	92
		201	—	120 Dozing	92
29	Dozer	290	—	114	86
30	Dozer (no exhaust silencer)	290	—	124	96

Table D.3 **Historic sound level data on site preparation** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass), capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq, T}$ [A1] at 10 m dB
31	Tracked crane fitted with excavator attachment	52	—	116	88
32	Dragline excavator	56	—	109	81
33	Dragline excavator	69	—	114	86
34	Tracked excavator	34	—	111	83
35	Tracked excavator	45	—	106	78
36	Tracked excavator	54	—	110	82
37	Tracked excavator	63	—	111	83
38	Tracked excavator	65	—	111	83
39	Tracked excavator	71	—	114	86
40	Tracked excavator	72	—	108	80
41	Tracked excavator (idling)	73	—	96	68
42	Tracked excavator	186	—	116	88
43	Tracked excavator	60	—	113	85
	Lorry	—	—	—	85
44	Tracked excavator	72	—	109	81
	Lorry	—	—	—	81
45	Tracked excavator	72	—	110	82
	Lorry	—	—	—	82
46	Tracked excavator	72	—	110	82
	Lorry	—	—	—	82
47	Tracked excavator/loader	60	—	115	87
48	Wheeled loader	90	—	115	87
49	Wheeled loader	242	—	123	95
50	Wheeled loader	410	—	104	76
51	Wheeled loader	37	—	112	84
	Lorry	—	—	—	84
52	Wheeled loader	242	—	114	86
	Dump truck	309	—	109	86
53	Tracked loader	37	—	110	82
54	Tracked loader	71	—	111	83
55	Tracked loader	205	—	112	84
56	Tracked loader	37	—	110	82
	Lorry	—	—	—	82
57	Tracked loader	71	—	108	80
	Lorry	—	—	—	80

Table D.3 **Historic sound level data on site preparation** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass), capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m dB
58	Tracked loader	138	—	110	82
	Lorry	—	—	—	82
59	Tracked loader	243	—	105	77
	Lorry	310	35 t	105	77
	Tipping fill				
60	Dump truck	450	50 t	110	82
	Spreading fill				
61	Wheeled excavator/loader	46	—	104	76
62	Dozer	200	—	109	81
63	Dozer	200	—	112	84
64	Dozer	240	—	117	89
	Levelling ground				
65	Dozer	46	—	111	81
66	Dozer	48	—	112	84
67	Dozer	104	—	116	88
68	Dozer (blown exhaust)	104	—	122	94
69	Dozer	170	—	112 forward	87
			—	115 reverse	87
70	Dozer	200	—	117 forward	90
			—	118 reverse	90
71	Dozer	218	—	113 forward	85
			—	108 reverse	85
72	Dozer	218	—	111	83
73	Dozer	289	—	114	86
74	Grader	87	—	105 forward	77
			—	104 reverse	76
75	Grader	168		112	84
76	Grader	—	—	111	83
	Trenching				
77	Wheeled excavator/loader	46	—	109	81
78	Wheeled excavator/loader	46	—	111	83
79	Wheeled excavator/loader	52	—	101	73[A)] (10)
80	Wheeled excavator/loader	52	—	106	78[A)] (10)
81	Wheeled excavator/loader	52	—	107	79
82	Wheeled excavator/loader	52	—	108	80
83	Wheeled excavator/loader	52	—	110	82

Table D.3 **Historic sound level data on site preparation** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass), capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m dB
84	Wheeled excavator/loader	34	—	110	82
	Lorry	—	—	—	82
85	Wheeled excavator/loader	52	—	105	77
86	Water pump	0.6	75 mm bore	100	72
87	Tracked excavator	45	—	112	84
88	Tracked excavator	37	—	107	79
89	Tracked excavator	46	—	109	81
90	Tracked excavator	70	—	104	76
91	Tracked excavator	70	—	104	76
92	Tracked excavator (plus lorry)	—	—	104	76
93	Tracked excavator	72	—	110	82[A)] (15)
94	Tracked excavator	78	—	116	88
95	Tracked excavator	83	—	110	82
96	Tracked excavator/loader	45	—	109	81
97	Tracked excavator/loader	52	—	105	77
98	Dumper	13	—	101	73
99	Compressor	—	3.5 m^3/min	106[B)]	86
	Pneumatic breaker	—	14 kg	113	86
100	Compressor	—	3.5 m^3/min	112	84
	Pneumatic breaker	—	27 kg	112	84
101	Compressor	—	4 m^3/min	100	85
	Pneumatic breaker	—	30 kg	113	85
102	Pneumatic spade	—	4 kg	113	85
103	Pneumatic spade	—	4 kg	115	87
104	Pneumatic spade	—	14 kg	115	87
105	Pneumatic spade	—	27 kg	115	87
106	Trenching machine	25	—	105	77
	Trench filling				
107	Wheeled excavator/loader	46	—	110	82
108	Tracked excavator	57	—	97	69
109	Tracked excavator	73	—	108	80
110	Dumper	13	2 t	102	74
111	Tracked loader	42	—	110	82
	Unloading and levelling hardcore				
112	Tipper lorry	75	—	113	85
113	Tracked loader	52	—	112	84

Table D.3 **Historic sound level data on site preparation** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass), capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1⟩ $L_{Aeq,\,T}$ ⟨A1] at 10 m dB
	Rolling gravel/brick				
114	Road roller	5	—	108	80
	Compacting fill				
115	Vibratory roller	9	—	102	74
116	Vibratory roller	50	7 000 kg	106	78
117	Dozer plus vibratory roller	104	—	114	86
		—	—	114	86
118	Compactor rammer	—	111 kg	108	80
	Compacting sub-base				
119	Compactor rammer	3	—	105	77
120	Compactor rammer	225	—	117	89
	Compacting earth				
121	Compactor rammer	—	111 kg	—	91
	Ground consolidation drilling				
122	Tracked pneumatic rock drill	—	120 mm piston	122	94
123	Pneumatic rock drill mounted on tracked excavator	—	120 mm piston	128	100
124	Pneumatic rock drill mounted on tracked excavator	—	120 mm piston	132	104
	Diaphragm wall construction				
125	Tracked excavator	46	—	113	85

A) [A1⟩ Drive-by ⟨A1] maximum sound pressure level, [A1⟩ L_{Amax} ⟨A1], at 10 m. Values of equipment speed, in kilometres per hour, are given in parentheses.

B) Side panels open.

Table D.4 **Historic sound level data on piling: piling operations**

Ref no.	Pile Depth	Pile Width A)	Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m (one cycle)
	m	m				dB			%	dB
	Trenching sheets									
1	3	0.4	Double acting air trenching hammer	48 kg·m	Steel	126	Mixed fill	15 min to 30 min	90	97
2	3	0.4	Double acting air trenching hammer	22 kg·m	None	113	Chalk/ballast	12 min	84	85
	Sheet steel piling									
3	3	0.95	Diesel hammer	5500 kg·m	None	136	Silt/rock	45 min	65	106
4	Last 1.5	0.95	Diesel hammer	3731 kg·m	None	128	Sand/gravel driving	—	100	100
5	5	0.48	Diesel hammer	3000 kg·m	None	133	Clay	50 min	80	104
6	3	0.48	Air hammer	22 kg piston	None	126	Clay	10 min	50	93
7	3	0.95	Double acting air hammer	300 kg·m	None	122	Wet clay extraction	—	100	94
8	8	0.5	Drop hammer	2.75 t, 2 m drop	Wood	114	Fill	67 min	40	83
9	8	0.5	Drop hammer	2.5 t, 2 m drop	Wood	111	Fill	50 min	40	81
10	11	0.4	Drop hammer	2.5 t, 1 m drop	Wood	122	Chalk	—	40	91
11	9	0.4	Enclosed drop hammer	3 t	Wood	110	Boulder clay	60 min	50	75
12	4	0.95	Hydraulic	220000 kg/pile	None	94	Clay	120 min	90	65
13	6	0.9	Hydraulic	220000 kg/pile	None	106	Wet clay	12 h	100	78
14	6	0.9	Hydraulic	220000 kg/pile	None	98	Wet clay	12 h	45	68
	Sheet steel piling (pairs)									
15	8	0.4 each	Enclosed drop hammer	3 t, 1 m drop	Wood/plastic	117	Fill/clay	60 min	75	88
16	8	0.4 each	Enclosed drop hammer	3 t, 1 m drop	Wood/plastic	109	Fill/clay	52 min	40	77

Table D.4 **Historic sound level data on piling: piling operations** *(continued)*

Ref no.	Pile Depth	Pile Width A)	Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level [A1) $L_{Aeq,T}$ (A1] at 10 m (one cycle)
	m	m				dB			%	dB
	Tubular steel casing/pile cast in place									
17	23	0.4 dia.	Drop hammer	4 t, 1 m drop	Aluminium alloy	129	Fill/clay	33 min	60	100
18	23	0.4 dia.		4 t, 1 m drop	Wood	119	Fill/clay	58 min	80	89
19	23	0.4 dia.		4 t, 1 m drop	Wood	118	Fill/clay	75 min	50	87
20	23	0.4 dia.		4 t, 1 m drop	Wood	122	Chalk	—	50	91
21	10	0.4 dia.	Diesel hammer	5 500 kg·m	Wood	132	Clay	60 min	50	101
22	8	1.25	Electric vibratory extractor	24 Hz	None	125	Clay	15 min	35	93
	Impact bored/pile cast in place									
23	14	0.5 dia	Tripod winch	25 kW	None	103	Hard clay	1.5 days	85	73
24	9.5	0.5 dia.		18 kW	None	104	Rough/fill/clay/ limestone	9 h	85	76
25	10	0.3 dia.		12 kW	None	112	Gravel/clay	4 h	65	84
26	10	0.5 dia.	Pair tripod winches	2 × 16 kW	None	112	Sand fill/wet clay	—	100	83
	H-section steel piling									
27	8	0.37 sq.	Drop hammer	5 t	Wood	125	Clay/flint/chalk	60 min	50	94
28	10	0.36 sq.	Diesel hammer	6 219 kg·m	None	125	Fill/clay sandstone	30 min	70	96
	Precast concrete piles									
29	10	0.535 dia.	Drop hammer	6 t, 0.5 m drop	Wood	124	Fill	5 min	30	91
30	25	0.285 sq.		5 t, 1.0 m drop	Wood	123	Clay/flint/chalk	2.5 h	80	87
31	20	0.275 sq.		4 t, 0.5 m drop	Wood	116	Chalk/clay	47 min	60	87
32	20	0.275 sq.		4 t, 0.5 m drop	Wood	116	Fill/clay/sand	67 min	30	82

Table D.4 **Historic sound level data on piling: piling operations** *(continued)*

Ref no.	Pile Depth	Pile Width A)	Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m (one cycle)
	m	m				dB			%	dB
	Bored piling/pile cast in place									
33	15	1.5 dia.	Crane mounted auger	Crane 113 kW Donkey 85 kW	None	116	Clay	60 min	55	87
34	19	1.07 dia.	Crane mounted auger	Crane 100 kW Donkey 75 kW	None	116	Fill/clay	40 min	25	83
35	13	1 dia.	Crane mounted auger	Crane 116 kW Donkey 82 kW	None	113	Clay	Boring	100	85
36	26	0.82 dia.	Crane mounted auger	Crane 75 kW Donkey 150 kW	None	118	Clay	Boring	100	90
37	20	0.75 dia.	Crane mounted auger	Crane 99 kW Donkey 125 kW	None	111	Clay/silt	30 min	30	79
38	15	0.75 dia.	Crane mounted auger	Crane 58 kW Donkey 97 kW	None	116	Clay	60 min	50	85
39	10	0.75 dia.	Crane mounted auger	Crane 58 kW Donkey 97 kW	None	112	Clay	40 min	50	82
40	13	0.61 dia.	Crane mounted auger	Crane 100 kW Donkey 37 kW	None	124	Clay	52 min	15	88
41	15.7	0.55 dia	Crane mounted auger	Crane 100 kW Donkey 134 kW	None	112	Clay	90 min	50	81
42	8	0.4 dia.	Crane mounted auger	Crane 58 kW Donkey 134 kW	None	116	Clay	Boring	100	88
43	8	0.4 dia.	Crane mounted auger, pile case vibratory driven	—	None	116	Dry clay	—	100	88

Table D.4 **Historic sound level data on piling: piling operations** *(continued)*

Ref no.	Pile Depth	Pile Width A)	Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m (one cycle)
	m	m				dB			%	dB
44	10	0.48 dia	Lorry mounted auger	75 kW	None	109	Sand/clay	—	50	79
45	5	0.25 dia.		54 kW	None	112	Clay	10 min	50	81
46	4	0.225 dia.		39 kW	None	102	Clay	10 min	30	71
47	33	1.18 dia.	Oscillatory bored	164 kW	None	115	Clay/chalk	8 h	100	81
48	See Table D.5									
49	See Table D.5									
	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
58	10 (4 m exposed)	0.96	Double acting air impulse hammer	15 kN·m	Air cushion	111	—	—	100	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

Table D.4 **Historic sound level data on piling: piling operations** *(continued)*

Ref no.	Pile Depth	Pile Width A)	Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level A1) $L_{Aeq,T}$ (A1 at 10 m (one cycle)	
	m	m				dB			%	dB	
	Tubular casing										
61	23	1.07 dia.	Double acting diesel hammer	6 219 kgf·m	Not known	122	Silt overlying chalk	—	100	94	
62	23	1.07 dia.	Double acting diesel hammer	16 000 kgf·m	Not known	132	Silt overlying chalk	—	100	104	
	Tubular steel casing/pile cast in place										
63a)	13	0.35 dia.	Drop hammer	3.3 t, 1.2 m drop	Resilient composite pad	130	Estuarial alluvia	20 min	20	95	
63b)	13	0.35 dia.	Drop hammer	3.3 t, 1.2 m drop	Resilient composite pad	126	Estuarial alluvia	20 min	30	93	97
63c)	13	0.35 dia.	Drop hammer, extracting casing	3.3 t	Resilient composite pad	120	Estuarial alluvia	20 min	10	82	
64a)	14	0.4 dia.	Drop hammer	4 t, 1.2 m drop	Resilient composite pad	132	Dense sand	45 min	40	100	
64b)	14	0.4 dia.	Drop hammer	4 t, 1.2 m drop	Resilient composite pad	125	Dense sand	45 min	20	90	100
64c)	14	0.4 dia.	Drop hammer, extracting casing	4 t	Resilient composite pad	118	Dense sand	45 min	5	77	
65a)	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	
65b)	8	0.35 dia.	Drop hammer, partially enclosed acoustically	3.3 t, 1.2 m drop	Resilient composite pad	122	Silt/peat/shale/ sandstone	25 min	35	89	91
65c)	8	0.35 dia.	Drop hammer, partially enclosed acoustically, extracting casing	3.3 t, 1.2 m drop	Resilient composite pad	121	Silt/peat/shale/ sandstone	25 min	8	82	
66a)	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	97
66b)	8	0.4 dia.	Drop hammer, partially enclosed acoustically	4 t, 1.6 m drop	None	125	Stiff to hard sandy clay	30 min	30	92	
67a)	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	86
67b)	5	0.45 dia.	Internal drop hammer	3 t, 4 m drop	Dry mix aggregate plug	115	Made ground overlying clay	40 min	50	84	
68a)	14	0.4 dia.	Internal drop hammer	3 t, 4 m drop	Dry mix aggregate plug	111	Ballast	—	50	80	84
68b)	14	0.4 dia.	Internal drop hammer	3 t, 4 m drop	Dry mix aggregate plug	116	Ballast	—	25	82	

Table D.4 **Historic sound level data on piling: piling operations** *(continued)*

Ref no.	Pile Depth	Pile Width A)	Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level [A1) $L_{Aeq,T}$ (A1] at 10 m (one cycle)	
	m	m				dB			%	dB	
	Impact bored/pile cast in place										
69a)	20	0.5 dia.	Tripod winch	20 kW	None	106	Fill/ballast/stiff clay	6 h	30	73	83
69b)	20	0.5 dia.	Tripod winch	20 kW	None	108	Fill/ballast/stiff clay	6 h	60	78	
69c)	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	
69d)	20	0.5 dia.	Tripod winch, driving casing	3/4 t, 1 m drop	Steel	122	Fill/ballast/stiff clay	6 h	2.5	78	
70a)	25	0.6 dia.	Tripod winch	20 kW	None	108	Fill/sand/ballast/ stiff clay	10 h	30	75	88
70b)	25	0.6 dia.	Tripod winch	20 kW	None	113	Fill/sand/ballast/ stiff clay	10 h	60	83	
70c)	25	0.6 dia.	Tripod winch, driving casing	3/4 t, 1 m drop	Steel	127	Fill/sand/ballast/ stiff clay	10 h	2	82	
70d)	25	0.6 dia.	Tripod winch, driving casing	3/4 t, 1 m drop	Steel	129	Fill/sand/ballast/ stiff clay	10 h	2	84	
	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	Hydraulic drop hammer, enclosed acoustically	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	

Table D.4 **Historic sound level data on piling: piling operations** *(continued)*

Ref no.	Pile Depth	Pile Width [A)]	Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m (one cycle)
	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			60 kN·m	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			3 t, 0.3 m drop	Hardwood	119	Stiff clay overlying mudstone	—	100	91
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			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

Table D.4 **Historic sound level data on piling: piling operations** *(continued)*

Ref no.	Pile Depth	Pile Width A)	Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m (one cycle)	
	m	m				dB			%	dB	
84	20	0.08 m² 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 m² 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	
86	20	0.406 dia. modular shell	Drop hammer driving on mandrel/pile cast in place	5 t, 0.75 m drop	Wood/sisal	114	Fill overlying chalk	41 min	30	82	
87	28	0.444 dia. modular shell		6 t, 1 m drop	Wood	121	Sand/clay/chalk	57 min	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	
89a)	25	0.6 dia.		90 kW	None	110	Sand/gravel/stiff clay	90 min	85	81	85
89b)	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	
92a)	25	0.9 dia.	Crane-mounted auger	90 kW	None	114	Fill/clay	3 h	95	86	87
92b)	25	0.9 dia.	Crane-mounted auger: kelly bar clanging	90 kW	None	122	Fill/clay	3 h	3	79	

Table D.4 **Historic sound level data on piling: piling operations** *(continued)*

Ref no.	Pile		Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m (one cycle)	
	Depth	Width A)									
	m	m				dB			%	dB	
93	30	1.05 dia.	Crane-mounted auger	120 kW	None	117	Ballast/clay	5 h	100	89	
94a)	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
94b)	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	Sands/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	Sands 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	

Table D.4 **Historic sound level data on piling: piling operations** *(continued)*

Ref no.	Pile		Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [/A1] at 10 m (one cycle)	
	Depth	Width [A)]									
	m	m				dB			%	dB	
	Diaphragm walling										
101	25	1.0 × 4.0	Crane-mounted hydraulically operated trenching grab guided by kelly bar	90 kW	None	114	Sands and gravels overlying chalk	12 h	100	86	
102	25	1.0 × 4.0	Crane-mounted hydraulically operated trenching grab guided by kelly bar	90 kW	None	116	Sands and gravels overlying chalk	12 h	100	86	
103	25	1.0 × 4.5	Crane-mounted rope operated trenching grab	8 t, 10 m drop	None	113	Sands and gravels overlying clay	10 h	80	84	
	Vibroreplacement/vibrodisplacement										
104a)	4	0.5 dia. approx.	Stone column formation by crane-mounted hydraulically powered vibrating poker. Compressed air flush; nose cone air jets exposed	90 kW	None	110	Miscellaneous fill	15 min	80	81	85
104b)	4	0.5 dia. approx.	Stone column formation by crane-mounted hydraulically powered vibrating poker. Compressed air flush; nose cone air jets exposed	90 kW	None	117	Miscellaneous fill	15 min	20	82	
105a)	—	2.4 × 2.4	Tamping weight raised by large crawler crane	120 kW	None	114	Made ground and fill	10 min	80	85	86
105b)	—	2.4 × 2.4	Tamping weight released by crane: impact of weight	20 t, 20 m drop	None	125	Made ground and fill	1 drop per min	1.5	79	
106a)	—	2.4 × 2.4	Tamping weight raised by large crawler crane	120 kW	None	110	Made ground and fill	10 min	80	81	82
106b)	—	2.4 × 2.4	Tamping weight released by crane: impact of weight	20 t, 20 m drop	None	122	Made ground and fill	1 drop per min	1.5	76	

Table D.4 **Historic sound level data on piling: piling operations** *(continued)*

Ref no.	Pile Depth	Pile Width [A)]	Method	Energy, power rating	Dolly	Sound power level L_{WA}	Soil	Cycle time	On-time	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m (one cycle)	
	m	m				dB			%	dB	
	Installation of vertical band drains										
107a)	7	0.1	Hydraulic vibratory lance starting up	50 kW	None	113	Sandy silty fill	5 min	1	65	80
107b)	7	0.1	Hydraulic vibratory lance installing band drain	50 kW	None	107	Sandy silty fill	5 min	70	76	
107c)	7	0.1	Hydraulic vibratory lance being extracted	50 kW	None	115	Sandy silty fill	5 min	15	79	

NOTE 1 Energy and power relationship: 1 kgf·m = 9.81 joules (J).

NOTE 2 1 t dropped 1 m = 9.81.10³ J = 9.81 kJ = 9.81 kN·m; 1 kW = 10³ J/s = 1 kJ/s.

NOTE 3 Depths, cycle times where quoted and on-times are typical for specific cases but can vary considerably according to ground and other conditions.

A) dia. = diameter; sq. = square section.

Table D.5 **Historic sound level data on piling: ancillary operations**

Ref. no	Equipment	Power rating	Equipment size, weight (mass), capacity	Sound power level L_{WA}	On-time	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m
		kW	kg	dB	%	dB
	Cleaning welds on piles					
48	Pneumatic chipping hammer	—	4	116	100	88
	Shaping top of bored pile for fitting concrete cap					
49	Pneumatic chipping hammer (2)	—	11 each	119	30	86

Table D.6 **Historic sound level data on concreting operations**

Ref. no	Equipment	Power rating	Equipment size, weight (mass), capacity	Sound power level L_{WA}	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m
		kW		dB	dB
	Preparation, mixing and discharging of concrete				
1	Concrete mixer	1.1	0.1 m^3	92	64
2	Concrete mixer	1.1	0.1 m^3	100	72
3	Concrete mixer	2	0.14 m^3	89	61
4	Concrete mixer	2	0.14 m^3	91	63
5	Concrete mixer	4.1	0.14 m^3	102	74
6	Concrete mixer	4.1	0.2 m^3	99	71
7	Concrete mixer	4.1	0.3 m^3	104	76
8	Concrete mixer	—	0.4 m^3	90	62
9	Batching plant	—	19 m^3/h	104	76
10	Batching plant	—	27 m^3/h	106	78
11	Batching plant	—	360 m^3/day	108	80
12	Truck mixer (discharging)	—	6 m^3	112	84 A)
	Mixing and pumping grout				
13	Grout mixer and pump	34	—	108	80
	Pinning reinforcing				
14	Pneumatic hammer fitted with attachment for pinning reinforcement	—	15 kg	118	90
	Pumping concrete into bored pile				
15	Truck mixer	22 B)	—	109	81
16	Lorry mounted concrete pump	130	—	109	81

Table D.6 **Historic sound level data on concreting operations** *(continued)*

Ref. no	Equipment	Power rating	Equipment size, weight (mass), capacity	Sound power level L_{WA}	Activity equivalent continuous sound pressure level [A1) $L_{Aeq, T}$ (A1] at 10 m
		kW		dB	dB
	Pumping concrete to foundations, and compaction				
17	Lorry mounted concrete pump	97	—	109	81
18	Tracked crane	92	—	109	81
19	Compressor	—	4 m^3/min	100	72
20	Poker vibrators (5)	2 each poker	—	102 each poker	81
	Pumping concrete to 2nd floor				
21	Truck mixer	22 B)	—	—	74
22	Lorry mounted concrete pump	100	—	106	78
	Oversite concreting				
23	Truck mixer	22 B)	6 m^3	100	72
24	Tracked excavator	63	—	—	72
	Placing concrete to office complex superstructure				
25	Truck mixer	22	—	111	83
26	Tracked crane	200	—	116	88
	Placing concrete for road foundation				
27	Truck mixer	22 B)	—	116	88
28	Wheeled excavator/loader	52	—	102	74
	Placing concrete and compaction				
29	Truck mixer (2)	—	5 m^3 each	108	86
	Tracked crane	62	—	101 (lifting) 94 (idle)	
	Poker vibrator	3	—	112	
	Hosing down truck mixer drum				
30	Truck mixer	—	10 t (6 m^3)	108	80
	Pumping concrete to bridge sections and compaction				
31	Lorry mounted concrete pump	97	—	118	90
32	Poker vibrators (5)	2 each poker	—	100 each poker	79
	Pumping concrete				
33	Truck mixer	—	6 m^3	96	68
34	Lorry mounted concrete pump	100	—	107	79
35	Truck mixer	—	5 m^3	100	72
36	Lorry mounted concrete pump	100	—	106	78
	Placing concrete for bored piles (including hosing down of the truck mixer drum)				
37	Truck mixer	—	5 m^3	114	86

Table D.6 **Historic sound level data on concreting operations** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass), capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m dB
	Placing concrete for building foundations, and compaction				
38	Truck mixer	—	6 m^3	116	88
39	Lorry mounted crane	78	—	116	88
40	Poker vibrators (2)	0.75 each poker	—	98 each poker	73
	Compaction of concrete				
41	Generator	—	200 kV·A	122	94
42	Poker vibrator	—	—	122	94
43	Compressor	—	3 m^3/min	105	77
	Compressor, small petrol driven	—	—	—	
	Poker vibrators (2)	—	—	—	
	Floating concrete				
44	Power float	3	—	100	72
	Scabbling concrete				
45	Compressor	4.1	3.5 m^3/min	100	83
	Pneumatic chipper	—	—	111	
	Chipping concrete				
46	Pneumatic chipping hammer	—	4 kg	103	75
47	Pneumatic chipping hammer	—	4 kg	117	89
48	Pneumatic chipping hammer	—	5 kg	110	82
49	Pneumatic chipping hammer	—	14 kg	106	78
	Grinding foundation slab				
50	Pneumatic concrete grinder	—	225 mm blade	115	87
	Remedial work on concrete beam				
51	Pneumatic breaker	—	41 kg	124	96
	Repair to wall cladding				
52	Electric percussion drills (2)	—	10 kg	105	78
		—	4 kg	98	
	Cutting concrete pipes				
53	Hand-held petrol driven disc cutter	—	—	112	84
	Drilling into a concrete beam				
54	Electric percussion drill	—	10 kg	104	89 C)
	Drilling for soil stack passing through concrete floors				
55	Pneumatic chipper/drill	—	4 kg	114	95 C)

A) Drive-by maximum sound pressure level, [A1] L_{Amax} [A1], at 10 m.

B) Truck mixer provided with donkey engine.

C) Includes the reverberation of sound within the building.

Table D.7 **Historic sound level data on general site activities**

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass), capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m dB
	Dismantling scaffolding				
1	Scaffold poles and clips	—	Various	—	80
	Loading scaffolding				
2	Scaffold poles	—	6 m length	100	72
3	Scaffold frames and clips	—	2 m × 0.5 m	96	68
	Supplying air to power tools and for general site use				
4	Compressor	26	1.1 m^3/min	76 front	48
				79 side	51
				81 rear	53
			(Side panel open)	91 side	63
5	Compressor	26	2.8 m^3/min	91	63
6	Compressor	26	3 m^3/min	105	77
7	Compressor	—	3.5 m^3/min	89	61
8	Compressor	—	3.5 m^3/min	98	70
9	Compressor	—	3.5 m^3/min	102	74
10	Compressor	—	3.7 m^3/min	106	78
11	Compressor	—	4 m^3/min	102	74
12	Compressor	—	4 m^3/min	108	80
13	Compressor	—	4 m^3/min	92	64
14	Compressor	—	4 m^3/min	92	64
15	Compressor	—	4 m^3/min	93	65
16	Compressor	—	4 m^3/min	96	68
17	Compressor (sound reduced)	—	4 m^3/min	90	62
18	Compressor	—	4.5 m^3/min	99	71
19	Compressor	—	4.5 m^3/min	102	74
20	Compressor	—	4.5 m^3/min	104	76
21	Compressor	—	4.5 m^3/min	107	79
22	Compressor	—	4.5 m^3/min	109	81
23	Compressor (sound reduced)	—	4.5 m^3/min	98	70
24	Compressor	—	5 m^3/min	95	67
25	Compressor	—	7 m^3/min	98	70
26	Compressor	—	7 m^3/min	100	72
27	Compressor	—	7 m^3/min	100	72
28	Compressor (sound reduced)	—	7 m^3/min	100	72

Table D.7 **Historic sound level data on general site activities** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass), capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m dB
29	Compressor	—	8.5 m³/min	102	74
30	Compressor	—	10.5 m³/min	105	77
31	Compressor	—	10.5 m³/min	114	86
32	Compressor	—	13.6 m³/min	111	83
33	Compressor	—	17 m³/min	108	80
34	Compressor	—	17 m³/min	111	83
35	Compressor	—	17 m³/min	111	83
36	Compressor	—	17 m³/min	120	92
37	Compressor	—	17 m³/min	123	95
38	Compressor	—	4.5 m³/min	104	83
			7.1 m³/min	110	79
39	Compressor (unsilenced)	—	Up to 10 m³/min	113 A)	89 B), C)
40	Compressor (unsilenced)	—	10 m³/min to 34 m³/min	117 A)	93 B), C)
41	Compressor (unsilenced)	—	Above 34 m³/min	121 A)	85 B), C)
42	Compressor (sound reduced)	—	Up to 10 m³/min	100 A)	72 B), C)
43	Compressor (sound reduced)	—	10 m³/min to 34 m³/min	102 A)	74 B), C)
44	Compressor (sound reduced)	—	Above 34 m³/min	103 A)	75 B), C)
	Supplying electricity for power tools, site machines and ancillary equipment				
45	Petrol driven generator	—	1.5 kV·A	95	67
46	Petrol driven generator	—	2 kV·A	105	77
47	Petrol driven generator	—	2 kV·A	111	83
48	Petrol driven generator	—	2.5 kV·A	98	70
49	Petrol driven generator	—	4 kV·A	104	76
50	Petrol driven generator	—	4 kV·A	108	80
51	Petrol driven generator	—	7.5 kV·A	100	72
52	Petrol driven generator (power supply for temporary traffic lights)	—	—	94	66
53	Diesel driven generator	9	—	102	74

Table D.7 **Historic sound level data on general site activities** *(continued)*

Ref. no	Equipment	Power rating	Equipment size, weight (mass), capacity	Sound power level L_{WA}	Activity equivalent continuous sound pressure level [A1] $L_{Aeq, T}$ [A1] at 10 m
		kW		dB	dB
54	Diesel driven generator (power supply for hydraulic piling rig)	—	—	89	61
55		—	50 kV·A	92	64
56	Diesel driven generator (power supply for tower crane)	—	75 kV·A	110	82
	Electric supply for arc welders				
57	Diesel driven generator	—	5 kV·A	104	76
58		—	9 kV·A	107	79
59		—	10 kV·A	103	75
60		—	10 kV·A	108	80
61		—	12.5 kV·A	107	79
62		—	—	100	72
63		—	—	107	79
	Drilling concrete				
64	Hand-held pneumatic rock drill	—	14 kg	118	90
	Draining trench				
65	Water pump	1	—	95	67
66		1.5	—	100	72
67		41	0.42 m^3/s	105	77
	Pumping water				
68	Water pump	4.5	—	94	66
69		4.5	—	104	76
70		4.5	—	108	80
71		4.5	—	109	81
72		7.5	—	102	74
73		7.5	—	106	78
74		—	7.5 mm bore	100	72
	Cutting timber				
75	Hand-held electric circular saw	—	150 mm blade	105	77
76		—	225 mm blade	109	81
77		—	225 mm blade	110	82
78	Circular saw, bench mounted	—	660 mm blade (free running)	106	78

Table D.7 **Historic sound level data on general site activities** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass), capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m dB
79	Pneumatic circular saw	—	(Cutting 250 mm × 250 mm cedar beam)	103	75
	Hammering				
80	Club hammer	—	1.5 kg	107	79
	Distribution of materials				
81	Dumper	5.5	—	96	68 D) (1.5)
82	Dumper (idling)	5.5	—	91	63
83	Dumper (idling)	6	—	95	67
84	Dumper (idling)	9	—	88	60
85	Dumper (idling)	13	—	92	64
86	Dumper (idling)	13	2 t	95	67
87	Dumper	13	—	103	75 D) (15)
88	Dumper	13	2.25 t	106	78 D) (10)
89	Dumper	13	—	110	82 D) (15)
90	Dumper (pulling away)	13	—	112	84 D) (—)
91	Dumper	28	—	117	89 D) (20)
92	Dumper	—	—	107	79 D) (5)
93	Site fork lift trucks	32	—	104	76 D) (10)
94	Site fork lift trucks	32	—	116	88 D) (15)
95	Site fork lift trucks	57	—	122	94 D) (15)
96	Site fork lift trucks (idling)	57	—	105	77
		57	—	122	94 D) (15)
97	Diesel hoist	6	—	101	73
98	Diesel hoist	6	—	104	76
99	Diesel hoist	—	1.27	105	77
100	Diesel hoist (poorly maintained)	—	Wheel-barrow (2)	116	88
	Lifting operations				
101	Wheeled crane	4	—	94	66
102	Wheeled crane	4	—	103	75
103	Wheeled crane	4	—	110	82
104	Wheeled crane	30	—	112	84

Table D.7 **Historic sound level data on general site activities** *(continued)*

Ref. no	**Equipment**	**Power rating** kW	**Equipment size, weight (mass), capacity**	**Sound power level L_{WA}** dB	**Activity equivalent continuous sound pressure level [A1⟩ $L_{Aeq,\,T}$ ⟨A1] at 10 m** dB
105	Tracked crane	30	—	108	80
106	Tracked crane	42	22 t	99	71
107	Tracked crane (moving)	42	22 t	114	86
108	Tracked crane (idling)	56	20 t	99	71
109	Tracked crane	56	—	103	75
110		56	—	106	78
111		56	—	109	81
112		58	34 t	102	74
113		58	—	107	79
114		62	—	101	73
115		62	—	110	82
116		67	—	108	80
117		75	25 t	110	82
118		80	—	99	71
119		100	—	109	81
120		42	22 t	104	76
		72	25 t	104	76
	Arrival and departure of vehicles				
121	Lorry (pulling up)	—	10 t	98	70 D)
122	Lorry (unloading)	—	6 m^3	112	—

A) Average sound power levels.

B) [A1⟩ $L_{Aeq,\,T}$ ⟨A1] at 10 m calculated from L_{WA} – 28.

C) These are typical noise level values for portable diesel driven compressors both in unsilenced and sound-reduced forms. [A1⟩ Source: British Compressed Air Society ⟨A1]

D) Drive-by maximum sound pressure level, [A1⟩ L_{Amax} ⟨A1], at 10 m. Values of equipment speed, in kilometres per hour, are given in parentheses.

Table D.8 **Historic sound level data on roadworks**

Ref. no	Equipment	Power rating	Equipment size, weight (mass), capacity	Sound power level L_{WA}	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,\,T}$ [A1] at 10 m
		kW		dB	dB
	Breaking road surface				
1	Pneumatic breaker	—	35 kg	114	86
2	Pneumatic breaker	—	35 kg	118	90
3	Pneumatic breaker	—	35 kg	121	93
4	Pneumatic breaker	—	35 kg	123	95
5	Compressor	—	3.5 m³/min	112	91
6	Pneumatic breaker (2)	—	35 kg	115	
7		—	35 kg	115	
8	Compressor	—	4 m³/min	106	87
9	Pneumatic breaker	—	35 kg	114	
10	Tractor mounted compressor	39	Integral compressor	122	94
11	Pneumatic breaker	—	27 kg		
12	Wheeled excavator/loader fitted with hydraulic rock breaker	52	—	106	78
13	Tracked excavator fitted with hydraulic rock breaker	73	—	110	82
		—	200 kg		
	Removing road surface				
14	Road raiser and lorry	97	—	115	87
	Removing broken road surface				
15	Wheeled excavator/loader	57	—	103	75
16	Wheeled excavator/loader	46	—	108	80 A) (0.3)
	Lorry	—	10 t		
	Road planing				
17	Road planer	124	—	111	83 A) (0.3)
	Pinning rails for slipform paving				
18	Tractor mounted compressor	41	4 m³/min	114	89
19	Pneumatic hammer	—	—	114	
	Slipforming concrete road				
20	Paving train	195	—	109	81 A) (0.4)

Table D.8 **Historic sound level data on roadworks** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass), capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m dB
	Road surfacing				
21	Asphalt melter	—	—	103	75
22	Asphalt spreader	53	—	110	82 A) (2)
23	Asphalt spreader and chipping hopper	53	—	114	86 A) (1.5)
24	Asphalt spreader	90	13 t	101	73 A) (1.5)
25	Road roller Lorry	— —	10 t 24 t	96	68 A) (4)
26	Asphalt spreader Chip spreader Road roller Lorry	90 — — —	13 t — 10 t —	108	80 A) (1.5)
27	Road roller (2)	—	10 t each	104	76 A) (5)
28	Road roller	5	—	121 B)	93 A) (10)
29	Road roller	5	—	105 C)	77 A) (10)
30	Road roller	51	—	101	73
	Road sweeping				
31	Lorry mounted road sweeper	—	—	101	73 A) (2)
	Installation of traffic light controls				
32	Groove cutter	45	—	115	87
	Excavating trench				
33	Tracked excavator	46		102	74

A) Drive-by maximum sound pressure level, [A1] L_{Amax} [A1], at 10 m. Values of equipment speed, in kilometres per hour, are given in parentheses.

B) Travelling on concrete.

C) Travelling on gravel/brick.

Table D.9 **Historic sound level data on motorway construction**

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass), capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m dB	
	Levelling ground and earth removal					
1	Dozer	109	—	113	85 A)	(10)
2	Dozer	200	—	104	76 A)	(2)
3	Dozer	200	—	126	98 A)	(5)
4	Dozer	200	—	129	101 A)	(5)
5	Dozer (idling)	240	—	101	73	
6	Grader	140	—	113	85 A)	(20)
7	Grader	150	—	111	83 A)	(10)
8	Grader	168	—	111	83 A)	(2)
9	Grader	168	—	112	84 A)	(24)
10	Grader	168	—	114	86 A)	(2)
11	Grader	168	—	110	—	(—)
12	Scraper	109	—	118	90 A)	(10)
13	Scraper (unladen)	475	—	120	92 A)	(30)
14	Scraper (laden)	475	—	123	95 A)	(30)
15	Scraper	475	—	125	97 A)	(10)
16	Scraper	480	—	108	80 A)	(25)
17	Scraper	480	—	110	82 A)	(2)
18	Dump truck	110	—	118	90 A)	(10)
19	Dump truck	—	20 t	102	74 A)	(10)
20	Dump truck	—	20 t	103	75 A)	(10)
21	Dump truck	—	20 t	104	76 A)	(15)
22	Dump truck	—	20 t	108	80 A)	(10)
23	Dump truck	—	20 t	110	82 A)	(10)
24	Dump truck	—	24 t	104	76 A)	(15)
25	Dump truck	309	—	110	82 A)	(30)
26	Dump truck	309	—	111	83 A)	(30)
27	Dump truck	310	35 t	105	—	(—)
28	Dump truck	310	35 t	106	78 A)	(5)
29	Dump truck	310	35 t	109	81 A)	(20)
30	Dump truck	310	35 t	109	81 A)	(30)
31	Dump truck	310	35 t	110	82 A)	(1.5)
32	Dump truck	310	35 t	111	83 A)	(30)
33	Dump truck	310	35 t	112	84 A)	(35)
34	Dump truck	310	35 t	113	85 A)	(40)
35	Dump truck	310	35 t	113	85 A)	(30)
36	Dump truck	310	35 t	115	87 A)	(40)
37	Dump truck	310	35 t	119	91 A)	(20)

Table D.9 **Historic sound level data on motorway construction** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass), capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq, T}$ [A1] at 10 m dB
38	Dump truck (36) B)	450	50 t	103 laden; 110 empty	76
39	Dump truck	450	50 t	103	75 A) (—)
40	Dump truck	450	50 t	104	76 A) (5)
41	Dump truck	450	50 t	106	78 A) (10)
42	Dump truck	450	50 t	110	82 A) (15)
43	Dump truck	450	50 t	120	92 A) (35)
44	Dump truck (45) B)	112	—	108	76
	Scraper	475	—	123	
45	Dump truck (30) B)	301	—	111	82
	Grader (10) B)	150	—	111	
	Scraper (50) B)	475	—	122	
46	Scraper (28) B)	230	—	123	83
	Dozer with scraper box (48) B)	200	—	121	
47	Dozer pushing	306	—	122	94
	Scraper	475	—		
48	Tracked excavator	298	—	113	87
	Dumper truck	309	—	110	
49	Tractor pulling dump truck	63	—	113	85
50	Tractor (idling)	63	—	99	71

A) Drive-by maximum sound pressure level, [A1] L_{Amax} [A1], at 10 m. Values of equipment speed, in kilometres per hour, are given in parentheses.

B) Number of passes per hour.

Table D.10 **Historic sound level data on opencast coal sites: pre 1984**

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass)[A)], capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,\,T}$ [A1] at 10 m dB
	Drilling blastholes				
1	Compressor and pneumatic drilling rig	115	—	113	85
2		160	—	112	84
3		160	—	114	86
4		170	—	119	91
5		170	—	120	92
6	Diesel powered combined rig (rotary)	160	170 mm borehole	113	85
7		160	170 mm borehole	114	86
	Breaking out and loading				
8	Diesel powered face shovel (crowd action)	56	Coaling 0.67 m^3 Shovel	110	82
9		56		111	83
10		56		112	84
11		56		113	85
12		56		113	85
13		56		114	86
14		56		114	86
15		56		114	86
16		56		114	86
17		56		114	86
18		56		115	87
19		56		115	87
20		71	Coaling 6.1 m^3/h	108	80
21		408		114	86
22		408		114	86
23	Diesel powered hydraulic shovel (or back acter)	60	Coaling	108	80
24		77		106	78
25		95		110	82
26		95		111	83
27		95		112	84
28		95		112	84
29		95		113	85
30		95		113	85
31		101	Coaling	113	85
32		101	Coaling	114	86
33		112	Coaling 3.8 m^3	115	87
34		242	3.8 m^3	115	87
35		242	3.8 m^3	115	87
36		242	3.8 m^3	116	88
37		244	3.1 m^3	116	88
38		336	6.0 m^3	112	84
39		470	6.5 m^3	117	89
40		537	7.6 m^3	114	86
41		665	8.4 m^3	117	89

Table D.10 **Historic sound level data on opencast coal sites: pre 1984** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass)[A)], capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m dB
42	Electric powered face shovel	225	—	104	76
43		225	—	110	82
44		225	—	110	82
45		225	—	113	85
46		261	4.6 m^3	105	77
47		261	4.6 m^3	110	82
48		261	4.6 m^3	110	82
49		261	4.6 m^3	113	85
50		448	9.2 m^3	109	81
51		448	9.2 m^3	109	81
52		448	9.2 m^3	111	83
53		448	9.2 m^3	112	84
54	Diesel powered dragline	225	—	118	90
55		269	4 m^3	118	90
56		353	4 m^3	109	81
57		353	4 m^3	111	83
58		353	4 m^3	112	84
59		353	4 m^3	113	85
60		353	4 m^3	114	86
61		394	3.4 m^3	104	76
62		394	3.4 m^3	105	77
63		394	3.4 m^3	109	81
64		394	3.4 m^3	109	81
65		408	5.3 m^3	107	79
66		408	5.3 m^3	109	81
67		408	5.3 m^3	110	82
68		408	5.3 m^3	112	84
69		408	5.3 m^3	113	85
70		408	5.3 m^3	113	85
71		408	5.3 m^3	114	86
72		408	5.3 m^3	114	86
73		408	5.3 m^3	114	86
74		408	5.3 m^3	114	86
75		408	5.3 m^3	122	94
76		480	5.7 m^3	113	85
77		480	5.7 m^3	115	87
78		480	5.7 m^3	115	87
79		480	5.7 m^3	115	87
80		480	5.7 m^3	119	91

Table D.10 **Historic sound level data on opencast coal sites: pre 1984** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass)[A)], capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq, T}$ [A1] at 10 m dB
81	Electric powered dragline	746	9.2 m³	110	82
82		1 119	11.5 m³	110	82
83		1 305	19 m³	114	86
84		1 305	19 m³	115	87
85		1 865	24.5 m³	107	79
86		4 476	50 m³	111	83
87		4 476	50 m³	111	83
88		4 476	50 m³	113	85
89		4 476	50 m³	113	85
90	Diesel powered front end loader (wheeled)	60	—	104	76
91		60	—	107	79
92		60	—	113	85
93		60	—	114	86
94		97	2.3 m³	108	80
95		97	2.3 m³	117	89
96		127	3.05 m³	112	84
97		127	3.05 m³	115	87
98		127	3.05 m³	115	87
99		127	3.05 m³	116	88
100		127	3.05 m³	119	91
101		127	3.05 m³	120	92
102		280	6.1 m³	119	91
103		410	6.1 m³	121	93
104		515	7.6 m³	121	93
105	Diesel powered front end loader (crawler)	60	1.15 m³	109	81
106		60	1.15 m³	116	88
107		71	1.34 m³	112	84
108		71	1.34 m³	113	85
109		142	2.3 m³	108	80

Table D.10 **Historic sound level data on opencast coal sites: pre 1984** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass)[A)], capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m dB
110	Diesel powered dump trucks (4-stroke)	127	—	112	84
111		127	—	115	87
112		336	35 s. tons	112	84
113		336	35 s. tons	113	85
114		336	35 s. tons	114	86
115		336	35 s. tons	115	87
116		336	35 s. tons	117	89
117		336	35 s. tons	117	89
118		336	35 s. tons	117	89
119		336	35 s. tons	117	89
120		336	35 s. tons	118	90
121		336	35 s. tons	118	90
122		336	35 s. tons	118	90
123		336	35 s. tons	118	90
124		336	35 s. tons	119	91
125		448	50 s. tons	115	87
126		448	50 s. tons	116	88
127		448	50 s. tons	116	88
128		448	50 s. tons	117	89
129		448	50 s. tons	117	89
130		448	50 s. tons	117	89
131		448	50 s. tons	117	89
132		448	50 s. tons	118	90
133		448	50 s. tons	118	90
134		448	50 s. tons	118	90
135		448	50 s. tons	118	90
136		448	50 s. tons	118	90
137		448	50 s. tons	118	90
138		448	50 s. tons	118	90
139		448	50 s. tons	119	91
140		448	50 s. tons	119	91
141		448	50 s. tons	119	91
142		448	50 s. tons	120	92
143		448	50 s. tons	120	92
144		448	50 s. tons	120	92
145		448	50 s. tons	120	92
146		448	50 s. tons	121	93
147		448	50 s. tons	121	93
148		448	50 s. tons	121	93
149		650	85 s. tons	114	86

Table D.10 **Historic sound level data on opencast coal sites: pre 1984** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass)[A)], capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1) $L_{Aeq,T}$ (A1] at 10 m dB
150	Diesel powered dump trucks (2-stroke)	324	35 s. tons	121	93
151		324	35 s. tons	122	94
152		370	35 s. tons	124	96
153		370	35 s. tons	125	97
154		370	35 s. tons	127	99
155		370	35 s. tons	128	100
156		395	45 s. tons	120	92
157		395	45 s. tons	122	94
158		395	45 s. tons	125	97
159		395	45 s. tons	126	98
160		395	45 s. tons	127	99
161		395	45 s. tons	128	100
162		407	45 s. tons	120	92
163		407	45 s. tons	121	93
164		407	45 s. tons	121	93
165		433	50 s. tons	120	92
166		433	50 s. tons	121	93
167		433	50 s. tons	121	93
168		433	50 s. tons	121	93
169		433	50 s. tons	122	94
170		454	50 s. tons	120	92
171		488	50 s. tons	119	91
172		488	50 s. tons	120	92
173		488	50 s. tons	121	93
174		488	50 s. tons	121	93
175		488	50 s. tons	124	96
176		522	70 s. tons	120	92
177		522	70 s. tons	120	92
178		522	70 s. tons	121	93
179		522	70 s. tons	121	93
180		522	70 s. tons	122	94
181		522	70 s. tons	125	97
182		746	100 s. tons	—	—
183		746	100 s. tons	120	92
184	Diesel powered (4-stroke) dump trucks, electric drive	740	100 s. tons	116	88
185		740	100 s. tons	116	88
186		740	100 s. tons	118	90
187		740	100 s. tons	118	90
188		740	100 s. tons	119	91
189		740	100 s. tons	119	91
190		740	100 s. tons	119	91
191		740	100 s. tons	119	91
192		740	100 s. tons	120	92
193		740	100 s. tons	120	92

Table D.10 **Historic sound level data on opencast coal sites: pre 1984** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass)[A)], capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m dB
194	Tractor scraper, elevating, diesel powered, 4-stroke	246	16.8 m³ heaped	112	84
195		246	16.8 m³ heaped	112	84
196		246	16.8 m³ heaped	113	85
197		246	16.8 m³ heaped	113	85
198		246	16.8 m³ heaped	114	86
	Tractor scraper loading and haulage				
199	Tractor scraper, single engine, 4-stroke	336	16 m³ struck	103	75
200		336	23.7 m³ heaped	114	86
201		336	23.7 m³ heaped	114	86
202		336	23.7 m³ heaped	117	89
203	Tractor scraper, tandem, 4-stroke	526	16 m³ struck	113	85
204		526	23.7 m³ heaped	114	86
205		526	23.7 m³ heaped	115	87
206		526	23.7 m³ heaped	117	89
207		526	23.7 m³ heaped	118	90
208	Tractor scraper tandem, 2-stroke	448	18.4 m³ struck	114	86
209		448	24 m³ heaped	118	90
210		448	24 m³ heaped	118	90
211		448	24 m³ heaped	119	91
212		448	24 m³ heaped	120	92
213		448	24 m³ heaped	122	94
214		448	24 m³ heaped	125	97
215		248	24 m³ heaped	127	99
216		448	24 m³ heaped	128	100
217		448	24 m³ heaped	128	100
218		447	24 m³ heaped	129	101
219		448	24 m³ heaped	130	102

Table D.10 **Historic sound level data on opencast coal sites: pre 1984** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass)[A)], capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1) $L_{Aeq, T}$ (A1] at 10 m dB
	Tractor (bulldozing, push loading, ripping)				
220	Tractor, crawler mounted (dozer)	56	8820 kg	114	86
221		56	8820 kg	117	89
222		56	8820 kg	119	91
223		104	14270 kg	110	82
224		104	14270 kg	114	86
225		104	14270 kg	116	88
226		104	14270 kg	117	89
227		104	14270 kg	117	89
228		104	14270 kg	126	98
229		149	20230 kg	113	85
230		149	20230 kg	116	88
231		149	20230 kg	117	89
232		149	20230 kg	118	90
233		224	31980 kg	113	85
234		224	31980 kg	113	85
235		224	31980 kg	114	86
236		224	31980 kg	115	87
237		224	31980 kg	116	88
238		224	31980 kg	116	88
239		224	31980 kg	116	88
240		224	31980 kg	117	89
241		224	31980 kg	117	89
242		224	31980 kg	117	89
243		224	31980 kg	118	90
244		224	31980 kg	118	90
245		224	31980 kg	118	90
246		224	31980 kg	118	90
247		224	31980 kg	119	91
248		224	31980 kg	120	92
249		224	31980 kg	121	93
250		224	31980 kg	121	93
251		224	31980 kg	123	95
252		224	31980 kg	126	98
253		224	31980 kg	126	98
254		239	31980 kg	118	90
255		239	31980 kg	120	92
256		239	31980 kg	120	92
257		239	31980 kg	120	92
258		276	31980 kg	121	93
259		306	42780 kg	101	73
260		306	42780 kg	115	87
261		306	42780 kg	116	88
262		306	42780 kg	117	89
263		306	42780 kg	120	92
264		306	42780 kg	120	92
265		306	42780 kg	123	95
266		306	42780 kg	125	97
267		522	77870 kg	115	87

Table D.10 **Historic sound level data on opencast coal sites: pre 1984** *(continued)*

Ref. no	Equipment	Power rating	Equipment size, weight (mass)[A)], capacity	Sound power level L_{WA}	Activity equivalent continuous sound pressure level [A1] $L_{Aeq,T}$ [A1] at 10 m
		kW		dB	dB
268	Tractor, wheel mounted (dozer)	225	33 629 kg	116	88
269	Tractor, wheel mounted (dozer)	225	33 629 kg	122	94
270	Motor grader	112	13 620 kg	117	89
271	Motor grader	112	13 620 kg	118	90
272	Motor grader	134	18 440 kg	110	82
273	Motor grader	134	18 440 kg	113	85
274	Motor grader	134	18 440 kg	114	86
275	Motor grader	134	18 440 kg	115	87
276	Motor grader	187	24 520 kg	110	82
277	Motor grader	187	24 520 kg	111	83
278	Motor grader	187	24 520 kg	115	87
279	Motor grader	187	24 520 kg	116	88
280	Motor grader	187	24 520 kg	116	88
281	Motor grader	187	24 520 kg	117	89
	Coal haulage				
282	Coal lorry	160	—	109	81
283	Coal lorry	160	—	109	81
284	Coal lorry	160	—	109	81
285	Coal lorry	160	—	111	83
286	Coal lorry	160	—	111	83
287	Coal lorry	160	—	111	83
288	Coal lorry	160	—	112	84
289	Coal lorry	160	—	113	85
290	Coal lorry	160	—	113	85
291	Coal lorry	160	—	113	85
292	Coal lorry	160	—	113	85
293	Coal lorry	160	—	113	85
294	Coal lorry	160	—	114	86
295	Coal lorry	160	—	114	86
296	Coal lorry	160	—	115	87
297	Coal lorry	160	—	115	87
298	Coal lorry	160	—	117	89
299	Coal lorry	160	—	118	90
300	Coal lorry	160	—	119	91
301	Coal lorry	160	—	119	91

A) s. tons = short tonnes.

Table D.11 **Historic sound level data on opencast coal sites: post 1990**

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass)[A)], capacity	Average sound power level L_{WA} dB
	Drilling blastholes			
1	Compressor and drilling rig (top hammer)	—	100 mm borehole	117
2	Consolidated rig (down-the-hole hammer)	160	—	112
	Breaking out and loading			
3	Diesel excavators	60	0.5 m^3	103
4	Diesel excavators	70	0.5 m^3	102
5	Diesel excavators	70	0.9 m^3	104
6	Diesel excavators	110	0.9 m^3	107
7	Diesel excavators	125	1.0 m^3	103
8	Diesel excavators	100	1.3 m^3	106
9	Diesel excavators	110	1.3 m^3	105
10	Diesel excavators	160	1.4 m^3	106
11	Diesel excavators	120	1.5 m^3	104
12	Diesel excavators	125	1.5 m^3	105
13	Diesel excavators	145	2.0 m^3	108
14	Diesel excavators	242	3.8 m^3	108
15	Diesel excavators	250	4.0 m^3	109
16	Diesel excavators	275	5.0 m^3	114
17	Diesel excavators	300	6.0 m^3	117
18	Diesel excavators	435	8.0 m^3	116
19	Diesel excavators	610	9.5 m^3	116
20	Diesel excavators	750	12.0 m^3	116
21	Diesel excavators	870	12.0 m^3	117
22	Diesel excavators	1 000	14.0 m^3	117
23	Diesel excavators	1 516	20.0 m^3	120
	Draglines			
24	Diesel	400	5.3 m^3	107
25	Electric	895	9.2 m^3	108
26	Electric	11 689	50.0 m^3	115
	Front end loaders			
27	Diesel front end loaders	161	3.8 m^3	107
28	Diesel front end loaders	280	5.2 m^3	110
29	Diesel front end loaders	515	8.9 m^3	111

Table D.11 **Historic sound level data on opencast coal sites: post 1990** *(continued)*

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass)[A)], capacity	Average sound power level L_{WA} dB
	Dump trucks			
30	Diesel: 4 stroke	475	55 s. tons	113
31	Diesel: 4 stroke	485	58 s. tons	118
32	Diesel: 4 stroke	750	85 s. tons	112
33	Diesel: 4 stroke	650	95 s. tons	115
34	Diesel: 4 stroke	960	150 s. tons	118
35	Diesel: 4 stroke	1 270	195 s. tons	118
	Tractor scrapers			
36	Single engine	340	23.7 m^3	107
37	Tandem	520	23.7 m^3	109
	Tractor			
38	Crawler mounted dozer	104	14.2 t	107
39	Crawler mounted dozer	123	17.8 t	109
40	Crawler mounted dozer	410	32.8 t	113
41	Crawler mounted dozer	212	36.8 t	112
42	Crawler mounted dozer	276	42.5 t	113
43	Crawler mounted dozer	460	52.0 t	113
44	Crawler mounted dozer	575	95.8 t	116
	Motor grader			
45	Motor grader	205	27.2 t	112
	Coal haulage			
46	(No data given)			
47	Rigid truck	117	—	109
48	Rigid truck	170	—	111
49	Articulated truck	180	—	102
50	Articulated truck	240	—	110
	Water bowsers			
51	Rigid dump truck	450	—	113
52	Rigid dump truck	430	—	117
53	Tractor scraper	215	—	112

A) s. tons = short tonnes.

Table D.12 **Historic sound level data on dredging**

Ref. no	Equipment	Power rating kW	Equipment size, weight (mass), capacity	Sound power level L_{WA} dB	Activity equivalent continuous sound pressure level [A1) $L_{Aeq,\,T}$ (A1] at 10 m dB
	Dredging				
1	Ship chain bucket	—	35 m long	124	96
	Digging out river bed				
2	Tracked excavator	46	—	112	85
	Water pump	6	—	104	
	Clearing river bank				
3	Tracked loader	37	—	108	80
	Dredging gravel				
4	Tracked crane (no exhaust silencer)	92	—	124	96
	Loading dredged aggregates				
5	Wheeled loader	93	—	112	84

Annex E (informative) Significance of noise effects

E.1 Example criteria for the assessment of the A1 potential significance A1 of noise effects

A1 This annex gives examples only. It does not comprise an exhaustive set of provisions regarding noise effects.

The examples cited in this annex offer guidance that might be useful in the implementation of discretionary powers for the provision of off-site mitigation of construction noise arising from major highways and railway developments [see Note to item a)]. These powers were introduced in the Noise Insulation Regulations 1975 [30, 31, 32] under the Land Compensation Act 1973 [33, 34, 35] (see **A.3.4**) and the Noise Insulation (Railways and other Guided Transport Systems) Regulations 1995 [37] (see **A.3.5**), respectively. Off-site noise mitigation might not be applicable in all circumstances or to other categories of construction project. See also **E.4**. A1

A pragmatic approach needs to be taken when assessing the noise effects of any construction project, i.e. the guidance provided below would generally only apply to projects of significant size, and lesser projects might not need to be assessed or might only require general consideration of noise effects and mitigation. Generally, the local planning authority, or a planning consultant experienced in these matters, will be able to advise as to the extent of the assessment that might be required.

Construction noise assessments are generally undertaken for three main reasons.

a) *For Environmental Impact Assessments (EIAs)*. Most major developments now need to be assessed in accordance with the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 [47]. This is where the development might result in significant effects upon the environment. Therefore, criteria are needed to allow these assessments to be undertaken. A1 *Text deleted* A1

A1 *NOTE The assessments can include likely eligibility for noise insulation or temporary re-housing, as forms of mitigation, but such eligibility needs to be confirmed later in the process when a contractor is appointed and detailed method statements and programme information are available.* A1

b) *Assessments for developments that do not require EIA*. Construction noise assessments are sometimes required by developers to advise on the likely effects that might arise and appropriate actions that might need to be taken to minimize effects.

c) *Control of Pollution Act (CoPA) 1974 [9], Section 61, "Applications for prior consent for work on construction sites"*. Applications under this section of the CoPA are often found to be desirable and useful by both the local authority and the contractor. The applications would usually include (as identified in the CoPA):

   1) details of the works and the method by which they are to be carried out; and

   2) the steps proposed to be taken to minimize noise resulting from the works.

   However, it is good practice to carry out construction noise predictions to provide additional information and to determine, for projects of significant size, any eligibility for noise insulation or temporary re-housing. By gaining consent under Section 61, the contractor gains protection from action under Section 60 of the CoPA, whereby a stop or enforcement notice cannot be served on the contractor, as long as the works are carried out in accordance with the details in the application.

This annex describes methods to identify the likely significance of noise levels from surface construction activity.

E.2 [A1⟩ Potential significance based on fixed noise limits ⟨A1]

For projects of significant size such as the construction of a new railway or trunk road, historically, there have been two approaches to determining whether construction noise levels [A1⟩ could be significant. ⟨A1]

The older and more simplistic is based upon exceedance of fixed noise limits which were originally promoted by the Wilson Committee in their report on noise [60] as presented to Parliament in 1963. These noise limits were then included in Advisory Leaflet 72 [61], first published in 1968; the accompanying wording was subsequently revised and the 1976 version is quoted below:

> "Noise from construction and demolition sites should not exceed the level at which conversation in the nearest building would be difficult with the windows shut. The noise can be measured with a simple sound level meter, as we hear it, in A-weighted decibels (dB(A))– see note below. Noise levels, between say 07.00 and 19.00 hours, outside the nearest window of the occupied room closest to the site boundary should not exceed:
>
> - 70 decibels *(dBA) in rural, suburban and urban areas away from main road traffic and industrial noise*;
> - 75 decibels *(dBA) in urban areas near main roads in heavy industrial areas*.
>
> These limits are for daytime working outside living rooms and offices. In noise-sensitive situations, for example, near hospitals and educational establishments – and when working outside the normal hours say between 19.00 and 22.00 hours – the allowable noise levels from building sites will be less: such as the reduced values given in the contract specification or as advised by the Environmental Health Officer (a reduction of 10 dB(A) may often be appropriate). Noisy work likely to cause annoyance locally should not be permitted between 22.00 hours and 07.00 hours."

The above principle has been expanded over time to include a suite of noise levels covering the whole day/week period taking into account the varying sensitivities through these periods. [A1⟩ Examples are provided in **E.3.2** (see Table E.1) and in **E.4** (see Table E.2), and the levels shown in Table E.2 are often used as limits above which noise insulation would be provided if the temporal criteria are also exceeded. ⟨A1]

E.3 [A1⟩ Potential significance ⟨A1] based upon noise change

E.3.1 General

An alternative and/or additional method to determine the [A1⟩ potential significance ⟨A1] of construction noise levels is to consider the change in the ambient noise level with the construction noise. [A1⟩ *Text deleted* ⟨A1] There are two main methods, both with similar approaches, of which examples are provided in **E.3.2** and **E.3.3**.

E.3.2 Example method 1 – The ABC method

[A1⟩ Table E.1 shows an example of the threshold of potential significant effect at dwellings when the site noise level, rounded to the nearest decibel, exceeds the listed value. The table can be used as follows: for the appropriate period (night, evening/weekends or day), the ambient noise level is determined and rounded to the nearest 5 dB. This is then compared with the site noise level. If the site noise level exceeds the appropriate category value, then a potential significant effect is indicated. The assessor then needs to consider other project-specific factors, such as the number of receptors affected and the duration and character of the impact, to determine if there is a significant effect. ⟨A1]

Table E.1 **Example threshold of [A1⟩ potential significant ⟨A1] effect at dwellings**

Assessment category and threshold value period	Threshold value, in decibels (dB) [A1⟩ ($L_{Aeq,\,T}$) ⟨A1]		
	Category A [A)]	Category B [B)]	Category C [C)]
Night-time (23.00–07.00)	45	50	55
Evenings and weekends [D)]	55	60	65
Daytime (07.00–19.00) and Saturdays (07.00–13.00)	65	70	75

[A1⟩ *NOTE 1 A potential significant effect is indicated if the $L_{Aeq,\,T}$ noise level arising from the site exceeds the threshold level for the category appropriate to the ambient noise level.*

NOTE 2 If the ambient noise level exceeds the Category C threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a potential significant effect is indicated if the total $L_{Aeq,\,T}$ noise level for the period increases by more than 3 dB due to site noise. ⟨A1]

NOTE 3 Applied to residential receptors only.

A) Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values.

B) Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as category A values.

C) Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than category A values.

D) 19.00–23.00 weekdays, 13.00–23.00 Saturdays and 07.00–23.00 Sundays.

E.3.3 Example method 2 – 5 dB(A) change

[A1⟩ Noise levels generated by site activities are deemed to be potentially significant if the total noise (pre-construction ambient plus site noise) exceeds the pre-construction ambient noise by 5 dB or more, subject to lower cut-off values of 65 dB, 55 dB and 45 dB $L_{Aeq,\,T}$ from site noise alone, for the daytime, evening and night-time periods, respectively; and a duration of one month or more, unless works of a shorter duration are likely to result in significant effect. ⟨A1]

These evaluative criteria are generally applicable to the following resources:

- residential [A1⟩ buildings ⟨A1];
- hotels and hostels;
- buildings in religious use;
- buildings in educational use;
- buildings in health and/or community use.

[A1⟩ For public open space, the impact might be deemed to cause significant effects if the total noise exceeds the ambient noise ($L_{Aeq,\ T}$) by 5 dB or more for a period of one month or more. However, the extent of the area impacted relative to the total available area also needs to be taken into account in determining whether the impact causes a significant effect. ⟨A1]

E.4 [A1⟩ Example of thresholds used to determine the eligibility for noise insulation and temporary rehousing ⟨A1]

[A1⟩ *COMMENTARY ON **E.4***

If the contractor has applied best practicable means to the provision of mitigation, i.e. all reasonable measures have been taken to reduce the noise levels, but levels are still such that widespread community disturbance or interference with activities or sleep is likely to occur, there are two further provisions that can be made if the construction activities are likely to continue for a significant period of time either continuously or sporadically. These are as follows.

a) Noise insulation (NI). This is the provision of secondary glazing to the windows of affected habitable rooms. Additional ventilation provision might also be necessary to allow the windows to be kept closed whilst maintaining the appropriate number of air changes in the room. Secondary glazing increases attenuation and this can provide a significant improvement to the internal noise environment.

b) Temporary or permanent re-housing (TRH). Where construction noise levels are such that noise insulation will not provide sufficient attenuation to prevent disturbance or interference with activities or sleep, then the occupants can be temporarily re-housed away from the construction site. However, if the nature of the construction activities means that re-housing would be necessary for a significant extent of time, e.g. in excess of six months, then there might be advantages in offering permanent re-housing, i.e. the property would be purchased by the developer and the occupants would purchase another property elsewhere. The property would then remain vacant or be used by site personnel for the duration of the works, after which it can be re-sold. ⟨A1]

Where, in spite of the mitigation measures applied and any Section 61 consents under the Control of Pollution Act 1974 [9], noise levels at some properties are expected to exceed trigger levels for the periods defined below, a scheme for the installation of noise insulation or the reasonable costs thereof, or a scheme to facilitate temporary rehousing of occupants, as appropriate, will be implemented by the developer or promoter. The scheme will include provision for the notification of affected parties.

[A1⟩ Noise insulation, or the reasonable costs thereof, will be offered by the developer or promoter to owners, where applied for by owners or occupiers, subject to meeting the other requirements of the proposed scheme, where the construction of the development causes, or is expected to cause, a measured or predicted airborne construction noise level that exceeds either of the following at property lawfully occupied as a permanent dwelling:

- the noise insulation trigger levels presented in Table E.2 for the corresponding times of day;

- a noise level 5 dB or more above the existing pre-construction ambient noise level for the corresponding times of day;

whichever is the higher;

and for a period of 10 or more days of working in any 15 consecutive days or for a total number of days exceeding 40 in any 6 consecutive months. ⟨A1⟩

Table E.2 **Examples of time periods, averaging times and noise levels associated with the determination of eligibility for noise insulation**

Time	**Relevant time period**	**Averaging time, *T***	**Noise insulation trigger level dB $L_{Aeq,T}$ A)**
Monday to Friday	07.00 – 08.00	1 h	70
	08.00 – 18.00	10 h	75
	18.00 – 19.00	1 h	70
	19.00 – 22.00	3 h	65
	22.00 – 07.00	1 h	55
Saturday	07.00 – 08.00	1 h	70
	08.00 – 13.00	5 h	75
	13.00 – 14.00	1 h	70
	14.00 – 22.00	3 h	65
	22.00 – 07.00	1 h	55
Sunday and Public Holidays	07.00 – 21.00	1 h	65
	21.00 – 07.00	1 h	55

A) All noise levels are predicted or measured at a point 1 m in front of the most exposed of any windows and doors in any façade of any eligible dwelling.

⟨A1⟩ Temporary rehousing, or the reasonable costs thereof, will be offered by the developer or promoter to owners, where applied for by owners or occupiers, subject to meeting the other requirements of the proposed scheme, where the construction of the development causes, or is expected to cause, a measured or predicted airborne construction noise level that exceeds either of the following at property lawfully occupied as a permanent dwelling:

- a noise level 10 dB above any of the trigger noise levels presented in Table E.2 for the corresponding times of the day; or
- a noise level 10 dB above the pre-construction ambient noise level for the corresponding times of the day;

whichever is the higher;

and for a period of 10 or more days of working in any 15 consecutive days or for a total number of days exceeding 40 in any 6 consecutive months. ⟨A1⟩

⟨A1⟩ Non-residential buildings the occupants of which are likely to be particularly sensitive to noise ⟨A1⟩ (these include commercial and educational establishments, hospitals and clinics) will be subject to individual consideration by the developer or promoter, upon application by the affected party.

E.5 Construction works involving long-term substantial earth moving

A1 Where construction activities involve large scale and long term earth moving activities, then this is more akin to surface mineral extraction than to conventional construction activity. In this situation, the guidance contained within the Technical Guidance to the National Planning Policy Framework [15] needs to be taken into account when setting criteria for acceptability.

The Technical Guidance states:

> "Subject to a maximum of 55 dB(A) LAeq, 1h (free field), mineral planning authorities should aim to establish a noise limit at the noise-sensitive property that does not exceed the background level by more than 10 dB(A). It is recognised, however, that in many circumstances it will be difficult to not exceed the background level by more than 10 dB(A) without imposing unreasonable burdens on the mineral operator. In such cases, the limit set should be as near to that level as practicable during normal working hours (0700–1900) and should not exceed 55 dB(A) LAeq, 1h (free field). Evening (1900–2200) limits should not exceed background level by more than 10 dB(A) and night-time limits should not exceed 42 dB(A), LAeq, 1h (free field) at noise-sensitive dwellings."

Based upon the above, it is suggested that the limit of 55 dB $L_{\text{Aeq, 1 h}}$ is adopted for daytime construction noise for these types of activities but only where the works are likely to occur for a period in excess of six months. Precedent for this type of approach has been set within a number of landmark appeal decisions associated with the construction of ports.

Other recommendations with regard to noise emissions given in paragraphs 28 to 31 of the Technical Guidance to the National Policy Planning Framework [15] should also be taken into account, where appropriate. A1

Annex F (informative) Estimating noise from sites

F.1 Factors for consideration

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

Before work starts the following need to be considered.

a) Local authorities need to know the expected levels of site noise in order that assessments can be made as to whether potential problems exist and whether controls are necessary. They also need to ensure that any noise limits proposed are practicable for the developments concerned and that the limits are capable of protecting the community from excessive noise.

b) Developers, architects and engineers need to know whether their intended site operations will cause noise problems and, if so, whether the operations will be able to conform to the specified noise limits.

c) Contractors need to select the most appropriate plant in accordance with any specified limits. They also need to know at the tender stage what noise controls are necessary so that they can make appropriate cost allowances.

As explained in **6.2**, site noise can be assessed in terms of the equivalent continuous sound level and/or in terms of the maximum level. The level of sound in the neighbourhood that arises from a site will depend on a number of factors. The estimation procedures described in this annex take into account the more significant factors, these being:

1) the sound power outputs of processes and plant;

2) the periods of operation of processes and plant;

3) the distances from sources to receiver;

4) the presence of screening by barriers;

5) the reflection of sound;

6) soft ground attenuation (see **F.2.2.2.1**).

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

F.2 Methods of calculation

F.2.1 General

Site noise is produced by many different activities and types of plant, the noise from which varies not only in intensity and character but also in location and over time. There can also be many combinations of these activities of both a static and a mobile nature. However, reasonably accurate predictions can be made by approaching the problem in a logical way and by analysing all activities involved. The starting point in predicting noise levels is to determine the noise level of the source(s). There are three preferred means of obtaining the necessary data.

a) Carry out or obtain noise measurements of a similar item of plant, operating in the same mode and at the same power over a representative time period including a sufficient number of operating cycles. The measurements may be taken at any appropriate distances but are generally taken at 10 m; measurements at other distances generally need to be corrected back to 10 m for reference purposes.

b) Use the sound power levels and values of activity [A1] $L_{Aeq,\,T}$ [A1] given in Annexes C and D. Many of the measurements in Annex D were carried out prior to the introduction of quieter plant as a result of the implementation of EC noise limits; on this basis, there is a clear preference to use data contained within Annex C, where identical or appropriately similar plant are included, as opposed to using older data from Annex D. However, older plant might still be in operation on some sites and the data could then be relevant. The percentage on-times where quoted in the tables only relate to the period over which the measurement was taken.

c) Obtain the maximum permitted sound power level of the plant under EC Directive 2000/14/EC [11]. Table F.1 shows the current relevant values, which relate to static tests on full power. It is intended to introduce a dynamic test for the earth-moving equipment listed in Table F.1 and to lower the limits progressively. Adjust the sound power levels quoted in Table F.1 to allow for variations of power under typical working conditions over the relevant assessment period (e.g. 1 h, 12 h). Apply a further correction for the distance ratio (see Table F.2).

The method given in item a) is likely to provide the most accurate prediction.

Table F.1 **EC noise limits for certain items of construction equipment**

Type of equipment	Net installed power, P	Cutting width, L	Electric power, P_{el} A)	Mass of appliance, m	Permissible sound power level, L_{WA}, re 1 pW	
					Stage I	Stage II
	kW	cm	kV·A	kg	dB	
Compaction machines (vibrating rollers, vibratory plates, vibratory rammers)	$P \leqslant 8$				108	105 B)
	$8 < P \leqslant 70$				109	106 B)
	$P > 70$				$89 + 11 \lg P$	$86 + 11 \lg P$ B)
Tracked dozers, tracked loaders, tracked excavator-loaders	$P \leqslant 55$				106	103 B)
	$P > 55$				$87 + 11 \lg P$	$84 + 11 \lg P$ B)
Wheeled dozers, wheeled loaders, wheeled excavator-loaders, dumpers, graders, loader-type landfill compactors, combustion-engine driven counterbalanced lift trucks, compaction machines (non-vibrating rollers), paver-finishers, hydraulic power packs	$P \leqslant 55$				104	101 B)
	$P > 55$				$85 + 11 \lg P$	$82 + 11 \lg P$ B)
Mobile cranes	$P \leqslant 55$				104	101 C)
	$P > 55$				$85 + 11 \lg P$	$82 + 11 \lg P$ C)
Excavators, builders' hoists for the transport of goods, construction winches, motor hoes	$P \leqslant 15$				96	93
	$P > 15$				$83 + 11 \lg P$	$80 + 11 \lg P$
Hand-held concrete-breakers and picks				$m \leqslant 15$	107	105
				$15 < m < 30$	$94 + 11 \lg m$	$92 + 11 \lg m$ B)
				$m > 30$	$96 + 11 \lg m$	$94 + 11 \lg m$
Tower cranes					$98 + \lg P$	$96 + \lg P$
Welding and power generators			$P_{el} \leqslant 2$		$97 + \lg P_{el}$	$95 + \lg P_{el}$
			$2 < P_{el} \leqslant 10$		$98 + \lg P_{el}$	$96 + \lg P_{el}$
			$10 > P_{el}$		$97 + \lg P_{el}$	$95 + \lg P_{el}$
Compressors			$P \leqslant 15$		99	97
			$P > 15$		$97 + 2 \lg P$	$95 + 2 \lg P$

Table F.1 **EC noise limits for certain items of construction equipment** *(continued)*

Type of equipment	**Net installed power, *P***	**Cutting width, *L***	**Electric power, P_{el} A)**	**Mass of appliance, *m***	**Permissible sound power level, L_{WA}, re 1 pW**	
					Stage I	**Stage II**
	kW	cm	kV·A	kg	dB	
Lawn mowers, lawn trimmers, lawn-edge trimmers		$L \leqslant 50$			98	96
		$50 < L \leqslant 70$			100	98
		$70 < L \leqslant 120$			100	100
		$L > 120$			105	105

The permissible sound power level is to be rounded up or down to the nearest integer number (less than 0.5, use lower number; greater than or equal to 0.5, use higher number).

lg is an abbreviation used in EC Directive 2000/14/EC [11] to represent logarithm to the base 10.

Stage I limits came into force on 3 January 2003 and Stage II limits came into force on 3 January 2006, with the exceptions noted below.

A) P_{el} for welding generators: conventional welding current multiplied by the conventional load voltage for the lowest value of the duty factor given by the manufacturer. P_{el} for power generators: prime power according to BS ISO 8528-1:2005, **13.3.2**.

B) For the following types of equipment the figures for Stage I continue to apply for Stage II:
- walk-behind vibrating rollers;
- vibratory plates (>3 kW);
- vibratory rammers;
- dozers (steel tracked);
- loaders (steel tracked >55 kW);
- combustion-engine driven counterbalanced lift trucks;
- compacting screed paver-finishers; and
- hand-held internal combustion-engine concrete-breakers and picks ($15 < m < 30$).

C) For single engine mobile cranes the figures for Stage II came into force on 4 January 2008.

Table F.2 **Relationship of distance ratio and on-time correction factor for slow moving plant**

Distance ratio, *D*	Correction factor, *F*
0.5	1.00
0.7	0.80
1	0.63
1.5	0.50
2	0.40
3	0.28
4	0.20
5	0.16
6	0.13
7	0.10
8	0.09
9	0.08
10	0.08
>10	0.06

NOTE $D = l_{tr}/d_{min}$

where:

l_{tr} *is the traverse length (see **3.17**);*

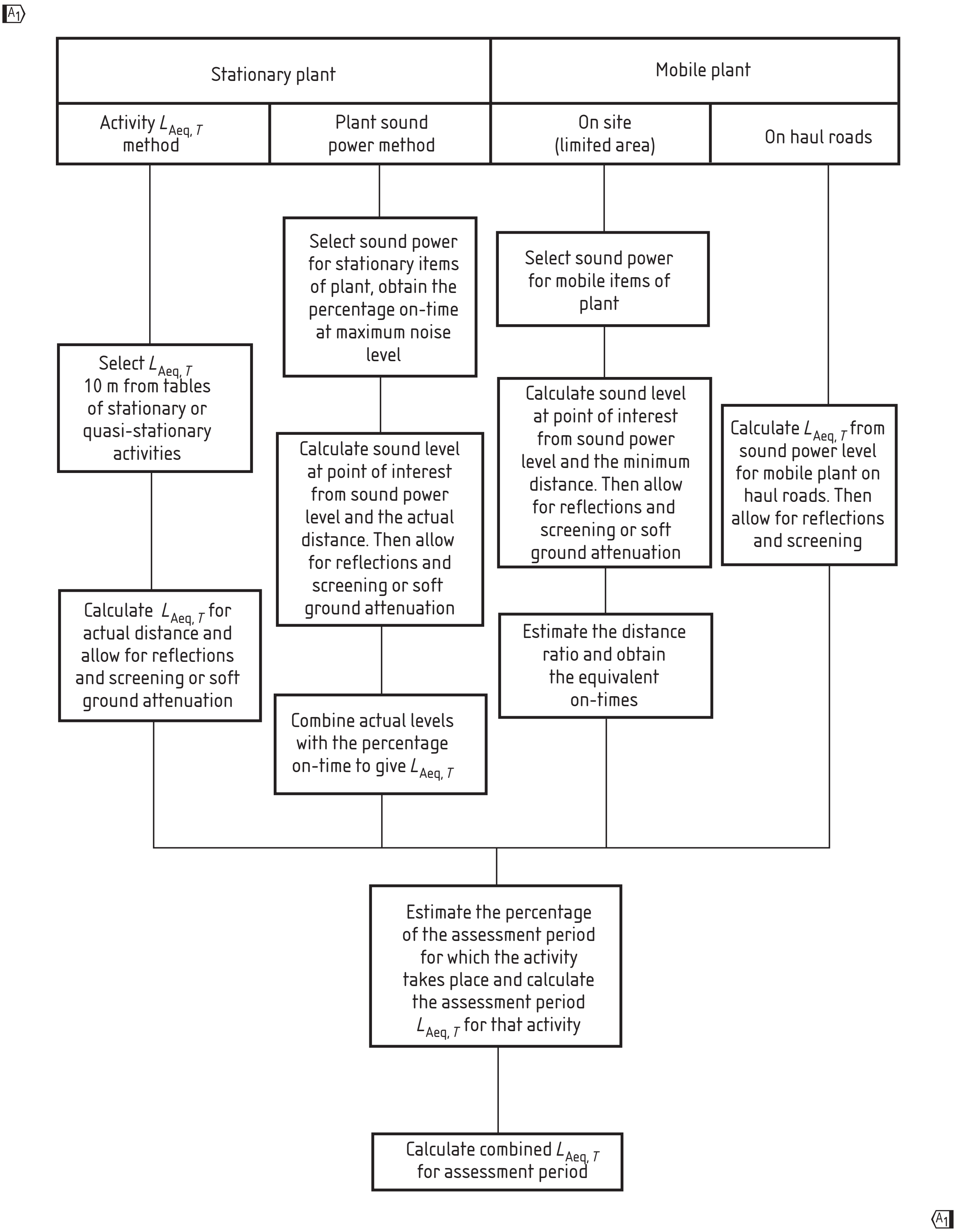
d_{min} *is the minimum distance from the plant to the receiver location.*

*(See **F.2.7.1.3**.)*

A general approach to the prediction of site noise is shown in Figure F.1, where four methods of calculating [A1⟩ $L_{Aeq,\,T}$ ⟨A1] noise levels are indicated. Examples of methods that can be used are given in **F.2.2** to **F.2.5**. In practice, noise prediction at a point of interest might involve a combination of all four methods. The use of other methods is not precluded but might need agreement with the parties concerned.

The general methods of calculation given in **F.2.2** to **F.2.5** will be suitable for many situations. Nevertheless, these methods have been developed in relation to construction sites and have only been tested on such sites. They do not preclude the use of more precise methods.

Figure F.1 **Flow chart for the prediction of site noise**



F.2.2 Method for activity A1 $L_{Aeq,T}$ A1

F.2.2.1 General

The activity A1 $L_{Aeq,T}$ A1 method (see **F.2.2.2**) can be used for stationary and quasi-stationary activities and is the best method to use when these activities and their locations are clearly defined. Either measurements can be made on a similar item of plant operating in the relevant mode and power, or the values of A1 $L_{Aeq,T}$ A1 given in Annexes C and D can be used. The activity A1 $L_{Aeq,T}$ A1 needs to be corrected for source-receiver distance, reflections and screening or soft ground attenuation. The advantages of this method are that the variations in plant cycle times, interactions between various items of plant during the activity and the consequent overall variation of noise level with time are automatically taken into account. For continuous plant, it is necessary to determine the proportion of the assessment period during which the plant is operating and to adjust the A1 $L_{Aeq,T}$ A1 for periods of non-operation. For cyclic or intermittent plant, the number of complete sequences that will occur within the working day needs to be estimated and the A1 $L_{Aeq,T}$ A1 adjusted, if necessary, for standing or idling time. **F.2.6** covers these allowances.

F.2.2.2 Method

F.2.2.2.1 Procedure

NOTE 1 Hard ground is taken to refer to ground surfaces which reflect sound, e.g. paved areas, rolled asphalt and surface water. Soft ground is taken to refer to surfaces which are absorbent to sound, e.g. grassland, cultivated fields or plantations. Where the ground cover between the source and the receiver is a combination of hard and soft, it is described as mixed.

NOTE 2 It is a matter of personal preference which method is used.

Account needs to be taken of the nature of the ground over which the sound is being propagated. The ground can be characterized as hard, soft or mixed (see Figure F.2 and **F.2.2.2.2**).

The procedure is as follows.

a) *Stage 1*. Obtain an activity A1 $L_{Aeq,T}$ A1 by direct measurement of similar plant in the same mode of operation, or use the values given in Annexes C and D.

b) *Stage 2*. If the distance R, in metres (m), from the point of interest to the geometric centre of the plant or activity is other than 10 m, subtract from the A1 $L_{Aeq,T}$ A1 obtained in stage 1 a distance adjustment K_h or K_s, in decibels (dB), obtained either:

   1) from the following equations:

   $$K_h = 20\log_{10}\frac{R}{10} \tag{F.1}$$

   or

   $$K_s = \left(25\log_{10}\frac{R}{10}\right) - 2 \tag{F.2}$$

   where R ⩾ 25 m;

   or

   2) from Figure F.2, which is based on equations (F.1) and (F.2). Both methods give the same result.

c) *Stage 3*. Make allowances for reflections and screening (see also **8.3.3**, Figures F.2 and F.3 and Annex B).

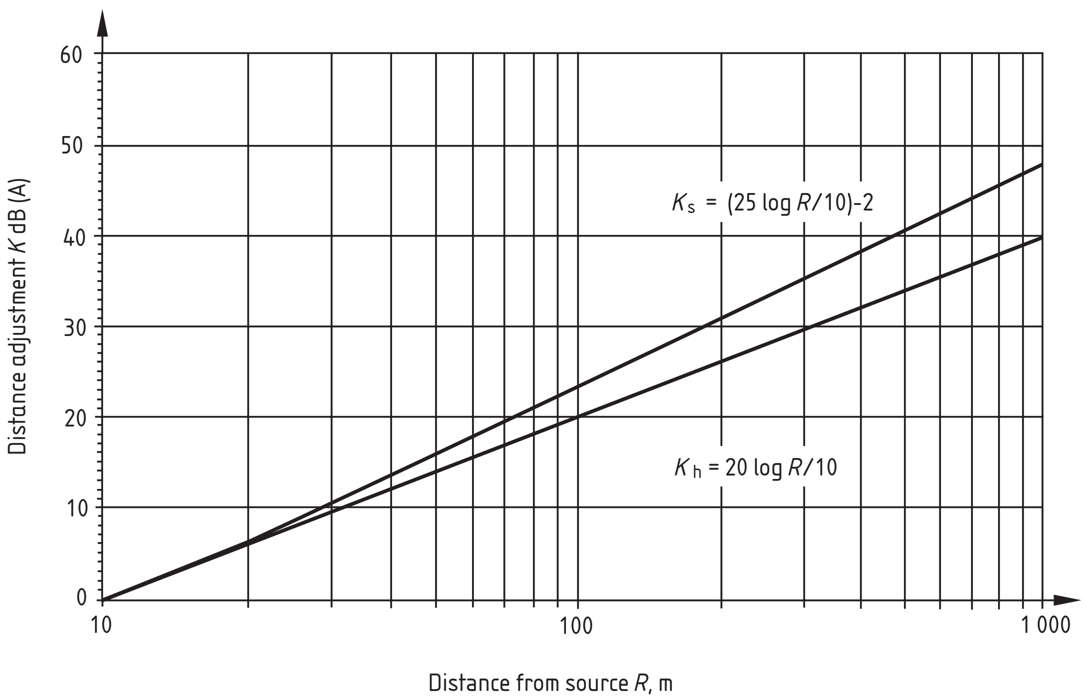
   The accurate determination of the effectiveness of a barrier is a complex process. A knowledge of sound pressure levels at separate frequencies and also of the geometry of the receiving position in relation to the source and the barrier are required. Calculations may be made in octave bands instead of "A" weighting to provide a more accurate barrier attenuation; if the octave band sound levels (see Tables C.1 to C.11) and the positions of the sources, receiver and barrier are known. The barrier attenuation can be calculated from Figure F.3. The final results of this analysis then needs to be logarithmically summed and weighted to provide an "A" weighted level.

In the absence of spectral data, as a working approximation, if there is a barrier or other topographic feature between the source and the receiving position, assume an approximate attenuation of 5 dB when the top of the plant is just visible to the receiver over the noise barrier, and of 10 dB when the noise screen completely hides the sources from the receiver. High topographical features and specifically designed and positioned noise barriers could provide greater attenuation. Subtract the attenuation from the value of [A1] $L_{Aeq, T}$ [/A1] calculated at the point of interest. Where the point of interest is 1 m from the façade of a building, make an allowance for reflection by adding 3 dB to the calculated (free field) levels.

d) *Stage 4*. Repeat stages 1 to 3 for each activity.

e) *Stage 5*. Estimate the percentage of the assessment period for which each activity takes place. Then use one of the methods outlined in **F.2.6** to predict the assessment period [A1] $L_{Aeq, T}$ [/A1] from the individual activity [A1] $L_{Aeq, T}$ [/A1] values obtained in stage 3, which might be on a shorter time-base.

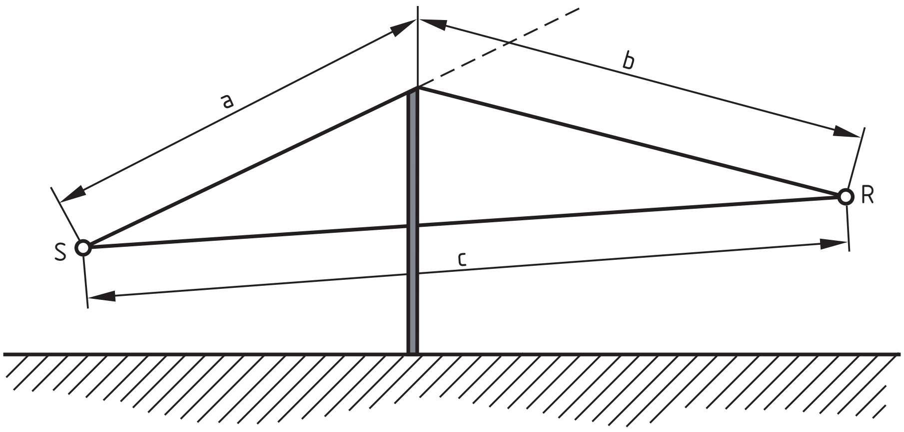
Figure F.2 **Distance adjustment *K* for activity [A1] $L_{Aeq, T}$ [/A1] method**



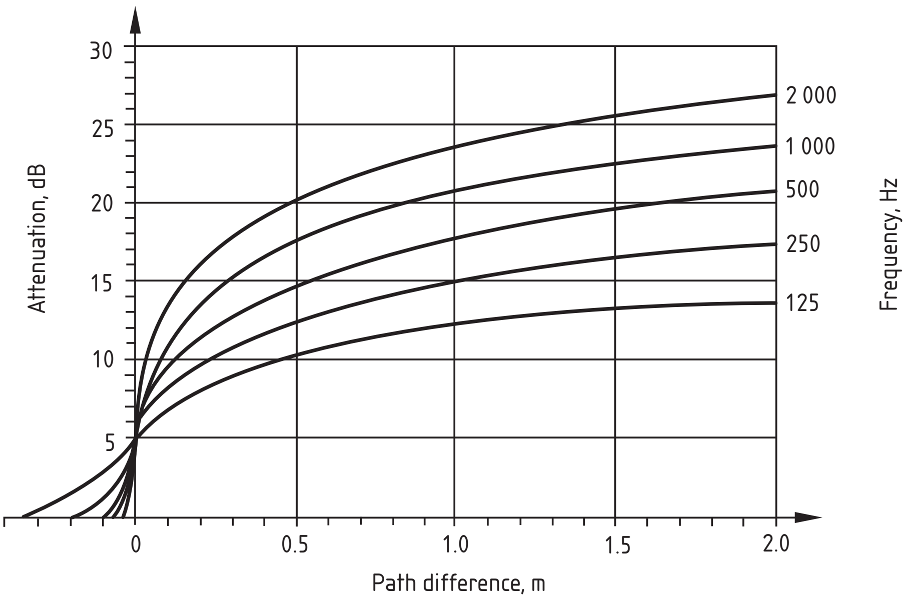
NOTE K_s *= distance adjustment for soft ground;* K_h *= distance adjustment for hard ground.*

Figure F.3 **Screening effect of barriers**

Unless otherwise stated, dimensions are in metres



a) Illustration of path difference (a + b – c) introduced by a barrier



b) Barrier attenuation at different frequencies of sound

Key

S Source

R Receiver

F.2.2.2.2 Distance adjustment

For propagation over hard ground, $K = K_h$. For propagation over 100% soft ground, $K = K_s$, providing that the source is operating at ground level and the receiver is no more than 2.5 m above the ground. If either the source or receiver is more than 2.5 m above the ground, the additional attenuation offered by soft ground needs to be reduced until at 15 m its value is the same as that at hard ground.

For propagation over mixed soft and hard ground, the additional attenuation due to soft ground (K_s – K_h) needs to be reduced according to the proportion of soft ground [e.g. for 25% soft ground, the adjustment is 0.25(K_s – K_h)].

Soft ground attenuation does not apply for propagation distances less than 25 m.

It is not usually advisable to combine the effects of screening and soft ground attenuation. Take either the attenuation from screening and hard ground propagation, or the attenuation of soft ground, whichever is the greater.

At distances over 300 m noise predictions have to be treated with caution, especially where a soft ground correction factor has been applied, because of the increasing importance of meteorological effects.

F.2.3 Method for plant sound power level

F.2.3.1 General

The plant sound power method (see **F.2.3.2**) can be used in the absence of sufficient data for the activity A1 $L_{Aeq, T}$ A1 method (see **F.2.2**) but it is necessary to know the on-time of the plant in order that comparable accuracy of site noise prediction can be obtained.

Where possible, the values given in Annex C are to be used as representative of operating plant. The sound power level values can be obtained by adding 28 dB(A) to the A1 $L_{Aeq, T}$ A1 values at 10 m distance. Alternatively, the values in Annex D could be used but these are of older plant and might provide a worst case. The third option is to use the maximum sound power levels of the plant permitted under EC Directive 2000/14/EC [11], as given in Table F.1.

The method involves the calculation of A1 $L_{Aeq, T}$ A1 from the plant sound power levels, typical percentage on-times and various allowances for distance, reflections, and screening or soft ground attenuation. Since this method necessitates the introduction into the calculation of the additional variable of percentage on-time, the method is more suitable for use in situations where an A1 $L_{Aeq, T}$ A1 for a similar activity is not available.

Neither this method nor the activity A1 $L_{Aeq, T}$ A1 method is suitable for predicting the A1 $L_{Aeq, T}$ A1 of mobile plant operating either on site in close proximity to the point of interest or on haul roads. Techniques for the estimation of noise of such mobile plant are given in **F.2.4**. The technique for plant operating over short traverses is similar to the sound power method but is modified for equivalent on-time related to traverse length and minimum distance to the point of interest.

F.2.3.2 Method

F.2.3.2.1 Procedure

The procedure is defined below. However, if only the highest L_{pA} is required, stages 2 and 5 can be omitted.

a) *Stage 1*. Select the sound power levels L_{WA} from measured data, Annexes C or D or Table F.1.

b) *Stage 2*. Obtain the average percentage on-time from estimates of the time that the plant will be operating at full power.

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

   Using the distance, R, in metres (m), from the point of interest to the source, calculate the sound level [A1) $L_{Aeq,\,T}$ (A1] at the point of interest by subtracting from the sound power level L_{WA} obtained in stage 1 a distance allowance K' (in dB) obtained either:

   1) from the following equations:

   $$K_h' = (20\log_{10}R) + 8 \qquad \text{(F.3)}$$

   or

   $$K_s' = (25\log_{10}R) + 1 \qquad \text{(F.4)}$$

   where R ⩾ 25 m;

   or

   2) from Figure F.4, which is based on equations (F.3) and (F.4).

NOTE 1 In practice, sources of noise such as construction site equipment do not radiate sound uniformly in all directions. Equations (F.3) and (F.4) can be adapted to allow for this directivity effect and for reflections within the site. However, for the purposes of calculations in this standard the effect is ignored.

NOTE 2 The sound level can be calculated for various conditions of operation, such as working and idling, using either of the two methods.

d) *Stage 4*. If necessary, adjust each sound level for reflections if the receiving position is 1 m from the façade of a building, i.e. apply a façade correction, and for screening, as detailed in stage 3 of **F.2.2.2.1**, adding or subtracting the allowances from the sound level L_{pA} obtained in stage 3 of the present procedure.

e) *Stage 5*. Calculate the activity [A1) $L_{Aeq,\,T}$ (A1] at the point of interest for the period of that activity by subtracting from the modified L_{pA} obtained in stage 4 the adjustment K_T obtained from Figure F.5 for the on-time obtained in stage 2.

f) *Stage 6*. Repeat stages 1 to 5 for each activity.

g) *Stage 7*. Estimate the percentage of the assessment period for which each activity takes place, then use one of the methods outlined in **F.2.6** to predict the assessment period [A1) $L_{Aeq,\,T}$ (A1] from the individual activity [A1) $L_{Aeq,\,T}$ (A1] values calculated in stage 5, which may be on a shorter time-base.

Figure F.4 **Distance adjustment *K'* for plant sound power method**

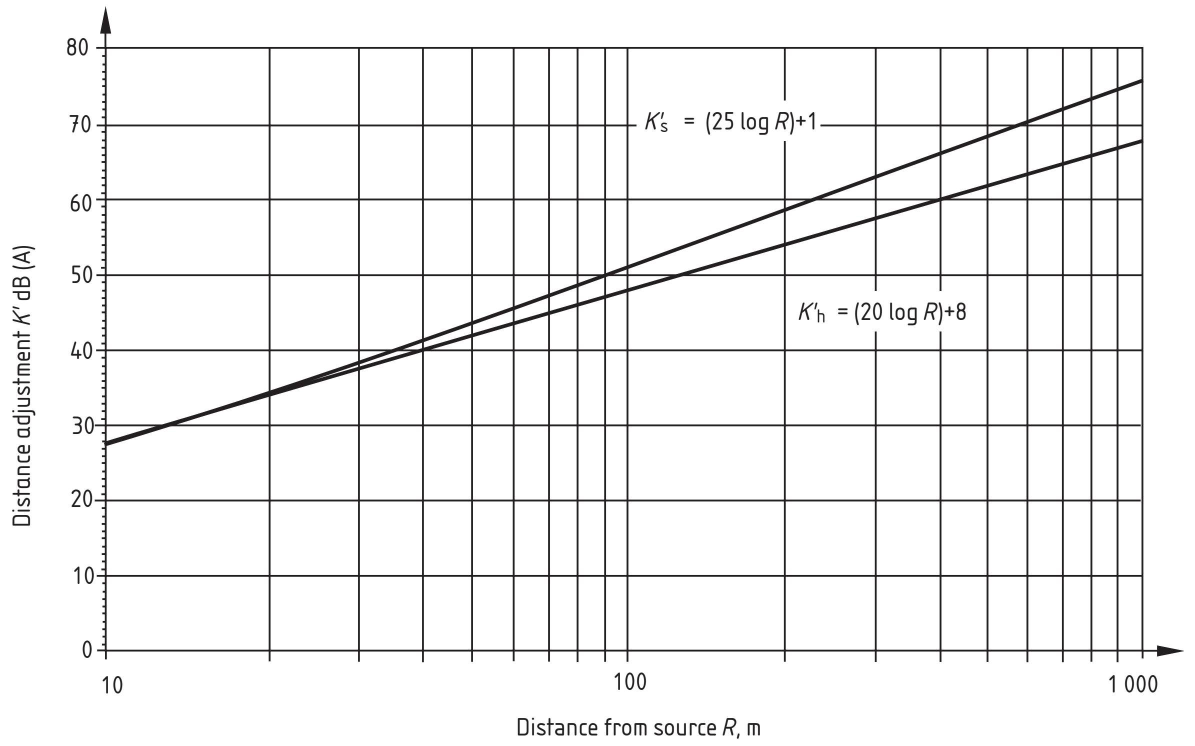
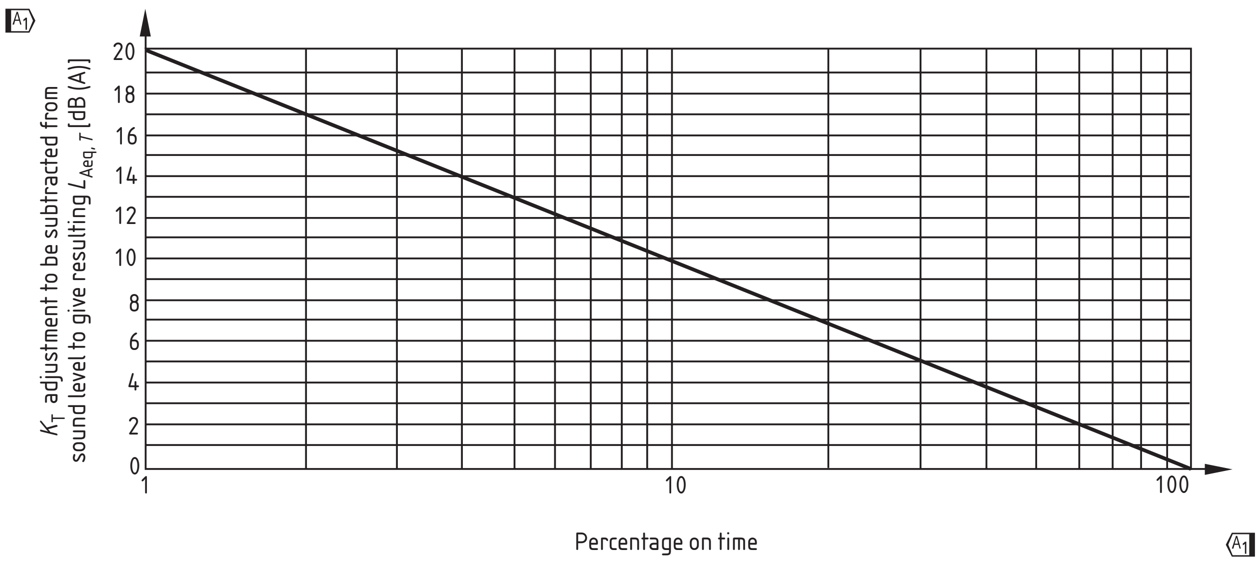


Figure F.5 **Adjustment to sound level to give resulting A1 $L_{Aeq, T}$ A1 (plant sound power method)**



F.2.3.2.2 Distance adjustment

For propagation over hard ground, $K' = K_h'$. For propagation over 100% soft ground, $K' = K_s'$, providing that the source is operating at ground level and the receiver is no more than 2.5 m above the ground. If either the source or receiver is more than 2.5 m above the ground, the additional attenuation offered by soft ground needs to be reduced until at 15 m its value is the same as that at hard ground.

For propagation over mixed soft and hard ground, the soft ground attenuation ($K_s' - K_h'$) needs to be reduced according to the proportion of soft ground [e.g. for 25% soft ground, the adjustment will be 0.25($K_s' - K_h'$)]. Soft ground attenuation does not apply for propagation distances less than 25 m. Either the attenuation from screening and hard ground propagation, or the attenuation of soft ground needs to be taken.

It is not usually advisable to combine the effects of screening and soft ground attenuation. At distances over 300 m, caution is needed, especially on applying the soft ground curves, because of the increasing importance of meteorological effects.

F.2.4 Method for mobile plant in a defined area

F.2.4.1 General

The prediction of the A1 $L_{Aeq,\,T}$ A1 from mobile plant operating over a small area or on site (see **F.2.4.2**) can be used for other activities when items of mobile plant are operating in close proximity to the point of interest, taking into account the adjustment of the predicted A1 $L_{Aeq,\,T}$ A1 for standing and idling time of the plant.

F.2.4.2 Method

The procedure for fixed plant in **F.2.2** and **F.2.3** can be used.

Estimates of the A1 $L_{Aeq,\,T}$ A1 from mobile plant working in a limited area made using the methods described in **F.2.2** or **F.2.3** tend to err on the high side because the orientation of the plant varies relative to the point of interest. The errors for estimates of sound level at some distance from the site can be neglected, but when the point of interest is close to the site, i.e. the traverse length is greater than half of the minimum distance to the point of interest, a further refinement is necessary to minimize errors.

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

a) *Stage 1*. Select the sound power level given in Table F.1 or Annexes C and D.

b) *Stage 2*. Calculate the sound level at the receiving position for the plant from the sound power level when the plant is at its closest proximity to the receiving position, as detailed in stage 3 of **F.2.3.2.1**.

c) *Stage 3*. If necessary, make allowances for reflections if the receiving position is 1 m from the façade of a building and for screening as detailed in stage 3 of **F.2.2.2.1**, adding or subtracting the allowances from the sound level A1 $L_{Aeq,\,T}$ A1.

d) *Stage 4*. Estimate the distance ratio (traverse length/minimum distance to receiving position) and obtain the equivalent on-time from Table F.2.

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

f) *Stage 6*. Repeat stages 1 to 5 for each activity of this type where:

$$t_c = T_t \times F \qquad \text{(F.5)}$$

where:

t_c is the corrected on-time;

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

F is the on-time correction factor.

g) *Stage 7*. Use one of the methods outlined in **F.2.6** to predict the assessment period [A1) $L_{Aeq,\,T}$ (A1] from the sound level L_{pA} and the corrected on-times.

F.2.5 Method for mobile plant using a regular well-defined route (e.g. haul roads)

F.2.5.1 General

The prediction of [A1) $L_{Aeq,\,T}$ (A1] from mobile plant using a regular route (see **F.2.5.2**) can be used when items of mobile plant pass at a known rate per hour.

In the absence of data measured directly for items of plant to be used on the site under assessment, the sound power levels stated in EC Directive 2000/14/EC [11] (see Table F.1) or the values given in Annexes C and D can be used.

F.2.5.2 Method

For mobile items of plant that pass at intervals (such as earth-moving machinery passing along a haul road), it is possible to predict an equivalent continuous sound level using the following method.

a) *Stage 1*. The general expression for predicting the [A1) $L_{Aeq,\,T}$ (A1] alongside a haul road used by single engined items of mobile plant is:

$$\text{[A1)}\ L_{Aeq,\,T}\ \text{(A1]} = L_{WA} - 33 + 10\log_{10}Q - 10\log_{10}V - 10\log_{10}d \qquad \text{(F.6)}$$

where:

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

Q is the number of vehicles per hour;

V is the average vehicle speed, in kilometres per hour (km/h);

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

Estimates of the [A1) $L_{Aeq,\,T}$ (A1] from a haul road used by other types of mobile plant with twin engines can be made by adding a further 3 dB(A) to the [A1) $L_{Aeq,\,T}$ (A1] calculated using equation (F.6).

b) *Stage 2*. If necessary, adjust the equivalent sound level for reflections (if the receiving position is 1 m from a building façade) and for screening (as detailed in stage 3 of **F.2.2.2.1**), adding or subtracting the allowances from the [A1) $L_{Aeq,\,T}$ (A1] obtained in stage 1 of the present procedure.

c) *Stage 3*. Where the angle of view, a_v (in degrees), of the haul road is less than 180°, apply an angle of view correction A, where:

$$A = 10\log(a_v/180) \qquad \text{(F.7)}$$

d) *Stage 4*. Repeat stages 2 and 3 for each activity.

e) *Stage 5*. Estimate the percentage of the assessment period for which each activity takes place, then use one of the methods outlined in **F.2.6** to predict the assessment period [A1⟩ $L_{Aeq,\,T}$ ⟨A1] from the individual activity [A1⟩ $L_{Aeq,\,T}$ ⟨A1] values obtained in stage 4, which might be on a shorter time-base than the assessment period.

F.2.6 Summation of sound levels

F.2.6.1 Conditions constant

When conditions on site are such that all activities affecting the noise level at the point of interest are carried out continuously for any assessment period, the activity [A1⟩ $L_{Aeq,\,T}$ ⟨A1] values obtained from **F.2.2**, **F.2.3**, **F.2.4** and/or **F.2.5** can be combined in the same way as actual continuous sound levels. It is possible to combine the separate sound levels in pairs. This is done by obtaining the difference between them and adding a correction to the higher level; approximate corrections are given in Table F.3. For a number of activities, this process can be repeated by combining two levels at a time until a single value is obtained, starting with the lowest pair of levels and working upwards in sequence.

Table F.3 **Addition of steady sound levels**

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

The generalized formula for the combination of two sound levels dB_1 and dB_2 is:

$$dB_{Total} = 10\log_{10}\left(10^{\frac{(dB_1)}{10}} + 10^{\frac{(dB_2)}{10}}\right) \qquad \text{(F.8)}$$

As this method is used when the activity [A1⟩ $L_{Aeq,\,T}$ ⟨A1] values are appropriate for a complete assessment period, the calculated sound level will be the combined equivalent continuous sound level [A1⟩ $L_{Aeq,\,T}$ ⟨A1] for that period only. For other periods it is necessary to use the method described in **F.2.6.2**.

F.2.6.2 Conditions varying during the assessment period

When conditions on site are such that some or all of the activities affecting the noise level at the point of interest continue for less than the assessment period, the values of [A1⟩ $L_{Aeq,\,T}$ ⟨A1] obtained from **F.2.2**, **F.2.3**, **F.2.4** and/or **F.2.5** may be combined as in equation (F.9).

$$L_{Aeq,\,T} = 10\log 10 \frac{1}{T}\sum_{i=1}^{n} t_i 10^{0.1L_i} \qquad \text{(F.9)}$$

where:

[A1⟩ $L_{Aeq,\,T}$ ⟨A1] is the combined equivalent continuous A-weighted sound pressure level, in decibels (dB), over a given period T;

L_i is the individual equivalent continuous A-weighted sound pressure level, [A1⟩ $L_{Aeq,\,T}$ ⟨A1], for an item of plant or activity during a period t_i, in decibels (dB);

n is the total number of individual equivalent continuous A-weighted sound pressure levels to be combined.

F.2.7 Example calculations

F.2.7.1 Example 1 – Building, office development

F.2.7.1.1 General

This example is based on Figure F.6.

Excavations are in progress for foundations of an office block, including breaking out of some old concrete bases, at a site next to existing offices. A tracked excavator (95 kW) is digging out spoil, placing it on a temporary tip which partially screens the machine from the offices. A wheeled loader (75 kW) is backfilling part of the excavated area with spoil from a nearby pile. Two hand-held breakers are being used to break out old concrete and are powered from a sound-proofed compressor.

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

a) excavator: 8 h;

b) loader: 4 h;

c) breakers: 3 h.

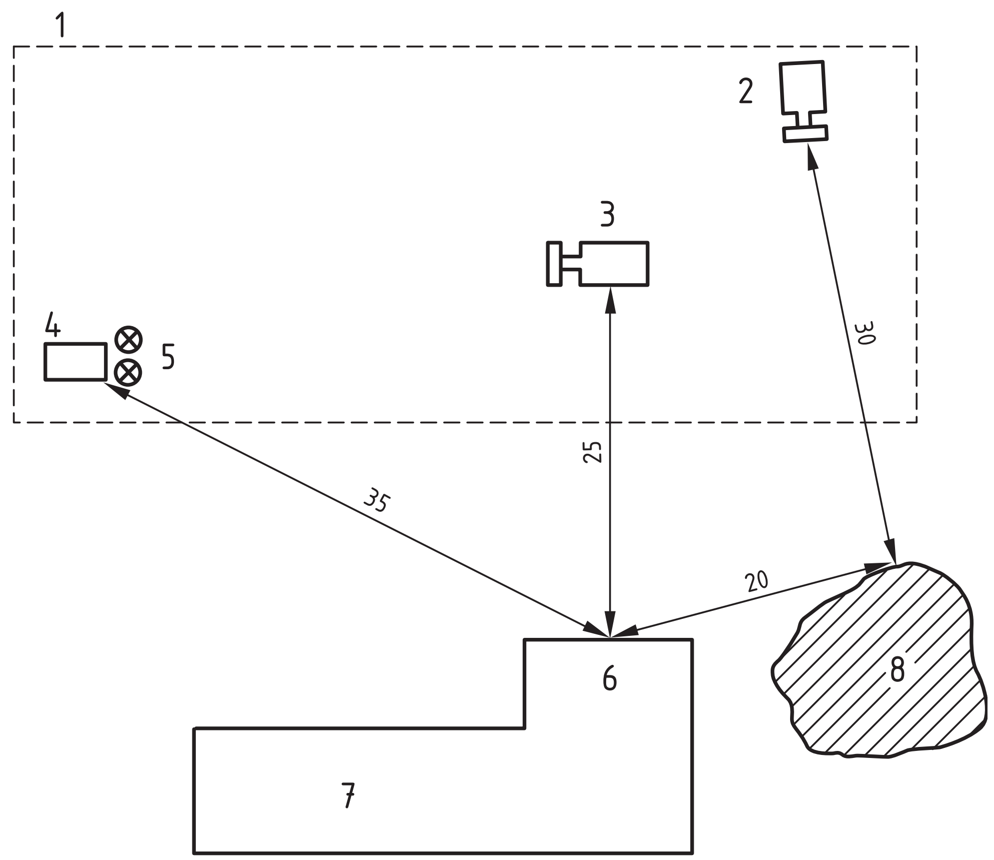
The example predicts the 10 h [A1⟩ $L_{Aeq,\,T}$ ⟨A1] at the façade of the office nearest to the site activities.

Consider the plant that is operating and select the methods to be used for the plant types. The excavator, compressor and breakers can be treated by the activity [A1⟩ $L_{Aeq,\,T}$ ⟨A1] method (see **F.2.2**) whereas the wheeled loader which is mobile in operation has to be treated by the method for mobile plant on site (see **F.2.4**).

The example calculations are shown in Tables F.4 and F.5, and described in **F.2.7.1.2** and **F.2.7.1.3**.

Figure F.6 **Office development site showing plant locations in relation to the nearest affected façade**

Dimensions in metres (m)



Key

1 Site boundary
2 Loader
3 Excavator
4 Compressor
5 Breakers
6 Prediction point
7 Existing offices
8 Spoil

Table F.4 **Example of prediction of noise from stationary plant**

Plant type	[A1] $L_{Aeq,T}$ [A1] at 10 m	Distance	Adjustments			Resultant [A1] $L_{Aeq,T}$ [A1]	Duration of activity	Duration of activity as percentage of 10 h	Correction to $L_{Aeq(10h)}$	Activity $L_{Aeq(10h)}$
			Distance	Screening	Reflection					
	dB	m	dB	dB	dB	dB	h	%	dB	dB
Step 1	**Step 2**	**Step 3**	**Step 4**	**Step 5**	**Step 6**	**Step 7**	**Step 8**	**Step 8**	**Step 10**	**Step 11**
Excavator	71	25	–8	–5	+3	61	8	80	–1	60
Compressor	65	35	–11	0	+3	57	3	30	–5	52
Breaker	83	35	–11	0	+3	75	3	30	–5	70
Breaker	83	35	–11	0	+3	75	3	30	–5	70

Table F.5 **Example of prediction of noise from mobile plant**

Plant type	Average L_{WA}	Distance	Adjustments			Resultant L_{pA}	Distance ratio	Equivalent on-time	Duration of activity	Correct percentage on-time	Correction to $L_{Aeq(10h)}$	Activity $L_{Aeq(10h)}$
			Distance	Screening	Reflection							
	dB	m	dB	dB	dB	dB			h	%	dB	dB
Step 1	**Step 2**	**Step 3**	**Step 4**	**Step 5**	**Step 6**	**Step 7**	**Step 8**	**Step 9**	**Step 10**	**Step 11**	**Step 12**	**Step 13**
Loader	99	20	–34	0	+3	68	30/20 =1.5	0.5	4	20	–7	61

F.2.7.1.2 Activity L_{Aeq} method

Calculate the estimated noise using the method described in **F.2.2** as follows.

NOTE Step numbers refer to Table F.4.

a) Tabulate the activities of items of plant (step 1).

b) Select the [A1⟩ $L_{Aeq,\,T}$ ⟨A1] at 10 m from the item of plant or activity (step 2). Use measured values of activity [A1⟩ $L_{Aeq,\,T}$ ⟨A1] for the same plant in the same mode of operation, or use the values in the following tables: for the excavator see Table C.4, reference number 5; for the compressor see Table C.5, reference number 5 and for the two breakers see Table C.1, reference number 6.

c) Take the distance from the drawing of the plant or activity to the point of interest (step 3) and obtain the corresponding allowance, in decibels, from Figure F.2 (step 4).

d) Include allowances for screening (step 5) and reflections (step 6) from which the [A1⟩ $L_{Aeq,\,T}$ ⟨A1] of each activity is obtained (step 7).

e) Then tabulate the duration of each activity, in hours, as the percentage of the 10 h period (steps 8 and 9) and use with each activity [A1⟩ $L_{Aeq,\,T}$ ⟨A1] to obtain a correction to $L_{Aeq(10h)}$ from Figure F.5 (step 10).

f) Add the correction to $L_{Aeq(10h)}$ to the resultant [A1⟩ $L_{Aeq,\,T}$ ⟨A1] to obtain the activity $L_{Aeq(10h)}$ (step 11).

F.2.7.1.3 Mobile plant on site

Calculate the estimated noise using the method described in **F.2.4** as follows.

NOTE Step numbers refer to Table F.5.

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

b) Select the sound power level L_{WA} for the item of plant (step 2). For the loader refer to Table B.4, reference number 13, or take the EC limit of 103 dB for L_{WA} from Table F.1.

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

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

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

f) Use the equivalent on-time, duration of activity (step 10) and equation (F.5) to obtain the corrected on-time (step 11).

g) Use the corrected on-time as a percentage of 10 h period (step 11) and the resultant sound level (step 7) to obtain the correction to $L_{Aeq(10\,h)}$ from Figure F.5 (step 12).

h) Add the correction to $L_{Aeq(10\,h)}$ to the resultant L_{pA} to obtain the activity $L_{Aeq(10\,h)}$ (step 13).

F.2.7.1.4 Resultant noise level

The $L_{Aeq(10\,h)}$ values from all the activities, the activity [A1⟩ $L_{Aeq,\,T}$ ⟨A1] and mobile plant on site methods are added together using Table E3. The addition of noise levels 60 dB, 52 dB, 70 dB, 70 dB and 61 dB gives a combined $L_{Aeq(10\,h)}$ level of 74 dB to the nearest whole number.

F.2.7.2 Example 2 – Civil engineering: spoil movement on a haul road

F.2.7.2.1 General

This example is based on Figure F.7.

Spoil is being taken from civil engineering works along a haul road which passes 50 m from a farm house across substantially hard ground. The loads are carried in articulated dump trucks (190 kW). The condition of the haul road is maintained by a grader (205 kW). Details of the journeys made are as follows.

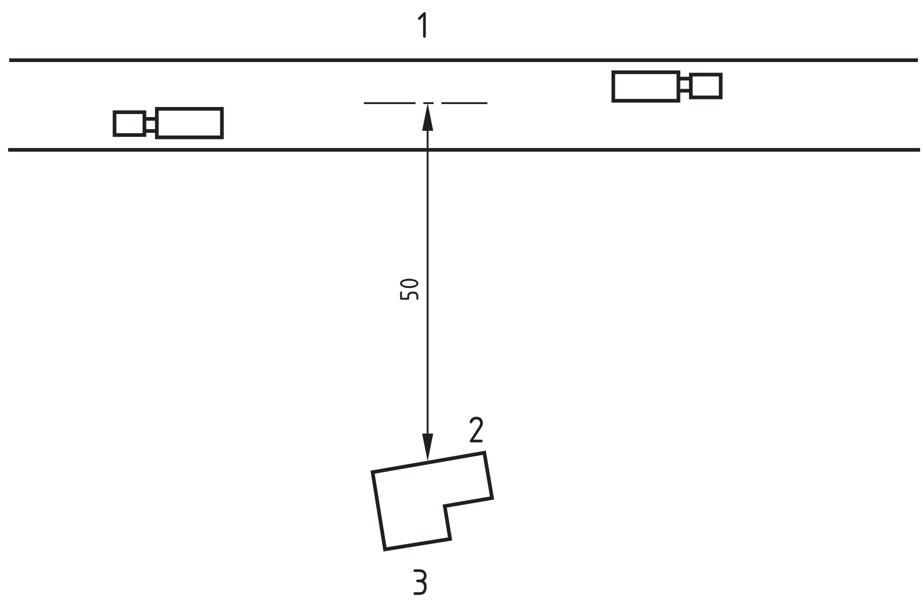
a) dump trucks: 12 journeys each way per hour at 25 km/h;

b) grader: one journey each way per hour at 7 km/h.

Operations are continuous for the 12 h day. The angle of view of the haul road is 180°. The method to be adopted for predicting the noise is that for mobile plant on haul roads (see **F.2.5**). The prediction method is based on equation (F.6).

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

Dimensions in metres (m)



Key

1 Haul road

2 Prediction point

3 Farm house

F.2.7.2.2 Sound level of plant

Calculate the sound level as follows.

a) *Dump trucks*. Assume an average sound power level for trucks travelling at similar speed. Refer to Table C.4, reference numbers 1 and 2, and Table C.5, reference numbers 16 and 17.

Average L_{WA} = 108 dB

Using equation (F.6) and substituting for Q = 24 (12 return journeys), V = 25 km/h and d = 50 m, then:

$L_{Aeq(1\ h)}$ = 58 dB

b) *Grader*. Select the sound power level from the tables. Refer to Table C.5, reference numbers 14 and 15 and Table C.6, reference number 31.

Average L_{WA} = 113 dB

Using equation (F.6) and substituting for Q = 2 (one return journey), V = 7 km/h and d = 50 m, then:

$L_{Aeq(1\ h)}$ = 58 dB

F.2.7.2.3 Resultant noise level

The total [A1] $L_{Aeq,\ T}$ [/A1] from the two types of plant is obtained by combining these levels using Table F.3 as follows.

Combine 58 dB with 58 dB: the difference is 0 dB so add 3 dB = 61 dB.

As the point of interest is at the building façade, an allowance for reflections of +3 dB is made; there is no allowance for screening as there is direct line of sight.

As operations are continuous over the 12 h day there is no correction necessary for duration of activity.

Hence the resultant façade level:

$L_{Aeq(12\ h)}$ = 61 + 3 = 64 dB

Annex G (normative) Noise monitoring

COMMENTARY ON ANNEX G

This annex gives guidance on the monitoring of noise from sites for the purposes of assessing compliance with noise control targets. Only noise affecting the neighbourhood, i.e. the area around the site, is considered. The need for, and the frequency of, monitoring will be determined by the specific circumstances of the site.

NOTE The monitoring of occupational noise within the working area of the site is covered under the Control of Noise at Work Regulations 2005 [2].

G.1 Instrumentation

[A1) The instrumentation system should be designed to determine equivalent continuous A-weighted sound pressure level (see **3.7**). The instrumentation should conform to the requirements for integrating averaging sound level meters, preferably of type 1 as specified in BS 7580-1:1997, but at least of type 2 as specified in BS 7580-2:1997, with verification of conformity being undertaken by periodic testing in accordance with these standards. Alternatively, instrumentation conforming to BS EN 61672-1:2013, preferably of class 1, but at least of class 2, should be used and should be periodically tested in accordance with BS EN 61672-3:2013. Alternative instrumentation, if used, should provide equivalent performance in respect of frequency and time weightings and tolerances.

NOTE 1 BS EN 61672-1:2013, which superseded BS EN 61672-1:2003, is the current British Standard specification for integrating averaging sound level meters, BS EN 61672-1:2003 having superseded BS EN 60804:2001, which in turn superseded BS EN 60804:1994. However, many meters conforming to BS EN 60804:1994 remain in use and are regarded as acceptable for the purposes of this British Standard. BS 7580-1:1997 and BS 7580-2:1997, which specify the test procedures for the verification of conformity to the requirements given in BS EN 60804:1994 for type 1 and type 2 meters respectively, remain current.

NOTE 2 Users of this part of BS 5228 are advised to consider the desirability of having meters tested periodically, for verification purposes, by a test laboratory that is accredited to BS EN ISO/IEC 17025 by a national or international accreditation body.

Manufacturers' instructions that accompany measuring instruments should be followed strictly. Every precaution should be taken before use to ensure that the instruments are accurately calibrated and, in the case of battery-operated instruments, that the batteries have not run down. A sound calibrator or pistonphone, preferably one conforming to BS EN 60942:2003, class 1, should be used to check the correct operation of the meter.

In addition to the periodic testing recommended in the first paragraph, sound calibrators should be used whenever monitoring takes place; typically before and after each measurement session.

NOTE 3 BS EN 60942:2003 is the current British Standard for sound calibrators. Sound level meters conforming to BS EN 60804:1994 might have been supplied with sound calibrators conforming to BS 7189:1989 (identical with IEC 942:1988) which was superseded by BS EN 60942:1998. (A1]

G.2 Measurement methods

G.2.1 General

Various alternative methods of noise measurement are described in this annex. The method to be selected in a particular case will depend on the temporal variations of noise level, on the resources available, on the location and on the time period over which the noise is to be measured.

Precautions should be taken to ensure that measurements are not affected by the presence of measurement personnel, by wind or other extraneous sources such as electric fields. If it is known that a measured sound level has been affected, the factors involved should be noted at the same time as the sound level. In some situations it is possible to correct the measured noise level for the effects of extraneous noise. When such a correction is made, it should be noted and the possible effects on measurement accuracy should be borne in mind.

When carrying out source noise measurements, research [62] has shown that the largest error is likely to be due to inaccuracies in the estimation of the distance from the source to the microphone. As error of 10% is likely to result in an error of 0.8 dB, consequently it is recommended that to maintain precision, the perpendicular source to receiver distance be determined with the greatest possible accuracy.

G.2.2 Sampling methods

Representative construction noise levels can be obtained in a variety of ways when the testing of compliance with noise control targets or limits is necessary. The most robust method is to permanently monitor construction noise levels at fixed locations and these can then be routinely checked against the stated limits on a day to day basis. However, this is not always either necessary or practicable and sampling techniques can be used to estimate the [A1] $L_{Aeq,\,T}$ [A1] over similar periods.

Sampling techniques can be divided into the following two broad categories.

a) *Regular sampling throughout the whole period* (e.g. 5 min/h over the working period). This procedure still requires the presence of staff and instrumentation during the full working period but permits measurements to be undertaken at several locations.

b) *A single sample*. This procedure is useful when it is only possible to visit the site for a limited period. The reliability of this technique can be improved by avoiding periods when the site is not operating normally (e.g. meal breaks). However, if adopting this technique, then it is critical that the activity occurring during the monitoring is similar to that which would occur for the full period.

The size of possible errors in estimates of [A1] $L_{Aeq,\,T}$ [A1] values obtained by sampling will depend on the type of sampling technique adopted, the length of time for which the noise is sampled and the pattern of noise emitted by the site.

Table G.1 provides some guidance on typical ranges of errors likely to be encountered when various sampling strategies are used. The figures quoted in the table are based on measurements at a number of construction sites but might not be applicable for large sites where there are very wide fluctuations in noise level or activity (e.g. for some types of piling).

Table G.1 **Estimation of daily [A1⟩ $L_{Aeq,T}$ ⟨A1] according to sampling technique**

Sampling technique	Daily [A1⟩ $L_{Aeq,T}$ ⟨A1] estimated within 95% confidence dB
5 min every 1 h	±2.5
20 min every 1 h	±1.5
Single 20 min sample	±5 [A)]
Single 60 min sample	±3 [A)]

[A)] These figures assume that measurements are taken only when the site is working normally (e.g. not during meal breaks).

G.3 Monitoring of [A1⟩ L_{Amax} ⟨A1] and [A1⟩ $L_{A01,T}$ ⟨A1]

As noted in **6.2**, the measurements of [A1⟩ L_{Amax} ⟨A1] and [A1⟩ $L_{A01,T}$ ⟨A1] are useful for rating the noise from isolated events which might not always be apparent from a longer period [A1⟩ $L_{Aeq,T}$ ⟨A1]. As with [A1⟩ $L_{Aeq,T}$ ⟨A1], various methods are available including the use of automatic, unattended equipment. However, these measures are particularly susceptible to extraneous unwanted noises. When, therefore, the object of the measurements is to assess compliance with noise control targets, measurement data from unattended equipment should be used with caution.

[A1⟩ L_{Amax} ⟨A1] and [A1⟩ $L_{A01,T}$ ⟨A1] should be measured using a sound level meter using the fast time weighting.

G.4 Information to be recorded

The following information should be recorded:

a) the measured values of [A1⟩ $L_{Aeq,T}$ ⟨A1] and, where appropriate, [A1⟩ L_{Amax} ⟨A1] or [A1⟩ $L_{A01,T}$ ⟨A1], together with details of the appropriate time periods;

b) details of the instrumentation and measurement methods used, including details of any sampling techniques, position of microphone(s) in relation to the site and system calibration data;

c) any factors that might have adversely affected the reliability or accuracy of the measurements;

d) plans of the site and neighbourhood showing the position of plant, associated buildings and notes of site activities during monitoring period(s);

e) notes on weather conditions, including where relevant, wind speed/direction, temperature, presence of precipitation, etc.;

f) time, date and name of person carrying out the measurement.

Annex H (informative) Types of piling

H.1 General

Piles can be divided into two main categories: bearing piles and embedded retaining wall piles. It is possible in principle to install either category by driving, pressing or boring (see Figure H.1). Ground or other site conditions can, however, prohibit the use of one or other of these techniques, which are described in more detail in **H.2** to **H.4**.

There are other methods of forming medium to deep foundations under certain conditions. These include the installation of stone columns by vibroreplacement (see **H.5**), deep compaction by dynamic consolidation (see **H.6**), and diaphragm walling (see **H.7**). Although the mechanical plant and equipment can differ in some ways from those used in conventional piling, the problems of protecting the neighbourhood from noise disturbance are similar.

H.2 Driven piles

*NOTE See **8.5.1** for guidance on control of impact-driven piles.*

In conventional driven piling, a hammer is used to strike the top of the pile via a helmet and/or a sacrificial dolly. High peak noise levels will arise as a result of the impact. The hammer can be a simple drop hammer or it can be actuated by steam, air, hydraulic or diesel propulsion. Displacement piles can be top-driven, bottom-driven or can be driven by means of a mandrel.

In certain ground conditions it might be possible to drive piles using a vibratory pile driver, in which cases high impact noise might not arise, but the continuous forced vibration together with structure-borne noise can give rise to some disturbance.

Enlarged pile heads are sometimes formed for compression piles beneath a reinforced embankment or a concrete slab. Installation of the temporary former can give rise to some disturbance.

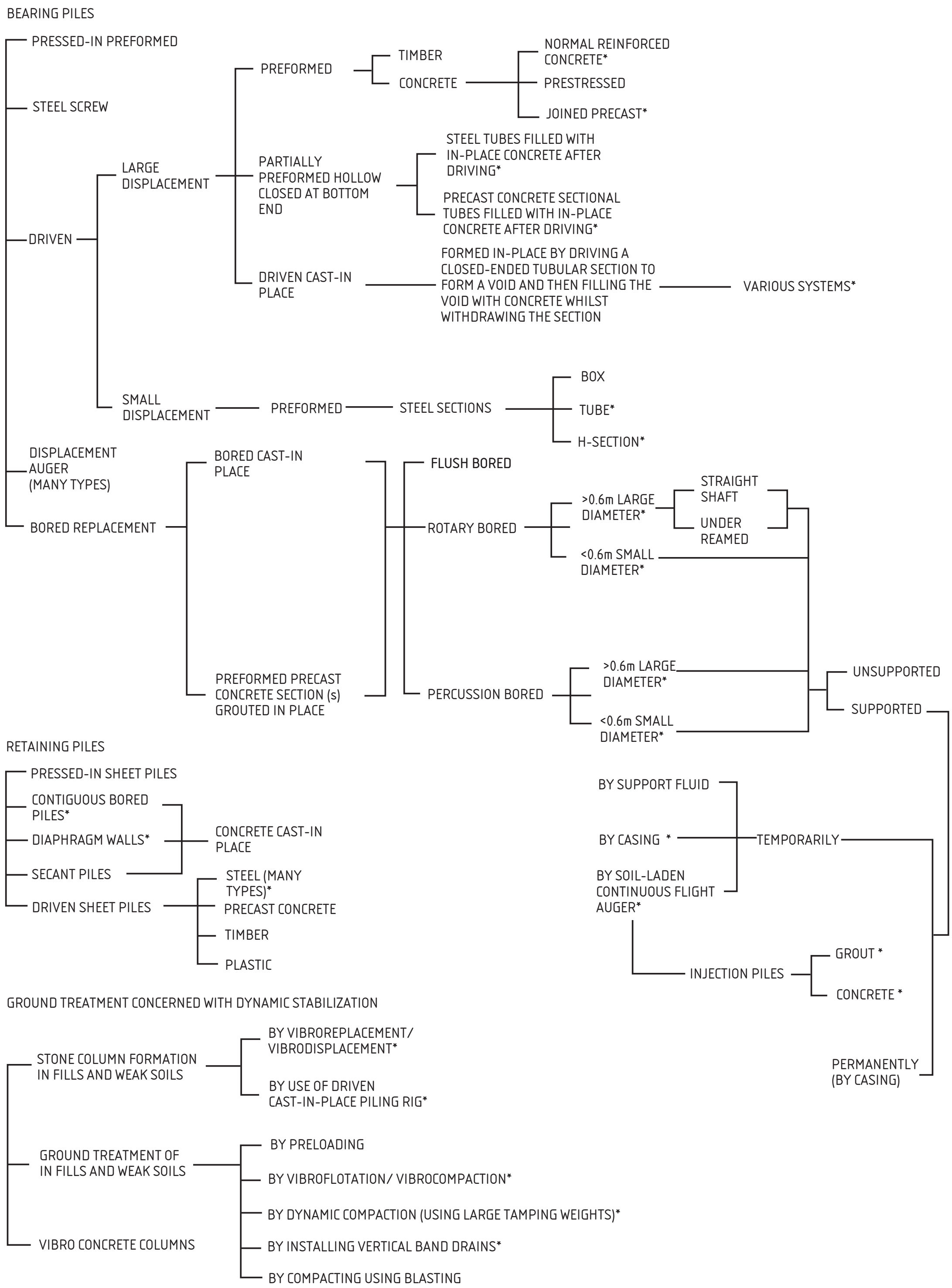
When piles are driven for temporary works, further disturbance can occur if the piles are extracted at a later date.

H.3 Pressed-in piles

A method for installing either retaining or bearing steel piles without either hammering or vibratory driving is by pressing. One or a pair of piles is pushed into the ground using the reaction of a group of several more adjacent piles. The main source of noise is the engine driving the hydraulic power pack for the pressing system. Other sources of noise include cranes and ancillary equipment.

To aid pile installation, pre-boring and/or water jetting can be used.

Figure H.1 **Piling and kindred ground treatment systems**



NOTE 1 The type of pile to be used on any site is normally governed by such criteria as loads to be carried, strata to be penetrated and the economics of the system.

NOTE 2 Where necessary, allowance needs to be made for the extraction of piles in addition to their installation.

*NOTE 3 Sound level data for systems marked thus * are included in Tables A1 C.3, C.12 and D.4 A1.*

H.4 Bored piles

Bored piles can be constructed by means of a rotary piling rig or by impact boring. In the former case the major source of noise is the more or less steady noise of the engine that supplies the power to perform the drilling. In some soils it is necessary to insert steel casings for part of the depth. If the casings have to be driven in and/or extracted by hammering, high peak noise levels will result. Similar considerations apply to the impact boring technique. The noise characteristics are therefore likely to be at a relatively steady and continuous level with intermittent high peaks superimposed upon it.

Bored piling sites frequently need much ancillary equipment including support fluid preparation and reclamation plant, reinforcing cage manufacturing plant, pumps and handling cranes. The layout of plant on the site is important for efficient operation and can exert considerable influence on noise control. The support fluid, which might be water, polymer or a bentonite suspension, can be used to provide bore stability, and all ancillary plant associated with this needs to be taken into account in the noise assessment.

Coring through existing piles and foundations is becoming more common on urban sites. Noise resulting from this process will need to be assessed and other foundation solutions considered such as the re-use of piles or foundations.

A method for boring piles that does not need a temporary casing is the use of a continuous flight auger and the injection of concrete or grout to form the piles. It might not be applicable in some ground conditions, and the range of pile diameters and depths is limited. However, this is the most used piling method in the UK. Enlarged pile heads are sometimes formed for compression piles beneath a reinforced embankment or a concrete slab. Installation of the temporary former can give rise to some disturbance.

Proprietary displacement auger piling methods are available which produce little or no spoil.

H.5 Vibroflotation/vibrocompaction and vibroreplacement/vibrodisplacement

A method for improving the bearing capacity of weak soils and fills is to use a large vibrating poker which can be mounted on a crane or an excavator base. In loose cohesionless soils the vibrations cause compaction to a denser state; this process is known as vibroflotation or vibrocompaction. In other weak soils a vibrating poker is used to form a hole which is then backfilled with graded stone and compacted by the poker; this process is known as vibroreplacement or vibrodisplacement. Water or compressed air can be used as a jetting and flushing medium.

Vibro concrete columns (VCC) are backfilled with concrete instead of graded stone.

Typically, vibrating pokers are actuated by electric or hydraulic motors. To reduce the noise of the operation, attention needs to be paid to the generator or power pack as appropriate. Other sources of noise could include pumps when using water flush, or air escaping from the poker when this is exposed.

H.6 Deep compaction by dynamic consolidation

An alternative method for improving the bearing capacity of weak soils and fills is to drop a large tamping weight from a height on to the ground at selected locations. Typically in the UK, tamping weights between 10 t and 20 t are used and are dropped from heights between 10 m and 25 m. The tamping weight is normally raised by and dropped from a very large crawler crane and the noise characteristic contains both steady (crane engine) and impulsive (impact of weight on ground) components.

H.7 Diaphragm walling

Diaphragm walling can be used when deep foundation elements are needed with both retaining and bearing capabilities. The soil is excavated in a trench under a thixotropic bentonite suspension in a series of panels, usually using a special clamshell grab; when the full depth has been reached a reinforcing cage is inserted and concrete is placed by tremie pipe, thus displacing the bentonite mud to the surface.

The grab is normally suspended from a crawler crane, although a tracked excavator base is sometimes used. Diaphragm walling sites frequently need much ancillary equipment including bentonite preparation and reclamation plant, reinforcing cage manufacturing plant, pumps and handling cranes. The layout of plant on the site is important for efficient operation and can exert considerable influence on noise control.

An alternative to the grab is a reverse circulation mill which allows almost continuous removal of spoil within the bentonite mud suspension returns.

Annex I (informative) Air overpressure

I.1 Description

Whenever blasting is carried out, energy is transmitted from the blast site in the form of airborne pressure waves. These pressure waves comprise energy over a wide range of frequencies, some of which are higher than 20 Hz and therefore perceptible as sound, whereas the majority are below 20 Hz and hence inaudible, but can be sensed as concussion. It is the combination of the sound and concussion that is known as air overpressure.

The attenuation effects due to the topography, either natural or manufactured, between the blast and the receiver are much greater on the audible component of the pressure wave, whereas the effects are relatively slight on the lower frequency concussive component. The energy transmitted in the audible part of the pressure wave is much smaller than that in the concussive part and therefore baffle mounds or other acoustic screening techniques do not significantly reduce the overall air overpressure intensity.

Air overpressure can excite secondary vibrations at an audible frequency in buildings and it is usually this effect which has been found to give rise to comment from occupants. There is no known evidence of structural damage to structures from excessive air overpressure levels from quarry blasting.

Meteorological conditions, over which an operator has no control, such as temperature, cloud cover, humidity, wind speed, turbulence and direction, all affect the intensity of air overpressure at any location and cannot be reliably predicted. These conditions vary in time and position and therefore the reduction in air overpressure values as the distance from the blast increases might be greater in some directions than others.

I.2 Sources of blast-generated air overpressure

The use of detonating cord, inadequate or poor stemming and gas venting are major sources of air overpressure and can be controlled with good blast design. The use of detonating cord can be avoided by adopting the technique of down-the-hole initiation but, if used, any exposed lengths need to be covered with a reasonable thickness of selected overburden. Sufficient stemming with appropriate material such as sized stone chippings is needed. Gas venting can be minimized by good blast design, accurate drilling and careful placement of the correct amount of explosives. The other major sources of air overpressure from blasting are the reflection of stresses from a free face of an unbroken rock mass and also from the physical movement of a rock mass around the shot holes and at other free faces.

Detailed requirements for the use of explosives at quarries are contained in the Quarries (Explosives) Regulations 1988 [63] and the Quarries (Explosives) Regulations (Northern Ireland) 2006 [64].

I.3 Criteria

As the airborne pressure waves pass any single point the pressure of the air rises rapidly to a value above atmospheric pressure, falls to below atmospheric pressure, then returns to normal pressure after a series of oscillations. The maximum value above atmospheric pressure is known as peak air overpressure and is measured in pressure terms and generally expressed in linear decibels (dB lin) (see **I.4**).

Routine blasting can regularly generate air overpressure levels at adjacent premises of around 120 dB (lin). This level corresponds to an excess air pressure which is equivalent to that of a steady wind velocity of 5 $m \cdot s^{-1}$ (Beaufort force 3, gentle breeze) and is likely to be above the threshold of perception.

Windows are generally the weakest parts of a structure and research by the United States Bureau of Mines [65] has shown that a poorly mounted window that is prestressed might crack at 150 dB (lin), with most windows cracking at around 170 dB (lin), whereas structural damage would not be expected at levels below 180 dB (lin).

I.4 Measurement

Measurement of air overpressure needs to be undertaken with microphones with an adequate low frequency response to fully capture the dominant low frequency component. A 2 Hz high pass system has been found to be satisfactory. Most of the equipment more commonly used for noise measurement is therefore not suitable for measuring overpressure. Although monitoring of air overpressure can be undertaken, due to the uncertainties with meteorological conditions, it is not possible to predict the location of the maximum air overpressure.

Additionally, pressure variations in the atmosphere due to windy conditions can mask the blast generated air overpressure levels. For these reasons it is not accepted practice to set specific limits for air overpressure. In order to control air overpressure the best practical approach is to take measures to minimize its generation at source.

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Further reading

NOTE These publications were listed in the previous edition of BS 5228. They are no longer specifically referred to in the standard but have been retained as they provide additional guidance.

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Appendix AP2.3

BS 7385-2:1993

Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration

BRITISH STANDARD

BS 7385-2:
1993

Evaluation and measurement for vibration in buildings —

Part 2: Guide to damage levels from groundborne vibration

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the General Mechanical Engineering Standards Policy Committee (GME/-) to Technical Committee GME/21, upon which the following bodies were represented:

Electricity Association
Federation of Civil Engineering Contractors
Imperial College of Science and Technology
Institute of Sound and Vibration Research
Institution of Mechanical Engineers
Lloyds Register of Shipping
Ministry of Defence
Open University
Power Generation Contractors' Association (BEAMA Ltd.)
Railway Industry Association of Great Britain
Sira Test and Certification Ltd.
Society of British Aerospace Companies Limited
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The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

Association of Consulting Engineers
British Coal Corporation
British Railways Board
British Society for Strain Measurements
Department of the Environment (Building Research Establishment)
Department of Trade and Industry (National Engineering Laboratory)
Department of Transport (Transport Research Laboratory)
Health and Safety Executive
Heriot-Watt University
Institute of Acoustics
Institute of Explosives Engineers
Institution of Environmental Health Officers
University of Leeds

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Contents

Foreword

This Part of BS 7385 has been prepared under the direction of the General Mechanical Engineering Standards Policy Committee. It should be considered together with BS 7385-1:1990 *Guide for measurement of vibrations and evaluation of their effects on buildings.*

More detailed consideration of the methodology for measurement, data analysis, reporting and building classification is given in BS 7385-1, to which the reader is referred for further guidance beyond the basic principles given here.

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 and ii, pages 1 to 10, 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.

Introduction

Groundborne vibration from sources such as blasting, piling, machinery or road/rail traffic can be a source of concern for occupants of buildings in the vicinity. This concern can lead to a need to assess the effect of the imposed vibration on the building structure to ascertain whether damage could occur. This Part of BS 7385 provides guidance on the assessment of the possibility of vibration-induced damage in buildings due to a variety of sources.

There is a lack of reliable data on the threshold of vibration-induced damage in buildings both in countries where national standards already exist and in the UK. This Part of BS 7385 has been developed from an extensive review of UK data, relevant national and international documents and other published data. Although a large number of case histories was assembled in the UK database [1], very few cases of vibration-induced damage were found. It has been necessary therefore, to refer to the results of experimental investigations carried out in other countries into vibration-induced damage thresholds.

This Part of BS 7385 sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. It is intended to provide a standard procedure for measuring, recording and analysing building vibration together with an accurate record of any damage occurring.

1 Scope

This Part of BS 7385 gives guidance on the levels of vibration above which building structures could be damaged. It identifies the factors which influence the vibration response of buildings, and describes the basic procedure for carrying out measurements. Vibrations of both transient and continuous character are considered. A method of assessment which takes into account the characteristics of the vibration, the building and the measured data is given. It is appropriate for the types of investigation given in BS 7385-1, but for detailed engineering analysis, criteria other than the vibration levels may need to be considered.

Only the direct effect of vibration on buildings is considered. The indirect effects on the building structure due to ground movement, the movement of loose objects within buildings, the possibility of damage to sensitive equipment and the effect of vibration on people are outside the scope of this Part of BS 7385. There is a major difference between the sensitivity of people in feeling vibration and the onset of levels of vibration which damage the structure. Levels of vibration at which adverse comment from people is likely are below levels of vibration which damage buildings, except at lower frequencies. The evaluation of human exposure to vibration in buildings is covered in BS 6472.

This Part of BS 7385 does not consider the many other causes of cracking in buildings; cracking commonly occurs in buildings whether they are exposed to vibration or not (see annex A).

Damage due to earthquakes, air overpressure, wind or the sea are also outside the scope of this Part of BS 7385. It is applicable only to vibration transmitted through the ground and not to vibration set up by machinery within a building. Chimneys, bridges and underground structures such as chambers, tunnels and pipelines are not covered.

2 References

2.1 Normative references

This Part of BS 7385 incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on page 10. Subsequent amendments to, or revisions of, any of these publications apply to this Part of BS 7385 only when incorporated in it by updating or revision.

2.2 Informative references

This Part of BS 7385 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 10, but reference should be made to the latest editions.

3 Definitions

For the purposes of this Part of BS 7385, the following definitions apply.

3.1
peak particle velocity (p.p.v.)

the maximum instantaneous velocity of a particle at a point during a given time interval

NOTE Whereas the disturbance caused by a vibration source propagates away from that source with a certain wave velocity, ground particles oscillate with a variable particle velocity. At a given location along the propagation path the motion may be defined in terms of three mutually perpendicular components (usually vertical, transverse and longitudinal or radial). In order to ensure that the peak particle velocity is correctly measured, all three components have to be measured simultaneously.

3.2
peak component particle velocity

the maximum value of any one of three orthogonal component particle velocities measured during a given time interval

3.3
dynamic magnification

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

NOTE 1 The dynamic magnification is not necessarily greater than 1 (values less than 1 indicating a reduction of vibration levels).

NOTE 2 In common practice the dynamic magnification is based on a comparison of values of p.p.v. from time histories, and is therefore frequency independent. The dynamic magnification does however vary with frequency and, when based upon a comparison of spectral peaks, is called a spectral magnification or amplification.

4 Characteristics of building vibration

4.1 Duration

The structural response of a building can be significantly affected by the duration of the vibration to which it is exposed. The time characteristic of various vibration forcing functions is given in Table 1 of BS 7385-1:1990 and **3.2** of BS 7385-1:1990. The limit above which damage may be caused for vibration of a continuous nature may need to be lower than the corresponding limit for transient vibration. If the building is exposed to continuous vibration for a sufficient time (which is dependent on frequency and damping of the structure), it is possible for dynamic magnification to occur if a resonant frequency of the structure is close to the excitation frequency. The possibility of fatigue of building materials would also arise if a vibration source causes a sufficient number of stress reversals, however, no substantiated cases are known to have arisen from groundborne vibration.

4.2 Frequency range

Typical frequency ranges covering the dominant structural response to various sources of vibration are given in Table 1 of BS 7385-1:1990. The lowest frequency originating from man-made sources included in this Part of BS 7385 is 1 Hz and the highest frequency expected from either machinery or close-in construction blasting in hard ground is 1 000 Hz, however a more limited range of 4 Hz to 250 Hz is usually encountered in buildings. For the purpose of selecting guide values from those given in this Part of BS 7385, it is the frequency of the input vibration to the building which is of relevance.

4.3 Sources of vibration

Sources of vibration which are considered include blasting (carried out during mineral extraction or construction excavation), demolition, piling, ground treatments (e.g. compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

5 Factors to be considered in building response

5.1 General

The response of a building to groundborne vibration is affected by the type of foundation, underlying ground conditions, the building construction and the state of repair of the building.

5.2 Foundation type and ground conditions

The interaction between the ground and the foundation of the structure can have a major effect on building response. The geology of the ground between the vibration source and the building also affects the input frequency spectrum to the building. In general stiffer foundations result in higher natural frequencies of the building-soil system and higher input frequencies are often associated with harder ground. Categories of foundations and types of soils are given in annex A of BS 7385-1:1990.

The strain imposed on a building at foundation level is proportional to the p.p.v. but is inversely proportional to the propagation velocity of the shear or compression waves in the ground [2]. Since the propagation velocity increases with ground stiffness, a higher p.p.v. measured with harder ground conditions may induce the same strain (cracking potential) as a lower p.p.v. measured with softer ground, provided that it occurs significantly far away from a resonance [3]. Thus where a structure closely follows the movement of the ground, it may be possible to allow a higher p.p.v. with hard ground conditions.

5.3 Type and construction of building

The strains induced in a building by a given vibration excitation will depend upon the dynamic characteristics of the particular type of building, i.e., the natural frequencies, mode shapes and damping. Natural frequencies are determined by the geometry of the building and the components, the degree of fixity of these components in the structure and the stiffness and mass of each component. Older, low-rise masonry structures tend to have higher natural frequencies in comparison with modern lightweight, flexible and taller buildings. Higher levels of strain will result when excitation frequencies are close to natural frequencies.

A classification of buildings is given in annex A of BS 7385-1:1990, with an indication of the relative resistance to vibration.

5.4 Building components

Individual building components such as walls, floors, beams or ceilings have natural frequencies which are usually higher than the frequencies of the building as a whole, and are therefore more susceptible to excitation at resonance by continuously operating machinery, than the building as a whole.

In assessing the effect of vibration on building components it should be noted that the dynamic stresses corresponding to a p.p.v. of 10 mm/s, range typically from only 0.4 % to 2.3 % of the allowable design stress for some specific building materials [4]. A method of estimating peak stress from p.p.v. is given in annex B of BS 7385-1:1990.

6 Measurement of vibration

6.1 General

The general principles for measuring vibration in buildings are given in BS 7385-1:1990. Guidance on specific measurements to be carried out for the purpose of assessing the possibility of vibration-induced damage are given in **6.2** to **6.6**.

6.2 Quantity to be measured

Peak particle velocity has been found to be the best single descriptor for correlating with case history data on the occurrence of vibration-induced damage. Cracking occurs however, due to excessive structural strain, due to either distortion as the building follows movement of the ground or ground motion which causes inertial loading of the building [2]. In some situations, therefore, it may be appropriate to measure strain directly.

The preferred method of measuring p.p.v. is to record simultaneously unfiltered time histories of the three orthogonal components of particle velocity, which allows any desired value to be extracted at a later stage. Where it has been demonstrated that time histories are consistent, then, as indicated in **6.1** of BS 7385-1:1990, it may be adequate to characterize the vibration by a continuous measurement of p.p.v. values. The maximum of the three orthogonal components should be used for the assessment, since the majority of data on which guide values have been based are expressed in peak component particle velocity. True resultant particle velocity is obtained by vectorily summing the three orthogonal components coincident with time. The peak true resultant particle velocity is the maximum value of the true vector sum obtained during a given time interval and should also be derived for reference.

NOTE 1 The use of the maximum vector sum, which takes the maximum of each component regardless of the time when it occurs, is discouraged, because it may include a large unknown safety factor.

NOTE 2 Where measurements are being made for the purposes of a detailed engineering analysis the peak true resultant particle velocity should be used, and the measuring directions should be recorded.

6.3 Measuring positions

Measurements should be taken at the base of the building on the side of the building facing the source of vibration, to define the vibration input to the building. Where this is not feasible, the measurement should be obtained on the ground, outside of the building (see also **7.2.2** of BS 7385-1:1990). One of the horizontal vibration components should be in the radial direction between the source and the building in the case of ground measurements or oriented parallel with a major axis of the building when investigating structural response. Vibration measurements at locations other than the base of the building should be taken for the purposes of a more detailed engineering analysis (see **9.2.4** of BS 7385-1:1990).

6.4 Mounting of transducer

Transducers should be mounted to reproduce faithfully the vibration in the frequency and magnitude ranges in which vibration response may be expected [5,6]. Detailed guidance is given on coupling the transducer to the building structure in **7.2** of BS 7385-1:1990.

6.5 Instrumentation

The measuring system, comprising transducers, signal conditioning and data recording elements should be selected according to the type of investigation intended. The overall system, and in particular the transducer, should have an adequate sensitivity and frequency range to cover the expected range of vibration frequency and velocity magnitudes. The time duration of the recorded time history will depend upon the character of the excitation, but should be such that the maximum response is recorded and the spectral characteristics are established with appropriate accuracy (see **3.2** and **6.1** of BS 7385-1:1990). Requirements for the measuring instrumentation are given in clause **6** of BS 7385-1:1990.

Periodic checks on the function and calibration of the instrumentation should also be carried out [6]. Calibration of the vibration transducer, should conform to BS 6955-0:1988.

6.6 Measurement procedure

The measurement procedure to be adopted depends on the type of investigation required, i.e. a preliminary assessment, a monitoring program, a field survey or a detailed engineering analysis (see **9.2** of BS 7385-1:1990). Where initial desk studies indicate that nearby buildings could be at risk, then trial measurements should be carried out to establish the vibration attenuation between the source and these buildings [2]. The survey record should be consistent with the type of investigation required (see **9.2** of BS 7385-1:1990), but should also include information on the vibration source, the site layout, ground conditions, type of building and condition, instrumentation and results [7,8] (more detailed guidance is given in annex B).

It is essential that data should be fully and correctly reported.

7 Assessment of vibration

7.1 General

The risk of vibration-induced damage should be evaluated taking into account the magnitude, frequency and duration of recorded vibration together with consideration of the type of building which is exposed.

7.2 Basis for damage criteria

Case-history data, taken alone, has so far not provided an adequate basis for identifying thresholds for vibration-induced damage [1,9]. Data from systematic studies [10 to 17], using a carefully controlled vibration source in the vicinity of buildings has therefore been used as the basis for defining damage thresholds. The majority of the data at the higher levels of vibration is usually associated with the effect on residential buildings excited by blasting and constructional activities.

7.3 Estimation of vibration frequency

Strains imposed in a building by ground motion will tend to be greater if lower frequencies predominate [18]. The relative displacements associated with cracking will be reached at higher vibration magnitudes with higher frequency vibration [3]. Thus a frequency-based vibration criterion is given in this Part of BS 7385 and some estimation of the frequency content of the recorded vibration has to be made.

The dominant frequency to use for the assessment is that associated with the greatest amplitude pulse. The method of estimating frequency depends on whether the vibration time history is simple or complex in character. The simplest case consists of a time history record with a single dominant pulse, where the dominant frequency may be taken as the inverse of twice the time interval of the two zero crossings on either side of the peak. This technique is only reliable where the vibration consists of a single frequency [19]. In more critical circumstances or if a visual examination of the vibration time history shows that it is multi-frequency in nature, then frequencies should be determined from an amplitude-frequency plot, with each significant peak being examined in turn [20].

7.4 Vibration guide values

7.4.1 *Nature of vibration guide values*

The vibration levels suggested are judged to give a minimal risk (see **9.7** of BS 7385-1:1990) of vibration-induced damage. Some data [13] suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK.

7.4.2 ***Guide values for transient vibration relating to cosmetic damage***

Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.

Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values.

NOTE Damage categories are defined in **9.9** of BS 7385-1:1990.

7.4.3 ***Guide values for continuous vibration relating to cosmetic damage***

The guide values in Table 1 relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings. Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 1 may need to be reduced by up to 50 %.

NOTE There are insufficient cases where continuous vibration has caused damage to buildings to substantiate these guide values but they are based on common practice.

7.5 Special cases

7.5.1 ***Fatigue considerations***

There is little probability of fatigue damage occurring in residential building structures due to either blasting [3, 21, 22], normal construction activities or vibration generated by either road or rail traffic. The increase of the component stress levels due to imposed vibration is relatively nominal and the number of cycles applied at a repeated high level of vibration is relatively low. Non-structural components (such as plaster) should incur dynamic stresses which are typically well below, i.e. only 5 % of, component yield and ultimate strengths [14]. Thus unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in Table 1 should not be reduced from fatigue considerations.

7.5.2 ***Important buildings***

Important buildings which are difficult to repair may require special consideration on a case-by-case basis. A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive.

7.5.3 ***Alternative evaluation technique***

In some cases in a detailed engineering analysis, the response spectrum technique [3,13] may be useful in evaluating the vibration of a building. This technique includes the effect of frequency and damping and can be used for any type of time history but has so far been applied mainly to seismic effects and shock.

7.5.4 ***Indirect damage due to soil compaction***

Damage to buildings can sometimes arise indirectly from vibration in certain ground conditions where the vibration is of sufficient magnitude to cause soil compaction (see annex C).

7.5.5 ***Underground constructions***

Structures below ground are known to sustain higher levels of vibration and are very resistant to damage unless in very poor condition.

Table 1 — Transient vibration guide values for cosmetic damage

Line (see Figure 1)	**Type of building**	**Peak component particle velocity in frequency range of predominant pulse**	
		4 Hz to 15 Hz	**15 Hz and above**
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commerical type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

NOTE 1 Values referred to are at the base of the building (see **6.3**).

NOTE 2 For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

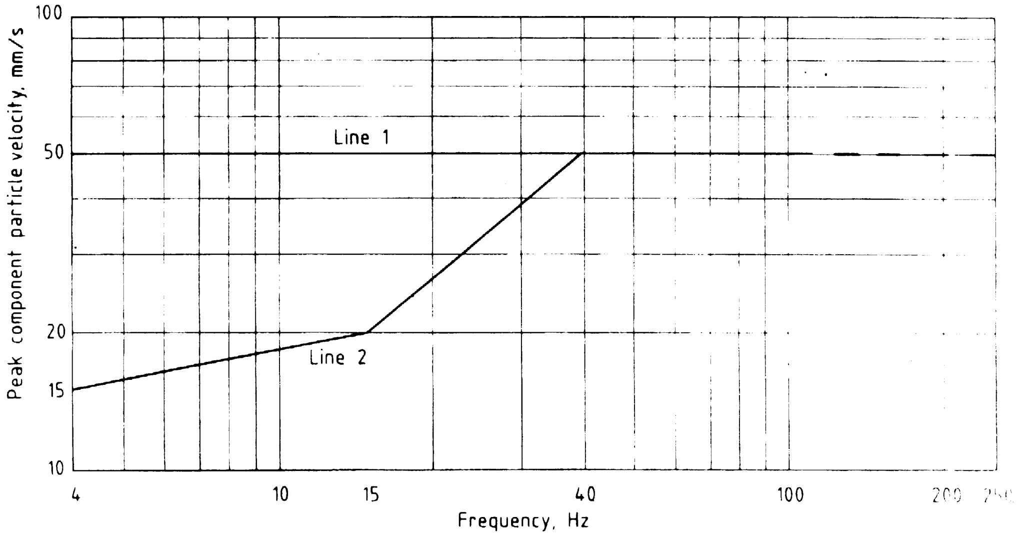

Figure 1 — Transient vibration guide values for cosmetic damage

Annex A (informative) Cracking in buildings

A.1 General

Cracking first occurs in buildings immediately after construction or over a period of several years, depending upon the methods and materials used in construction and change in ground characteristics caused by, for example, the removal of trees. Buildings have different life spans or time periods before deterioration or damage occurs. This time period depends upon the stresses to which the building has been exposed as well as the resistance of the building materials to physical and chemical effects.

Heat, moisture, settlement, occupational loads, prestressing forces, material creep and chemical changes all cause movements in the building. In an optimized design, the build up of stress concentrations in the structural elements should be minimized. If the design does not permit adequate relaxation of these stress concentrations, then cracks will develop which indicate where movement joints are required, or alternatively where further support or reinforcement is needed. Thus cracks normally exist to varying degrees in buildings not subjected to vibration and are not, in themselves, an indication of vibration-induced damage. There are many reasons why buildings crack and care is required to ascertain the true cause [23 to 25].

For a building not exposed to major external disturbances such as vibration, there exists a time rate of cracking due to natural ageing [26]. This natural cracking rate can be significantly increased by an external disturbance triggering cracks instantaneously, which can only be detected by a survey of building cracks immediately before and after the disturbance. A small increase in cracks or crack length however should not be taken as damage due to any imposed vibration. Buildings also expand and contract preferentially along existing weaknesses (cracks) between daytime and night-time and also seasonally. This continually varying expansion and contraction will return normal repair and repainting to the previous cracked state within several years or even months [3].

A.2 Wall or ceiling lining materials

Wall or ceiling lining materials rather than the main building components are often the most sensitive to imposed vibration. For cracking to occur, the vibration induced strain combines with the pre-existing strain so that the critical strain of a wall covering material is exceeded. The lowest critical strain is associated with old plaster and lath walls while the paper backing on gypsum-type wallboard has the highest resistance to imposed strain [14], although cracks can frequently occur at the joints between boards.

A.3 Age and existing condition of building

The age and existing condition of a building are factors to consider in assessing the tolerance to vibration. Older buildings may have soft mortar joints, simple footings or poor cross-bracing. Arches may be effectively articulated off the main structure. Modern buildings have limitations on deflections, deviations, inclinations, curvatures or widths of cracks allowed at the design stage (see ISO 4356). Guidance is available with respect to cracking for modern buildings according to the building materials involved, whether the cracks are surface cracks or through-cracks, whether they are likely to open further or close, whether they are repairable or capable of being covered by decoration, whether water penetration is a factor, and the probable attitude of persons affected, in view of the intended use of the building.

Historical damage due to sources other than vibration may also be masked by recent renovation and redecoration. The existence of major alterations can be a specific cause of an increased rate of cracking. If a building is in a very unstable state, then it will tend to be more vulnerable to the possibility of damage arising from vibration or any other groundborne disturbance.

Annex B (informative) Data to record during a survey

NOTE The following listing is intended to provide comprehensive background information for detailed investigations. The level of detail recorded should be commensurate with the type and purpose of the survey.

B.1 General

The following details should always be recorded:

a) testing organization;

b) name of person(s) carrying out the test;

c) date and time of measurement;

d) weather conditions and ambient temperature.

B.2 Details of vibration source

Details of the vibration source should always be recorded, e.g:

a) blasting: type of blasting (opencast coal, quarry, construction or demolition), charge type, charge weight per delay, initiation, firing pattern;

b) piling:

1) if percussive: hammer type, model number, weight and drop height (or energy);

2) if vibratory: operating frequency, pile type, size and length;

c) dynamic compaction: drop weight and drop height;

d) machine type: repetition rate, drop weight (if impact type of machine), speed, foundation details, workpiece details;

e) rail traffic: type of rail vehicle (locomotive/wagons), axle loading, number of wagons, speed, pass-by frequency; track details: rail shape and fixing, location of joints, railhead condition, type of track support;

f) road traffic: truck types, axle loading, speed, pass-by frequency, road alignment, condition of surface including potholes, manholes, location of expansion joints and other irregularities.

B.3 Site details

The following site details should be recorded:

a) sketch of site and location, photographs from source and receiver positions, section showing any sloping ground;

b) horizontal and vertical distances between source and measuring position at the building facade;

c) directions of measurement, other nearby sources of vibration.

B.4 Ground type

At source location, at the building and in between, the following details of ground type should be recorded:

a) geotechnical details (including borehole logs) at ground level and foundation level;

b) evidence of jointing or faulting and if measurable the orientation and depth;

c) wave velocity data;

d) changes in geology between source location and building location;

e) evidence of ground improvement or indications of made-up ground;

f) any history of underground mining/settlement in the area.

NOTE 1 Also see BS 5930:1981.

NOTE 2 Photographs should be included where appropriate.

B.5 Building structure

B.5.1 ***General***

The following details of the building structure should be recorded:

a) description of building, room sizes, layout and site plan and photographs;

b) type of construction, floor plans;

c) type of foundation, estimated depth and width;

d) general condition of the building structure, list of obvious defects, photographs;

e) approximate age of building, details of any major extensions, repairs, renovations (e.g. whether the same type of construction as the original been used).

B.5.2 ***Crack inspection report (pre-exposure and post-exposure)***

B.5.2.1 *General*

The dates and times of the pre-exposure inspection and the post-exposure inspection should be recorded.

B.5.2.2 *Internal*

The following internal details of the building should be recorded:

a) location, length, width, age and orientation (i.e. horizontal, vertical or diagonal) of cracks in each room;

b) type of wall finish, presence and orientation [see item a)] of any cracks;

c) ceiling type, presence and orientation of any cracks in the ceiling (i.e. parallel, perpendicular or diagonal with respect to a wall), evidence of any unstable plaster;

d) decorative condition and date last decorated, evidence of paint flaking;

e) windows, whether cracked or loose fitting, evidence of misting in any double glazed units, presence of gaps around the frame or the cill, or evidence of any corner cracks, especially near lintels;

f) door fitting, evidence of expansion due to moisture or cracking at the corners of the door frame;

g) evidence of lack of squareness at the corners of adjoining walls, type of floor and whether level.

B.5.2.3 *External*

The following external details of the building should be recorded:

a) wall construction (brick, concrete blocks or stone), wall condition, evidence of cracking, location, orientation (see item of a) **B.5.2.2**), length, width and age of external cracks, deviation from level of the first brick course, existence and width of gaps between path and wall;

b) evidence of settlement at one corner or along one side, slope of the ground between the source of vibration and the building;

c) evidence of large trees nearby or of large trees recently removed;

d) drainage details and depth of water table;

e) any noticeable settlement of nearby structures.

A photographic record should be taken of all visible cracks and defects. The photographs should be numbered and correlated with the written record.

B.6 Vibration assessment

B.6.1 ***Subjective observations***

The following subjective observations should be made and recorded:

a) whether vibration is detectable through feet or hands, by windows rattling or other audible effects;

b) whether vibration is worse on the ground floor or higher floors or at particular locations;

c) whether the vibration frequency is low or high;

d) the approximate duration and frequency of occurrence of the vibration.

B.6.2 ***Measurement details***

The following measurement details should be recorded:

a) transducer type, serial numbers, operating frequency limits, useable magnitude range, calibration factors;

b) type of signal conditioning or recording system, serial numbers, operating ranges, gain settings, trigger level, fullscale reading, time axis sensitivity, result of calibration procedure or date last calibrated;

c) measurement positions and axes, manner of coupling of the transducer to the building or the ground.

B.6.3 ***Test results***

The following test results should be recorded:

a) maximum p.p.v. including peak component and peak true resultant;

b) individual time histories and duration of vibration;

c) predominant frequencies in time histories and frequency spectra;

B.6.4 ***Assessment***

The following assessment of the test results should be made:

a) comparison of maximum p.p.v. (peak component value) with the vibration limit appropriate to the type of building and the duration of the source.

b) evaluation of the possibility of vibration-induced damage according to the vibration assessment, details of the site and condition of the building structure.

Annex C (informative) Building damage due to soil compaction

Depending upon the type of ground, ground vibration can cause consolidation or densification of the soil [3,22,27], which has been known to result in differential settlement and consequent building damage. Loose and especially water-saturated cohesionless soils are vulnerable to vibration which may cause liquefaction. It has been shown in laboratory tests that there can be a rearrangement of constituent particles at shear strains of 0.0001, and this becomes marked at strains of 0.001. Such soils, which may have shear wave propagation velocities of around 100 m/s start to become vulnerable at p.p.v. values of about 10 mm/s. The damage to the soil structure is then a function of the number of cycles of straining. The loading transmitted to the soil through the foundations may reduce the vulnerability of the soil to such damage, but there are cases where the acceptable vibration limit may be set by considerations of soil-structure interaction, rather than distortion or inertial response of the building itself.

List of references (see clause 2)

Normative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 6955, *Calibration of vibration and shock pick-ups.*

BS 6955-0:1988, *Guide to basic principles.*

BS 7129:1989, *Recommendations for mechanical mounting of accelerometers for measuring mechanical vibration and shock.*

BS 7385, *Evaluation and measurement for vibration in buildings.*

BS 7385-1:1990, *Guide for measurement of vibrations and evaluation of their effects on buildings.*

Informative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 5930:1981, *Code of practice for site investigations.*

BS 6472:1992, *Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz).*

ISO standards publications

INTERNATIONAL STANDARDS ORGANIZATION (ISO), GENEVA. (All publications are available from Customers Services, Publications, BSI.)

ISO 4356:1977, *Bases for the design of structures — Deformations of buildings at the serviceability limit states.*

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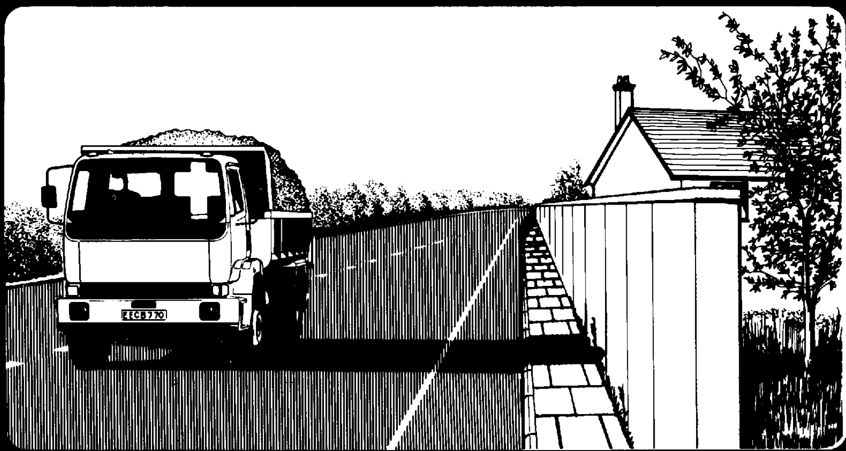
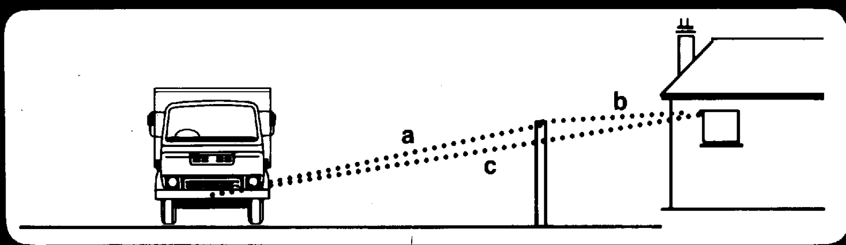
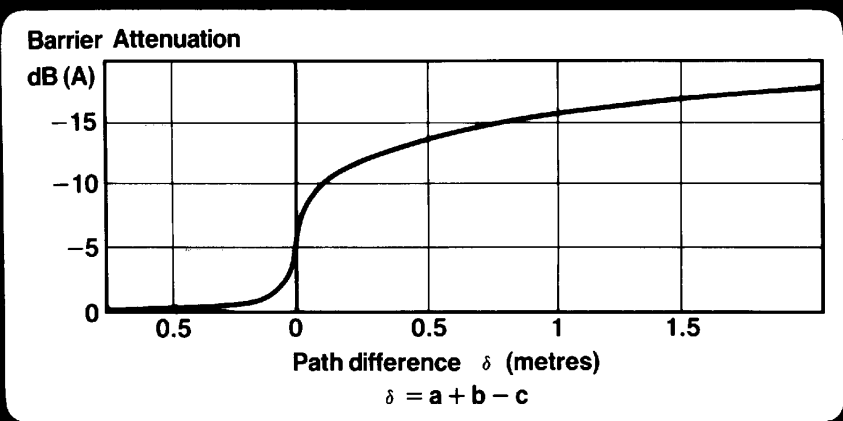
Appendix AP2.4

Calculation of Road Traffic Noise

Calculation of Road Traffic Noise







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DEPARTMENT OF TRANSPORT
WELSH OFFICE

Calculation of Road Traffic Noise

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Contents

Introduction

1. This memorandum describes the procedures for calculating noise from road traffic. These procedures are necessary to enable entitlement under the Noise Insulation Regulations to be determined but they also provide guidance appropriate to the calculation of traffic noise for more general applications e.g. environmental appraisal of road schemes, highway design and land use planning.

2. The method of calculation contained in this memorandum replaces the previous method first published in 1975. The revision was carried out by the Transport and Road Research Laboratory and the Department of Transport. The new method retains a great deal of the previous method including the philosophy of approach and most of the formulation but includes the results of recent research which extend the method to cover a wider range of applications. The presentation has also been changed to help to clarify some of the procedures to be adopted and to indicate the way the method is used in practice.

3. The memorandum is divided into three sections. In Section I, a general method of calculation is set out, step by step, for predicting noise levels at a distance from a highway, taking into account different traffic parameters, intervening ground cover, road configuration and site layout. Section II provides additional procedures that may need to be considered when applying the method given in Section I to specific situations e.g. road junctions. In deriving this prediction method, account has been taken of existing prediction methods together with additional published and unpublished data. The aim has been to permit prediction in as many cases as possible covering both free and non-free flowing traffic. Prediction will constitute the preferred calculation technique but in a small number of cases (see para 38) traffic conditions may fall outside the scope of the prediction method and it will then be necessary to resort to measurement. In Section III the procedure and requirements to be met during such measurements are detailed, together with details of a simplified measurement procedure which is acceptable in certain circumstances. Examples of the application of the procedures are given in Annexes 1–18.

Definition and interpretation

4. The procedures assume typical traffic and noise propagation conditions which are consistent with moderately adverse wind velocities and directions during the specified periods (see para 39.2). All noise levels are expressed in terms of the index L_{10} hourly or L_{10} (18-hour) dB(A). The value of L_{10} hourly dB(A) is the noise level exceeded for just 10% of the time over a period of one hour. The L_{10} (18-hour) dB(A) is the arithmetic average of the values of L_{10} hourly dB(A) for each of the eighteen one-hour periods between 0600 to 2400 hours. The source of traffic noise (the source line) is taken to be a line 0.5 metres above the carriageway level and 3.5 metres in from the nearside carriageway edge*.

* The edge of the carriageway is the edge of the traffic lanes excluding bus lay-bys, hard shoulders and hard strips.

5. The charts which form part of the memorandum include, where appropriate, a formula which is definitive over the quoted range of validity. While extrapolation outside these ranges can lead to progressive and significant error, calculations can be extended outside the quoted ranges for the purpose of assessing changes in noise levels, e.g. environmental appraisal of road schemes at distances greater than 300 metres from a road, and generally for situations where reduced accuracy in predicting absolute levels can be accepted. Care should be taken when interpreting noise level predictions which are close to the noise levels expected from non-traffic sources; the formulae given in the memorandum do not take account of extraneous noise sources. Site noise levels which are affected by noise from, eg trains, aircraft, industrial plant, general background sources etc, will tend to be under-estimated by the prediction method. In these circumstances and where overall site noise levels are required, recourse to the measurement method is advised.

Requirements for use with the Noise Insulation Regulations

6. When applying the memorandum for the purposes of calculating entitlement for noise insulation treatment under the Noise Insulation Regulations (see Annex 1) three conditions have to be tested:

(i) the combined expected maximum traffic noise level, i.e. the relevant noise level, from the new or altered highway together with other traffic in the vicinity must not be less than the specified noise level (68 dB(A) L_{10} (18-hour));

(ii) the relevant noise level is at least 1.0 dB(A) more than the prevailing noise level, i.e. the total traffic noise level existing before the works to construct or improve the highway were begun;

(iii) the contribution to the increase in the relevant noise level from the new or altered highway must be at least 1.0 dB(A).

7. The calculations shall be worked to 0.1 dB(A)*, keeping within the quoted range of validity of the charts or formulae, and these values used to determine whether the requirements under paras 6(ii) and 6(iii) are met. For comparison with the specified noise level, para 6(i), the relevant noise level from traffic expected to use any highway is to be rounded to the nearest whole number (0.5 being rounded up) (see Annex 1).

8. Noise shall be assessed at a reception point located 1 metre in front of the most exposed part of an external window or door of an eligible room.

9. The traffic flow to be used in the calculation shall be the maximum expected between 06.00 hours and 24.00 hours on a normal working day within a period of 15 years after opening to traffic. The estimate will normally be based upon the Annual Average Weekday Traffic (AAWT)** obtained for the base year and the traffic flow growth forecasts given in Charts 16 a-b. However, where particular local conditions indicate growth forecasts significantly different from these or where unusual traffic patterns exist then the local data are to be applied.

---

* Each step (involving a separate chart or formula) shall be rounded to the nearest 0.1 dB(A) (exact values of 0.05 dB(A) being rounded in such a direction that the overall predicted noise level is highest). This should ensure that different calculation processes give the same result and marginal rounding variations are avoided.

** Traffic Appraisal Manual – Department of Transport.

Section I – The prediction method (general procedures)

10. The method of predicting noise at a reception point from a road scheme consists of five main parts:

(i) divide the road scheme into one or more segments such that the variation of noise within the segment is small (para 11 refers);

(ii) calculate the basic noise level at a reference distance of 10 m away from the nearside carriageway edge for each segment (paras 12–16 refer);

(iii) assess for each segment the noise level at the reception point taking into account distance attenuation and screening of the source line (paras 17–24 refer);

(iv) correct the noise level at the reception point to take into account site layout features including reflections from buildings and facades, and the size of the source segment (paras 25–28 refer);

(v) combine the contributions from all segments to give the predicted noise level at the reception point for the whole road scheme (para 29 refers).

The above steps in the procedures are described in detail below and are shown diagrammatically in Chart 1.

Dividing the road scheme into segments

11. In practice, situations will be encountered where, due to changes in traffic variables, road gradient and curvature or due to progressive variation in screening, the generated noise varies significantly along the length of the road. In such cases the road is initially divided into a small number of separate segments so that within any one segment the noise level variation is less than 2 dB(A). Each segment is then treated as a separate road source and the noise contribution evaluated according to the method given below. Whilst it is not possible to give precise guidance on the procedure to adopt to determine segment boundaries for all road schemes the Annexes contain several examples of calculations on complex road schemes with multi-segment solutions which serve to illustrate the basic principles to be adopted.

Calculating the basic noise level for a road segment

12. The basic noise level at a reference distance of 10 m away from the nearside carriageway edge* is obtained from the traffic flow, the speed of the traffic, the composition of the traffic, the gradient of the road and the road surface. On any given road the traffic flow, mean speed and composition are interdependent; for example, increasing the traffic flow may cause a reduction in the mean speed so that the net increase in noise level may be comparatively small. Similar effects are observed with changes in composition. When estimating noise levels for projected road schemes, the values adopted for the traffic parameters should be compatible. When dealing with existing roads it may sometimes be desirable to make observations of these traffic parameters.

* The choice of reference point or distance is arbitrary and other reference distances could be used by changing the numerical values of constants appearing in certain of the predictions.

13. Traffic flow

13.1 On normal roads the flow of traffic in both directions shall be aggregated to obtain the total flow. But in cases where the two carriageways are separated by more than 5 metres or where the heights of the outer edges of the two carriageways differ by more than 1 metre, the noise level produced by each of the two carriageways shall be evaluated separately and then combined using Chart 11. In the case of the far carriageway the source line will be assumed to be 3.5 metres in from the far kerb and the effective edge of the carriageway used in the distance correction is 3.5 metres nearer than this, i.e. 7 metres in from the edge of the farside carriageway (see Annex 2).

13.2 Chart 2 gives the basic noise level hourly L_{10} in dB(A) for a given hourly traffic flow (q) at a mean speed of 75 km/h, with zero percentage of heavy vehicles (p), and zero gradient (G). Chart 3 gives the basic noise level L_{10} (18-hour)* in dB(A) for given traffic flows (Q) at a mean speed of 75 km/h, with zero percentage of heavy vehicles and zero gradient.

NB where hourly traffic flows are available the value of L_{10} (18-hour) should be determined using Chart 2 to obtain the eighteen, one-hour, L_{10} values over the prescribed period. Where 18-hour traffic flows only are available then Chart 3 applies.

13.3 When calculating noise levels from roads where the flow is low, i.e. below 200 veh/h or 4000 veh/18-hour day an additional correction may be required. Section II para 30 gives the procedure to be adopted to determine the correction for road schemes containing low traffic flows.

14. Percentage heavy vehicles and traffic speed

The correction for percentage heavy vehicles (p) and traffic speed (V) is determined using Chart 4.

14.1 The value of p is given by

$$p = \frac{100f}{q} \text{ or } \frac{100F}{Q}$$

depending on whether the correction applies to hourly L_{10} dB(A) or L_{10} (18-hour) dB(A) respectively,

f and F are the hourly and 18-hour flows of heavy vehicles respectively, ie all vehicles with an unladen weight exceeding 1525 kg,

q and Q are the hourly and 18-hour flows respectively of all light and heavy vehicles. (NB Where motorcycle and moped flows are known then they should be included in the light vehicle group).

* Census data collected on a 16-hour day basis may be converted to 18-hour flows by the addition of 5 per cent.

14.2 The value of V to be used in Chart 4 depends upon whether the road is level or on a gradient. For *level* roads the traffic speed to be used in the calculation is as set out below for the appropriate class of road (for exceptions see para 14.4).

Road classification	Traffic speed
Roads not subject to a speed limit of less than 60 mph	
Special roads (rural) excluding slip roads	108 km/h
Special roads (urban) excluding slip roads	97 km/h
All-purpose dual carriageways excluding slip roads	97 km/h
Single carriageways, more than 9 metres wide	88 km/h
Single carriageways, 9 metres wide or less	81 km/h
(Slip roads are to be estimated individually)	
Roads subject to a speed limit of 50 mph	
Dual carriageways	80 km/h
Single carriageways	70 km/h
Roads subject to a speed limit of less than 50 mph but more than 30 mph	
Dual carriageways	60 km/h
Single carriageways	50 km/h
Roads subject to a speed limit of 30 mph or less	
All carriageways	50 km/h

14.3 For roads *with a gradient* traffic speeds will be reduced from the values given above for level roads (for exceptions see para 14.4 below). The reduction in traffic speed (ΔV) depends upon the percentage gradient (G) and the percentage heavy vehicles (p) according to the formula given on Chart 5. The value of traffic speed to be used in Chart 4 for roads with a gradient is obtained by determining the appropriate traffic speed from the road classification table and reducing this value by the amount ΔV (see Annex 3). In the case where carriageways are treated separately or for one way traffic schemes the speed correction should not be applied to the downward flow.

14.4 The traffic speed values obtained under paras 14.2 and 14.3 do not apply when data based on particular local conditions (including the criteria for speed limits) indicate a traffic speed significantly different from the prescribed mean speed for the type of road. In these cases the highway authority's estimate or measurement of speed based on a representative sample shall be used.

15. Gradient

Chart 6 provides the adjustment for the extra noise from traffic on a gradient (G) expressed as a percentage. It should be noted that corrections for traffic speed on a gradient have already been taken into account under paragraph 14. In the case of carriageways treated separately (see para 13.1) or one-way traffic schemes, the correction to the basic noise level applies only for the upward flow. (In the case of one-way traffic schemes where the flow is downhill and the gradient exceeds 10 per cent it may be appropriate to use the measurement method).

16. Road surface
The correction for road surface depends upon a number of factors, eg. the amount of texture on the road surface, whether this texture is random distributed chippings (as in bituminous surfaces) or transversely aligned (as for concrete surfaces) and, for bituminous surfaces, whether they are essentially impervious to surface water or have an open structure with rapid drainage qualities.

For roads which are impervious to surface water and where the traffic speed (V) used in Chart 4 is $\geqslant 75$ km/h the following correction to the basic noise level is required;

for concrete surfaces

$$\text{Correction} = 10 \text{ Log}_{10} (90 \text{ TD} + 30) - 20 \text{ dB(A)};$$

for bituminous surfaces

$$\text{Correction} = 10 \text{ Log}_{10} (20 \text{ TD} + 60) - 20 \text{ dB(A)};$$

where TD is the texture depth*.

For road surfaces and traffic conditions which do not conform to these requirements a separate correction to the basic noise level is required.

16.1 *Impervious road surfaces*
For impervious bituminous and concrete road surfaces, 1 dB(A) should be subtracted from the basic noise level when the traffic speed (V) used in Chart 4 is < 75 km/h.

16.2 *Pervious road surfaces*
Roads surfaced with pervious macadams have different acoustic properties from the surfaces described above. For roads surfaced with these materials 3.5 dB(A) should be subtracted from the basic noise level for all traffic speeds.

Propagation

17. The level obtained by applying paragraphs 12–16 is the basic noise level for a specific road segment. Further corrections are now needed to take into account, as appropriate, the effects of distance from the source line, the nature of the ground surface, and screening from any intervening obstacles. At this stage no account needs to be taken of the size of the road segment in relation to the total road length or of the effects of reflections from nearby buildings and other site layout features etc. The method of calculating the effects of propagation and screening can generally be broken down into separate parts – (see Chart 1).

(i) Calculate the correction for distance disregarding the presence of ground or intervening obstacles.

(ii) Decide whether the road segment is obstructed or unobstructed.

(iii) For unobstructed road segments calculate the effect of absorbing ground where necessary. For obstructed road segments apply a screening correction.

Details of the calculation process are given in the following paragraphs (18–24).

* Texture depth (TD) measured by the sand-patch test.

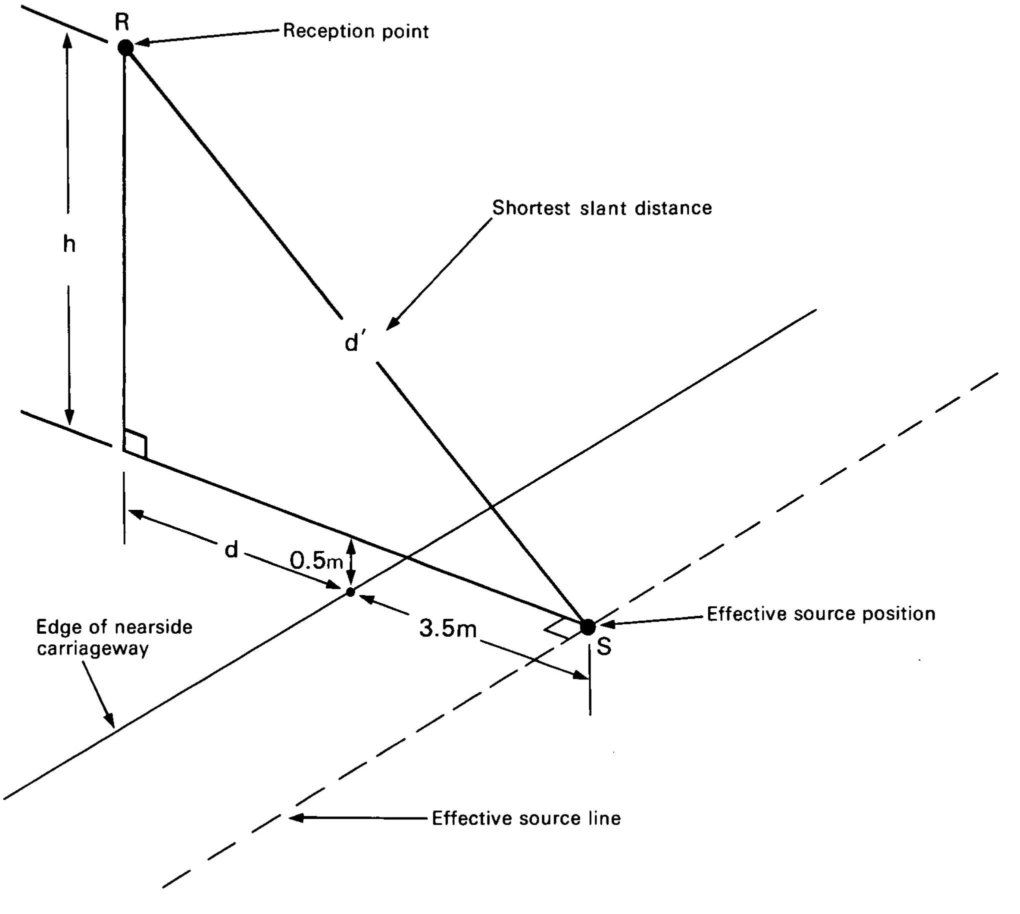
18. Distance correction
For reception points located at distances greater than or equal to 4 metres from the edge of the nearside carriageway, the distance correction given in Chart 7 is to be applied to the basic noise level. For distances less than 4 metres from the carriageway edge, the distance correction should be determined assuming the reception point is located at 4 metres from the nearside carriageway edge and Chart 7 applied. For the purposes of the Noise Insulation Regulations, the measurement method should be used when the predicted level at distances less than 4 metres is within 3 dB(A) of the specified level. The distance correction is calculated along the shortest slant distance signified (d′) from the source line to the reception point. This value is determined from the shortest horizontal distance (d) from the edge of the nearside carriageway to the reception point and the height (h) of the reception point relative to the source line at the point where the slant line intersects the source line at the effective source position, S, (see Fig 1). For some segments it may be necessary to extend the source line so that d′ is calculated along the line which passes through the reception point and is perpendicular to the extended source line. In such cases, the value of h is the height of the reception point relative to the source line at the effective source position where the slant line intersects the *extended* source line (see Annex 4).

18.1 Extending the source line as described above may exceptionally cause it to pass directly through or within 7.5 metres of the reception point, thereby precluding the use of Chart 7 since the reception point would then be less than 4 metres from the carriageway edge. In such cases, the noise level is to be calculated for at least two positions located nearby and either side of the reception point for which this anomaly does not occur and the mean value adopted (see Annex 5).

19. Unobstructed propagation
Having applied the distance correction it is necessary to decide whether the source line of the road segment is obstructed or unobstructed. In general, road segments will have been chosen such that within any segment the source line is either clearly obstructed or unobstructed in order to comply with the basic rules regarding segmentation – see paragraph 11. In some cases, however, the source line may be partially obscured by intervening obstacles or the degree of screening may be slight. For these cases, it is necessary to calculate the noise levels assuming both unobstructed and obstructed propagation taking the lower of the two resulting levels (see para 22.3). For unobstructed propagation a correction for the prevailing ground cover shall be applied.

20. Ground cover correction
If the ground surface between the edge of the nearside carriageway of the road or road segment and the reception point is totally or partially of an absorbent nature, (eg grass land, cultivated fields or plantations) an additional correction for ground cover often referred to as ground absorption needs to be taken into account. The correction is progressive with distance and particularly affects reception points close to the ground. Chart 8 gives the correction for ground absorption in terms of the mean height of propagation (H) the distance (d) and the proportion of absorbing ground (I) between the edge of the nearside carriageway and the segment boundaries leading to the reception point R, see fig 2(a). To avoid the difficulty of defining adequately the many other more absorbent types of ground cover, the correction shown in Chart 8 is to be used for all predominantly absorbent surfaces. Thus the calculations will slightly underestimate attenuation effects, particularly where the intervening ground is intensively cultivated or planted.

Figure 1. **ILLUSTRATION OF SHORTEST SLANT DISTANCE d′ FOR A RECEPTION POINT R AT A HORIZONTAL DISTANCE (d+3.5) AND A RELATIVE HEIGHT h FROM THE EFFECTIVE SOURCE POSITION S**



$$d' = [h^2 + (d+3.5)^2]^{1/2}$$

20.1 Where the intervening ground cover is non-absorbent eg paved areas, rolled asphalt surfaces, water, the value of I is zero and no ground cover correction is applied.

20.2 Where the intervening ground cover is absorbent the correction given in Chart 8 is to be applied where the value of I = 1. The value of H is taken to be the average height above the intervening ground of the propagation path between the segment source line and the reception point. It is to be calculated along the bisector of the angle subtended by the segment source line at the reception point. Where the intervening ground is mainly flat, the value of H can be approximated by 0.5(h+1) metres, otherwise the value of H is calculated by taking the height of propagation above the ground at approximately equal intervals along the bisector, taking at least five height readings, and averaging the result (see Annexes 6 and 7). It should be noted that for values of $H > (d+5)/6$ metres no ground cover correction is required. In exceptional circumstances when values of $H < 0.75$ metres, H may be set equal to 0.75 metres and Chart 8 applied.

20.3 Where the intervening ground cover is partially of an absorbent nature further segmenting to separate areas where the ground cover can be defined as either absorbent or non-absorbent should be carried out, so that the 2 dB(A) variation within a segment is not reached (see para 11). The relevant ground cover correction paras 20.1 and 20.2 should then be applied.

20.4 In certain cases, where the intervening ground cover is a mixture of absorbent and non-absorbent areas the procedure outlined in para 20.3 may not be able to separate the areas into well defined ground cover types. For these cases the ground cover correction should be calculated in accordance with para 20.2 but with a value of I as shown below.

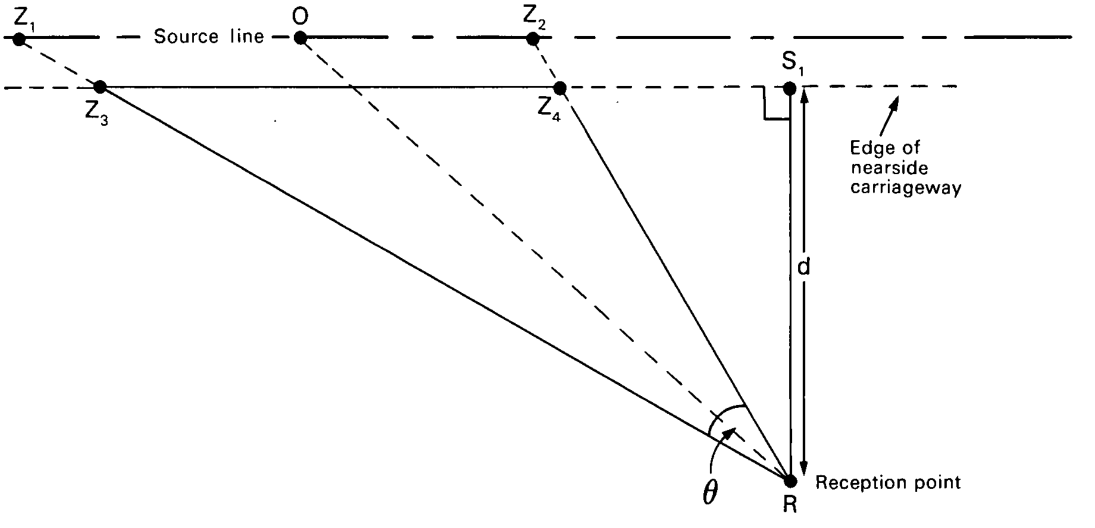
% of absorbent ground cover within the segment*	value of I to be used with Chart 8
<10	0**
10 – 39	0.25
40 – 59	0.5
60 – 89	0.75
⩾90	1.0

* the road surface should be ignored when calculating the area within the segment
**no correction required

For large segment areas the value of I can be determined by considering the ground cover contained within an area of $10d^2$ sq metres between the reception point and the edge of the nearside carriageway, see Fig 2(b). The area extends 5d metres either side of the shortest horizontal distance (d) from the edge of the nearside carriageway, and is contained within the rectangle $Z_1 Z_2 Z_5 Z_7$. For the segment with angle θ_1, the area to be considered for calculating the value of I is contained within the boundary R Z_1 Z_2 Z_3. Similarly for segments with angles θ_2, θ_3 and θ_4, the ground cover within the areas R Z_3 Z_4, R Z_4 Z_5 Z_6 and R Z_6 Z_7 respectively are used when calculating the value of I. In order to facilitate the calculation, areas of absorbent and non-absorbent ground can often by approximated by regular shapes whose area can be easily determined.

Fig.2 SITE GEOMETRY IN RELATION TO DETERMINING THE GROUND COVER CORRECTION USING CHART 8

2(a) For a simple road segment R Z_1 Z_2

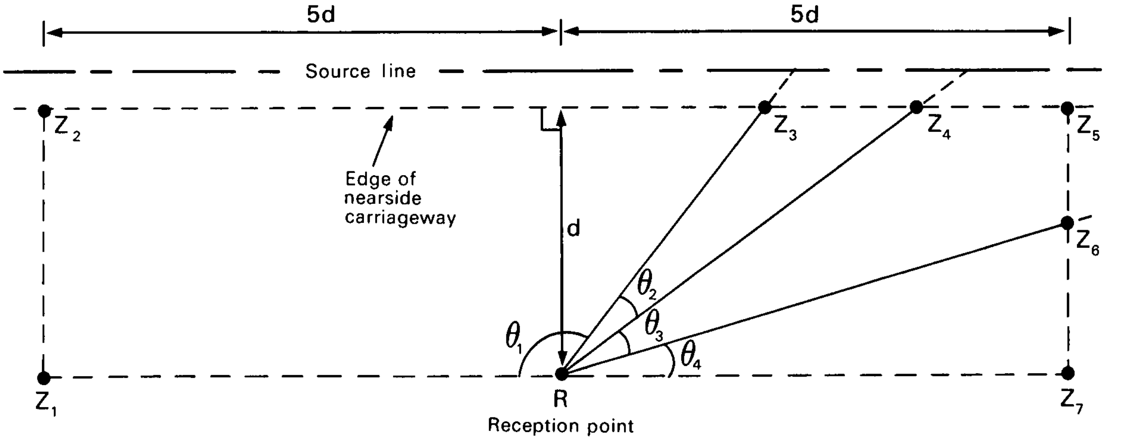


(i) The value of H (average height of propagation) is calculated along the line RO which bisects the segment angle θ

(ii) The area of ground cover to be considered when evaluating I is contained within the area defined by R Z_3 Z_4

(iii) The value of d is calculated along the shortest horizontal distance between the reception point R and the extended edge of the nearside carriageway (RS_1).

2(b) For large segment areas.



(i) For segment with angle θ_1 : the ground cover area is R Z_1 Z_2 Z_3.

(ii) For segment with angle θ_2 : the ground cover area is R Z_3 Z_4.

(iii) For segment with angle θ_3 : the ground cover area is R Z_4 Z_5 Z_6.

(iv) For segment with angle θ_4 : the ground cover area is R Z_6 Z_7.

20.5 In most cases when predicting for reception points 4 metres or more above ground, the presence of low walls, fences etc. may be ignored; below 4 metres screening effects such as reasonably continuous walls and other permanent features should be taken into account (but see also para 22.3).

20.6 Where the ground falls steeply away from the road, the screening effect of the road structure may also need to be taken into account by treating the edge of the structure as a barrier (see Annex 7).

21. Obstructed propagation

The screening effect of intervening obstructions such as buildings, walls, purpose-built noise barriers etc* needs to be taken into account. The degree of screening depends on the relative positions of the effective source position S, the reception point R and the point B where the diffracting edge along the top of the obstruction cuts the vertical plane, i.e. normal to the road surface, containing both S and R, see Fig 3(a). The region between the obstruction and the reception point is divided into the illuminated zone and shadow zone by the extended line SB, shown dotted in Fig 3(a).

The degree of screening is calculated from the path difference of the diffracted ray path SBR and the direct ray path SR. Figs 3(b) and 3(c) show the calculation of the path difference depending on whether the reception point is in the illuminated zone or the shadow zone respectively. The path difference is used in Chart 9 to calculate the potential barrier correction (A).

This correction is applied to the basic noise level corrected for distance according to the procedure given in para 18.

21.1 For the purposes of the Noise Insulation Regulations, it is required to calculate the path difference to the nearest 0.001 metres but the relative heights and horizontal distances need only be estimated to the nearest 0.1 metres.

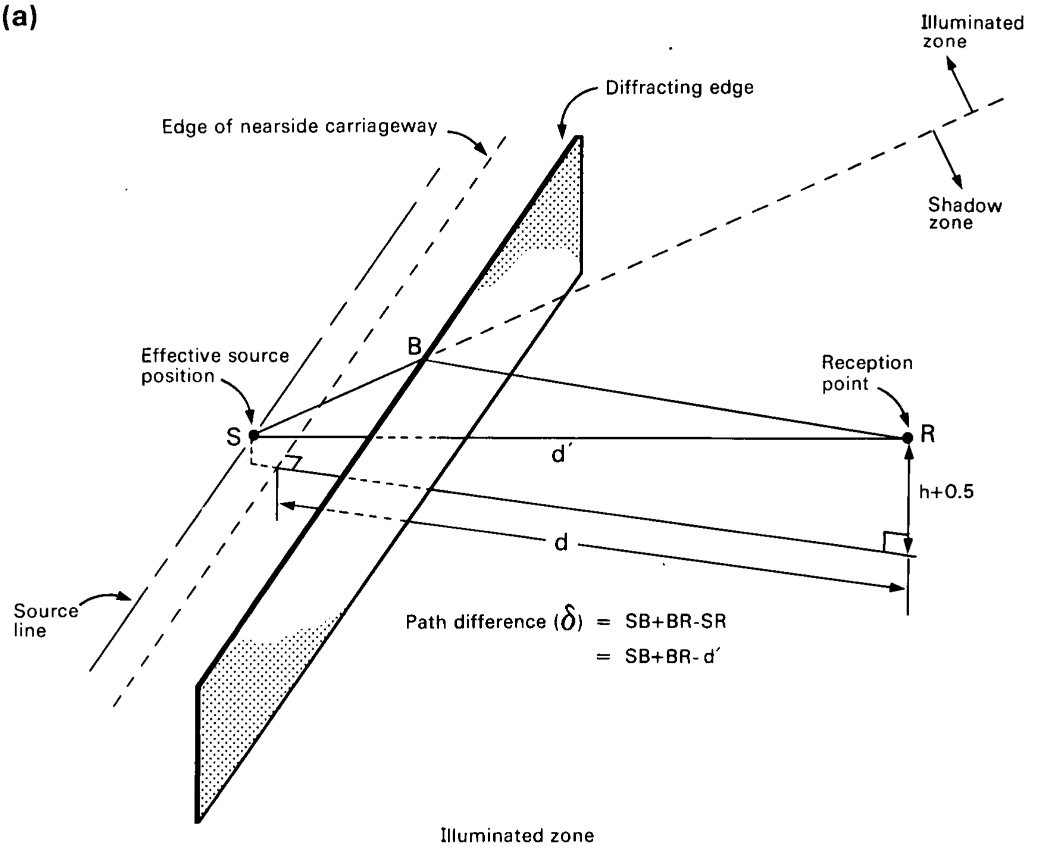
Chart 9a gives the polynomial expression for the value of A for both zones and should be used when calculating noise levels to the nearest 0.1 dB(A) (see para 7). However, Chart 9b may be used to estimate the value of A by rounding the value of the path difference (δ) to the nearest 0.01 metres and reading the value of A from the table. Generally this will provide values of A equal to or within 0.1 dB(A) of the value obtained using the polynomial expression. However, where adjacent values of A in the table differ by more than 0.1 dB(A) the polynomial expression should be used.

21.2 The above procedure applies to all types of obstructions in calculating the potential barrier correction. The following paragraphs (22–24) deal with various types of obstructions and to the specific procedures to adopt when calculating the potential barrier correction (A).

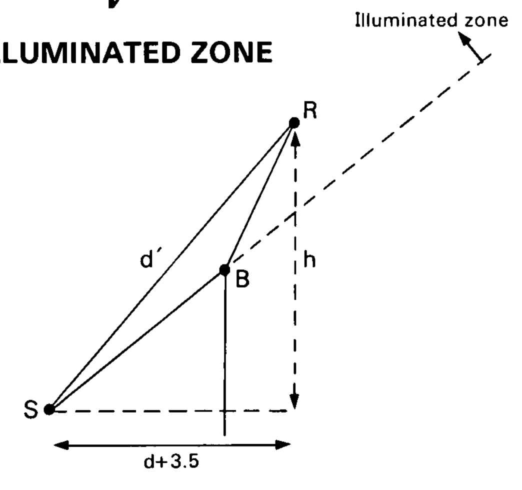
* Hedges, bill hoardings etc should be regarded as temporary structures and their screening effect ignored.

Figure 3. SITE GEOMETRY TO EVALUATE THE PATH DIFFERENCE (δ) FOR OBSTRUCTED PROPAGATION

3(a)

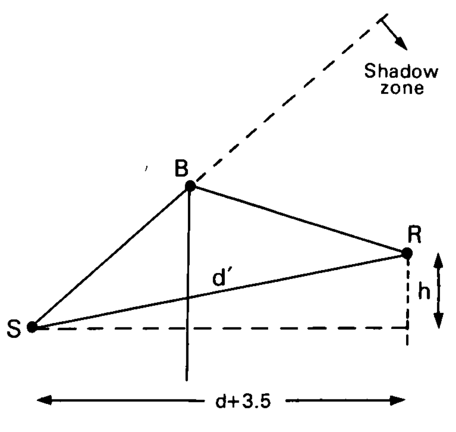


3(b) ILLUMINATED ZONE



Path difference (δ) = SB+BR-d′

3(c) SHADOW ZONE



Path difference(δ) = SB+BR-d′

N.B. Path difference is calculated in the vertical plane, normal to the road surface, containing both R and S

22. Barriers

Where a barrier is interposed between the noise source and reception point (either a purpose-built barrier or obstruction due to the site layout, buildings etc.) the additional correction shall be calculated using Chart 9* as outlined in para 21 and applied to the basic noise level corrected for distance according to the procedure given in para 18. The potential barrier correction is calculated in the same plane ie. normal to the road surface, as the distance correction (see Annex 8).

22.1 If the barrier is parallel to the source line but screens only part of a road segment then the barrier and the source line contained within the segment may need to be extended to enable the potential barrier correction to be calculated in the same plane, ie. normal to the road surface, as the distance correction (see Annex 9).

22.2 If the barrier is not parallel to the source line then the potential barrier correction will vary along the length of the barrier and it may be necessary to divide the barrier into a number of smaller segments. The number of segments required to calculate the screening of the barrier should be limited such that the variation in the potential barrier correction within each segment is less than 2dB(A). The potential barrier correction for each barrier segment is then determined by rotating the barrier segment about the point where the line bisecting the segment angle intersects the top edge of the barrier, so that the top edge of the barrier is parallel to the source line contained within the segment and then extended if necessary and Chart 9 applied (see Fig 4). An example of this procedure is given in Annex 10.

22.3 The additional attenuation referred to as ground absorption, para 20, is ignored when calculating the effects of barriers since the near ground rays are obstructed. However, under certain conditions (eg with low barriers erected on grassland) it is possible for these ground absorption effects to exceed the calculated screening provided by the barrier. The barrier will not raise the noise level in the screened zone, and in these circumstances the noise levels with and without the barrier should be calculated and the *lower* of the noise levels used (see Annexes 7 and 8).

22.4 Where more than a single barrier is interposed between the source line and the reception point a more complex procedure is required to calculate the potential barrier correction. The procedure is included in Section II para 35 (see Annex 11).

23. Safety fences

It has been shown that conventional low safety fences of double corrugated beam construction and with a relatively small gap to the ground (mounting height of centre of beam above adjoining carriageway surface of not more than 610 mm) have broadly the same effect as noise barriers whose height is equal to the width of the solid portion of the safety fence, although the overall screening is slight. Other safety barriers of smaller cross-section, e.g. rolled hollow beams, chains, wire rope etc, or with larger gaps to the ground are to be ignored in the calculation. Since the screening effect is likely to be slight, it may be necessary to adopt the procedure given in paragraph 22.3 particularly when the ground cover is predominantly absorbent (see Annex 8).

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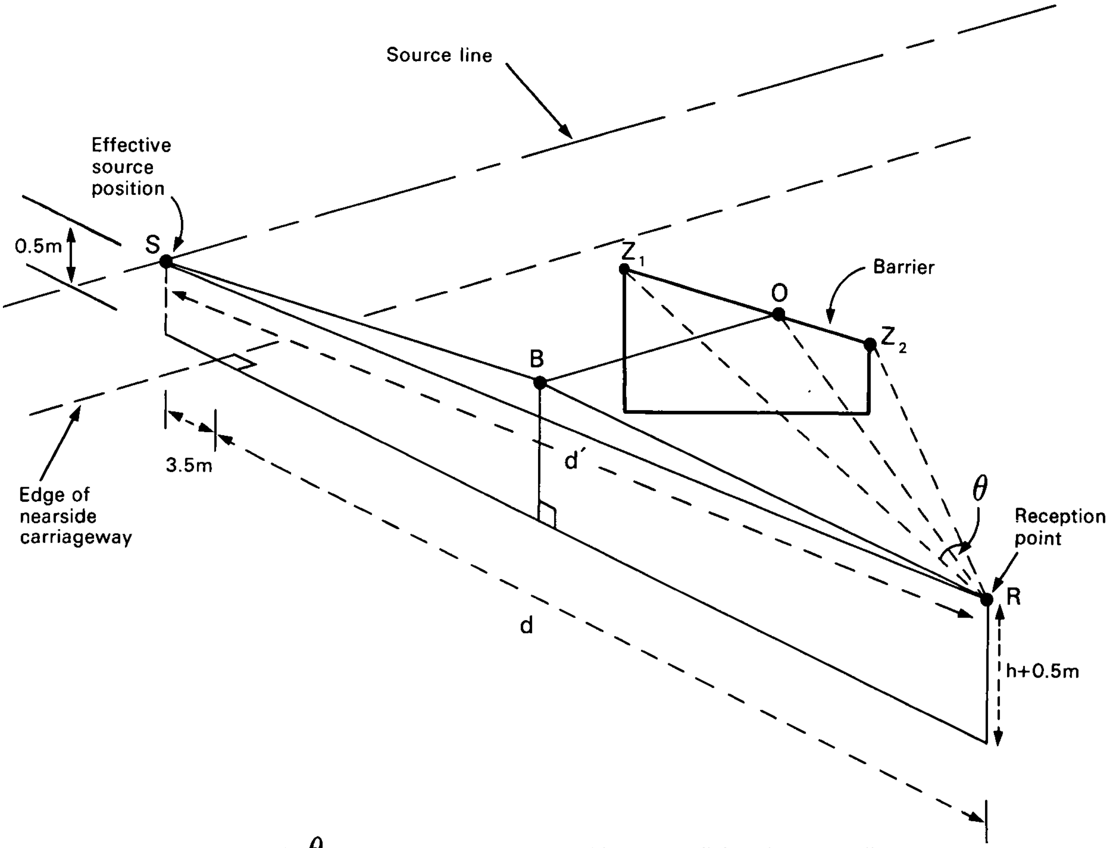
* Chart 9 gives the correction due to a massive barrier. The minimum superficial mass m (ie the mass per unit area) required to approximate this condition varies with the value of potential barrier correction (A) and for a solid barrier can be estimated from the formula $m = 3 \times \text{Antilog}_{10}[-(A + 10)/14]\ kg/m^2$. It should be noted that the value of A, as derived from Chart 9, will always be negative.

Figure 4 EVALUATING THE PATH DIFFERENCE (δ) FOR BARRIERS NOT PARALLEL TO THE SOURCE LINE.



The barrier subtends an angle θ at the reception point R and is not parallel to the source line. The line bisecting the angle θ cuts the top edge of the barrier, $Z_1 Z_2$ at O. Draw a line from O parallel to the source line to meet the vertical plane* which passes through the reception point R and the effective source position S at B. The potential barrier correction (A) is calulated from Chart 9 where the path difference (δ)= SB + BR - SR

* i.e. normal to the road surface

24. Buildings
To evaluate shielding due to an intervening building*, the effective height and position of the equivalent barrier shoud be determined geometrically, being defined by the intersection of two straight lines both just grazing the top edges of the building in question, one drawn from the reception point, the other drawn from the effective source position (see Annex 12). For equivalent barriers parallel to the source line the procedure given in para 22.1 applies, whereas for equivalent barriers not parallel to the source line the procedure given in para 22.2 applies.

Site layout

25. Having corrected the basic noise level from a road segment for propagation it is necessary to consider the effects of certain site layout features. Included in this part of the calculation are the effects of reflections from buildings and other hard rigid surfaces, propagation down side roads and corrections for the size of the segment. Situations where both screening and reflection effects combine, e.g. with retained cuts and dual noise barriers, require more complex correction procedures. These procedures are included in Section II para 36.

26. Reflection effects
Reflection of noise from hard rigid surfaces adjacent to the source or in the neighbourhood of the reception point increases the noise level compared with that calculated under the above procedures, which give the free-field noise level. The 'free-field' noise level is appropriate where the site is open and clear and the reception point is away from other facades.

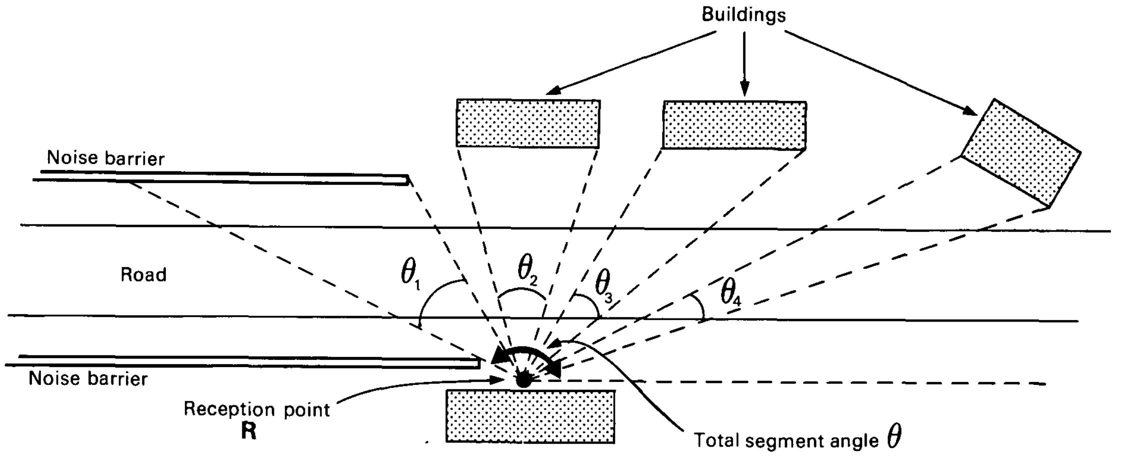
26.1 *Facade effect*
To calculate noise 1 metre in front of a facade, a correction of +2.5 dB(A) is to be made. (Other noise calculations along side roads lined with houses but away from the facade still require the same addition of the 2.5 dB(A) because of the proximity of facades, see para 27).

26.2 *Reflection from opposite facades*
Where there are houses, other substantial buildings or a noise fence or wall beyond the traffic stream along the opposite side of the road, a correction for reflection from the opposite facade facing the reception point is required. The correction only applies where the height of the reflecting surface is at least 1.5 metres above the road surface.

The correction for reflection from opposite facades is $+1.5(\theta'/\theta)$ dB(A)
where θ' is the sum of the angles subtended by all the reflecting facades on the opposite side of the road facing the reception point, and θ is the total angle subtended by the source line at the reception point (see Fig 5). The above correction is required in addition to the +2.5 dB(A) facade correction described in para 26.1. For calculating the reflection correction for a reasonably uniform row of houses on the opposite side of the road see para 34.2.

* The evaluation must normally be on the basis of the built form as it exists, but foreseeable changes may be taken in to account, eg where demolition without replacement is a firm intention for the near future.

Figure 5. CALCULATING THE REFLECTION CORRECTION FOR FACADES FACING THE RECEPTION POINT ON THE FAR-SIDE OF THE TRAFFIC STREAM



$$\text{REFLECTION CORRECTION} = +1.5\left(\frac{\theta'}{\theta}\right)\ \text{dB(A)}$$

where $\theta' = \theta_1 + \theta_2 + \theta_3 + \theta_4$

and θ = TOTAL SEGMENT ANGLE

27. Side roads
For side roads the above correction applies only when there are houses or other substantial reflecting walls along the main road opposite the aperture of the side road and within the angle of view of the reception point. In this case however, θ is the angle of view of the main road at the reception point defined by the aperture of the side road, and θ' is the sum of the angles subtended by all the reflecting facades on the opposite side of the main road facing the reception point contained within the total angle θ (see Annex 13).*

28. Size of segment
The noise level at the reception point from the segment of the road scheme depends upon the angle θ subtended by the segment boundaries at the reception point. This angle is often referred to as the *angle of view*. The correction for angle of view is obtained using Chart 10.

Combining contributions from segments

29. The final stage of the calculation process, to arrive at the predicted noise level, requires the combination of noise level contributions from all the source segments which comprise the total road scheme**. For a single segment road scheme then, of course, there is no further adjustment to be made. For road schemes consisting of more than one segment the predicted noise level at the reception point shall be calculated by combining the contributions from all the segments using Chart 11 to give the overall noise level (L). For the purposes of the Noise Insulation Regulations each contribution should be rounded to the nearest 0.1 dB(A) in accordance with para 7. Where more than two contributions are to be combined, section (ii) of Chart 11 applies.

* Where the traffic on the side road is not negligible it will be necessary to take this into account in calculating the total noise level. Due to the proximity of walls along side roads the facade correction of +2.5 dB(A) applies at all points along the side road (para 26.1 refers).
** It is important to combine noise level contributions logarithmically when calculating the overall noise level (L).

Section II – The prediction method (additional procedures)

30. Low traffic flows

The procedure given in Section I enables calculations of hourly L_{10} dB(A) and L_{10} (18-hour) dB(A) to be made for road schemes where traffic flows on any segment contained within the scheme are greater than or equal to 50 veh/h or 1000 veh/18-hour day. However, it is known that for traffic flows in the range $50 \leq q < 200$ veh/h or $1000 \leq Q < 4000$ veh/18-hour day, the noise level flow function takes a different form from that shown on Charts 2 and 3. For these flow ranges the noise level changes more rapidly with traffic flow than indicated. The rate at which the noise level changes with flow is also affected by the distance between the reception point and the effective source position. Consequently, for some road schemes where low traffic flows occur a further correction to the predicted noise level obtained by applying the procedure given in Section I may be needed. The following gives the method to be adopted in such cases. See Annex 14.

NB *Low traffic flow segment:* This term describes a road segment where the hourly traffic flow is in the range $50 \leq q < 200$ veh/h or the 18-hour traffic flow is in the range $1000 \leq Q < 4000$ veh/18-hour day *and* the shortest slant distance (d′) from the reception point to the effective source position is less than 30 metres.

Where the traffic flow on a segment is within the range quoted above but the shortest slant distance (d′) is equal to or greater than 30 metres no further correction is applied to the calculated noise level obtained following the procedure outlined in Section I.

Calculations of noise level for traffic flows below 50 veh/h or 1000 veh/18-hour day are unreliable and measurements should be taken when evaluating such cases.

30.1 To calculate the noise level from an individual low traffic flow segment the procedure outlined below should be followed.

1. Calculate the predicted noise level for the segment (L) by applying the procedure outlined in Section I, paragraphs 12–28.
2. The corrected predicted noise level (L_L) for the segment is given by

$$L_L = L + K$$

where $K = -16.6 (\text{Log}_{10}D)(\text{Log}_{10}C)^2$

and $D = \frac{30}{d'}$ where d′ is the shortest slant distance between the reception point and the effective source position,

and $C = \frac{q}{200}$ or $\frac{Q}{4000}$

depending upon whether the correction (K) is applied to an hourly L_{10} or L_{10} (18-hour) value respectively, and where q and Q are the hourly and 18-hour traffic flows respectively.

Chart 12 gives the correction value K.

NB The correction only applies when $50 \leq q < 200$ veh/h or $1000 \leq Q < 4000$ veh/18-hour day *and* $d' < 30$ metres, otherwise no correction should be applied.

30.2 Where a road scheme consists of one or more segments containing low traffic flows the overall predicted noise level from the road scheme is calculated by the following procedure.

1. Calculate the predicted noise level for each segment (L) by applying the procedure outlined in Section I paras 12–28.

2. For each low traffic flow segment apply the correction outlined in para 30.1.

3. Combine all the contributions from each segment using Chart 11.

NB (i) The method used for combining noise levels described above is an approximation. However, although a more precise solution can be found, this tends to be rather complicated and, in most cases, the results are not significantly different from those obtained using the above procedure.

(ii) For low flows, prediction of L_{10} (18-hour) dB(A) using 18-hour traffic flows can differ from values obtained by averaging the hourly values over the same period. In general, predictions of L_{10} (18-hour) dB(A) for low traffic flows should be calculated, where possible, using hourly traffic flow data to obtain the eighteen, one hour, L_{10} values over the prescribed period and then averaging these values. It should be noted that hourly L_{10} values are most sensitive to changes in traffic flow in the low flow region. For cases where the traffic flow cannot be determined accurately, the measurement method is preferred.

(iii) When determining the need to make corrections for low traffic flows special care should be taken to ensure that noise levels from non-traffic sources are substantially lower than the levels from the traffic otherwise site noise levels could be under predicted using the method (see also para 5).

31. End of scheme
Where a section of road has been improved or altered it may be necessary to predict the noise level at sites near to the end of the improved road scheme. The noise level is evaluated by treating the improved and non-improved sections of the road as separate segments. The noise level contribution from each segment at the receiver position is evaluated separately and finally combined using Chart 11. (Annex 15 gives an example calculation.)

32. Curved roads
Curved roads should be broken down into several straight line segments and each segment treated separately as detailed in Section I. The separate contributions at the reception point are combined using Chart 11 to obtain the predicted noise level (see Annex 4).

33. Multiple roads including road junctions
Calculation of noise from multiple roads is achieved as an extension of the procedures outlined in Section I. The contribution from each individual length of road is calculated separately, using the appropriate mean speed (see para 14) and ignoring any speed change at the junction, and the overall predicted noise level obtained using Chart 11. Some difficulties may be encountered, however, since the segment boundaries may not be precisely defined in all cases. In general, the location of segments will depend upon the presence of buildings and the position where the source lines of each road segment intersect. Annex 16 illustrates how segmentation of two particular junction designs could be achieved. For the roundabout site the source lines could have been drawn to intersect at different positions which would have resulted in different segment angles. In such situations the noise contribution from each road segment should be calculated for each possible segment angle and the maximum resultant predicted noise level taken.

34. Houses fronting onto a main road

34.1 *Screening effects*

Due to the need to take into account a large number of finite barriers, it may become tedious to calculate the received noise level behind a reasonably uniform row of houses which face on to a major road especially in the case where the reception point is some distance from the row of houses (eg the noise level at the second row of houses) using the procedures in paras 22 and 24. In such cases an equivalent barrier segment can be determined whose subtended angle θ is reduced to $\theta\gamma$ where γ is defined as

$$\gamma = \frac{b}{a + b}$$

where a is the mean opening between buildings and b is the mean length of building evaluated along the main road in the vicinity of the reception point. The original segment can then be treated as two separate segments whose subtended angles are $\theta\gamma$ (the screened segment), and $\theta\ (1 - \gamma)$ which represents the unscreened portion. The two segments are treated separately and their noise level contributions combined using chart 11 to obtain the total contribution from the segment. NB. When evaluating the contribution from the unscreened segment an appropriate ground cover correction, para 20, may be required. In such cases the mean height of propagation (H) may be determined along the original segment bisector, ignoring the presence of the houses, and the proportion of absorbent ground determined from the type of ground enclosed by the original segment boundaries (see Annex 17).

34.2 *Reflection effects*

Where a reasonably uniform row of houses exist which face the reception point on the opposite side of the traffic stream the reflection correction for opposite facades, see para 26.2, can be calculated using the value γ defined above. The reflection correction is equal to $+ 1.5\ \gamma$ dB(A).

35. Multiple screening

Where more than a single barrier is interposed between the source line and the reception point the following procedure shall be adopted to predict the overall noise level (see Annex 11).

(i) Where possible, segment the screened source line into single and multiple screened segments, in accordance with para 11 (see Fig 6).

(ii) For each segment, calculate the basic noise level in accordance with paras 12–16 and correct for distance in accordance with para 18.

(iii) For single screened segments, e.g. segment angle θ_1 and θ_4 in Fig 6, calculate the potential barrier correction in accordance with para 22 and correct the values obtained in step (ii) accordingly for each segment.

(iv) For segments containing double screening, e.g. segment angle θ_2 calculate the potential barrier correction for each barrier separately in accordance with para 22 and combine their potential barrier corrections using the formula:–

$$A_C = -10\text{Log}_{10}[\text{Antilog}_{10}(-A_A/10) + \text{Antilog}_{10}(-A_B J/10) - 1]$$

where A_A and A_B are the potential barrier corrections derived from Chart 9 (NB values of A will be negative) such that $A_A \leq A_B$ ie A_A has the most negative value

$$\text{and } J = \left(\frac{M}{d + 3.5} \right)^{\frac{1}{4}}$$

where M is the horizontal distance between the top edge of the barriers, and d is the shortest horizontal distance between the reception point and the edge of the nearside carriageway.

Correct the value obtained in step (ii) for the segment by adding the value A_C (NB A_C should be a negative value).

(v) For multiple screened segments, eg segment angle θ_3 in Fig 6, calculate the potential barrier correction for each barrier separately in accordance with para 22 and select the barrier which gives the most negative value, A_A. Combine the potential barrier correction A_A with each of the remaining potential barrier values, separately, as in step (iv) and select the A_C value which is most negative.

(vi) Correct the value obtained in step (ii) for the segment by adding the value A_C.

(vii) Correct the contributions from each segment to take account of reflection effects, angles of view and other site layout details and combine the values, para 29, to give the overall predicted noise level.

36. Combined screening and reflection effects
Where a road is flanked on both sides by substantial reflecting surfaces such as retained walls or purpose-built noise barriers the screening performance of such barriers can be reduced due to reflection effects. The procedure to adopt when calculating the reflection correction for these situations is outlined below.* This correction is in place of and is not additional to the correction given in para 26.2.

NB (i) If the height of reflecting wall or barrier is less than 1.5 metres above the road surface no reflection correction should be applied.

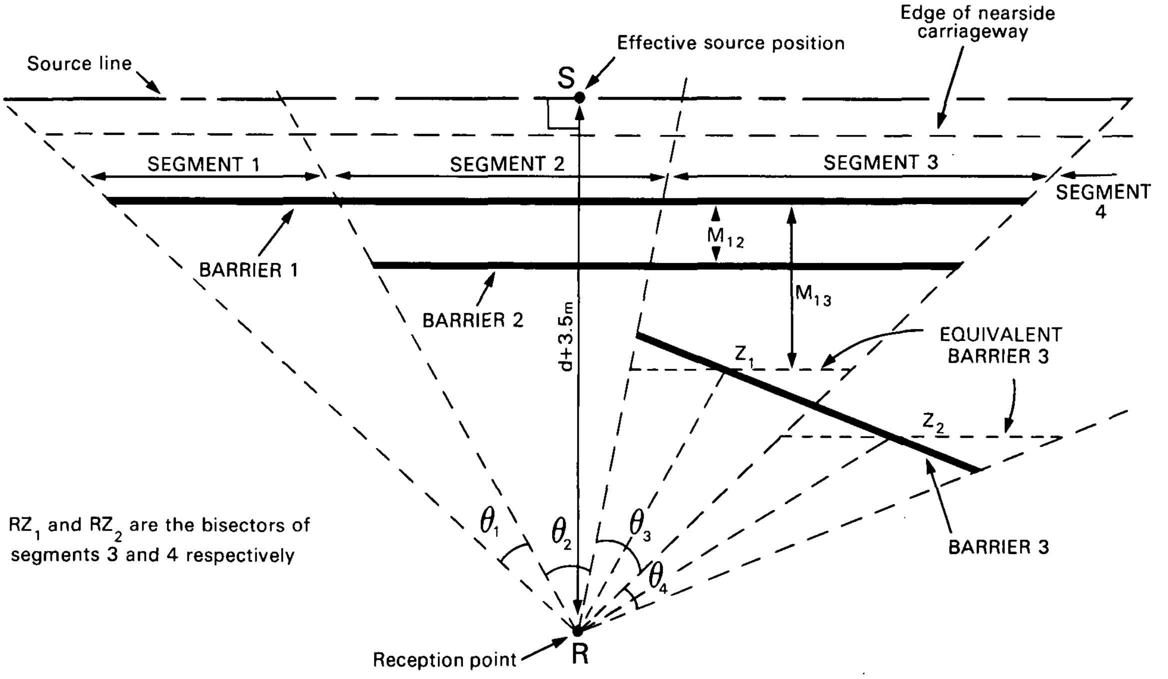
(ii) Although superficially similar, the reflection effects associated with a uniform row of houses along both sides of a road are not so obtrusive. In such cases correction for reflection effects is to be made in accordance with para 34.2.

(iii) The corrections given by these procedures assume continuous, hard, reflecting surfaces. Surfaces covered with vegetation or constructed from purpose-built sound absorbing material will reduce reflection effects and where these are present noise levels will tend to be over-predicted by the method.

(iv) Where a road runs into a cutting where the sides are of earth material or where there are earth embankments alongside the road, no reflection correction is required, but see also para 36.2(i).

* Where the two carriageways are treated individually, see para 13.1, the reflection correction is calculated for each carriageway separately. The parameters used in calculating the correction will be related to the carriageway being considered.

Figure 6. COMBINING POTENTIAL BARRIER CORRECTIONS FOR MULTIPLE SCREENED ROAD SEGMENTS.



SEGMENT 1	BARRIER 1	Potential barrier correction = A_1
SEGMENT 2	BARRIER 1 BARRIER 2	Potential barrier correction = A_1 Potential barrier correction = A_2 if $A_1 < A_2$ then using the same nomenclature as in para 35(iv) $A_A = A_1$ and $A_B = A_2$ and A_c (the combined potential barrier correction) can be calculated with $M = M_{12}$.
SEGMENT 3	BARRIER 1 BARRIER 2 BARRIER 3	Potential barrier correction = A_1 Potential barrier correction = A_2 Equivalent potential barrier correction = A_3 if $A_1 < A_2 < A_3$ then using the same nomenclature as in para 35(iv) $A_A = A_1$ and $A_B = A_2$ or A_3 depending on which value gives the most negative A_c value with $M = M_{12}$ or M_{13} respectively.
SEGMENT 4	BARRIER 3	Equivalent potential barrier correction = A_4

N.B.

(i) Path differences for all barriers are calculated in the vertical plane, ie normal to the road surface, passing through RS and used with Chart 9 to evaluate the potential barrier correction.

(ii) All potential barrier corrections are negative values.

36.1 Figures 7(a) and (b) show a section through a typical road element where dual barriers and retained cut run parallel to the source line. To calculate the noise level at the reception point, R, the following procedure should be adopted. (see Annex 18).

1. Segment the road scheme according to the procedure outlined in paragraph 11. Normally a length of road where dual barriers or walls of similar length run parallel to the source line will constitute a single segment.

NB The reflection correction is calculated in the same plane, i.e. normal to the road surface, as the distance correction and for some segments it may be necessary to extend the retaining walls and barriers together with the source line before the following procedures are applied.

2. Calculate the basic noise level and correct for distance and screening provided by the retained cut or barriers detailed in paragraphs 12–22.

3. Calculate the correction for reflections using the formula:

Correction = $[1.5 + (\Delta_2 - \Delta_3)\{1 + \Delta_5(\Delta_1 - 1)\}]\,\Delta_4$

(a) The value of Δ_1, depends on the relative height of the screening barrier above the road surface (W), the height of the reflecting barrier above the road surface (Y), and the height of the reception point R above the road surface (α), see Fig 7(a). Δ_1 is determined in the following way:–

if $Y \geqslant W$ and $\alpha \geqslant W$ $\quad \Delta_1 = W$
if $Y \geqslant W$ and $\alpha < W$ $\quad \Delta_1 = \alpha$ for $\alpha < 1$, $\Delta_1 = 1$
if $Y < W$ and $\alpha \geqslant Y$ $\quad \Delta_1 = Y$
if $Y < W$ and $\alpha < Y$ $\quad \Delta_1 = \alpha$ for $\alpha < 1$, $\Delta_1 = 1$.

(b) Apply Chart 13 to determine the value of Δ_2 as a function of α and Δ_3 as a function of the horizontal distance from the reception point to the top edge of the screening barrier, (β).

(c) Apply Chart 14 to determine the value of Δ_4 as a function of the horizontal distance between the top edge of the screening barrier and the base of the reflecting barrier (E).

(d) Apply Chart 15 to determine the value of Δ_5 as a function of the angle of the reflecting barrier to the vertical (∅).

4. Add the correction obtained in step 3 to the value obtained in step 2, and correct this value in accordance with the size of the segment – see paragraph 28.

5. Combine contributions from other segments using Chart 11 to obtain the predicted noise level.

36.2 The above procedure outlines the method to be adopted when calculating the reflection for typical dual barrier and retained cut situations. The following paragraphs give additional procedures to be adopted when calculating the reflection correction for some specific configurations.

(i) For dual barriers where either barrier is erected on top of an earth embankment, or cut where the sides are of earth material, the reflection correction outlined in para 36.1 is applied but with $\Delta_5 = 0$.

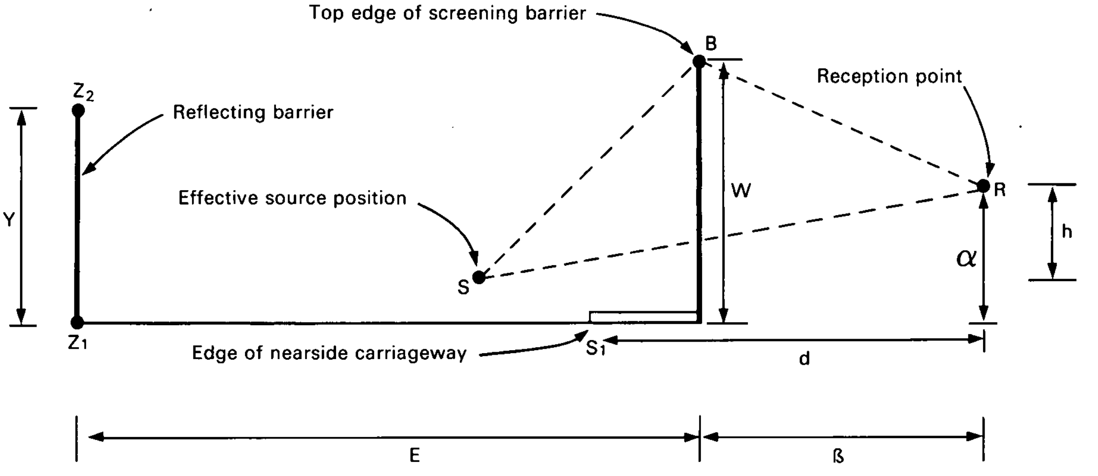
(ii) Where a barrier is erected on top of a retained cut the reflection correction outlined in para 36.1 is applied and the relevant parameters ie W, Y and ∅, where necessary, are calculated by treating the barrier and retaining wall as a single structure, see Fig 7(c).

(iii) Where the retaining walls or barriers run non-parallel to the source line it is required to rotate them parallel to the source line by the method outlined in para 22.2 before applying the reflection correction para 36.1.

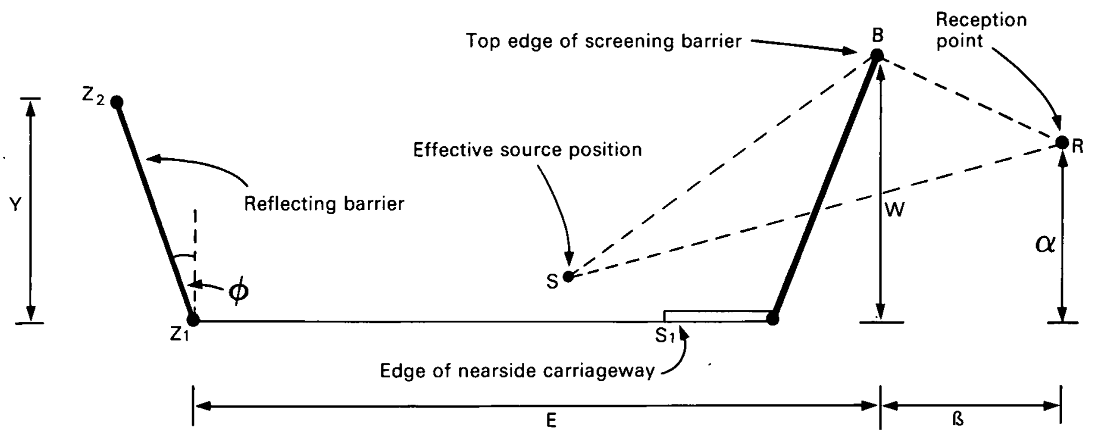
Figure 7. EXAMPLES OF DUAL BARRIERS AND RETAINED CUTS

7(a) DUAL BARRIERS.

(i) with vertical walls.

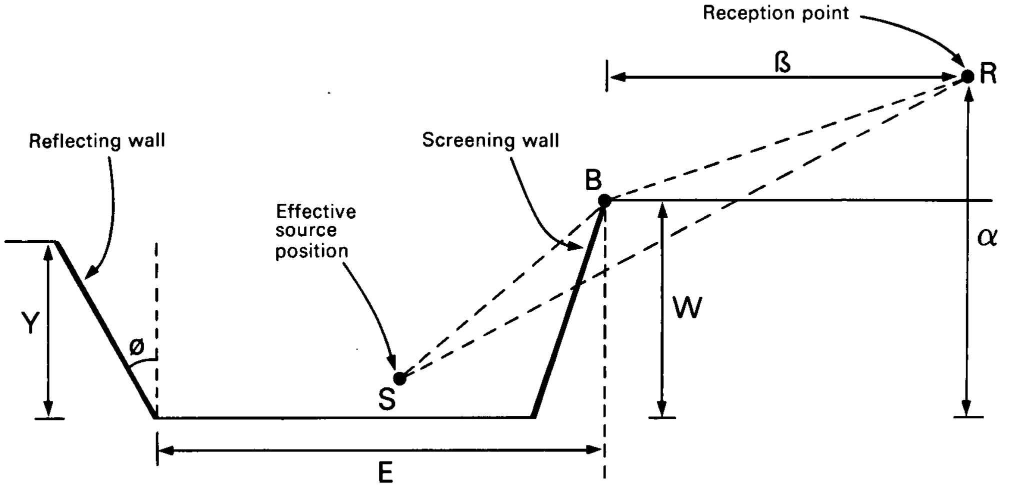


(ii) with sloping walls.



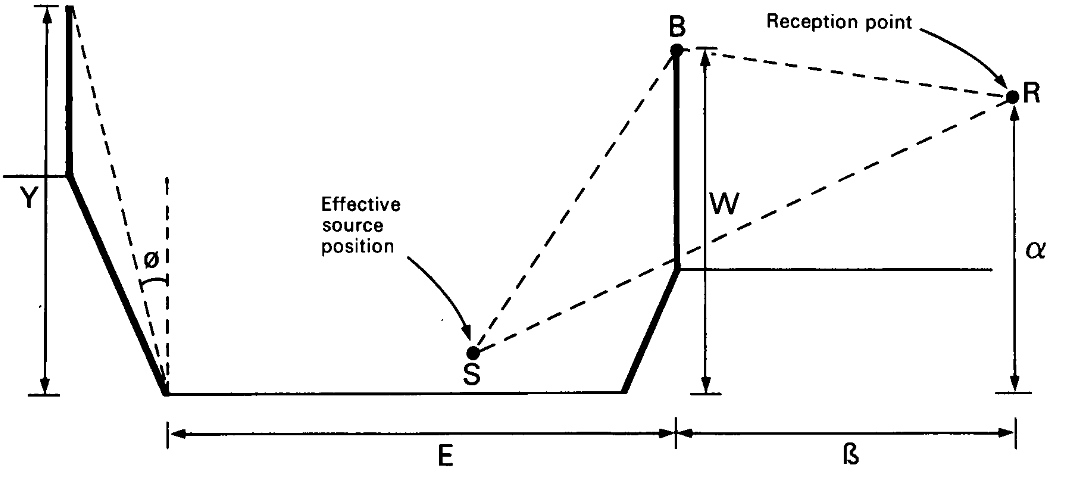
N.B. Potential barrier correction (A) is calculated from the path difference (δ = SB + BR - SR) and applying Chart 9.

7(b) RETAINED CUT



N.B. If the screening wall slopes the values of E and ß are measured relative to the top edge, B. The potential barrier correction (A) is calculated from the path difference (δ = SB + BR – SR) and applying Chart 9.

7(c) DUAL BARRIERS ERECTED ON TOP OF RETAINED CUT.



Section III – The measurement method

37. The method consists of measuring the noise from an actual flow of traffic on a road. Generally it will be required that the measurement position is close to the road so that other traffic or extraneous noises do not influence the measured level. The measured level is adjusted to give a noise level at 10 metres from the nearside carriageway edge by applying the necessary corrections in Section I. The algebraic sign of the corrections should be reversed before applying it to the measured level. The value obtained from the above procedure is the basic noise level and the calculation, as necessary, of L_{10} (18-hour) at the reception point is obtained using the procedures outlined in paras 17–28 of Section I.

37.1 For the purposes of the Noise Insulation Regulations and where there are no other significant noise sources in the area (or they are separately identifiable), measurements 1 metre from an eligible facade may be appropriate in such circumstances. The measured level can be used without the need to calculate the basic noise level when evaluating the L_{10} (18-hour) dB(A) level.

38. When to measure
The measurement method may be used where:–

(i) traffic conditions fall outside the range of validity of the Charts;

or (ii) traffic or site layout conditions are sufficiently complex or unusual to make the use of standard traffic data unreasonable;

or (iii) measurement provides a more economic method of determining the particular level of traffic noise.

However, the highway authority shall use the prediction method unless in their opinion it is inappropriate to the circumstances of the case.

39. Physical conditions for measurement
The following conditions should prevail throughout the measurement period.

39.1 *Road surface*
Measurements are to be made when the road surface in the measurement area is dry.

39.2 *Wind*
Measurements should be made where:

(i) the wind direction is such as to give a component from the nearest part of the road towards the reception point exceeding the component parallel to the road;

(ii) the average wind speed at a height of 1.2 metres and mid-way between the road and the reception point is not more than 2 m/s in the direction from the road to the reception point;

(iii) the wind speed at the microphone in any direction should not exceed 10 m/s.

In all cases it is recommended that a wind shield be used on the microphone and that measurements should only be carried out when the peaks of wind noise at the microphone are 10 dB(A) or more below the measured value of L_{10}.

40. Measuring equipment
Equipment used for the measurement of L_{10} should be capable of satisfying the specification given for guidance in Appendix 1. As regards calibration, evidence of general compliance with the requirements may be based upon manufacturers' published technical data but regular (not less than annual) checking is necessary to ensure that equipment is correctly calibrated. Guidance on minimum calibration requirements is given in Appendix 2.

41. Measurement procedure
The following procedure should be adopted when carrying out the measurements.

41.1. *Microphone position*
The measurement point should be chosen so that the view of the road in question is substantially unobstructed ($\theta > 160°$) and should normally be not less than 4 metres and not more than 15 metres from the nearside edge of the carriageway. The microphone should normally be placed at a height of 1.2 metres above the road surface and with the diaphragm or other sound-sensitive surface horizontal (grazing incidence). Where possible, free-field conditions should apply. However there should be no sound-reflecting surfaces (other than the ground) within 15 metres of the microphone position. Where there is doubt about whether free-field conditions prevail, particularly for the purposes of the Noise Insulation Regulations, a temporary screen to act as a facade should be erected (see also para 37.1). The screen should have an area of not less than 1 sq. metre and be positioned with its centre 1 metre behind the microphone. The screen may also assist in ensuring that extraneous noise sources do not affect the measured level. It should be noted that when a temporary screen is used the facade correction, para 26.1, should be subtracted from the measured level when evaluating the basic noise level.

41.2 *Sampling times*
The minimum sample length t_{min} leading to a valid measurement of L_{10} depends upon the registration rate r in samples per minute (in order to ensure a sufficient overall number of samples) and on the total flow q, in vehicles per hour, passing the measuring point (in order to ensure measurements include an adequate sample of vehicles). Provided q is greater than or equal to 100 veh/h the minimum sampling time can be determined from

$$t_{min} = \left(\frac{4000}{q} + \frac{120}{r} \right) \text{ minutes}$$

provided r is greater than 5 samples per minute and with the restriction that the sample length should not be less than 5 minutes in any one hour. For vehicle flows less than 100 veh/h the sampling rate, r, should be at least 1 sample per second and measurements should be taken for the full hour excluding time required for calibration and printer output, if required.

41.3 *Traffic counts*
Where possible the measurements of traffic flow and composition should be concurrent with measurements of the traffic noise.

42. Analysis of data

For any given sample, the noise level registrations are analysed to identify the number of registrations exceeding predetermined noise levels. These are converted to fractions of the measuring period, and L_{10}, the level exceeded for just 10% of the measuring period, determined by linear interpolation between the readings immediately on either side. (Care should be taken that the lower class limit of noise is used as independent variable and not the centre of the class interval.) To give adequate precision when determining the value of L_{10} by linear interpolation the interval between the predetermined noise levels is not to exceed 2.5 dB(A). However, systems with an inherent class-interval of 5 dB(A) may be employed provided that the analysis is repeated (eg by use of a tape recorder) with an additional 2.5 dB(A) attentuation in circuit in order to produce an effective interval of 2.5 dB(A).

42.1 *Derivation of L_{10} (18-hour) dB(A)*

The above procedure enables hourly L_{10} dB(A) levels to be derived and the L_{10} (18-hour) value is the arithmetic mean of the 18 one-hourly values of L_{10} covering the period 0600 to 2400 hours.

$$\text{ie } L_{10}\ (\text{18-hour}) = \frac{1}{18}\sum_{t=6}^{t=23} L_{10}\ (\text{hourly})_t$$

where t signifies the start time of the individual hourly L_{10} dB(A) values in the period 0600 to 2400 hours.

Unless measurements at the facade position have been carried out, see para 37.1, it is necessary to adjust the L_{10} (18-hour) value obtained above in accordance with the procedure outlined in para 37 to evaluate the L_{10} (18-hour) dB(A) value at the facade position.

42.2 *Calculation of future values of L_{10} (18-hour) dB(A)*

To forecast the L_{10} (18-hour) value relating to future traffic conditions (signified Q′, V′, p′) the following procedure is adopted (where Q, V, p are the current traffic conditions).

1. From the measurement method evaluate (L) the L_{10} (18-hour) dB(A) value at the reception point for the current traffic conditions.

2. Calculate the correction (ΔL_F) to take account of the change in traffic conditions.

$$\text{where } \Delta L_F = 10\ \text{Log}_{10}(Q'/Q) + 33\ \text{Log}_{10}\left[\frac{V' + 40 + \frac{500}{V'}}{V + 40 + \frac{500}{V}}\right] + 10\ \text{Log}_{10}\left[\frac{1 + \frac{5p'}{V'}}{1 + \frac{5p}{V}}\right]$$

3. Calculate the future value of L_{10} (18-hour) (L_F) from *one* of the following formulae:

(i) if Q and Q′ ⩾ 4000 veh/18-hour day

then $L_F = L + \Delta L_F$

(ii) if Q ⩾ 4000 and Q′ < 4000 veh/18-hour day

$$\text{then } L_F = L + \Delta L_F - 16.6 \left(\text{Log}_{10} \frac{30}{d'}\right) \left(\text{Log}_{10} \frac{Q'}{4000}\right)^2,$$

where d′ is the shortest slant distance between the reception point and the effective source position.

NB if d′ ⩾ 30 m $\quad L_F = L + \Delta L_F$

(iii) if Q < 4000 and Q′ ⩾ 4000 veh/18-hour day

$$\text{then } L_F = L + \Delta L_F + 16.6 \left(\text{Log}_{10} \frac{30}{d'}\right) \left(\text{Log}_{10} \frac{Q}{4000}\right)^2$$

NB if d′ ⩾ 30 m $\quad L_F = L + \Delta L_F$

(iv) if Q and Q′ < 4000 veh/18-hour day

$$\text{then } L_F = L + \Delta L_F - 16.6 \left(\text{Log}_{10} \frac{30}{d'}\right) \left(\text{Log}_{10} \frac{Q'}{Q}\right) \left(\text{Log}_{10} \frac{QQ'}{4000^2}\right)$$

NB if d′ ⩾ 30 m $\quad L_F = L + \Delta L_F$

NB When predicting future values of 18-hour L_{10} dB(A) foreseeable changes in screening, site-layout and road surface including the criteria for traffic speed (para 16) should be taken into account.

Shortened measurement procedure

43. Within certain limits (see para 44) the following shortened measurement procedure may be used. Measurements of L_{10} are made over any three consecutive hours between 1000 and 1700 hours. Using L_{10} (3-hour) as the arithmetic mean of the three consecutive values of hourly L_{10}, the current value of L_{10} (18-hour) can be calculated from the relation:

$$L_{10}\text{ (18-hour)} = L_{10}\text{ (3-hour)} - 1\text{ dB(A)}$$

$$\text{where } L_{10}\text{ (3-hour)} = \tfrac{1}{3} \sum_{10 \leq t \leq 14}^{t+2} L_{10}\text{ (hourly)}_t$$

and t signifies the start time of the individual hourly L_{10} dB(A) values.

The future value of L_{10} (18-hour) is calculated using the relevant formula given in para 42.2 above.

44. Provided that the future values of L_{10} (18-hour) estimated in this way are in excess of 69.0 dB(A) or are less than 66.0 dB(A) the calculated values may be used in part to determine entitlement under the Noise Insulation Regulations. Where the future value of L_{10} (18-hour) calculated in the shortened procedure lies within the range of 66.0–69.0 dB(A) or the increase in noise level of 1.0 dB(A) is critical (see para 6), full measurement of hourly L_{10} dB(A) throughout the 18-hour period is necessary, and the L_{10} (18-hour) dB(A) value calculated as outlined in para 42.1.

Comparative measurements

45. Comparative measurements of L_{10} (18-hour) may be made at a number of positions concurrently in terms of hourly L_{10} provided that the noise at each of the measuring positions is due to the same road carrying the same traffic under the same conditions. At one (control) position the noise should be measured through the period 0600 to 2400 hours on an average weekday. Relative measurements at the satellite positions should be made for not less than two identical periods each of at least 15 minutes duration* concurrently with measurements at the control position. The measurements at each satellite position should be taken at least 2 hours apart during the 18-hour period. Mean differences in the corresponding values of hourly L_{10} may then be applied to the values of L_{10} (18-hour) measured at the control position to determine L_{10} (18-hour) for the satellite positions.

* For certain vehicle flows a longer sampling time may be required. Paragraph 41.2 should be applied to derive an appropriate sampling time if longer than 15 minute periods are indicated.

Appendix 1 – Type specification for measuring equipment

(a) Microphone and amplifier
Over the frequency range of 63-5000 Hz the overall response of the measuring equipment including windshield, microphone, microphone preamplifier, measurement amplifier, and attenuators should comply with the A-weighting characteristics, accuracy requirements, and sensitivity to environmental factors such as temperature, relative humidity, shock and vibration, as specified for type 1 instruments in BS 5969: 1981, which is identical with IEC 651: 1979. Outside the frequency range 63-5000 Hz the overall sensitivity should not exceed the upper tolerance limit of the A-weighting characteristic specified in BS 5969: 1981.

(b) Magnetic tape recorder
When direct analysis is not employed and a magnetic tape recorder is used to store audio-frequency data (as opposed to digital data) for subsequent analysis, the record/replay system (including tape) should meet the following requirements.

(i) The gain of the recorder must be independent of input level (ie tape recorders using automatic gain control must not be used).

(ii) The device should be used in such a manner that the A-weighting characteristic is applied prior to tape recording.

(iii) The frequency-response of the complete measurement system including tape recorder should meet the tolerances specified in paragraph (a) above.

(iv) The performance of the recorder shall be such that the effective dynamic range is at least 35 dB (ie the difference between the output of the tape recorder when replaying a typical traffic noise spectrum at 3% distortion level and when replaying blank tape should be at least 35 dB). The system must be arranged so that the recorded value of L_{10} is at least 15 dB(A) above the inherent background noise level of the equipment and at least 10 dB(A) below the level corresponding to 3% pure-tone distortion at any frequency over the range 63-5000 Hz.

(v) The amplitude stability of a 1 kHz tone recorded at a level 10 dB below the 3% distortion level should be within ±1 dB throughout any one spool of tape at the tape speed used for the noise measurement. Measurements to verify this should be made using a device with an averaging time equal to that used in the measuring chain.

(c) Characteristics of indicating instrument
In principle the output from the measuring amplifier requires to be squared, averaged, converted to logarithmic form and finally displayed or digitally recorded. However, in some systems some of these operations may not be separable and it is therefore convenient to specify the overall performance of this part of the system.

The detector should operate over a minimum dynamic range of 40 dB and perform as a true mean square device to sinusoidal tone bursts having crest factors of up to 3 over the dynamic range corresponding to 50 to 85 dB(A) within an accuracy of ± 0.5 dB.

The effective averaging time should be 250 milliseconds with tolerances of + 250 ms and —150 ms.

Note 1: A convenient means of checking compliance with the averaging time requirements is to apply ⅓-octave band-limited white noise centred on a frequency of 500 Hz to the input of the detector and determine the standard deviation of the indicated level about the mean level. For a device complying with the above averaging time requirements the standard deviation of at least 500 independent samples of noise level should fall in the range 0.55 to 1.20 dB.

Note 2: An instrument complying with Section 7.2 of BS 5969: 1981 with dynamic characteristics designated F is deemed to comply with these requirements.

Note 3: Logarithmic level recorders with 25 dB potentiometer, writing speed set to 100 mm/s and with a lower limiting frequency of 20 Hz are deemed to comply with these requirements.

(d) Level resolution of digital recording system
In order to achieve adequate overall precision both in calibration and measurement the system should be generally capable of indicating changes in level of 0.5 dB(A).

Appendix 2 – Calibration of equipment

(a) On-site calibration
Immediately prior to and following each session of work the overall sensitivity of the electroacoustical system should be checked using an acoustic calibrator generating a known sound pressure at a known frequency. Measurements may be accepted as valid only if calibration levels agree within 1 dB.

Note 1: Sometimes a pistonphone operating at a nominal level of 124 dB at a frequency of 250 Hz is used for this purpose. As this level is outside the range required for traffic noise measurements, it will be necessary to introduce known additional attenuation (e.g. using a 'range-switch'). Care will therefore need to be exercised when interpreting the calibration signals and it is recommended that the same attenuation (e.g. 50 dB) be adopted as routine. Attention is also drawn to the fact that where the A-weighting network is permanently connected in circuit due allowance must also be made for the relative response of the A-weighting network at the frequency used (e.g. —8.6 dB at 250 Hz).

Note 2: Where a tape recorder forms part of the measuring chain and is used to store audio-frequency data it is a requirement that, in addition to the above, a constant calibration signal corresponding to a known sound pressure level be applied at the beginning and end of each individual spool of tape used. A tape-recorded sample may be accepted as valid only if at the time of analysis the indicated levels of the two calibrating signals agree within 1 dB.

(b) System calibration
To ensure overall measurement precision, within twelve months immediately prior to the measurement the overall system should have been directly compared with an independent reference system. This comparison is most easily effected by using both to measure and analyse the same noise sample. Likewise, the output level of the acoustic calibrator referred to in Appendix 2(a) should also have been checked by direct comparison with an independent reference device.

Appendix 3 – Glossary of symbols

Symbol	Description of Symbol	Relevant Paragraph
A	potential barrier correction for a single barrier (dB(A))	21
A_A	the highest potential barrier correction within a segment where the source line is screened by more than one barrier i.e. most negative value (dB(A))	35
A_B	the potential barrier correction of subsequent barriers within a segment where the source line is screened by more than one barrier (dB(A))	35
A_C	combined potential barrier correction for a multiple screened segment (dB(A))	35
a	mean opening between buildings for a uniform row of houses (metres)	34
b	mean length of buildings for a uniform row of houses (metres)	34
C	correction factor for low traffic flow roads	30
D	correction factor for low traffic flow roads	30
d	shortest horizontal distance between the reception point and the edge of the nearside carriageway (metres)	18
d′	shortest slant distance from the reception point to the effective source position (metres)	18
E	the horizontal distance between the top edge of a barrier or retaining wall and the base of the reflecting barrier or retaining wall (metres)	36
F	18-hour flow of heavy vehicles on a road (veh/18-hour day)	14
f	the hourly flow of heavy vehicles on a road (veh/h)	14
G	gradient of a road (%)	15
H	average height of propagation between the reception point and the effective source position above the intervening ground (metres)	20
h	relative height between the reception point and the effective source position (metres)	18
I	proportion of sound absorbing ground between the edge of the nearside carriageway and reception point contained within a segment	20
J	adjustment to the potential barrier correction for secondary screening	35
K	correction to the noise level to take account of low traffic flows (dB(A))	30

Symbol	Description of Symbol	Relevant Paragraph
L	the noise level, L_{10} hourly or L_{10} (18-hour), dB(A) from a road segment or road scheme	29
L_F	L_{10} (18-hour) dB(A) level from a road for future traffic conditions	42
ΔL_F	correction to the noise level to take account of future changes in traffic conditions (dB(A))	42
L_L	corrected contribution to the noise level from low flow traffic (dB(A))	30
M	the horizontal distance between the top edge of the barrier with the highest potential barrier correction and the top edge of subsequent barriers (metres)	35
p	percentage of heavy vehicles (%)	14
p'	percentage of heavy vehicles for future traffic conditions (%)	42
Q	18-hour traffic flow (veh/18-hour day)	13
Q'	18-hour traffic flow for future traffic conditions (veh/18-hour day)	42
q	hourly traffic flow (veh/h)	13
r	registration rate for sampling the noise level when measuring L_{10} dB(A) (samples/minute)	41
t	start time of the individual hourly L_{10} dB(A) values (hours)	42
t_{min}	the minimum sampling length, in minutes, required for a valid measurement of L_{10} dB(A)	41
V	mean speed of traffic on a road (km/h)	14
V'	mean speed of traffic for future traffic conditions (km/h)	42
ΔV	reduction in mean traffic speed on a road due to gradient (km/h)	14
W	height of screening barrier or retaining wall above road surface (metres)	36
Y	height of reflecting barrier or retaining wall above road surface (metres)	36
α	height of reception point above road surface (metres)	36
β	the horizontal distance from the reception point to the top edge of the barrier or retaining wall (metres)	36
γ	correction to the angle of view subtended by a uniform row of houses	34
$\Delta_1 - \Delta_5$	parameters used for calculating the reflection correction for dual barriers and retained cuts	36

Symbol	Description of Symbol	Relevant Paragraph
δ	path difference between the direct ray and diffracted ray due to screening of the source line (metres)	21
θ	angle of view of a segment (degrees)	28
θ'	combined angle of view of reflecting surfaces on the farside of the traffic stream facing the reception point (degrees)	26
$\varnothing$	angle of the reflecting barrier or retaining wall to the vertical (degrees)	36

CHART 1 FLOW CHART FOR PREDICTING NOISE FROM ROAD SCHEMES

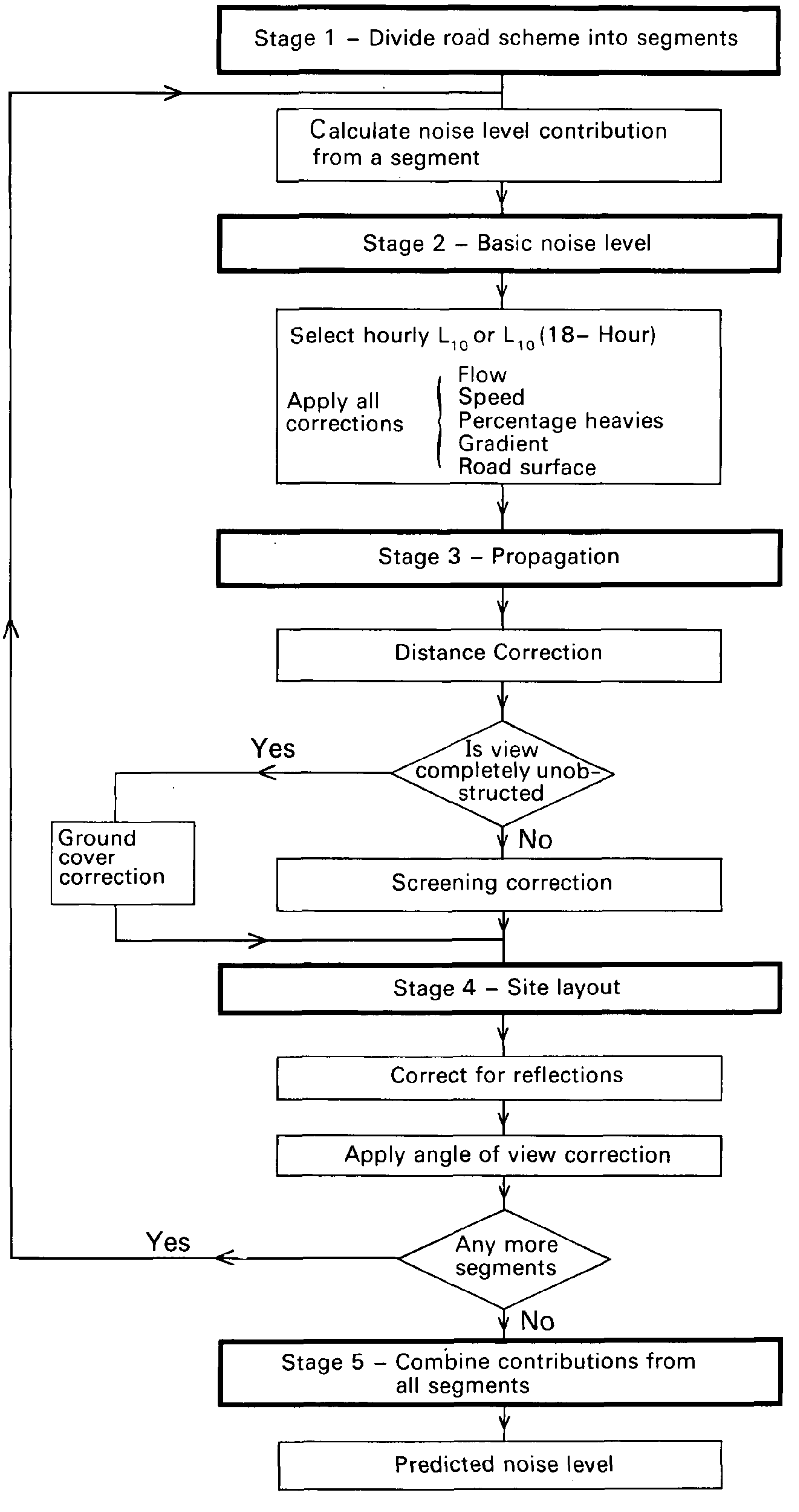
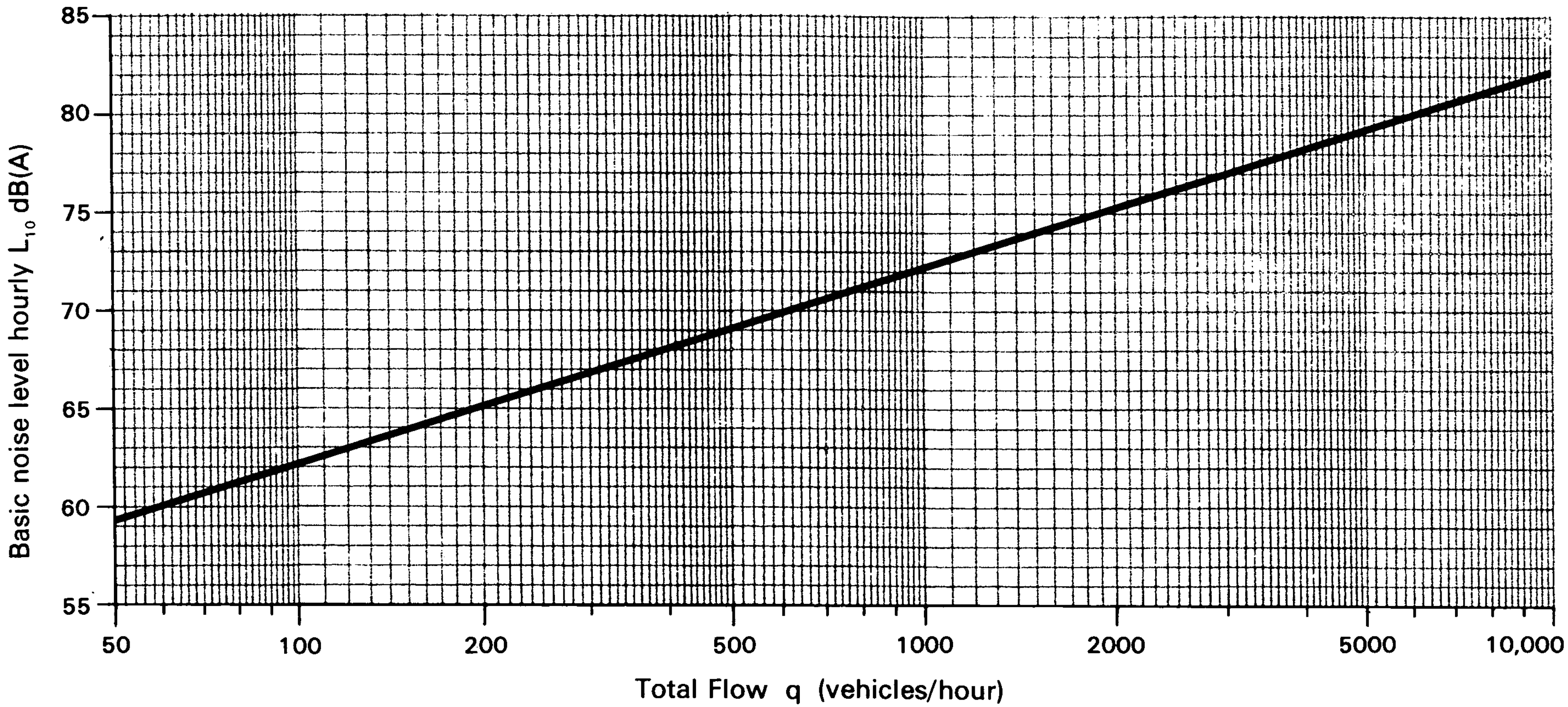
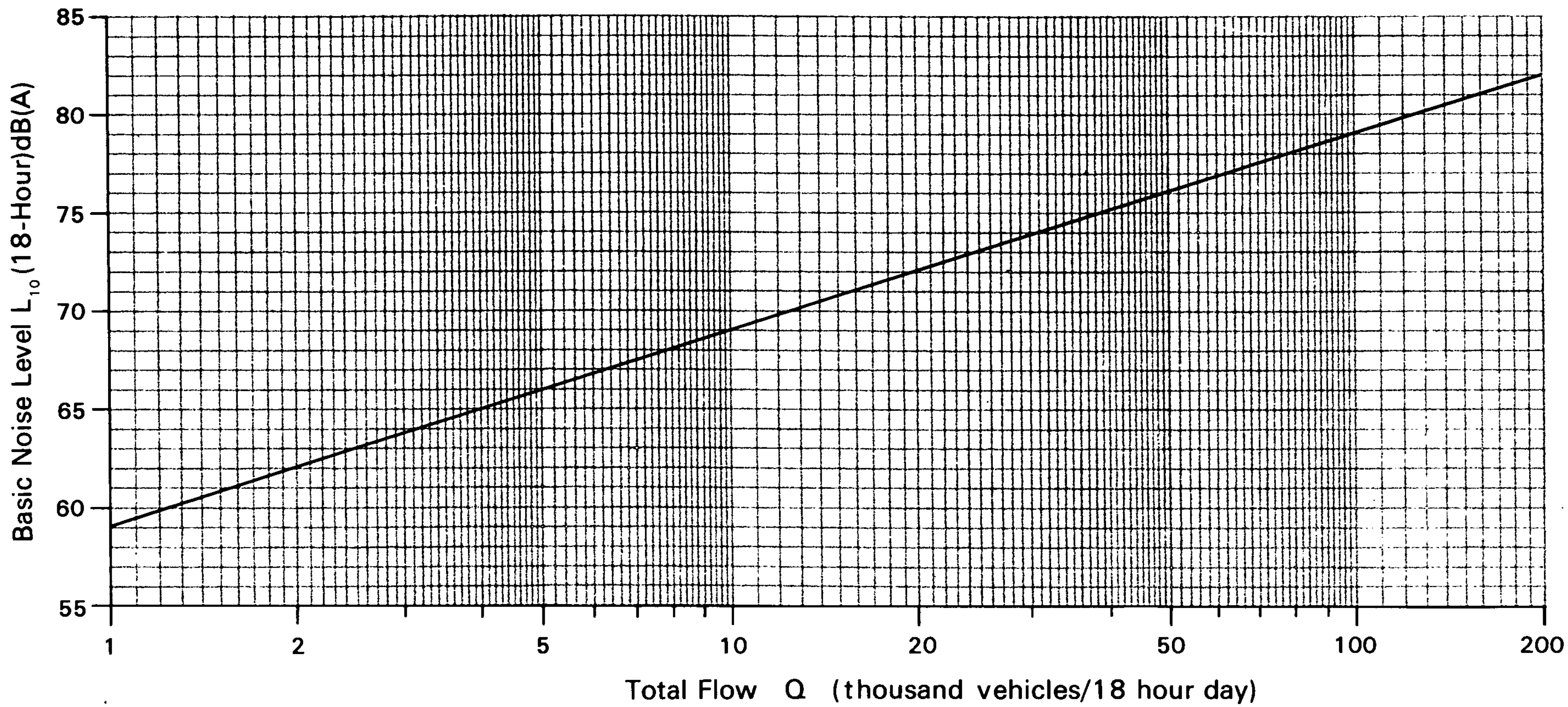


Chart 2 **PREDICTION OF BASIC NOISE LEVEL HOURLY L_{10} IN TERMS OF TOTAL HOURLY FLOW q (V = 75 km/h, p = 0, G = 0).**



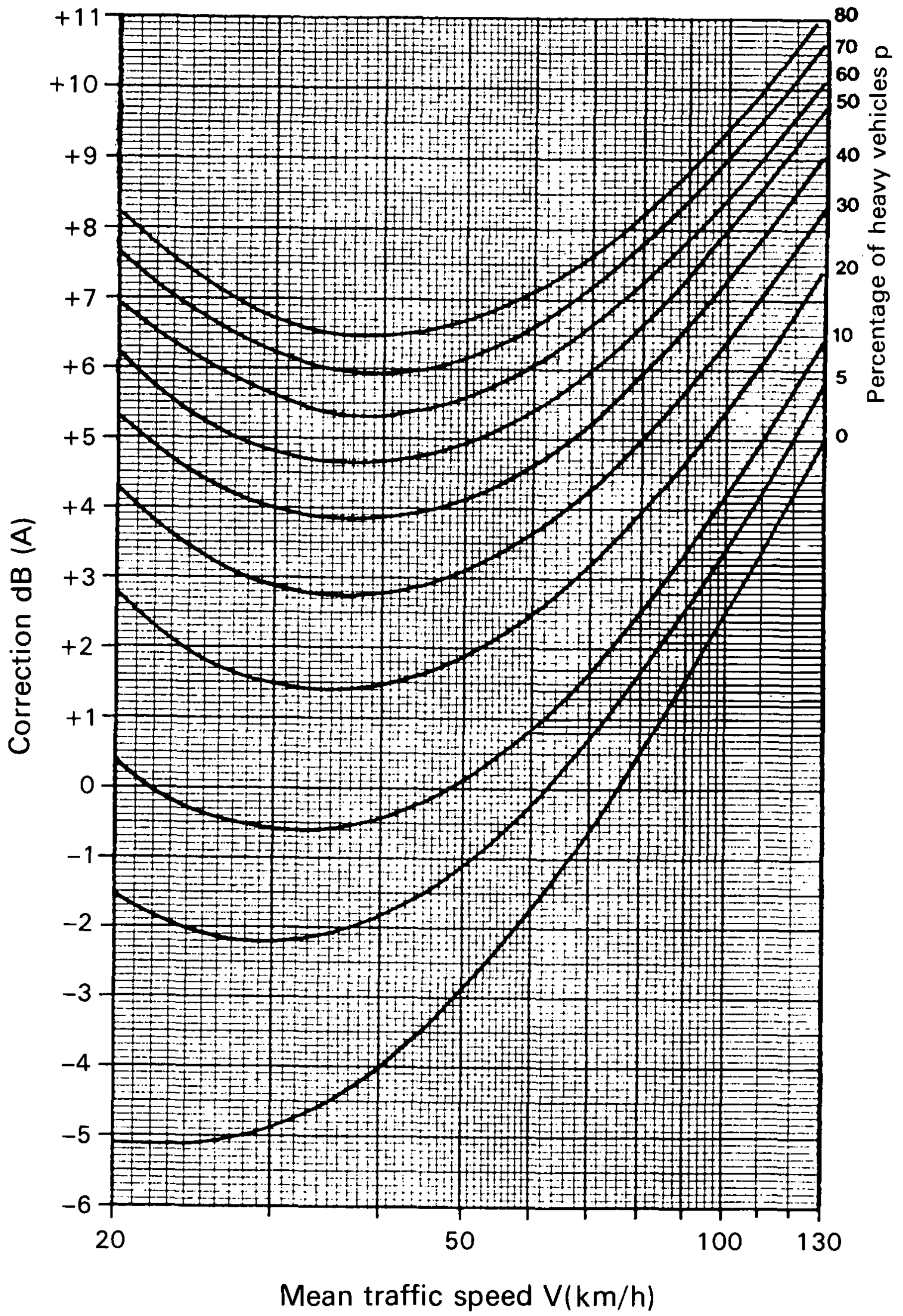
Basic noise level hourly $L_{10} = 42.2 + 10 \, Log_{10} q$ dB(A)

Chart 3 PREDICTION OF BASIC NOISE LEVEL L_{10} (18 HOUR) IN TERMS OF TOTAL 18-HOUR FLOW Q (V=75 km/h. p=0. G=0)



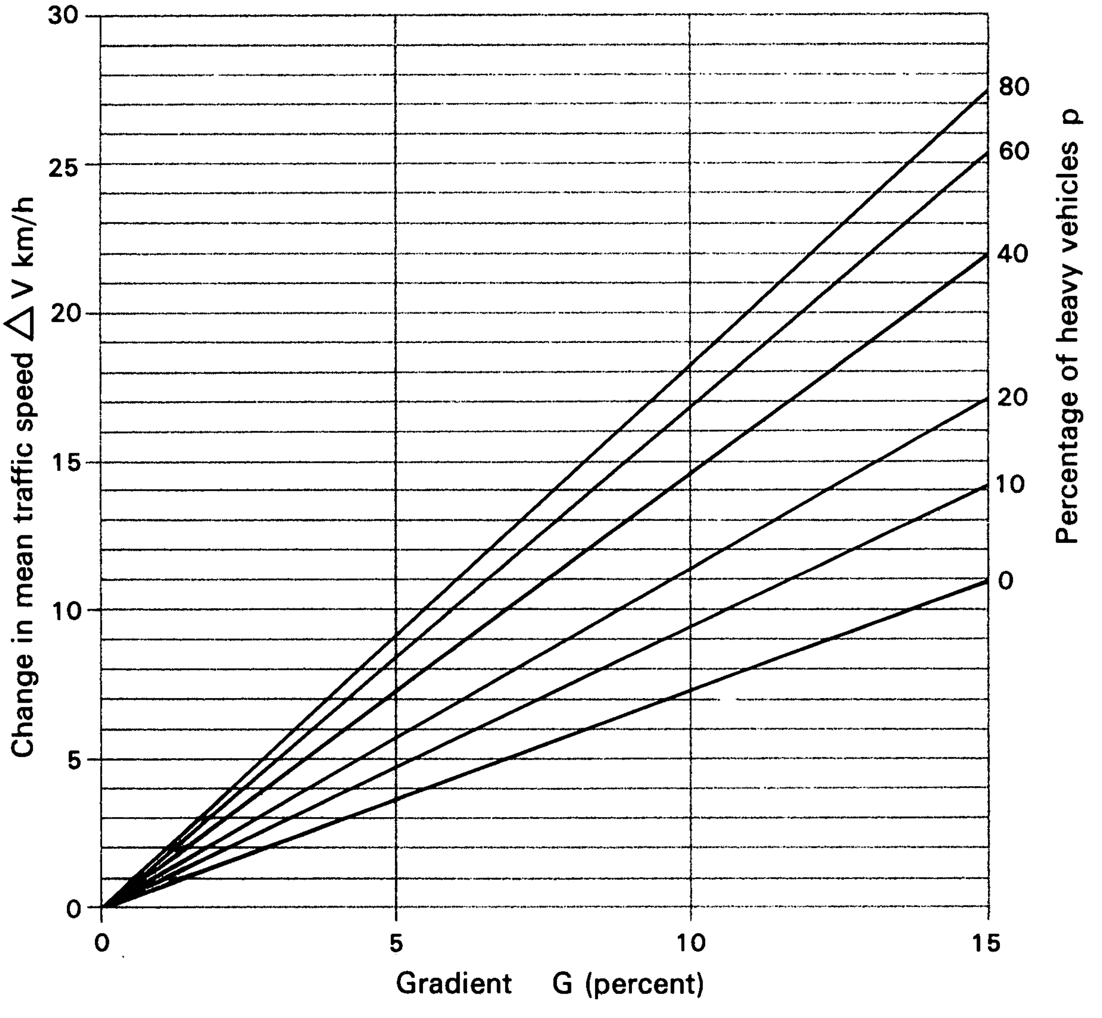
Basic noise level L_{10}(18 – hour) = 29.1 + 10 Log_{10}Q dB(A)

Chart 4 **CORRECTION FOR MEAN TRAFFIC SPEED V AND PERCENTAGE HEAVY VEHICLES p**



$$\text{Correction} = 33 \operatorname{Log}_{10}\left(V + 40 + \frac{500}{V}\right) + 10 \operatorname{Log}_{10}\left(1 + \frac{5p}{V}\right) - 68.8 \text{ dB(A)}$$

Chart 5 **CHANGE IN MEAN TRAFFIC SPEED Δ V IN TERMS OF THE PERCENTAGE HEAVY VEHICLES p AND GRADIENT G (percent).**



$$\Delta V = \left[0.73 + \left(2.3 - \frac{1.15p}{100}\right)\frac{p}{100}\right] \times G \text{ km/h.}$$

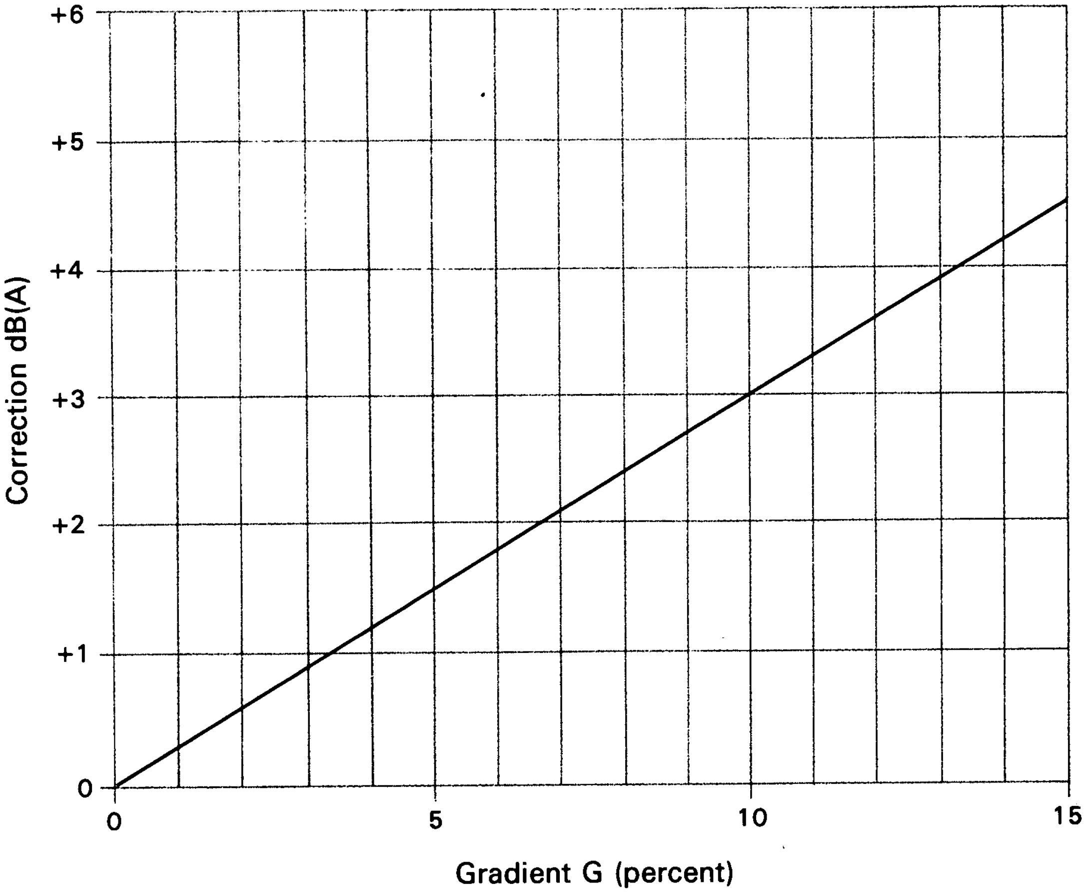
N.B. (i) To be used only when the mean traffic speed has been estimated from the class of road, para. 14.3

(ii) Not applicable to downward flows in the case of:

a. Carriageways treated separately (see para. 13.1)

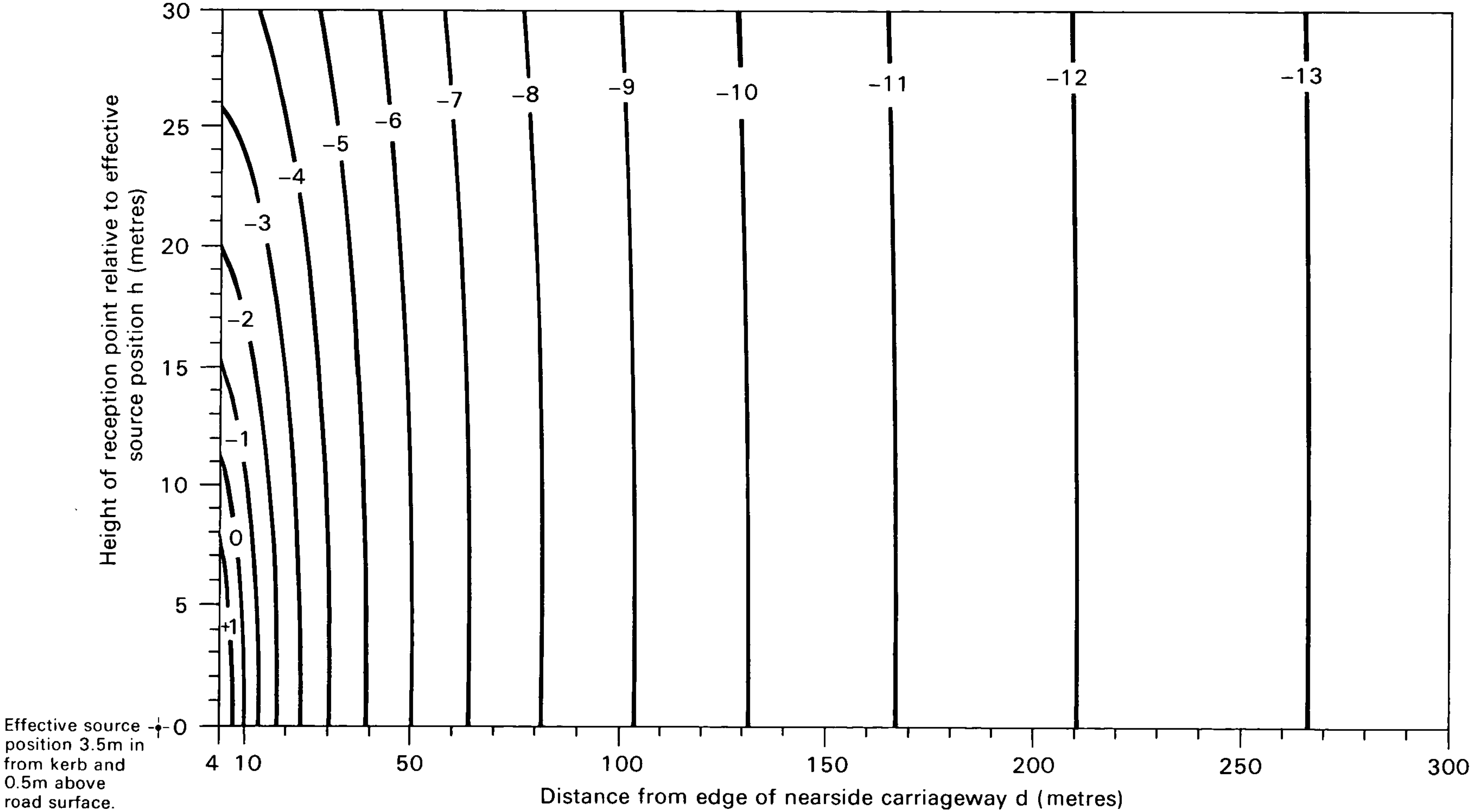
b. One way traffic schemes.

Chart 6 CORRECTION FOR GRADIENT G



Correction = 0.3 G dB(A)

Chart 7 CORRECTION FOR DISTANCE AS A FUNCTION OF HORIZONTAL DISTANCE FROM EDGE OF NEARSIDE CARRIAGEWAY d AND THE RELATIVE HEIGHT BETWEEN THE RECEPTION POINT AND THE EFFECTIVE SOURCE POSITION h.



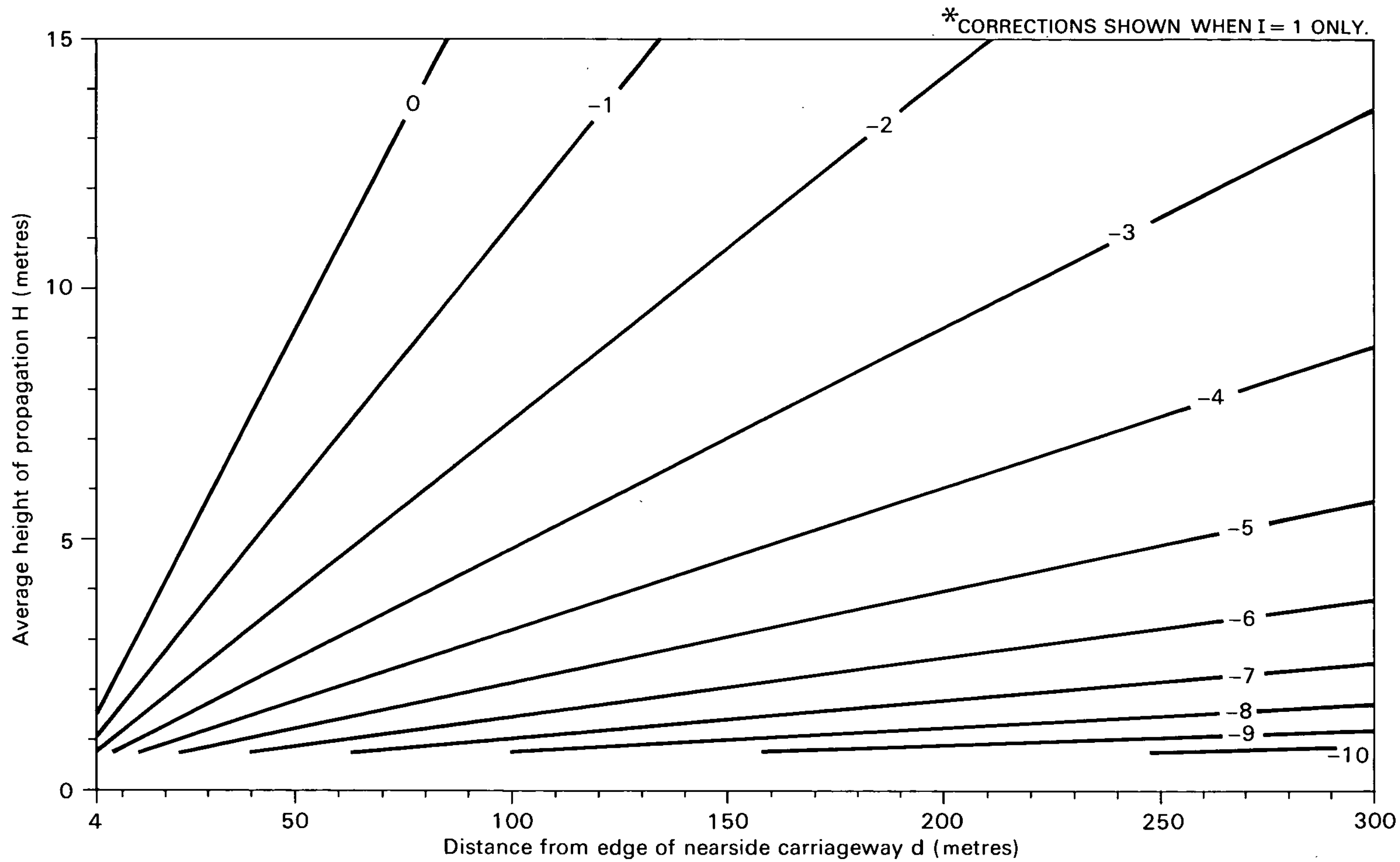
Correction = $-10 \log_{10}(d'/13.5)$ dB(A)

where d' = shortest slant distance from the effective source position

$= [(d + 3.5)^2 + h^2]^{1/2}$

Valid for $d \geqslant 4$ metres

Chart 8 CORRECTION FOR GROUND ABSORPTION AS A FUNCTION OF HORIZONTAL DISTANCE FROM EDGE OF NEARSIDE CARRIAGEWAY d, THE AVERAGE HEIGHT OF PROPAGATION H AND THE PROPORTION OF ABSORBENT GROUND I*



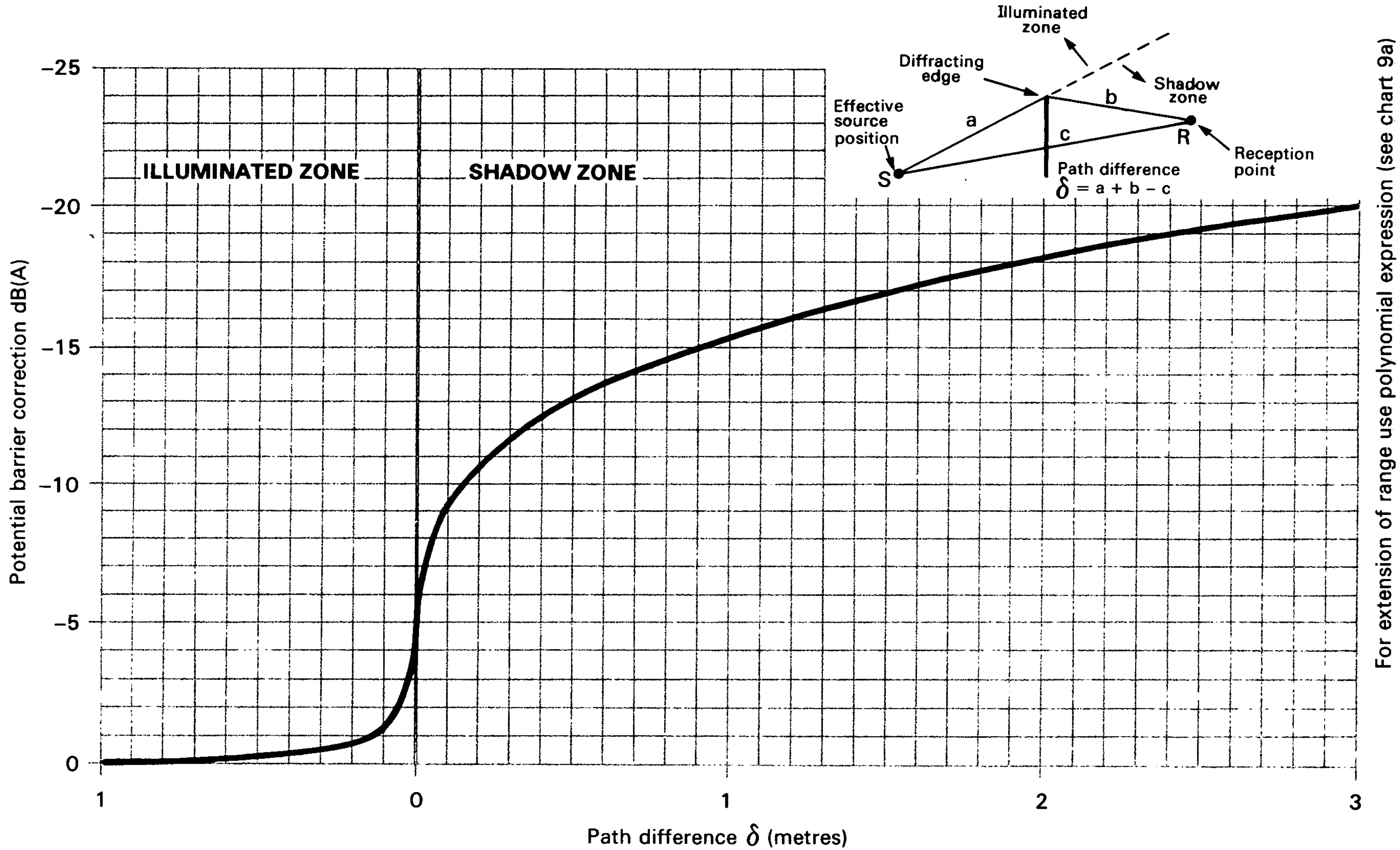
For $0.75 \leq H < \frac{d+5}{6}$; CORRECTION = $5.2\,I\,\log_{10}\left(\frac{6H-1.5}{d+3.5}\right)$ dB (A)

For $H < 0.75$ CORRECTION = $5.2\,I\,\log_{10}\left(\frac{3}{d+3.5}\right)$ dB (A)

For $H \geq \frac{d+5}{6}$ CORRECTION = 0

Valid for $d \geqslant 4$ metres

Chart 9 POTENTIAL BARRIER CORRECTION AS A FUNCTION OF PATH DIFFERENCE δ



(See next page for functional form)

Chart 9a

Polynomial expressions for potential barrier correction

Potential barrier correction $A = A_0 + A_1 x + A_2 x^2 + \ldots + A_n x^n$ where $x = \mathrm{Log}_{10}\,\delta$ (δ being the path difference in metres between the direct and diffracted rays), the coefficients A_n being given in the table below.

	Shadow zone	*Illuminated zone*
A_0	−15.4	0
A_1	−8.26	+0.109
A_2	−2.787	−0.815
A_3	−0.831	+0.479
A_4	−0.198	+0.3284
A_5	+0.1539	+0.04385
A_6	+0.12248	
A_7	+0.02175	
Range of validity	$-3 \leq x \leq +1.2$	$-4 \leq x \leq 0$

Outside the above ranges of validity the potential barrier correction is defined as follows:

	Shadow zone	*Illuminated zone*
	For $x < -3$ $A = -5.0$	For $x < -4$ $A = -5.0$
	For $x > 1.2$ $A = -30$	For $x > 0$ $A = 0$

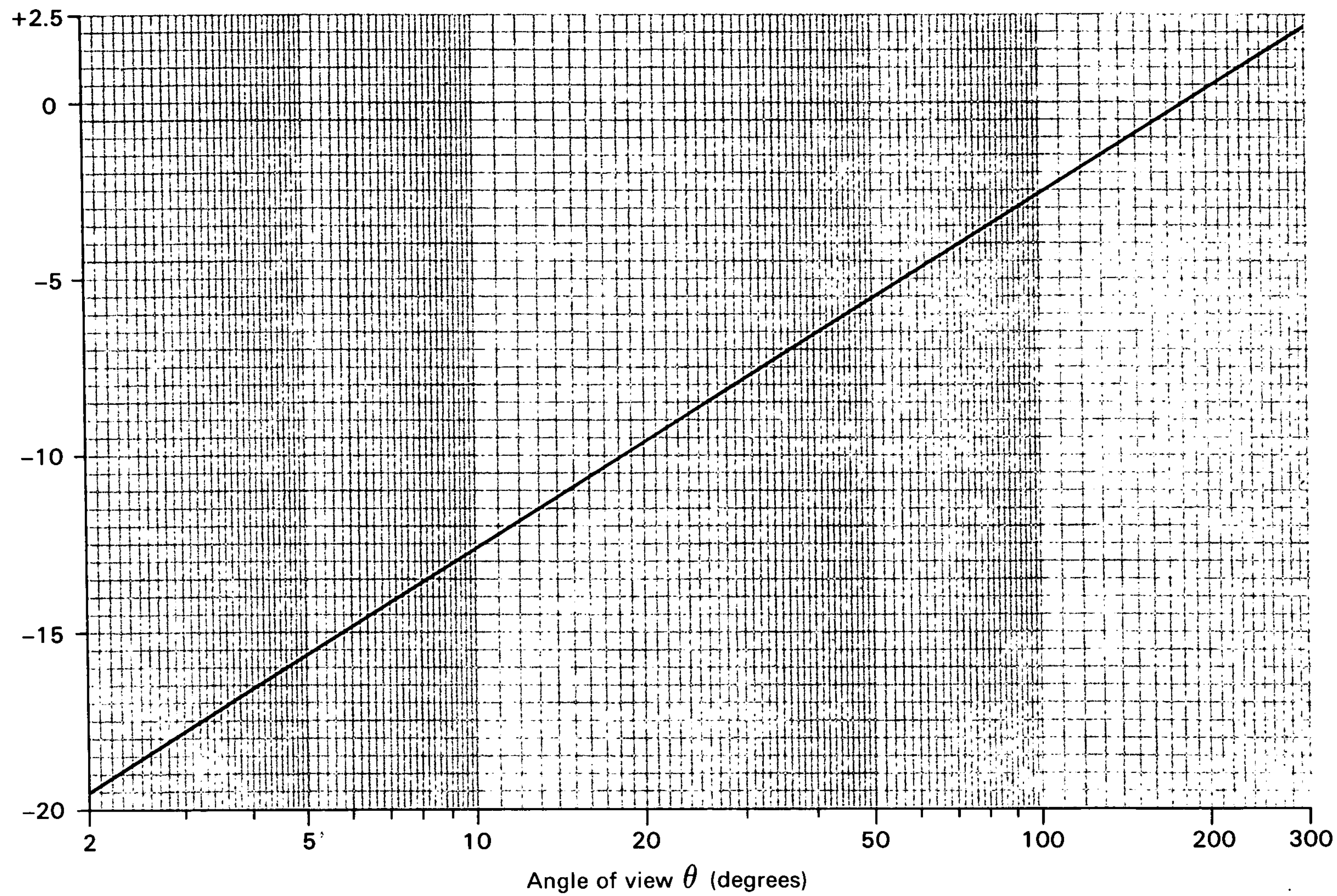
Chart 9b Potential barrier correction A* dB(A) for path differences (δ = i + j) calculated to the nearest 0.01 metres.**

j	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
i	*SHADOW ZONE*									
0.0	5.0	6.4	7.1	7.6	7.9	8.2	8.5	8.7	9.0	9.2
0.1	9.3	9.5	9.7	9.8	10.0	10.1	10.3	10.4	10.5	10.6
0.2	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.6	11.7
0.3	11.7	11.8	11.9	12.0	12.1	12.1	12.2	12.3	12.4	12.4
0.4	12.5	12.6	12.6	12.7	12.8	12.8	12.9	13.0	13.0	13.1
0.5	13.1	13.2	13.3	13.3	13.4	13.4	13.5	13.5	13.6	13.6
0.6	13.7	13.7	13.8	13.8	13.9	13.9	14.0	14.0	14.1	14.1
0.7	14.2	14.2	14.3	14.3	14.4	14.4	14.5	14.5	14.5	14.6
0.8	14.6	14.7	14.7	14.7	14.8	14.8	14.9	14.9	14.9	15.0
0.9	15.0	15.1	15.1	15.1	15.2	15.2	15.3	15.3	15.3	15.4
1.0	15.4	15.4	15.5	15.5	15.5	15.6	15.6	15.6	15.7	15.7
1.1	15.7	15.8	15.8	15.8	15.9	15.9	15.9	16.0	16.0	16.0
1.2	16.1	16.1	16.1	16.2	16.2	16.2	16.3	16.3	16.3	16.3
1.3	16.4	16.4	16.4	16.5	16.5	16.5	16.6	16.6	16.6	16.6
1.4	16.7	16.7	16.7	16.8	16.8	16.8	16.8	16.9	16.9	16.9
1.5	16.9	17.0	17.0	17.0	17.1	17.1	17.1	17.1	17.2	17.2
1.6	17.2	17.2	17.3	17.3	17.3	17.3	17.4	17.4	17.4	17.4
1.7	17.5	17.5	17.5	17.5	17.6	17.6	17.6	17.6	17.7	17.7
1.8	17.7	17.7	17.8	17.8	17.8	17.8	17.8	17.9	17.9	17.9
1.9	17.9	18.0	18.0	18.0	18.0	18.1	18.1	18.1	18.1	18.1
2.0	18.2	18.2	18.2	18.2	18.3	18.3	18.3	18.3	18.3	18.4
	ILLUMINATED ZONE									
0.0	5.0	3.5	2.8	2.3	2.0	1.8	1.6	1.5	1.3	1.2
0.1	1.1	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6
0.2	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0

* Values of A are negative

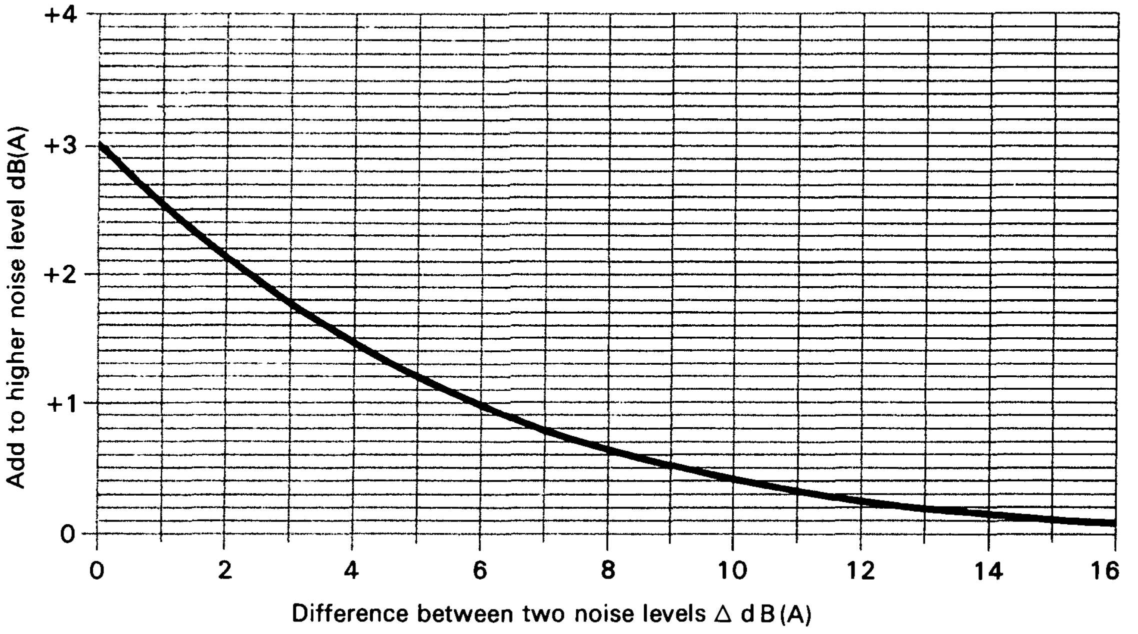
** e.g. where the reception point is in the shadow zone and δ = 1.45 metres:
then i = 1.4 and j = 0.05
from the table the value of A is − 16.8 dB(A).

Chart 10 CORRECTION FOR ANGLE OF VIEW OF ROAD, θ.



Correction = 10 $\log_{10}[\theta/180]$ dB(A)

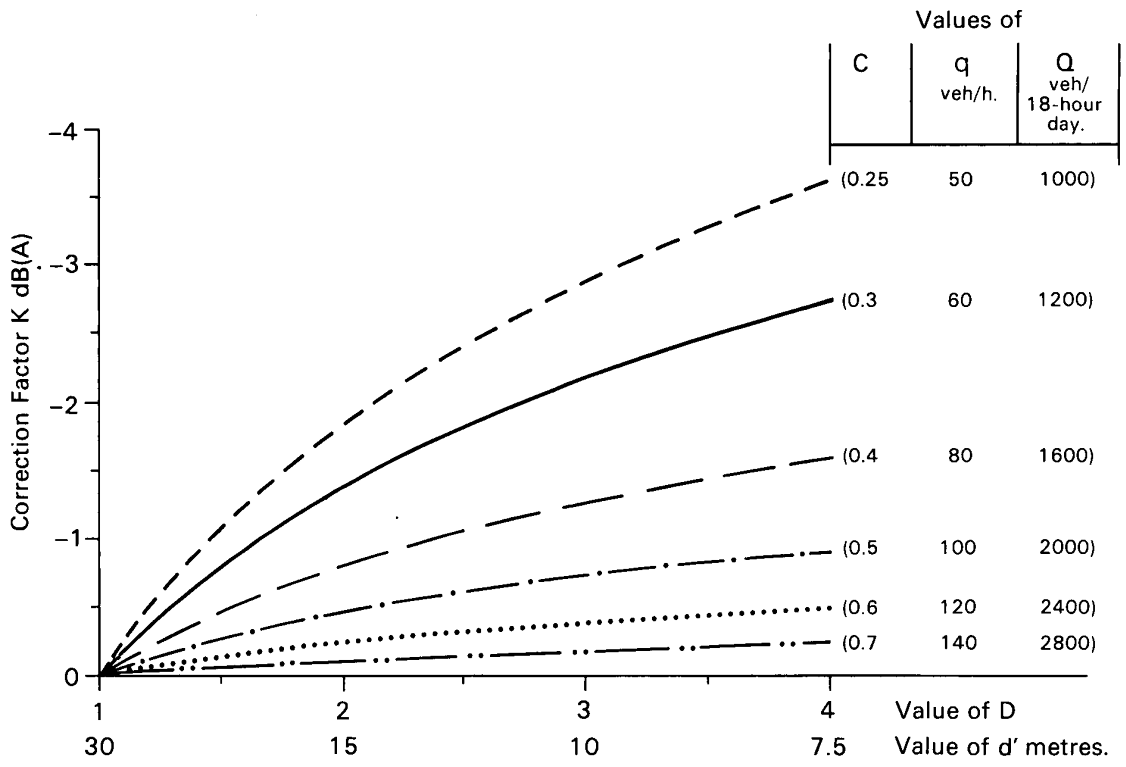
Chart 11 PROCEDURE FOR COMBINING NOISE LEVELS.



(i) Given two noise levels L and L − Δ then the combined level is
$L + 10\ Log_{10}[1 + Antilog_{10}(-\Delta/_{10})]$ dB (A)
which can be evaluated using the above chart.

(ii) With n component noise levels $L_1, L_2, \ldots\ldots, L_n$ the combined noise level due to all n components is given by
$L = 10\ Log_{10}[\sum_{1}^{n} Antilog_{10}(Ln/10)]$ dB (A)

Chart 12 CORRECTION FOR LOW TRAFFIC FLOW, K



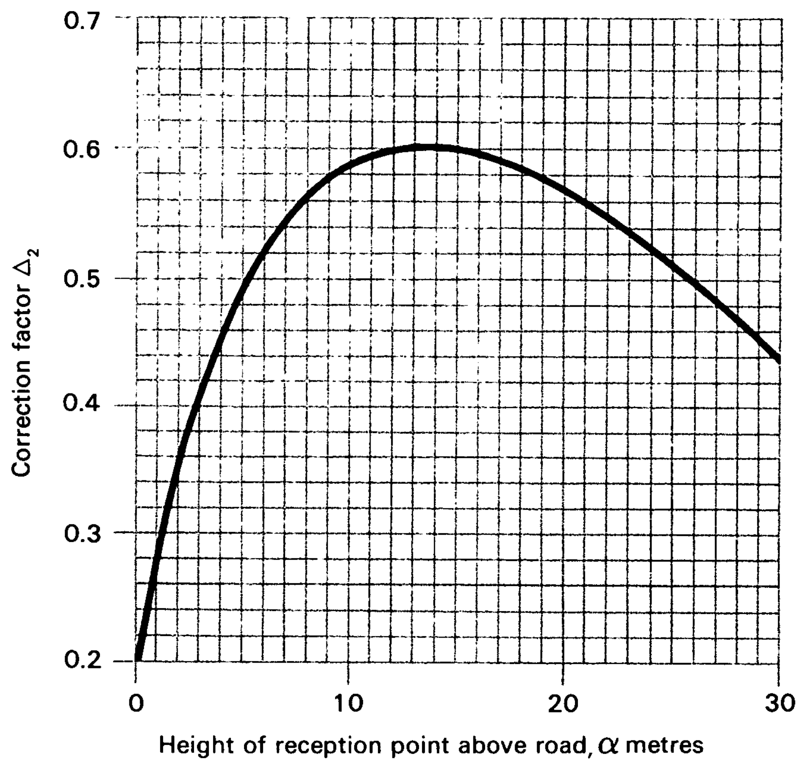
For $1 < D \leqslant 4$ and $0.25 \leqslant C < 1$

CORRECTION FACTOR $K=-16.6\,(\text{Log}_{10} D)(\text{Log}_{10} C)^2$ **dB(A)**

For $D \leqslant 1$	$K = O$	i.e.	$d' \geqslant 30$ metres.
For $C \geqslant 1$	$K = O$	i.e.	$q \geqslant 200$ veh/h.
		or	$Q \geqslant 4000$ veh/18 hour day.

Chart 13 CORRECTION FACTORS Δ_2 AND Δ_3 IN TERMS OF HEIGHT OF RECEPTION POINT α AND DISTANCE ß

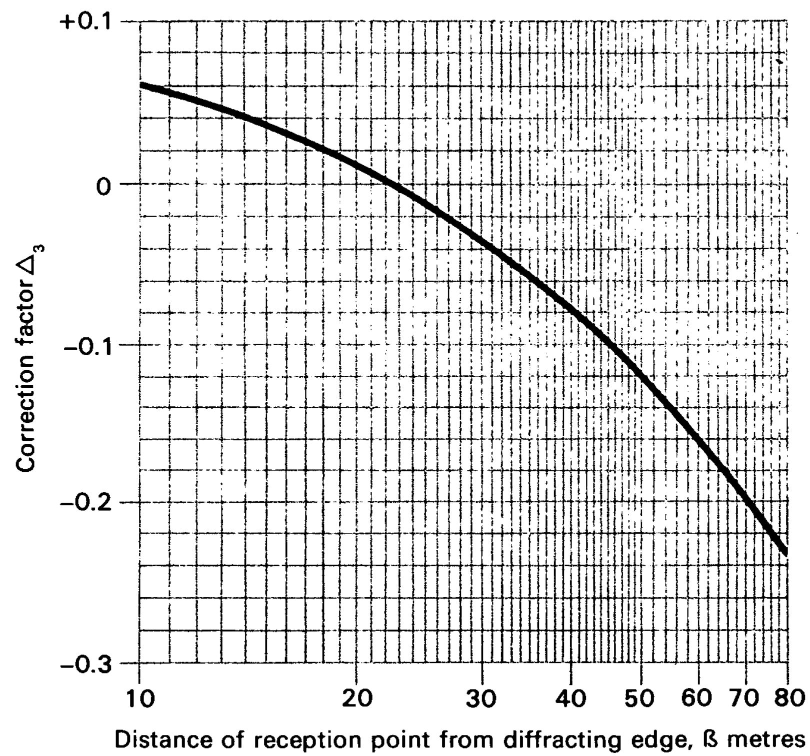
[To be used in conjunction with Charts 14 and 15]



CORRECTION FACTOR $\Delta_2=[8.2-3\mathrm{Log}_{10}(\alpha+10)]\mathrm{Log}_{10}(\alpha+10)-5$

for $\alpha < 0$ $\Delta_2 = 0.2$

for $\alpha > 30$ $\Delta_2 = 0.44$



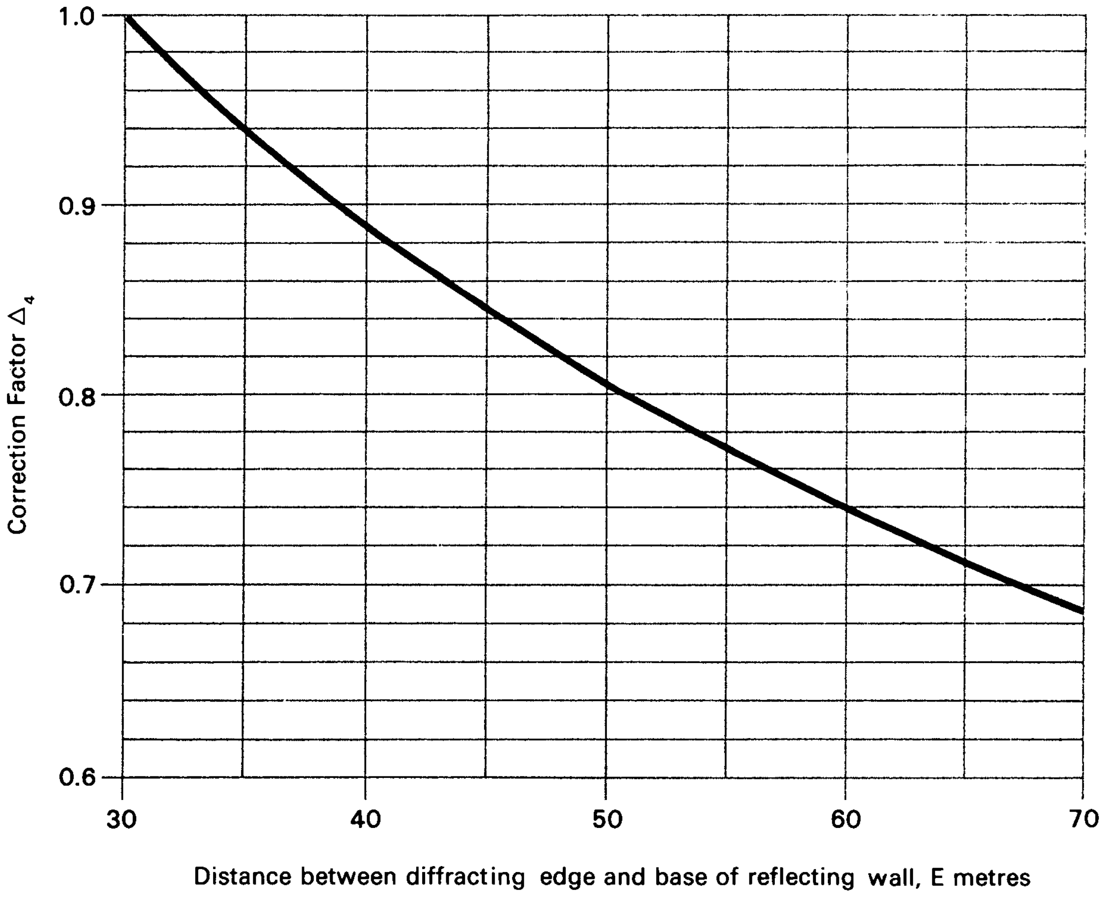
CORRECTION FACTOR $\Delta_3=[1-0.6\,\mathrm{Log}_{10}(35+\frac{ß}{2})]\mathrm{Log}_{10}(35+\frac{ß}{2})$

for $ß < 10$ $\Delta_3 = +0.06$

for $ß > 80$ $\Delta_3 = -0.23$

Chart 14 CORRECTION FACTOR Δ_4 IN TERMS OF DISTANCE, E.

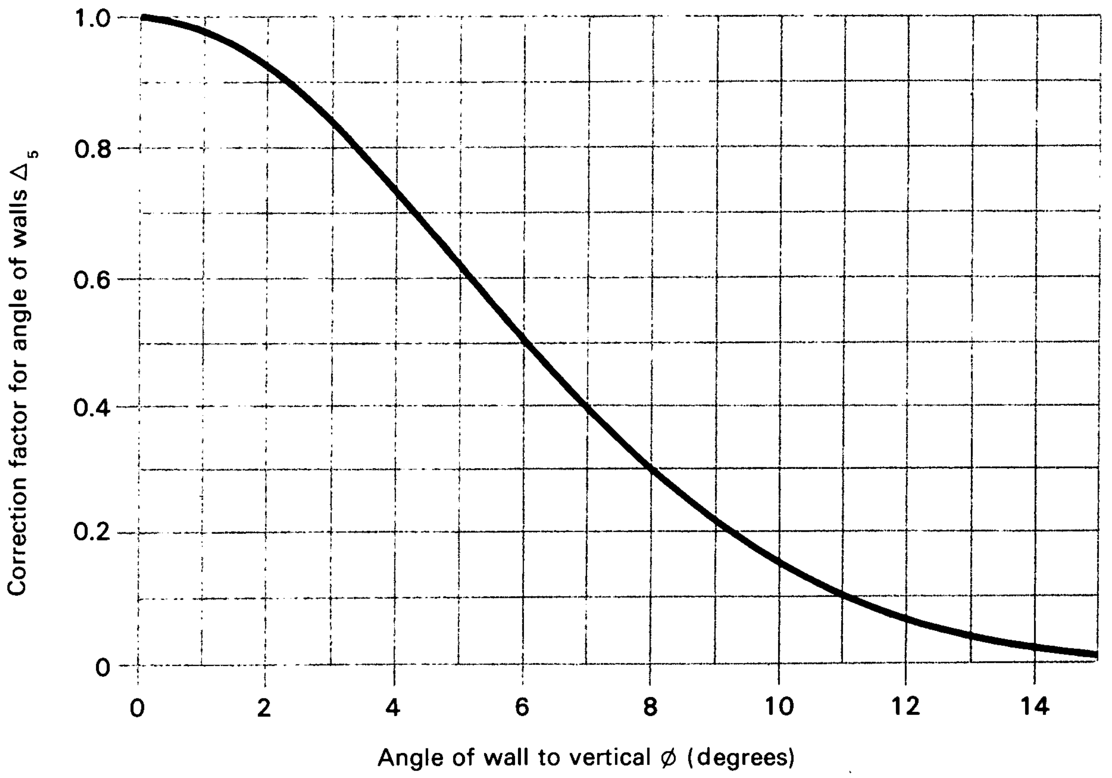
[To be used in conjunction with Charts 13 and 15]



CORRECTION FACTOR $\Delta_4 = \text{Log}_{10}[1+(270/E)]$ for $E < 30$, $\Delta_4 = 1$

for $E > 70$, $\Delta_4 = 0.69$

Chart 15 CORRECTION FACTOR Δ_5 FOR ANGLE OF THE REFLECTING WALL TO THE VERTICAL TO BE USED IN CONJUNCTION WITH CHARTS 13 to 14.



Correction Factor $\Delta_5 = \text{Exp}(-0.019\phi^2)$

where ϕ = angle of the reflecting wall to the vertical in degrees.

Chart 16a – Traffic Forecast Table

Light vehicles (1525kg or less unladen weight) *Percentage change over base year*

Future year	*Base year* 1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1986	0	0	0	0	0	0	0	0	0	0
1987	3	0	0	0	0	0	0	0	0	0
1988	7	3	0	0	0	0	0	0	0	0
1989	10	6	3	0	0	0	0	0	0	0
1990	13	9	6	3	0	0	0	0	0	0
1991	16	12	9	5	2	0	0	0	0	0
1992	18	14	11	8	5	2	0	0	0	0
1993	21	17	13	10	7	4	2	0	0	0
1994	23	19	15	12	9	6	4	2	0	0
1995	25	21	17	14	11	8	6	4	2	0
1996	27	23	19	16	12	10	8	5	3	2
1997	29	25	21	18	14	12	9	7	5	3
1998	31	27	23	19	16	13	11	9	7	5
1999	33	29	25	21	18	15	12	10	8	6
2000	35	31	26	23	19	17	14	12	10	8
2001	37	32	28	25	21	18	16	13	11	9
2002	39	34	30	26	23	20	17	15	13	11
2003	40	36	32	28	24	21	19	16	14	12
2004	42	38	33	30	26	23	20	18	16	14
2005	44	39	35	31	27	25	22	19	17	15
2006	46	41	37	33	29	26	23	21	19	17
2007	47	43	38	34	30	27	25	22	20	18
2008	49	44	40	36	32	29	26	24	21	19
2009	51	46	41	37	33	30	27	25	23	21
2010	52	47	43	39	35	32	29	26	24	22
2011	54	49	44	40	36	33	30	28	25	23
2012	55	50	46	42	38	34	32	29	27	24
2013	57	52	47	43	39	36	33	30	28	26
2014	59	54	49	44	40	37	34	31	29	27
2015	60	55	50	46	42	38	36	33	30	28
2016	62	57	52	47	43	40	37	34	32	29
2017	63	58	53	49	44	41	38	35	33	31
2018	65	60	55	50	46	42	39	37	34	32
2019	66	61	56	51	47	44	41	38	35	33
2020	68	62	57	53	48	45	42	39	37	34
2021	69	64	59	54	50	46	43	40	38	35
2022	71	65	60	56	51	48	45	42	39	37
2023	72	67	62	57	52	49	46	43	40	38
2024	74	68	63	58	54	50	47	44	41	39
2025	75	70	64	60	55	51	48	45	43	40

Chart 16b – Traffic Forecast Table

Heavy vehicles (over 1525kg unladen weight) *Percentage change over base year*

Future year	*Base year*									
	1986	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
1986	0	0	0	0	0	0	0	0	0	0
1987	1	0	0	0	0	0	0	0	0	0
1988	2	1	0	0	0	0	0	0	0	0
1989	2	2	1	0	0	0	0	0	0	0
1990	3	2	1	1	0	0	0	0	0	0
1991	4	3	2	1	1	0	0	0	0	0
1992	5	4	3	2	1	1	0	0	0	0
1993	5	4	4	3	2	1	1	0	0	0
1994	6	5	4	4	3	2	1	1	0	0
1995	7	6	5	4	3	3	2	1	1	0
1996	7	7	6	5	4	3	3	2	1	1
1997	8	7	6	6	5	4	3	3	2	1
1998	9	8	7	6	6	5	4	3	3	2
1999	10	9	8	7	6	6	5	4	3	3
2000	10	9	8	8	7	6	5	5	4	3
2001	11	10	9	8	7	7	6	5	5	4
2002	11	10	10	9	8	7	6	6	5	4
2003	12	11	10	9	9	8	7	6	6	5
2004	12	12	11	10	9	8	8	7	6	5
2005	13	12	11	10	10	9	8	7	7	6
2006	13	12	11	11	10	9	8	8	7	6
2007	14	13	12	11	10	9	9	8	7	6
2008	14	13	12	11	10	10	9	8	7	7
2009	14	13	12	12	11	10	9	8	8	7
2010	14	14	13	12	11	10	9	9	8	7
2011	15	14	13	12	11	11	10	9	8	8
2012	15	14	13	12	12	11	10	9	9	8
2013	15	14	14	13	12	11	10	10	9	8
2014	16	15	14	13	12	11	11	10	9	8
2015	16	15	14	13	12	12	11	10	9	9
2016	16	15	14	14	13	12	11	10	10	9
2017	16	16	15	14	13	12	11	11	10	9
2018	17	16	15	14	13	12	12	11	10	9
2019	17	16	15	14	13	13	12	11	10	10
2020	17	16	15	15	14	13	12	11	11	10
2021	18	17	16	15	14	13	12	12	11	10
2022	18	17	16	15	14	14	13	12	11	10
2023	18	17	16	15	15	14	13	12	11	11
2024	18	17	17	16	15	14	13	12	12	11
2025	19	18	17	16	15	14	13	13	12	11

Annexes 1 – 18

The following annexes are included to illustrate the methodology. In all cases the road surface is assumed to be impervious with a zero correction for texture depth.

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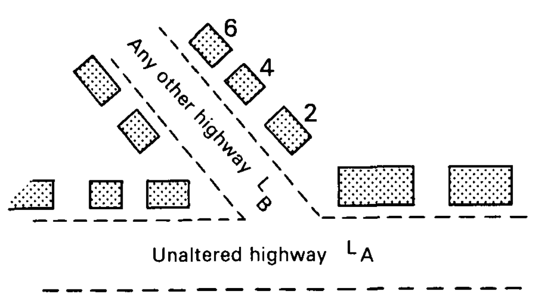
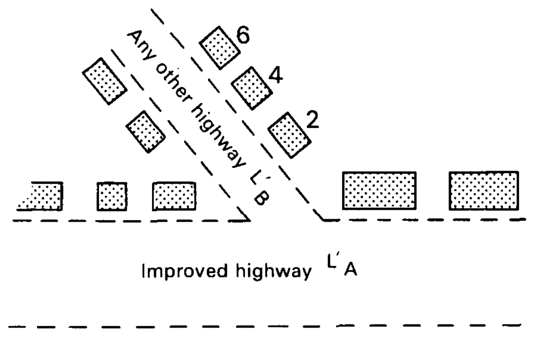
Annex. 1 ENTITLEMENT TO INSULATION UNDER THE NOISE INSULATION REGULATIONS 1975

CASE. 1.

1(a) BEFORE IMPROVEMENT

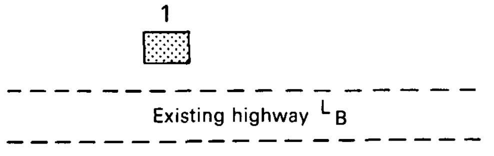


1(b) AFTER IMPROVEMENT (within 15 years)

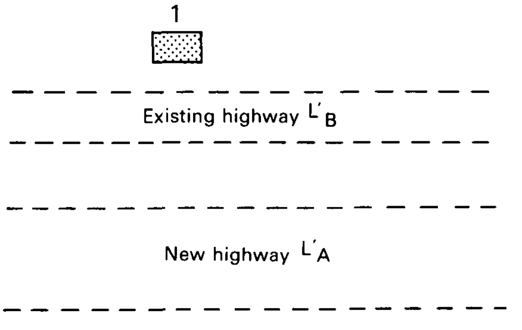


CASE. 2.

2(a) BEFORE IMPROVEMENT

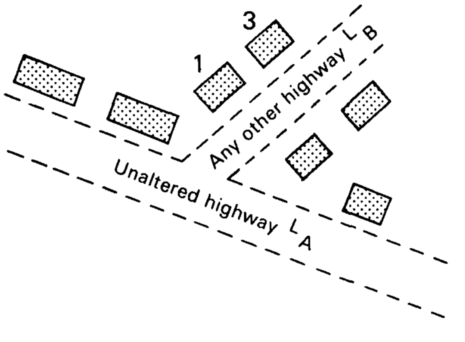


2(b) AFTER IMPROVEMENT (within 15 years)

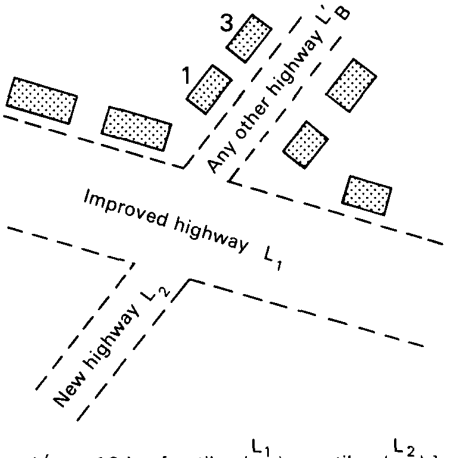


CASE. 3.

3(a) BEFORE IMPROVEMENT



3(b) AFTER IMPROVEMENT (within 15 years)



$$L'_A = 10 \log \left[\text{antilog} \left(\frac{L_1}{10}\right) + \text{antilog} \left(\frac{L_2}{10}\right) \right]$$

ANNEX 1. ENTITLEMENT TO INSULATION UNDER THE NOISE INSULATION REGULATIONS 1975

The following definitions apply when considering the conditions for entitlement (see para 6).

Prevailing Noise Level (PNL) = $10 \text{ Log}_{10} (\text{Antilog}_{10} \frac{L_A}{10} + \text{Antilog}_{10} \frac{L_B}{10})$

where L_A = noise level from a highway or highways which are to be altered

L_B = noise level from all other highways in the vicinity immediately before works to alter L_A begin.

Relevant Noise Level (RNL) = $10 \text{ Log}_{10} (\text{Antilog}_{10} \frac{L'_A}{10} + \text{Antilog}_{10} \frac{L'_B}{10})$

where L'_A = maximum noise level, within 15 years, from altered highways and/or from completely new highways.

L'_B = maximum level from all other highways within 15 years.

Taking the above definitions a property will be eligible for insulation when

(i) RNL ≥ 68 dB(A) [NB 67.5 dB(A) and above is rounded up to 68 dB(A)]
(ii) RNL − PNL ≥ + 1.0 dB(A)
(iii) RNL − L'_B ≥ + 1.0 dB(A)

For the purposes of illustration 3 cases are detailed below and a plan of each site is shown opposite.

CASE 1. To calculate whether there is entitlement at No 6. The noise levels at 1m from facade are

L_A = 64.2 dB(A), L_B = 64.1 dB(A) } Chart 11 Combined Noise Level PNL = 67.2 dB(A)

L'_A = 67.1 dB(A), L'_B = 66.4 dB(A) } Chart 11 Combined Noise Level RNL = 69.8 dB(A)

(i) RNL = 70 dB(A) (rounded to the nearest whole number)
(ii) RNL − PNL = 2.6 dB(A)
(iii) RNL − L'_B = 3.4 dB(A)

In this case there is possible entitlement, subject to Regulation 4.

CASE 2. To calculate whether there is entitlement at No 1. The noise levels at 1m from facade are

L_A = 0 (A new highway is to be constructed)

L_B = 70.1 dB(A) Therefore PNL = 70.1 dB(A)

L'_A = 66.1 dB(A), L'_B = 65.2 dB(A) } Chart 11 Combined Noise Level RNL = 68.7 dB(A)

(i) RNL = 69 dB(A) (rounded to the nearest whole number)
(ii) RNL − PNL = −1.4 dB(A)
(iii) RNL − L'_B = 3.5 dB(A)

There is no entitlement since the second condition is not met. The traffic has been moved away from the property and the noise level reduced.

CASE 3. To calculate whether there is entitlement at No 3. The noise levels at 1m from the facade are

L_A = 57.7 dB(A), L_B = 67.1 dB(A) } Chart 11 Combined Noise Level PNL = 67.6 dB(A)

L_1 = 61.7 dB(A), L_2 = 55.1 dB(A) } Chart 11 Combined Noise Level L'_A = 62.6 dB(A)

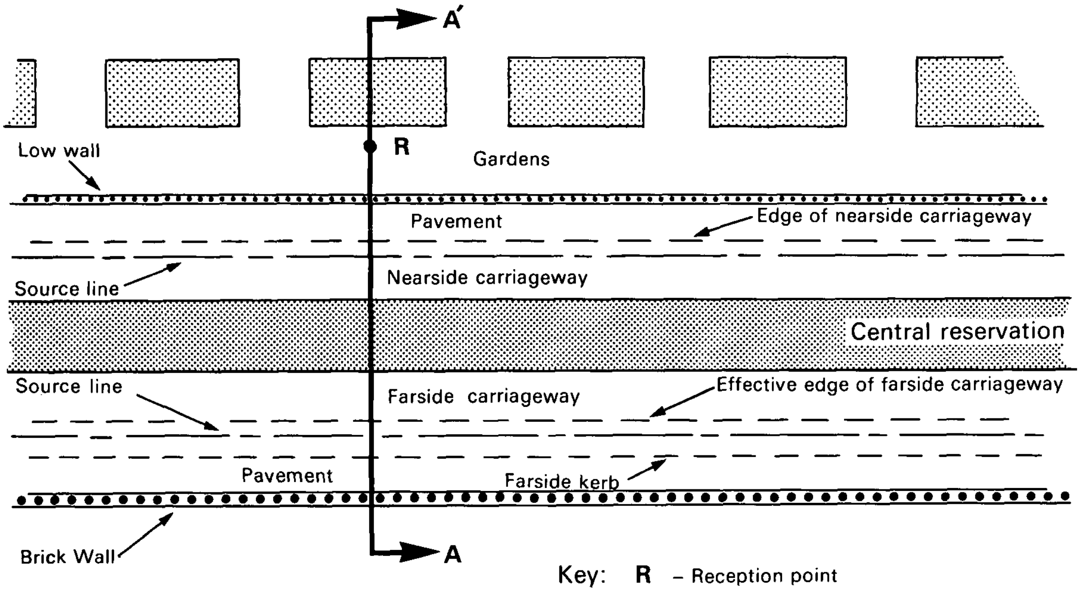
L'_A = 62.6 dB(A), L'_B = 69.3 dB(A) } Chart 11 Combined Noise Level RNL = 70.1 dB(A)

(i) RNL = 70 dB(A) (rounded to the nearest whole number)
(ii) RNL − PNL = +2.5 dB(A)
(iii) RNL − L'_B = +0.8 dB(A)

There is no entitlement since the third condition is not met. The actual contribution to the total noise level from the improved road and the new road is 0.8 dB(A).

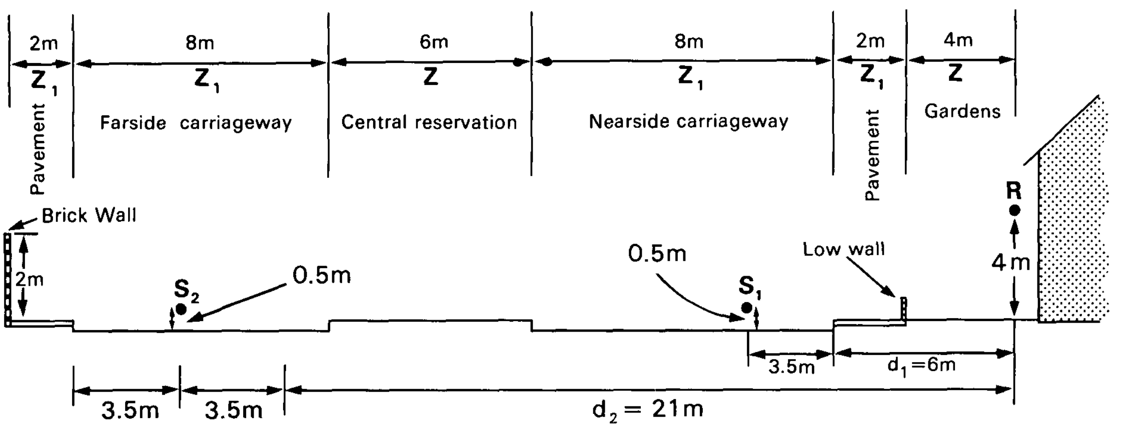
Annex. 2 HORIZONTALLY SEPARATED CARRIAGEWAYS.

PLAN VIEW



Key:
- R – Reception point
- S_1 – Source position segment 1
- S_2 – Source position segment 2
- Z – Absorbent ground cover
- Z_1 – Non-absorbent ground cover

CROSS - SECTION A A′



Segment 1: $H = 0.5(1 + 3.5) = 2.25$m

Percentage of absorbent ground $= \frac{4}{6} \times 100 \approx 67\%$; $I = 0.75$

Segment 2: $H = 2.25$m

Percentage of absorbent ground $= \frac{4+6}{21} \times 100 \approx 48\%$; $I = 0.50$

ANNEX 2. HORIZONTALLY SEPARATED CARRIAGEWAYS

OBJECT: To predict the value of L_{10} (18-hour) at a reception point 1m from the facade and at 1st floor level, 4m above the ground.

STAGE 1. SEGMENT ROAD SCHEME: The central reservation between the carriageways is greater than 5m and each carriageway needs to be treated as a separate segment (para 13.1). Segment 1 is the nearside carriageway and segment 2 is the farside carriageway.

STAGE 2. BASIC NOISE LEVEL: The road is on a gradient, the farside carriageway carrying the upward flow of traffic. Traffic speed is measured and no adjustment ΔV is required (para 14.4). The gradient correction is only applied to the upward flow (para 15). As the road surface is impervious and traffic speed less than 75 km/h a surface correction is required (para 16.1).

	SEGMENT	
	1	2
Traffic flow Q veh/18-hour day	26000	26000
Traffic speed V km/h	65	65
Heavy vehicles p %	22	22
Gradient G %	3.3 down	3.3 up
Road surface	Impervious	

	SEGMENT	
	1	2
Chart 3 L_{10} (18-hour) dB(A)	73.2	73.2
Chart 4 correction dB(A)	+3.2	+3.2
Chart 6 correction dB(A)	0	+1.0
correction dB(A)	−1.0	−1.0
Basic Noise Level dB(A)	75.4	76.4

STAGE 3. PROPAGATION: For segment 2 the effective edge of the farside carriageway is 7m in from the far kerb (para 13.1). Propagation is unobstructed, and the calculation of H and I are shown on the figure opposite.

	SEGMENT	
	1	2
Shortest horizontal distance d m	6	21
Height relative to source h m	3.5	3.5
Average height of propagation H m	2.25	2.25
Absorbent ground cover I	0.75	0.50
Barrier path difference δ m		

	SEGMENT	
	1	2
Chart 7 correction dB(A)	+1.2	−2.6
Chart 8 correction dB(A)	−0.4	−0.8
Chart 9 correction dB(A)	0	0
Propagation Correction dB(A)	+0.8	−3.4

STAGE 4. SITE LAYOUT: A facade correction is required (para 26.1). A reflection correction for the 2m high wall is required but only for segment 2 because it is only alongside this carriageway (para 26.2).

	SEGMENT	
	1	2
Facade		
Opposite facade angle θ′ deg.	0	180
Angle of view segment θ deg.	180	180

	SEGMENT	
	1	2
correction dB(A)	+2.5	+2.5
reflection correction dB(A)	0	+1.5
Chart 10 correction dB(A)	0	0
Site Layout Correction dB(A)	+2.5	+4.0

STAGE 5. COMBINING NOISE LEVELS:

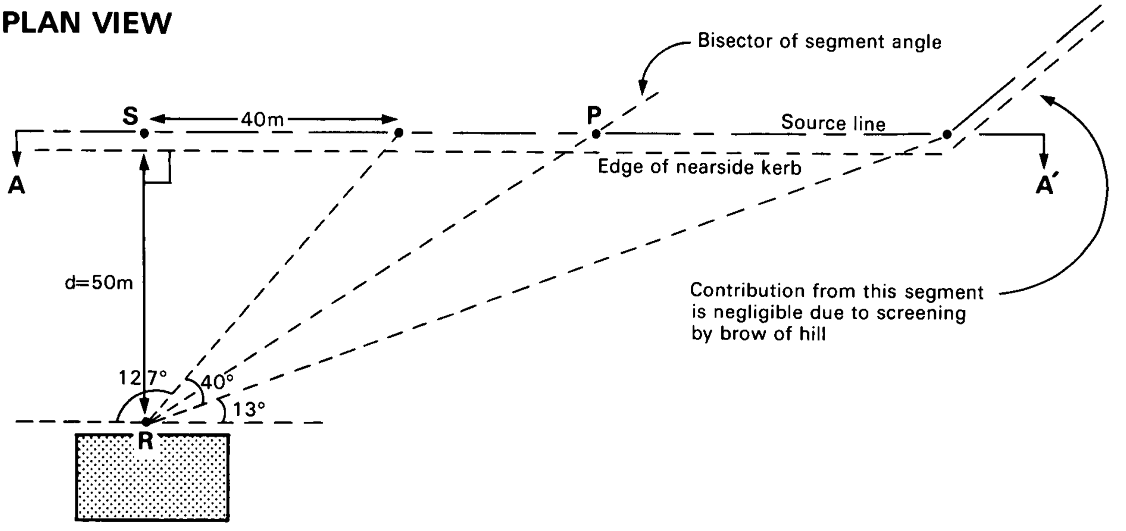
	SEGMENT	
	1	2
Basic Noise Level dB(A)	75.4	76.4
Propagation Correction dB(A)	+0.8	−3.4
Site Layout Correction dB(A)	+2.5	+4.0
Noise Contribution dB(A)	78.7	77.0
Chart 11 Combined Noise Level dB(A)	80.9	

Rounding to the nearest whole number:

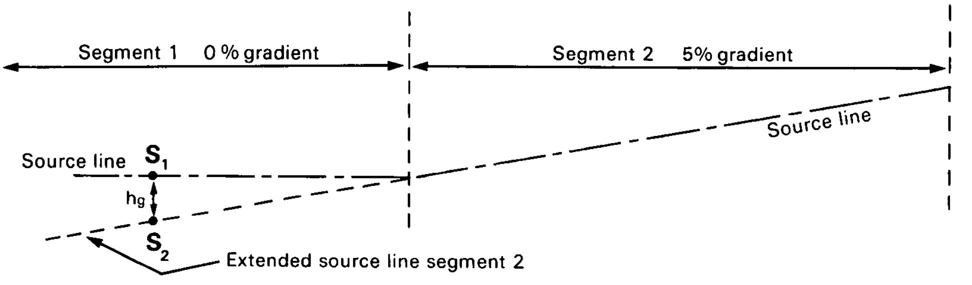
Predicted value of L_{10} (18-hour) is 81 dB(A)

Annex. 3. ROAD ON A GRADIENT.

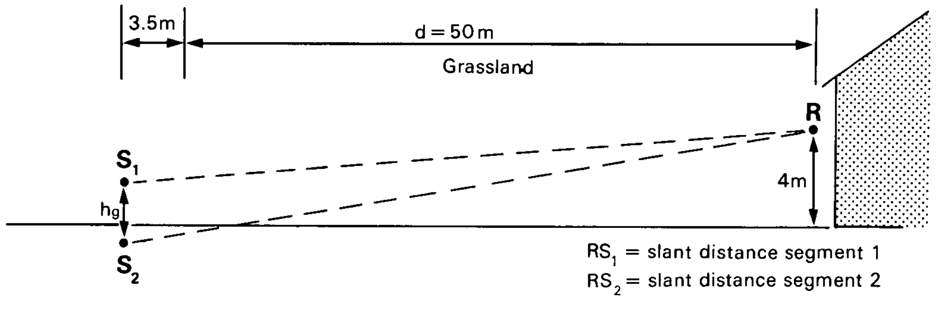
PLAN VIEW



CROSS-SECTION AA′



CROSS-SECTION RS



Segment 1 $h = 4 - 0.5 = 3.5m$ $d = 50m$

$H = 0.5(1 + 3.5) = 2.25m$

$I = 1$ (Grassland)

Segment 2 $h = 3.5 + h_g = 3.5 + \frac{40 \times 5}{100} = 5.5m$ $d = 50m$

$H = 0.5(1 + 3.5) = 2.25m$ (Calculated along bisector of segment angle, RP, and assuming the ground slopes uniformly towards the reception point)

$I = 1$ (Grassland)

ANNEX 3. ROAD ON A GRADIENT

OBJECT: To predict the value of L_{10} (18-hour) at a reception point 1m from the facade and at 1st floor level, 4m above the ground.

STAGE 1. SEGMENT ROAD SCHEME: The road scheme is divided into three segments. Segment 1 contains part of the road with zero gradient. Segment 2 contains part of the road with 5% gradient. Segment 3 contains the remaining part of the road screened by the intervening ground, its contribution is negligible and ignored in the calculation.

STAGE 2. BASIC NOISE LEVEL: The road is classified as a single carriageway with a 50 mph speed limit. Segment 2 has a gradient with an estimated speed of 70 km/h, an adjustment ΔV is required (para 14.3). Traffic speeds are less than 75 km/h and both segments have impervious road surfaces, a surface correction is required (para 16.1).

	SEGMENT	
	1	2
Traffic flow Q veh/18-hour day	14000	14000
Traffic speed V km/h	70	65.3*
Heavy vehicles p %	10	10
Gradient G %	0	5
Road surface	Impervious	

* Chart 5 ΔV = 4.7 km/h

	SEGMENT	
	1	2
Chart 3 L_{10} (18-hour) dB(A)	70.6	70.6
Chart 4 correction dB(A)	+1.8	+1.4
Chart 6 correction dB(A)	0	+1.5
correction dB(A)	−1.0	−1.0
Basic Noise Level dB(A)	71.4	72.5

STAGE 3. PROPAGATION: Propagation is unobstructed and the ground cover is grassland. For segment 1 the intervening ground is flat. For segment 2 the distance correction is calculated by extending the nearside edge of the carriageway (para 18) and ground attenuation is calculated along the bisector of the segment angle, see diagram opposite (para 20.2).

	SEGMENT	
	1	2
Shortest horizontal distance d m	50	50
Height relative to source h m	3.5	5.5
Average height of propagation H m	2.25	2.25
Absorbent ground cover I	1	1
Barrier path difference δ m		

	SEGMENT	
	1	2
Chart 7 correction dB(A)	−6.0	−6.0
Chart 8 correction dB(A)	−3.4	−3.4
Chart 9 correction dB(A)	0	0
Propagation Correction dB(A)	−9.4	−9.4

STAGE 4. SITE LAYOUT: A facade correction is required (para 26.1).

	SEGMENT	
	1	2
Facade		
Opposite facade angle θ′ deg.	0	0
Angle of view segment θ deg.	127	40

	SEGMENT	
	1	2
correction dB(A)	+2.5	+2.5
reflection correction dB(A)	0	0
Chart 10 correction dB(A)	−1.5	−6.5
Site Layout Correction dB(A)	+1.0	−4.0

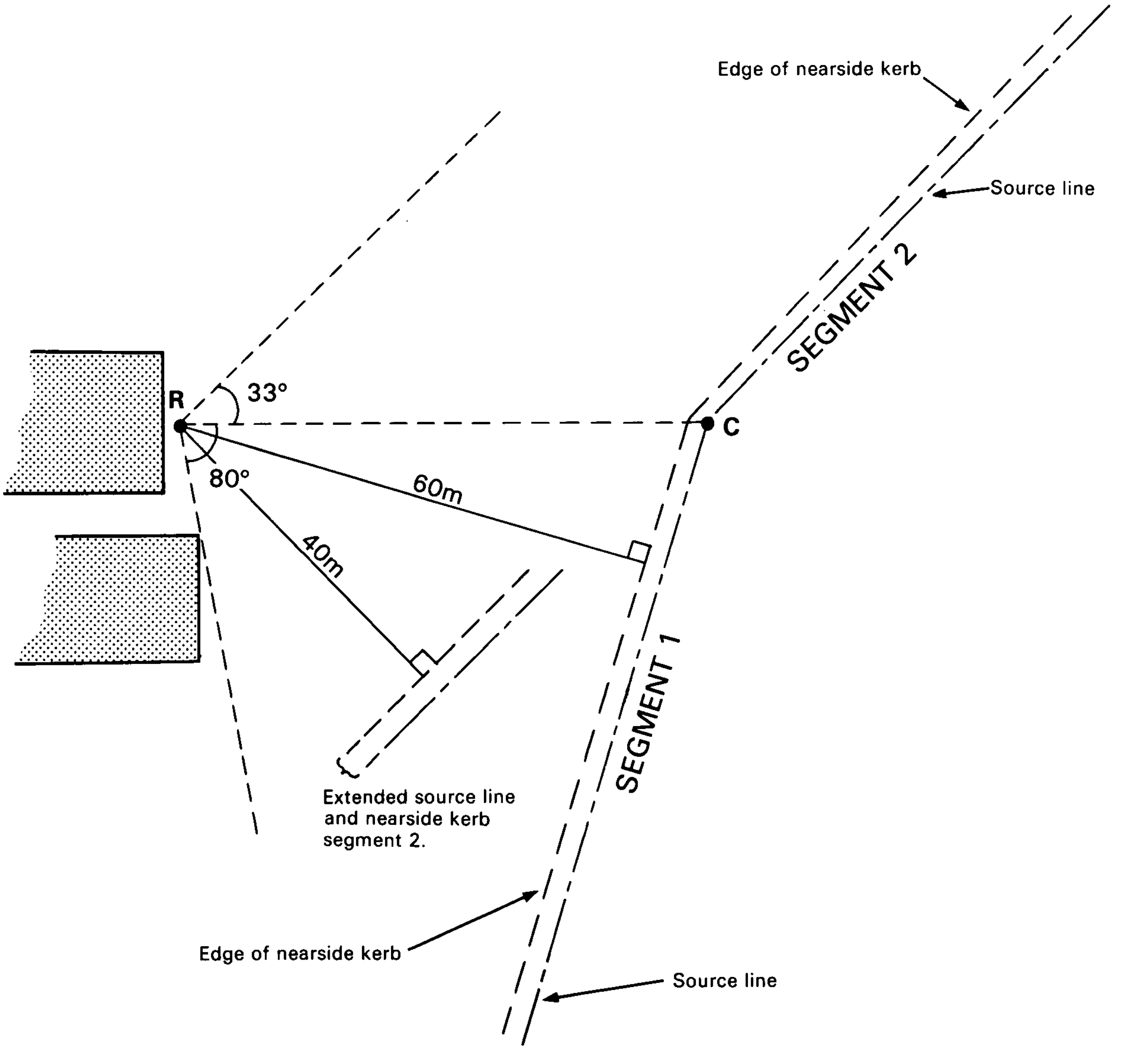
STAGE 5. COMBINING NOISE LEVELS:

	SEGMENT	
	1	2
Basic Noise Level dB(A)	71.4	72.5
Propagation Correction dB(A)	−9.4	−9.4
Site Layout Correction dB(A)	+1.0	−4.0
Noise Contribution dB(A)	63.0	59.1
Chart 11 Combined Noise Level dB(A)	64.5	

Rounding to the nearest whole number:

Predicted value of L_{10} (18-hour) is 65 dB(A)

Annex.4 USE OF A TWO SEGMENT APPROXIMATION FOR A CURVED ROAD.



Segment 1. h = 3.5m d = 60m
H = 0.5(1 + 3.5) = 2.25m I = 1 (Grassland)

Segment 2. h = 3.5m d = 40m
H = 0.5(1 + 3.5) = 2.25m I = 1 (Grassland)

ANNEX 4. USE OF A TWO SEGMENT APPROXIMATION FOR A CURVED ROAD

OBJECT: To predict L_{10} (18-hour) value at a reception point 1m from the facade and 4m above the ground.

STAGE 1. SEGMENT ROAD SCHEME: The curved road can be approximated, in this case, by two straight road segments. The segment boundary is determined by the point C where the two effective source lines intersect see diagram opposite.

STAGE 2. BASIC NOISE LEVEL: The road is subject to a speed limit of 30 mph. There is no gradient and no adjustment ΔV is required. The road surface is impervious and a surface correction is required as traffic speed is less than 75 km/h (para 16.1).

	SEGMENT 1	SEGMENT 2
Traffic flow Q veh/18-hour day	7000	7000
Traffic speed V km/h	50	50
Heavy vehicles p %	5	5
Gradient G %	0	0
Road surface	Impervious	

	SEGMENT 1	SEGMENT 2
Chart 3 L_{10} (18-hour) dB(A)	67.6	67.6
Chart 4 correction dB(A)	−1.0	−1.0
Chart 6 correction dB(A)	0	0
correction dB(A)	−1.0	−1.0
Basic Noise Level dB(A)	65.6	65.6

STAGE 3. PROPAGATION: Propagation is unobstructed and the intervening ground cover is flat grassland. For Segment 2 the distance correction is calculated by extending the edge of the nearside carriageway (para 18).

	SEGMENT 1	SEGMENT 2
Shortest horizontal distance d m	60	40
Height relative to source h m	3.5	3.5
Average height of propagation H m	2.25	2.25
Absorbent ground cover I	1	1
Barrier path difference δ m		

	SEGMENT 1	SEGMENT 2
Chart 7 correction dB(A)	−6.7	−5.1
Chart 8 correction dB(A)	−3.8	−2.9
Chart 9 correction dB(A)	0	0
Propagation Correction dB(A)	−10.5	−8.0

STAGE 4. SITE LAYOUT: A facade correction is required (para 26.1).

	SEGMENT 1	SEGMENT 2
Facade		
Opposite facade angle θ′ deg.	0	0
Angle of view segment θ deg.	80	33

	SEGMENT 1	SEGMENT 2
correction dB(A)	+2.5	+2.5
reflection correction dB(A)	0	0
Chart 10 correction dB(A)	−3.5	−7.4
Site Layout Correction dB(A)	−1.0	−4.9

STAGE 5. COMBINING NOISE LEVELS:

	SEGMENT 1	SEGMENT 2
Basic Noise Level dB(A)	65.6	65.6
Propagation Correction dB(A)	−10.5	−8.0
Site Layout Correction dB(A)	−1.0	−4.9
Noise Contribution dB(A)	54.1	52.7
Chart 11 Combined Noise Level dB(A)	56.5	

Rounding to the nearest whole number:

Predicted value of L_{10} (18-hour) is 57 dB(A)

Annex 5. EXTENDED SOURCE LINE PASSING CLOSE TO RECEPTION POINT.

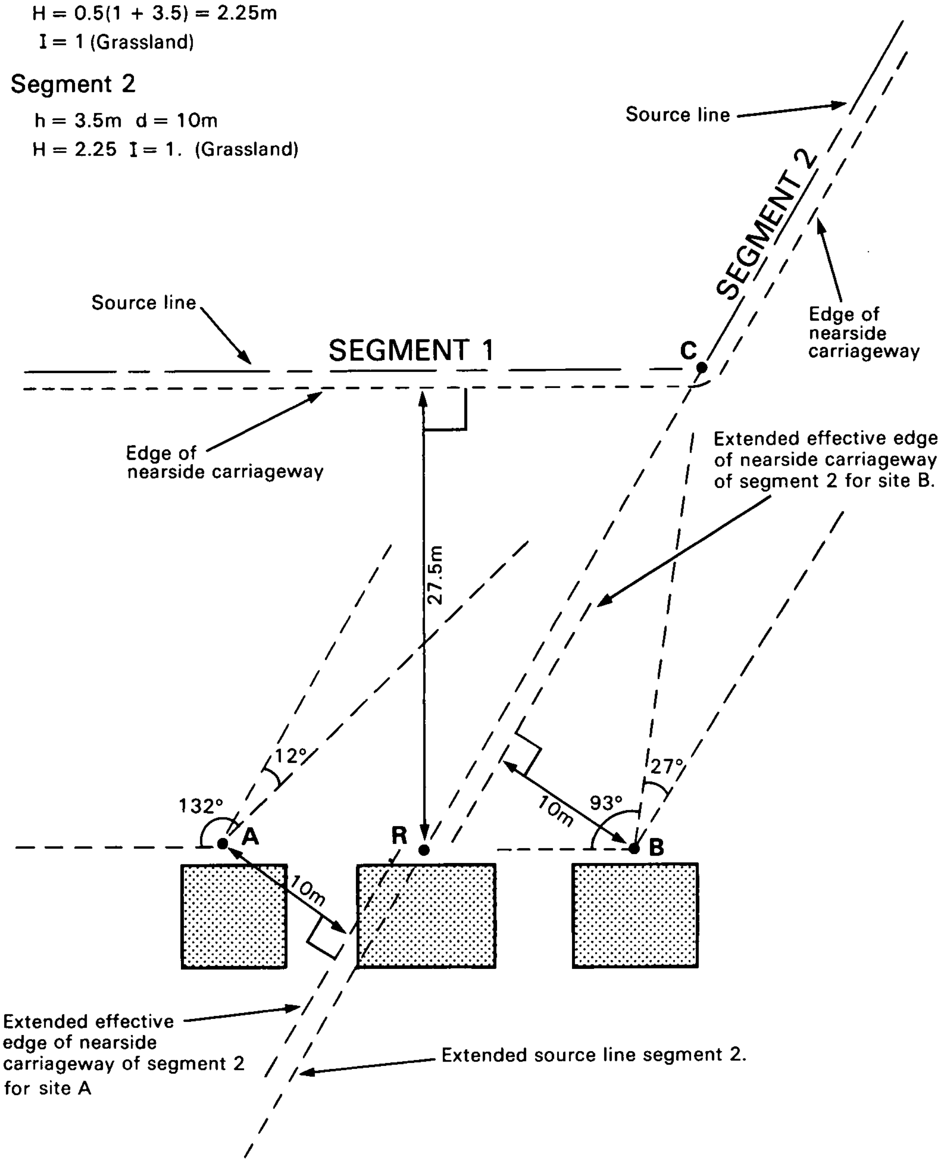
For both sites A and B.

Segment 1.

h = 3.5m, d = 27.5m
H = 0.5(1 + 3.5) = 2.25m
I = 1 (Grassland)

Segment 2

h = 3.5m d = 10m
H = 2.25 I = 1. (Grassland)



The extended source line for segment 2 passes through the reception point R and precludes the use of Chart 7 (valid for d ⩾ 4m). Two imaginary reception points A and B are chosen close to and either side of R so that this anomaly does not occur ie. at the reference distance d = 10m. The noise level at R is obtained by averaging the predicted values for sites A and B.

ANNEX 5. EXTENDED SOURCE LINE PASSING CLOSE TO RECEPTION POINT

OBJECT: To predict the L_{10} (18-hour) value at a reception point 1m from a facade and 4m above the ground.

STAGE 1. SEGMENT ROAD SCHEME: The road is curved and is approximated by two straight line segments. The segment boundary is determined by the point C where the two effective source lines intersect. For segment 2 the distance correction precludes the use of Chart 7 (d<4m). Two imaginary reception points A and B are chosen, either side of R where for segment 2, d≥4m.

STAGE 2. BASIC NOISE LEVEL: The road is subject to a speed limit of 30 mph. There is no gradient and no adjustment ΔV is required. The road surface is impervious and a surface correction is required as traffic speed is less than 75 km/h (para 16.1).

	A Segment 1	A Segment 2	B Segment 1	B Segment 2
Traffic flow Q veh/18-hour day	8000	8000	8000	8000
Traffic speed V km/h	50	50	50	50
Heavy vehicles p %	10	10	10	10
Gradient G %	0	0	0	0
Road surface	Impervious			

	A Segment 1	A Segment 2	B Segment 1	B Segment 2
Chart 3 L_{10} (18-hour) dB(A)	68.1	68.1	68.1	68.1
Chart 4 correction dB(A)	+0.2	+0.2	+0.2	+0.2
Chart 6 correction dB(A)	0	0	0	0
correction dB(A)	−1.0	−1.0	−1.0	−1.0
Basic Noise Level dB(A)	67.3	67.3	67.3	67.3

STAGE 3. PROPAGATION: Propagation is unobstructed and the intervening ground cover is flat grassland.

	A Segment 1	A Segment 2	B Segment 1	B Segment 2
Shortest horizontal distance d m	27.5	10	27.5	10
Height relative to source h m	3.5	3.5	3.5	3.5
Average height of propagation H m	2.25	2.25	2.25	2.25
Absorbent ground cover I	1	1	1	1
Barrier path difference δ m				

	A Segment 1	A Segment 2	B Segment 1	B Segment 2
Chart 7 correction dB(A)	−3.6	−0.1	−3.6	−0.1
Chart 8 correction dB(A)	−2.1	−0.3	−2.1	−0.3
Chart 9 correction dB(A)	0	0	0	0
Propagation Correction dB(A)	−5.7	−0.4	−5.7	−0.4

STAGE 4. SITE LAYOUT: A facade correction is required (para 26.1).

	A Segment 1	A Segment 2	B Segment 1	B Segment 2
Facade				
Opposite facade angle θ′ deg.	0	0	0	0
Angle of view segment θ deg.	132	12	93	27

	A Segment 1	A Segment 2	B Segment 1	B Segment 2
correction dB(A)	+2.5	+2.5	+2.5	+2.5
reflection correction dB(A)	0	0	0	0
Chart 10 correction dB(A)	−1.3	−11.8	−2.9	−8.2
Site Layout Correction dB(A)	+1.2	−9.3	−0.4	−5.7

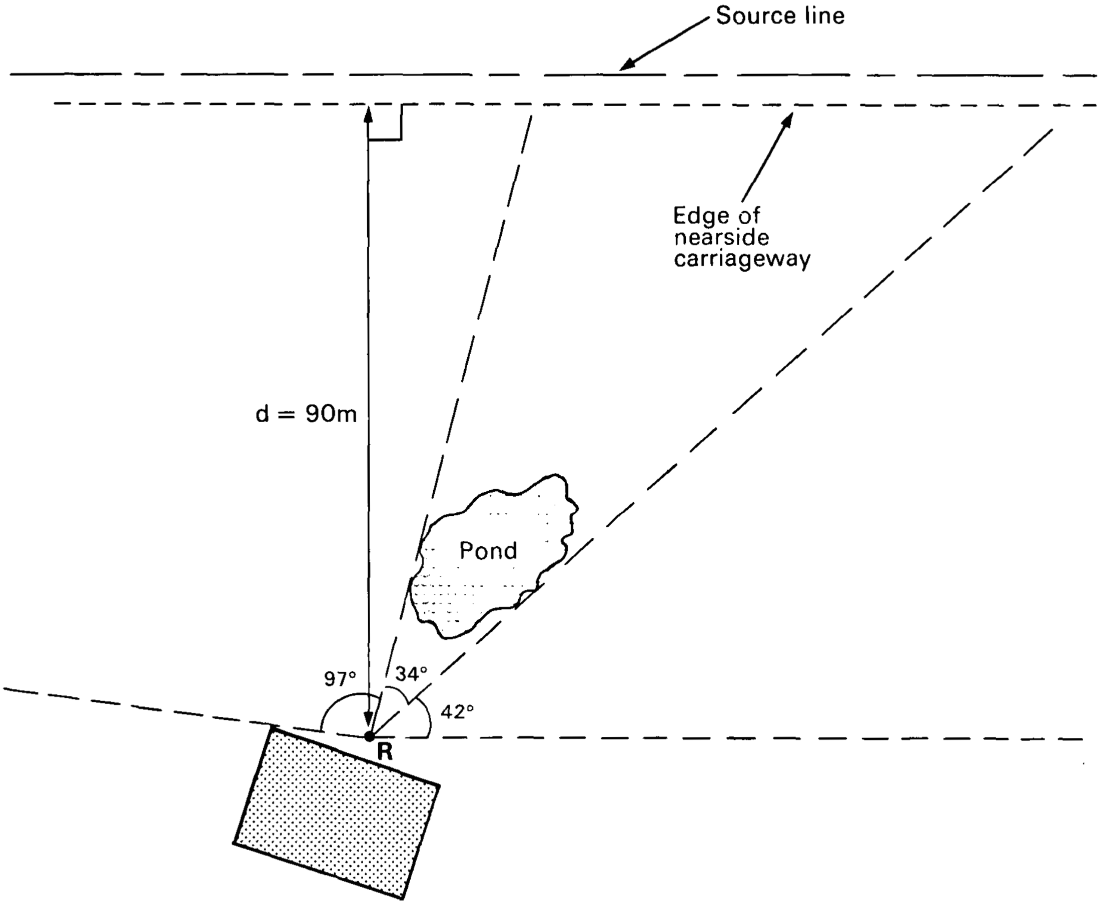
STAGE 5. COMBINING NOISE LEVELS:

	A Segment 1	A Segment 2	B Segment 1	B Segment 2
Basic Noise Level dB(A)	67.3	67.3	67.3	67.3
Propagation Correction dB(A)	−5.7	−0.4	−5.7	−0.4
Site Layout Correction dB(A)	+1.2	−9.3	−0.4	−5.7
Noise Contribution dB(A)	62.8	57.6	61.2	61.2
Chart 11 Combined Noise Level dB(A)	63.9		64.2	
Average Noise Level dB(A)	64.1			

Rounding to the nearest whole number:

Predicted value of L_{10} (18-hour) is 64 dB(A)

Annex. 6 PROPAGATION OVER MIXED GROUND COVER



The ground cover on either side of the pond is flat grassland and may be treated as a single segment, Segment 1, with an angle of view = 97° + 42° = 139°

Segment 1.
d = 90m
h = 3.5m
H = 0.5(1 + 3.5) = 2.25m
I = 1.0 (Grassland)

Segment 2.
d = 90m
h = 3.5m
H = 2.25m
I = 0.75 (the percentage of absorbent ground is between 60 - 89% see para 20.4).

ANNEX 6. PROPAGATION OVER MIXED GROUND COVER

OBJECT: To predict the L_{10} (18-hour) value at a reception point 1m from a facade and 4m above the ground.

STAGE 1. SEGMENT ROAD SCHEME: Most of the intervening ground cover is grassland and therefore absorbent while the pond is designated as non-absorbent, para 20.1. The angle of the view subtended by the pond at the reception point defines the boundary of segment 2. The area either side of segment 2 can be treated together by combining their angles of view to form segment 1 (paras 20.3 and 20.4).

STAGE 2. BASIC NOISE LEVEL: The road is a single carriageway subject to a speed limit of 50 mph. There is no gradient and no adjustment ΔV is required. The road surface is impervious and a surface correction is required as traffic speed is less than 75 km/h (para 16.1).

	SEGMENT 1	SEGMENT 2
Traffic flow Q veh/18-hour day	20000	20000
Traffic speed V km/h	70	70
Heavy vehicles p %	15	15
Gradient G %	0	0
Road surface	Impervious	

	SEGMENT 1	SEGMENT 2
Chart 3 L_{10} (18-hour) dB(A)	72.1	72.1
Chart 4 correction dB(A)	+2.6	+2.6
Chart 6 correction dB(A)	0	0
correction dB(A)	−1.0	−1.0
Basic Noise Level dB(A)	73.7	73.7

STAGE 3. PROPAGATION: Propagation is unobstructed and the intervening ground cover is flat. For Segment 2 it is estimated that the percentage of absorbent ground is between 60–89% and a value of I = 0.75 is used. (para 20.4).

	SEGMENT 1	SEGMENT 2
Shortest horizontal distance d m	90	90
Height relative to source h m	3.5	3.5
Average height of propagation H m	2.25	2.25
Absorbent ground cover I	1	0.75
Barrier path difference δ m		

	SEGMENT 1	SEGMENT 2
Chart 7 correction dB(A)	−8.4	−8.4
Chart 8 correction dB(A)	−4.6	−3.5
Chart 9 correction dB(A)	0	0
Propagation Correction dB(A)	−13.0	−11.9

STAGE 4. SITE LAYOUT: A facade correction is required (para 26.1).

	SEGMENT 1	SEGMENT 2
Facade		
Opposite facade angle θ′ deg.	0	0
Angle of view segment θ deg.	139	34

	SEGMENT 1	SEGMENT 2
correction dB(A)	+2.5	+2.5
reflection correction dB(A)	0	0
Chart 10 correction dB(A)	−1.1	−7.2
Site Layout Correction dB(A)	+1.4	−4.7

STAGE 5. COMBINING NOISE LEVELS:

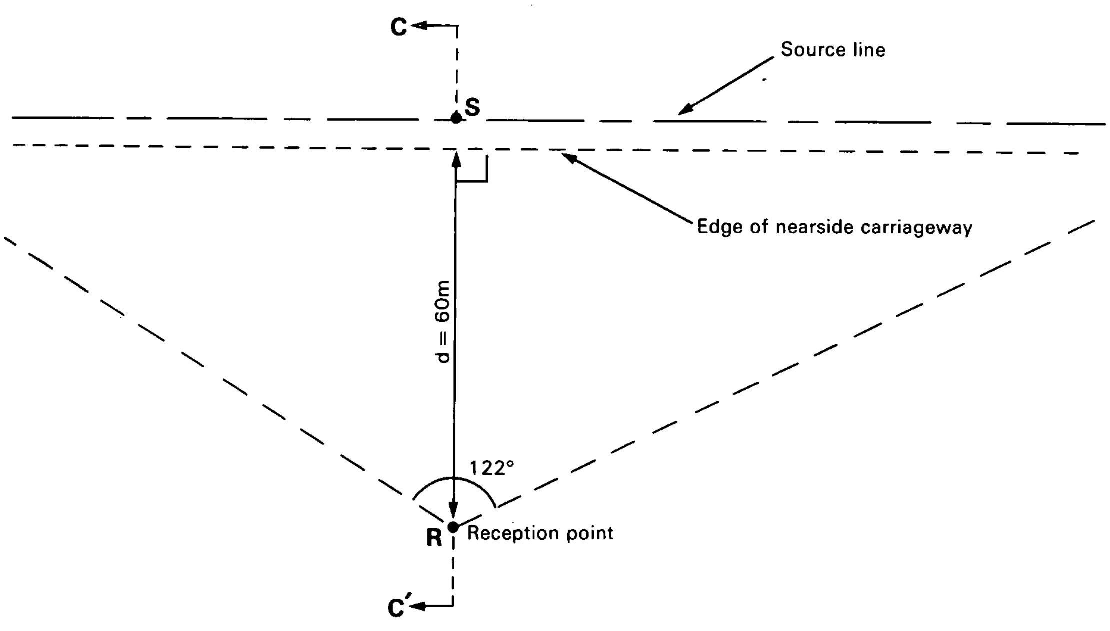
	SEGMENT 1	SEGMENT 2
Basic Noise Level dB(A)	73.7	73.7
Propagation Correction dB(A)	−13.0	−11.9
Site Layout Correction dB(A)	+1.4	−4.7
Noise Contribution dB(A)	62.1	57.1
Chart 11 Combined Noise Level dB(A)	63.3	

Rounding to the nearest whole number:

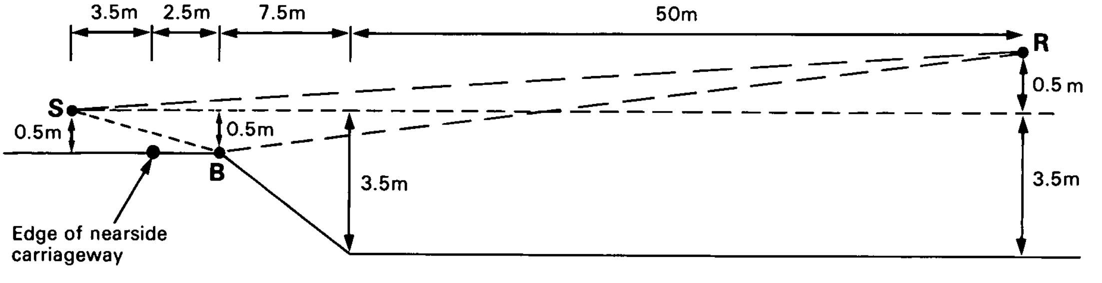
Predicted value of L_{10} (18-hour) is 63 dB(A)

Annex. 7 ELEVATED ROAD WITH GRASS BANKS.

PLAN OF SITE



CROSS-SECTION OF SITE CC'



CONDITION 1:

$d = 60m$

$h = 4 - 3.5 = 0.5m$

$$H = \frac{1}{63.5}\left(\frac{6(0.5 + 0.5)}{2} + \frac{7.5\,(0.5 + 3.5)}{2} + \frac{50(3.5 + 3.5)}{2}\right) + \frac{0.5}{2}$$

$= 3.29m$

$I = 1$ (Grassland)

CONDITION 2:

Path difference = SB + BR − SR

$= (0.5^2 + 6^2)^{\frac{1}{2}} + (1^2 + 57.5^2)^{\frac{1}{2}} - (0.5^2 + 63.5^2)^{\frac{1}{2}}$

$= 0.028m$

ANNEX 7. ELEVATED ROAD WITH GRASS BANKS

OBJECT: To predict the L_{10} (18-hour) value prior to the development of residential houses. A reception point is chosen 1m from the most exposed part of the proposed eligible facade and is 4m above the ground (para 8).

STAGE 1. SEGMENT ROAD SCHEME: The site is open with no changes in traffic variables or propagation conditions. The road can therefore be treated as a single segment.

STAGE 2. BASIC NOISE LEVEL: The road is classified as a dual carriageway with a speed limit of 50 mph. There is no gradient and no adjustment ΔV is required. The road surface is impervious and a surface correction is not required as traffic speed is greater than 75 km/h (para 16).

Traffic flow Q veh/18-hour day	35000
Traffic speed V km/h	80
Heavy vehicles p %	10
Gradient G %	0
Road surface	Impervious

Chart 3 L_{10} (18-hour) dB(A)	74.5
Chart 4 correction dB(A)	+2.6
Chart 6 correction dB(A)	0
correction dB(A)	0
Basic Noise Level dB(A)	77.1

STAGE 3. PROPAGATION: The road is elevated on a grass embankment. The view of the source line is unobstructed but the propagation path passes close to the edge of the embankment. The intervening ground cover is absorbent. The propagation correction is therefore calculated assuming ground attenuation (Condition 1) or that the embankment provides screening with the reception point in the illuminated zone (Condition 2), para 22.3.

	CONDITION	
	1	2
Shortest horizontal distance d m	60	60
Height relative to source h m	0.5	0.5
Average height of propagation H m	3.29	
Absorbent ground cover I	1	
Barrier path difference δ m		0.028

	CONDITION	
	1	2
Chart 7 correction dB(A)	−6.7	−6.7
Chart 8 correction dB(A)	−2.8	0
Chart 9 correction dB(A)	0	−2.4
Propagation Correction dB(A)	−9.5	−9.1

STAGE 4. SITE LAYOUT: Since residential development is planned a correction for the facade will normally be required (para 26.1).

	CONDITION	
	1	2
Facade		
Opposite facade angle θ′ deg.	0	0
Angle of view segment θ deg.	122	122

	CONDITION	
	1	2
correction dB(A)	+2.5	+2.5
reflection correction dB(A)	0	0
Chart 10 correction dB(A)	−1.7	−1.7
Site Layout Correction dB(A)	+0.8	+0.8

STAGE 5. COMPARING NOISE LEVELS:

	CONDITION	
	1	2
Basic Noise Level dB(A)	77.1	77.1
Propagation Correction dB(A)	−9.5	−9.1
Site Layout Correction dB(A)	+0.8	+0.8
Noise Level dB(A)	68.4	68.8

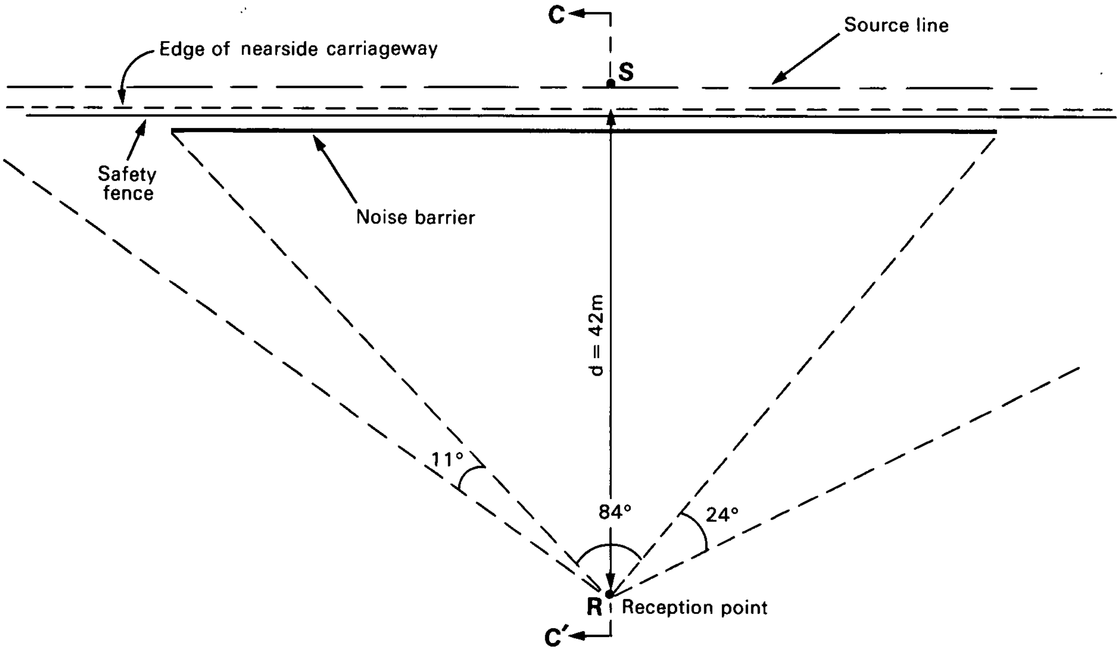
The level predicted assuming the edge of the embankment acts as a barrier is higher than the level predicted assuming ground attenuation. The lower of the two noise levels is adopted for prediction purposes, giving a value of 68.4 db(A).

Rounding to the nearest whole number gives:

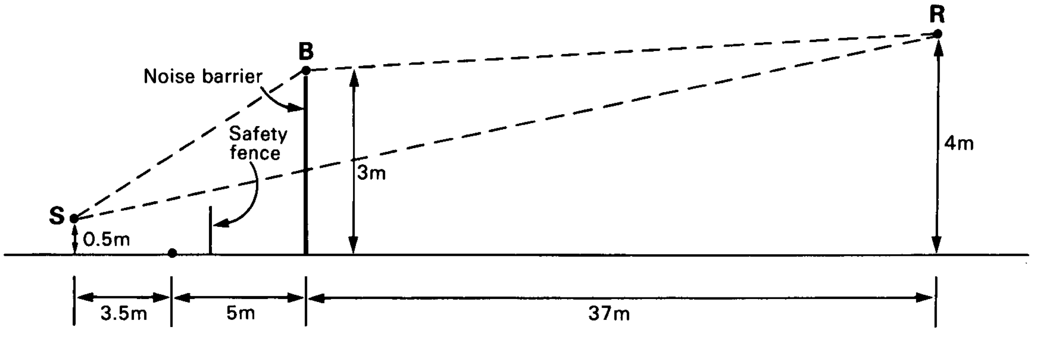
Predicted value of L_{10} (18-hour) is 68 dB(A)

Annex. 8 ROAD WITH PURPOSE - BUILT NOISE BARRIER

PLAN OF SITE



SECTION THROUGH CC′



Noise barrier path difference, δ = SB + BR − SR

$$= (2.5^2 + 8.5^2)^{\frac{1}{2}} + (1^2 + 37^2)^{\frac{1}{2}} - (3.5^2 + 45.5^2)^{\frac{1}{2}}$$

$$= 0.239\,\mathrm{m}$$

Safety fence path difference $< 0.001\,\mathrm{m}$.

ANNEX 8. ROAD WITH PURPOSE-BUILT NOISE BARRIER

OBJECT: To predict the L_{10} (18-hour) value 1 m from the rear facade of a dwelling. Reception point is 4m above the ground.

STAGE 1. SEGMENT ROAD SCHEME: Propagation is obstructed by a noise barrier which defines the boundaries of segment 1. A safety fence also runs along the whole length of the road. The segments either side of segment 1 can be treated as a single segment by combining their angles of view subtended at the reception point to form segment 2. The remainder of the site is effectively shielded by houses and may be ignored.

STAGE 2. BASIC NOISE LEVEL: Although the road is on a gradient no adjustment ΔV is required as the traffic speed is measured. A surface correction is not required as traffic speed is greater than 75 km/h (para 16).

	SEGMENT 1	SEGMENT 2
Traffic flow Q veh/18-hour day	6300	6300
Traffic speed V km/h	91	91
Heavy vehicles p %	12	12
Gradient G %	3	3
Road surface	Impervious	

	SEGMENT 1	SEGMENT 2
Chart 3 L_{10} (18-hour) dB(A)	67.1	67.1
Chart 4 correction dB(A)	+3.9	+3.9
Chart 6 correction dB(A)	+0.9	+0.9
correction dB(A)	0	0
Basic Noise Level dB(A)	71.9	71.9

STAGE 3. PROPAGATION: Segment 1 consists effectively of two barriers (para 22.4) but the screening due to the safety fence is small compared with the noise barrier and may be ignored.
For segment 2 the screening due to the safety fence is assumed greater than that offered by ground absorption (para 22.3). All path differences are calculated in the same vertical plane as the distance correction (para 21).

	SEGMENT 1	SEGMENT 2
Shortest horizontal distance d m	42	42
Height relative to source h m	3.5	3.5
Average height of propagation H m		
Absorbent ground cover I		
Barrier path difference δ m	0.239	<.001

	SEGMENT 1	SEGMENT 2
Chart 7 correction dB(A)	−5.3	−5.3
Chart 8 correction dB(A)	0	0
Chart 9 correction dB(A)	−11.2	−5.0
Propagation Correction dB(A)	−16.5	−10.3

STAGE 4. SITE LAYOUT: A facade correction is required (para 26.1).

	SEGMENT 1	SEGMENT 2
Facade		
Opposite facade angle θ′ deg.	0	0
Angle of view segment θ deg.	84	35

	SEGMENT 1	SEGMENT 2
correction dB(A)	+2.5	+2.5
reflection correction dB(A)	0	0
Chart 10 correction dB(A)	−3.3	−7.1
Site Layout Correction dB(A)	−0.8	−4.6

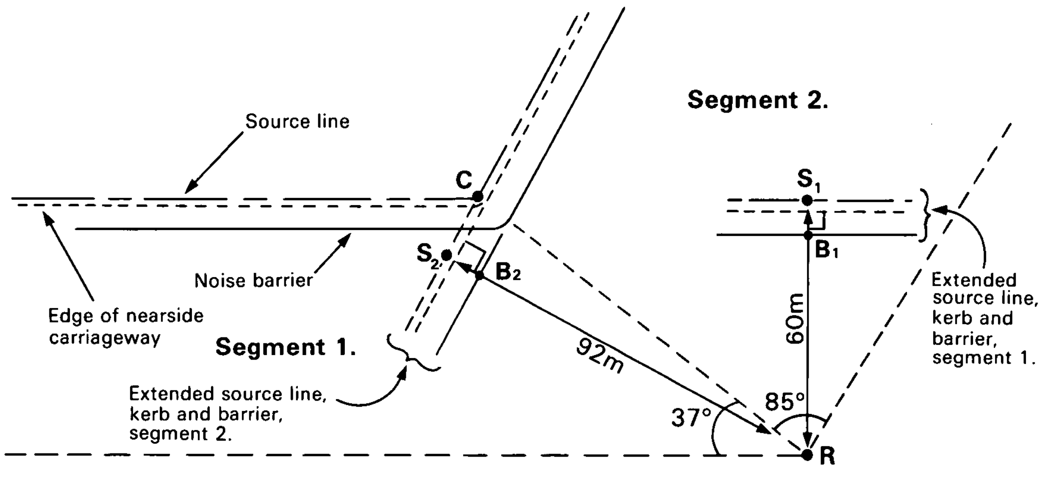
STAGE 5. COMBINING NOISE LEVELS:

	SEGMENT 1	SEGMENT 2
Basic Noise Level dB(A)	71.9	71.9
Propagation Correction dB(A)	−16.5	−10.3
Site Layout Correction dB(A)	−0.8	−4.6
Noise Contribution dB(A)	54.6	57.0
Chart 11 Combined Noise Level dB(A)	59.0	

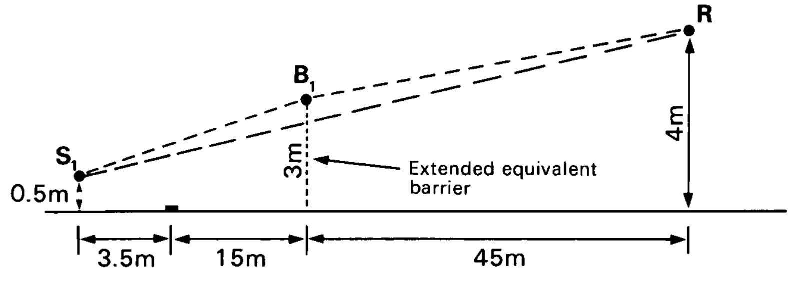
Rounding to the nearest whole number:

Predicted value of L_{10} (18-hour) is 59 dB(A)

Annex 9. CURVED ROAD WITH PURPOSE-BUILT NOISE BARRIER



Segment 1. Cross-section through RS_1

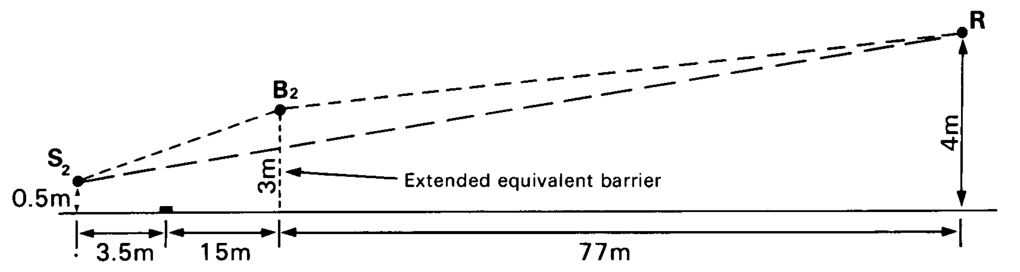


Path difference = $S_1B_1 + B_1R - S_1R$

$= (2.5^2 + 18.5^2)^{1/2} + (1^2 + 45^2)^{1/2} - (3.5^2 + 63.5^2)^{1/2}$

= 0.083m.

Segment 2. Cross section through RS_2



Path difference = $S_2B_2 + B_2R - S_2R$

$= (2.5^2 + 18.5^2)^{1/2} + (1^2 + 77^2)^{1/2} - (3.5^2 + 95.5^2)^{1/2}$

= 0.111m.

ANNEX 9. CURVED ROAD WITH PURPOSE-BUILT NOISE BARRIER

OBJECT: To predict the L_{10} (18-hour) value at a reception point 4m above the ground and 1m from a facade.

STAGE 1. SEGMENT ROAD SCHEME: The road is curved and may be approximated by two straight segments. The intersection of the source lines, C, defines the boundary of the two segments. A barrier runs parallel to the source line. The barrier is long so that the contribution from the segments at the extreme edges of the site can be ignored.

STAGE 2. BASIC NOISE LEVEL: Traffic speed is measured. The road has zero gradient and no adjustment ΔV is required. A surface correction is not required as the traffic speed is greater than 75 km/h.

	SEGMENT	
	1	2
Traffic flow Q veh/18-hour day	7200	7200
Traffic speed V km/h	85	85
Heavy vehicles p %	11	11
Gradient G %	0	0
Road surface	Impervious	

	SEGMENT	
	1	2
Chart 3 L_{10} (18-hour) dB(A)	67.7	67.7
Chart 4 correction dB(A)	+3.2	+3.2
Chart 6 correction dB(A)	0	0
correction dB(A)	0	0
Basic Noise Level dB(A)	70.9	70.9

STAGE 3. PROPAGATION: For both segments propagation is obstructed by a noise barrier. To calculate the distance correction and the path difference for each segment it is necessary to extend the edge of the nearside carriageway together with the source line and the barrier as shown in the diagram opposite (see para 22.1).

	SEGMENT	
	1	2
Shortest horizontal distance d m	60	92
Height relative to source h m	3.5	3.5
Average height of propagation H m		
Absorbent ground cover I		
Barrier path difference δ m	0.083	0.111

	SEGMENT	
	1	2
Chart 7 correction dB(A)	−6.7	−8.5
Chart 8 correction dB(A)	0	0
Chart 9 correction dB(A)	−9.0	−9.5
Propagation Correction dB(A)	−15.7	−18.0

STAGE 4. SITE LAYOUT: A facade correction is required (para 26.1).

	SEGMENT	
	1	2
Facade		
Opposite facade angle θ′ deg.	0	0
Angle of view segment θ deg.	37	85

	SEGMENT	
	1	2
correction dB(A)	+2.5	+2.5
reflection correction dB(A)	0	0
Chart 10 correction dB(A)	−6.9	−3.3
Site Layout Correction dB(A)	−4.4	−0.8

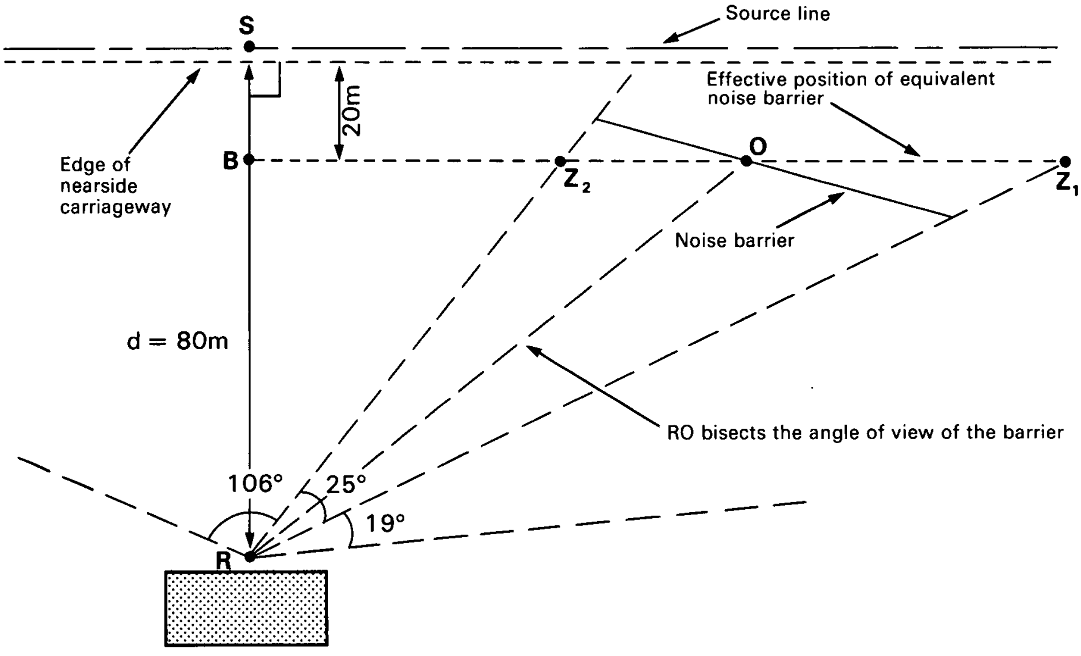
STAGE 5. COMBINING NOISE LEVELS:

	SEGMENT	
	1	2
Basic Noise Level dB(A)	70.9	70.9
Propagation Correction dB(A)	−15.7	−18.0
Site Layout Correction dB(A)	−4.4	−0.8
Noise Contribution dB(A)	50.8	52.1
Chart 11 Combined Noise Level dB(A)	54.5	

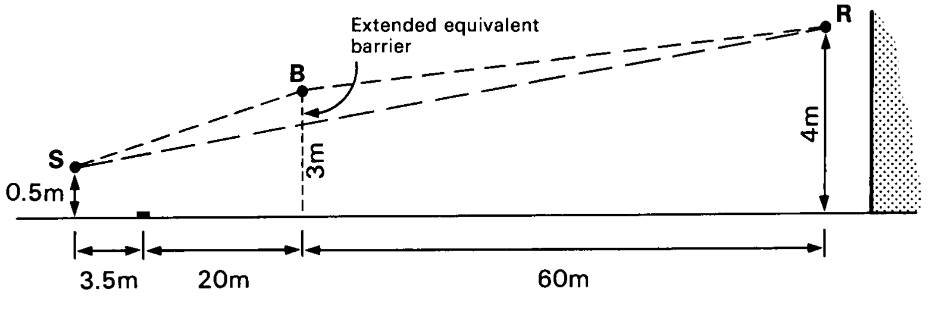
Rounding to the nearest whole number:

Predicted value of L_{10} (18-hour) is 55 dB(A)

Annex 10. SCREENING DUE TO NOISE BARRIER WHICH IS NOT PARALLEL TO THE ROAD.



Cross-Section through SR.



The path difference is calculated by extending the equivalent barrier Z_1Z_2 to B which lies in the vertical plane through SR, such that

path difference (δ) = SB + BR − SR

$= (2.5^2 + 23.5^2)^{\frac{1}{2}} + (1 + 60^2)^{\frac{1}{2}} - (3.5^2 + 83.5^2)^{\frac{1}{2}}$

= 0.068m

ANNEX 10. SCREENING DUE TO NOISE BARRIER WHICH IS NOT PARALLEL TO THE ROAD

OBJECT: To predict the L_{10} (18-hour) value 1m from a facade and 4m above the ground.

STAGE 1. SEGMENT ROAD SCHEME: Propagation is obstructed by a noise barrier which defines the boundaries of segment 1. The barrier is not parallel to the source line. A preliminary investigation reveals that the variation of barrier potential calculated for equivalent barriers parallel to the source at various points along the length of the barrier differs by less than 2 dB(A) and therefore further subdivision is not necessary (para 11). Segment 2 consists of the remaining segments where propagation is unobstructed.

STAGE 2. BASIC NOISE LEVEL: Traffic speed is measured. The road has zero gradient and no adjustment ΔV is required. A surface correction is not required as the traffic speed is greater than 75 km/h.

	SEGMENT 1	SEGMENT 2
Traffic flow Q veh/18-hour day	50000	50000
Traffic speed V km/h	100	100
Heavy vehicles p %	30	30
Gradient G %	0	0
Road surface	Impervious	

	SEGMENT 1	SEGMENT 2
Chart 3 L_{10} (18-hour) dB(A)	76.1	76.1
Chart 4 correction dB(A)	+6.5	+6.5
Chart 6 correction dB(A)	0	0
Correction dB(A)	0	0
Basic Noise Level dB(A)	82.6	82.6

STAGE 3. PROPAGATION: For segment 1 the barrier is rotated parallel to the source line about the bisector of the segment angle and extended so that the path difference is calculated in the same vertical plane as the distance correction (para 22.2). The intervening ground cover is grassland and flat.

	SEGMENT 1	SEGMENT 2
Shortest horizontal distance d m	80	80
Height relative to source h m	3.5	3.5
Average height of propagation H m		2.25
Absorbent ground cover I		1
Barrier path difference δ m	0.068	

	SEGMENT 1	SEGMENT 2
Chart 7 correction dB(A)	−7.9	−7.9
Chart 8 correction dB(A)	0	−4.4
Chart 9 correction dB(A)	−8.7	0
Propagation Correction dB(A)	−16.6	−12.3

STAGE 4. SITE LAYOUT: A facade correction is required (para 26.1).

	SEGMENT 1	SEGMENT 2
Facade		
Opposite facade angle θ′ deg.	0	0
Angle of view segment θ deg.	25	125

	SEGMENT 1	SEGMENT 2
correction dB(A)	+2.5	+2.5
reflection correction dB(A)	0	0
Chart 10 correction dB(A)	−8.6	−1.6
Site Layout Correction dB(A)	−6.1	+0.9

STAGE 5. COMBINING NOISE LEVELS:

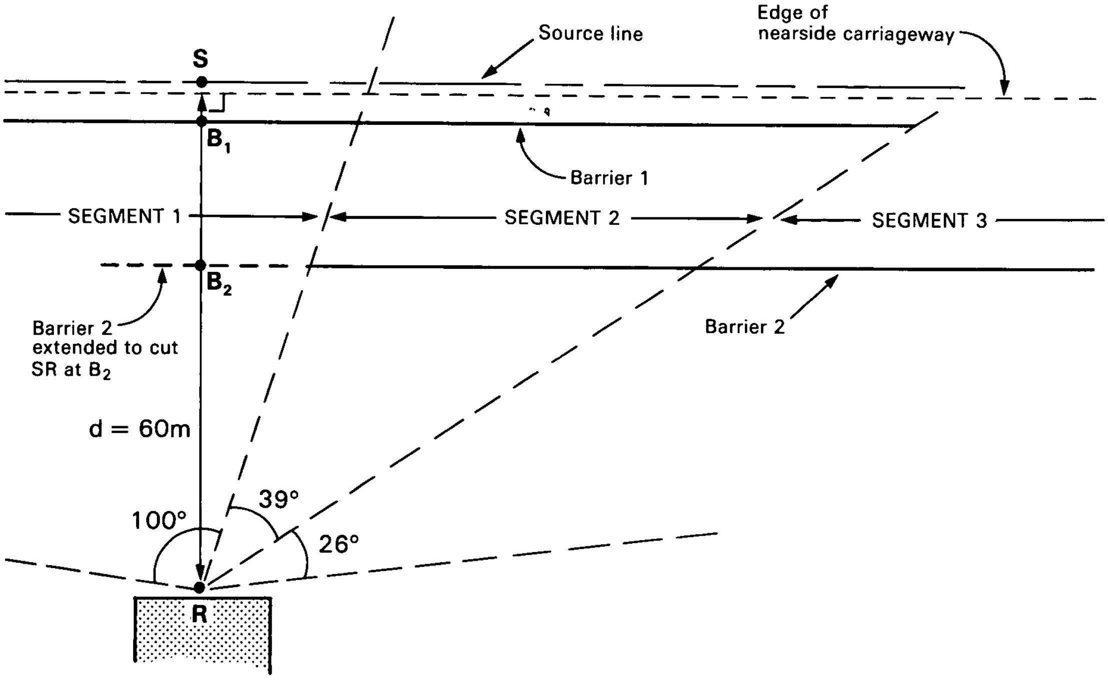
	SEGMENT 1	SEGMENT 2
Basic Noise Level dB(A)	82.6	82.6
Propagation Correction dB(A)	−16.6	−12.3
Site Layout Correction dB(A)	−6.1	+0.9
Noise Contribution dB(A)	59.9	71.2
Chart 11 Combined Noise Level dB(A)	71.5	

Rounding to the nearest whole number:

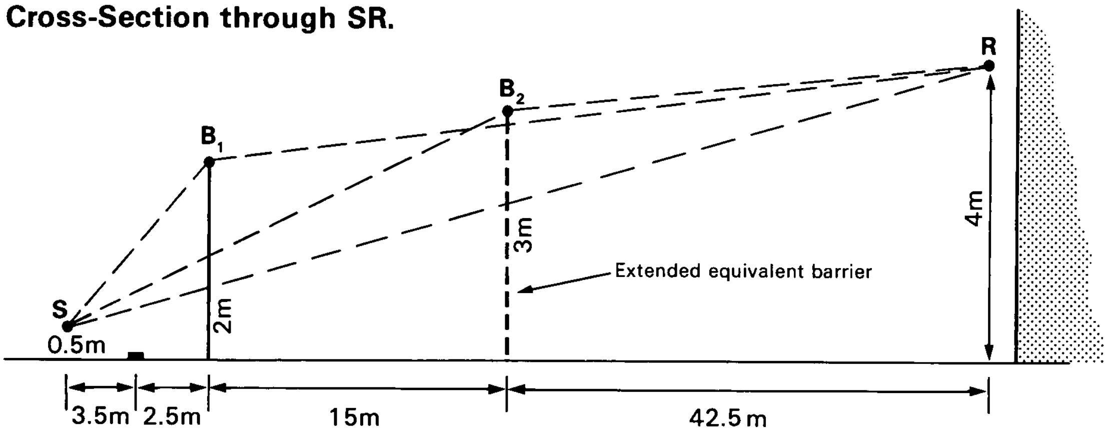
Predicted value of L_{10} (18-hour) is 72 dB(A)

Annex 11. ROAD SCREENED BY TWO NOISE BARRIERS

Plan of Site



Cross-Section through SR.



Barrier 1. Path difference $= SB_1 + B_1R - SR$

$$= (1.5^2 + 6^2)^{\frac{1}{2}} + (2^2 + 57.5^2)^{\frac{1}{2}} - (3.5^2 + 63.5^2)^{\frac{1}{2}}$$

$= 0.123$m

Barrier 2. The barrier is extended to meet the vertical plane through SR at B_2.
Path difference $= SB_2 + B_2R - SR$.

$$= (2.5^2 + 21^2)^{\frac{1}{2}} + (1 + 42.5^2)^{\frac{1}{2}} - (3.5^2 + 63.5^2)^{\frac{1}{2}}$$

$= 0.064$m.

ANNEX 11. ROAD SCREENING BY TWO NOISE BARRIERS

OBJECT: To predict the L_{10} (18-hour) value at a reception point 1m from a facade and 4m above the ground.

STAGE 1. SEGMENT ROAD SCHEME: As the degree of screening varies along the road length the road scheme is segmented at each point along the source line where the screening changes with respect to the position of the reception point, see figure opposite. Both barriers extend off the plan. At the extreme edges of the site further screening is provided by houses and the contribution to the overall noise level from these segments is negligible.

STAGE 2. BASIC NOISE LEVEL: The road is a single carriageway subject to a speed limit of 50 mph. There is no gradient and no adjustment ΔV is required. The road surface is impervious and a surface correction is required as traffic is less than 75 km/h (para 16.1).

	SEGMENT 1	SEGMENT 2	SEGMENT 3
Traffic flow Q veh/18-hour day	5000	5000	5000
Traffic speed V km/h	70	70	70
Heavy vehicles p %	10	10	10
Gradient G %	0	0	0
Road surface		Impervious	

	SEGMENT 1	SEGMENT 2	SEGMENT 3
Chart 3 L_{10} (18-hour) dB(A)	66.1	66.1	66.1
Chart 4 correction dB(A)	+1.8	+1.8	+1.8
Chart 6 correction dB(A)	0	0	0
correction dB(A)	−1.0	−1.0	−1.0
Basic Noise Level dB(A)	66.9	66.9	66.9

STAGE 3. PROPAGATION: For all segments the propagation is obstructed by noise barriers. For segment 2 both barriers provide screening and the potential barrier correction is calculated in accordance with para 35 where: $A_A = -9.7$ dB(A); $A_B = -8.6$ dB(A); M = 15m; d = 60m; and J = 0.7.

	SEGMENT 1	SEGMENT 2	SEGMENT 3
Shortest horizontal distance d m	60	60	60
Height relative to source h m	3.5	3.5	3.5
Average height of propagation H m			
Absorbent ground cover I			
Barrier path difference δ m	0.123		0.064
Distance between barriers M m		15	

	SEGMENT 1	SEGMENT 2	SEGMENT 3
Chart 7 correction dB(A)	−6.7	−6.7	−6.7
Chart 8 correction dB(A)	0	0	0
Chart 9 correction dB(A)	−9.7	0	−8.6
para 35 correction dB(A)	0	−10.9	0
Propagation Correction dB(A)	−16.4	−17.6	−15.3

STAGE 4. SITE LAYOUT: A facade correction is required (para 26.1).

	SEGMENT 1	SEGMENT 2	SEGMENT 3
Facade			
Opposite facade angle θ′ deg.	0	0	0
Angle of view segment θ deg.	100	39	26

	SEGMENT 1	SEGMENT 2	SEGMENT 3
correction dB(A)	+2.5	+2.5	+2.5
reflection correction dB(A)	0	0	0
Chart 10 correction dB(A)	−2.6	−6.6	−8.4
Site Layout Correction dB(A)	−0.1	−4.1	−5.9

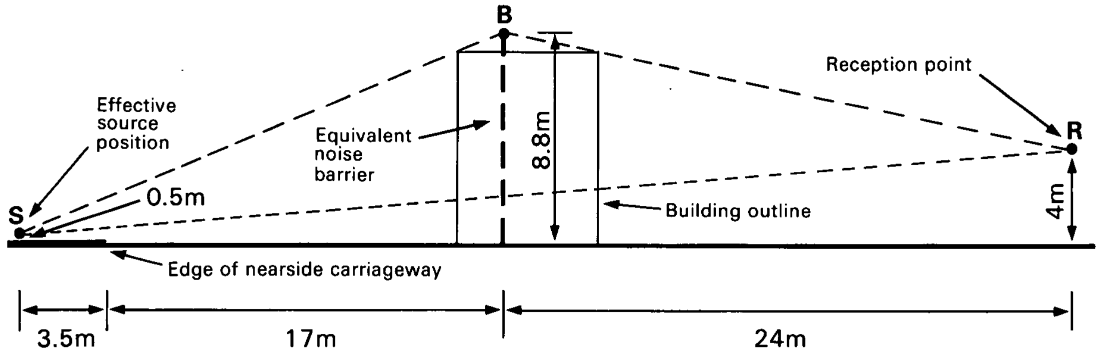
STAGE 5. COMBINING NOISE LEVELS:

	SEGMENT 1	SEGMENT 2	SEGMENT 3
Basic Noise Level dB(A)	66.9	66.9	66.9
Propagation Correction dB(A)	−16.4	−17.6	−15.3
Site Layout Correction dB(A)	−0.1	−4.1	−5.9
Noise Contributions dB(A)	50.4	45.2	45.7
Chart 11 Combined Noise Level dB(A)		52.6	

Rounding to the nearest whole number gives:

Predicted value of L_{10} (18-hour) is 53 dB(A)

Annex 12 SCHEMATIC EXAMPLE OF SCREENING BY FLAT–TOPPED BUILDINGS



ANNEX 12. SCHEMATIC EXAMPLE OF SCREENING BY FLAT-TOPPED BUILDINGS

OBJECT: To predict the potential barrier correction for an 8–metre high flat-topped building erected 15m from the nearside kerb. Note that this procedure is not usually required when evaluating ridged buildings as the ridge itself will generally define the equivalent barrier configuration.

PROCEDURE: (i) On a scaled cross-section draw a line from the effective source position S (3.5m in from the edge of the nearside kerb and 0.5m high) to pass through the near top edge of the building.

(ii) Draw a line from the reception point R (4m above the ground and 41m from the edge of the kerb) through the other top edge of the building and extend this to intersect the above line at B.

(iii) Scale off the height and position of the equivalent barrier from the intersection point B of the above two lines.

In the example given the effective height of the equivalent barrier is estimated to be 8.8m and the effective position of the equivalent barrier is 17m from the edge of the nearside kerb.

Having determined the equivalent barrier configuration it will, in general, still be necessary to calculate the path difference rather than to use graphical evaluation as the latter method is likely to lead to significant error (the path difference is the difference between two relatively large numbers).

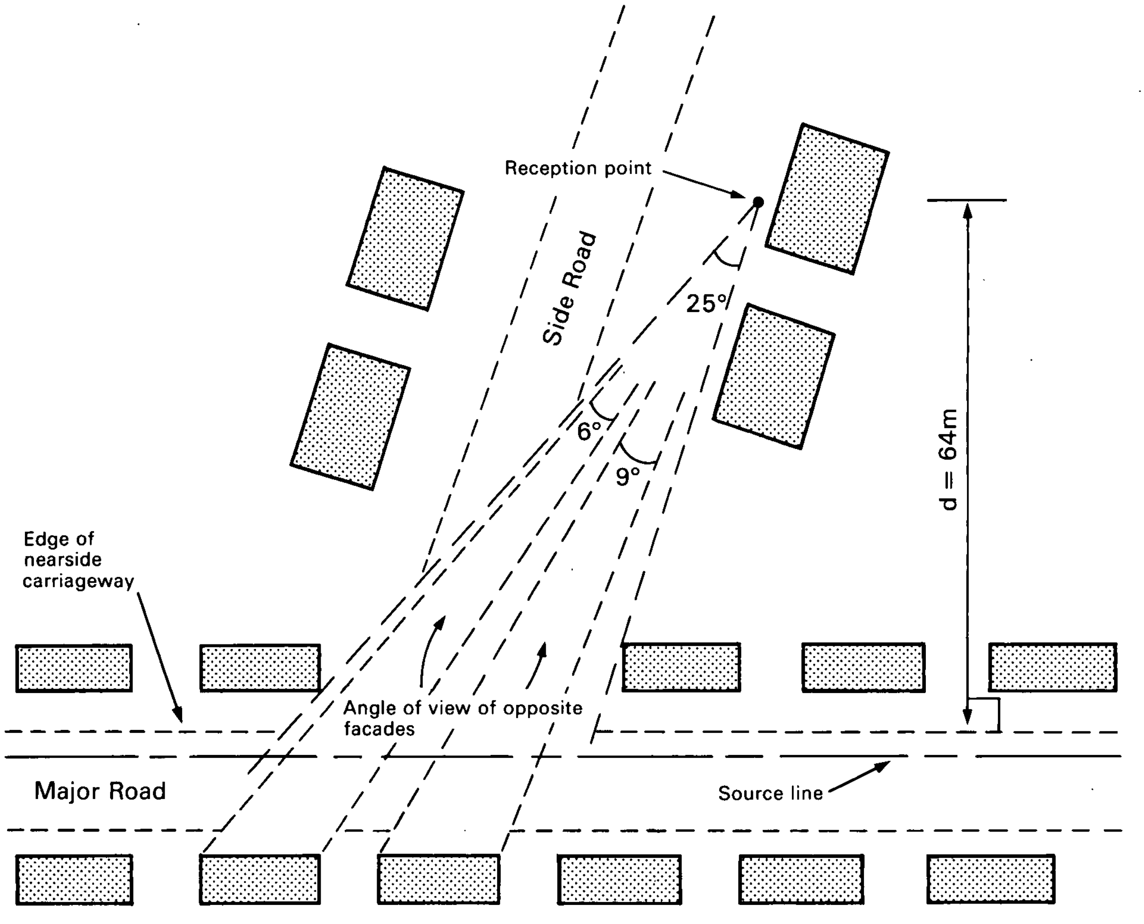
For this example:

$$\begin{aligned} \text{path difference} &= SB + BR - SR \\ &= (8.3^2 + 20.5^2)^{1/2} + (4.8^2 + 24^2)^{1/2} - (3.5^2 + 44.5^2)^{1/2} \\ &= 1.954\text{m} \end{aligned}$$

Chart 9. Potential barrier correction = −18.1 dB(A)

The remainder of the prediction procedures are illustrated by various other examples in these Annexes.

Annex 13. SIDE ROAD LEADING OFF A MAJOR ROAD WITH HOUSES FLANKING MAJOR ROAD.



Total angle of view of opposite facades = $6^\circ + 9^\circ = 15^\circ$

The reflection correction due to opposite facades = $\frac{15}{25} \times 1.5 = 0.9$ dB(A)

ANNEX 13. SIDE ROAD LEADING OFF A MAJOR ROAD WITH HOUSES FLANKING MAJOR ROAD

OBJECT: To predict the L_{10} (18-hour) value at a reception point 1m from a facade and 4m above the ground.

STAGE 1. SEGMENT ROAD SCHEME: The angle of view of the main road segment is limited by the side road aperture. The contribution to the overall noise level from other segments of the main road is negligible due to screening and may be ignored. For this example the contribution to the overall noise level from traffic in the side road is negligible.

STAGE 2. BASIC NOISE LEVEL: The road is not subject to a speed limit of less than 60 mph. There is no gradient and no adjustment ΔV is required. A surface correction is not required as the traffic speed is above 75 km/h (para 16).

Traffic flow Q veh/18-hour day	70000	Chart 3 L_{10} (18-hour) dB(A)	77.6
Traffic speed V km/h	81	Chart 4 correction dB(A)	+4.1
Heavy vehicles p %	20		
Gradient G %	0	Chart 6 correction dB(A)	0
Road surface	Impervious	correction dB(A)	0
		Basic Noise Level dB(A)	81.7

STAGE 3. PROPAGATION: There are no front gardens and the proportion of soft ground is estimated to be less than 10%, the intervening ground is flat. The value of I is therefore zero and no Chart 8 correction is required (para 20.4).

Shortest horizontal distance d m	64	Chart 7 correction dB(A)	−7.0
Height relative to source h m	3.5		
Average height of propagation H m		Chart 8 correction dB(A)	0
Absorbent ground cover I			
Barrier path difference δ m		Chart 9 correction dB(A)	0
		Propagation Correction dB(A)	−7.0

STAGE 4. SITE LAYOUT: A facade correction is required (para 26.1). There are also facades on the opposite side of the traffic stream (para 26.2).

Facade		correction dB(A)	+2.5
Opposite facade angle θ′ deg.	15	reflection correction dB(A)	+0.9
Angle of view segment θ deg.	25	Chart 10 correction dB(A)	−8.6
		Site Layout Correction dB(A)	−5.2

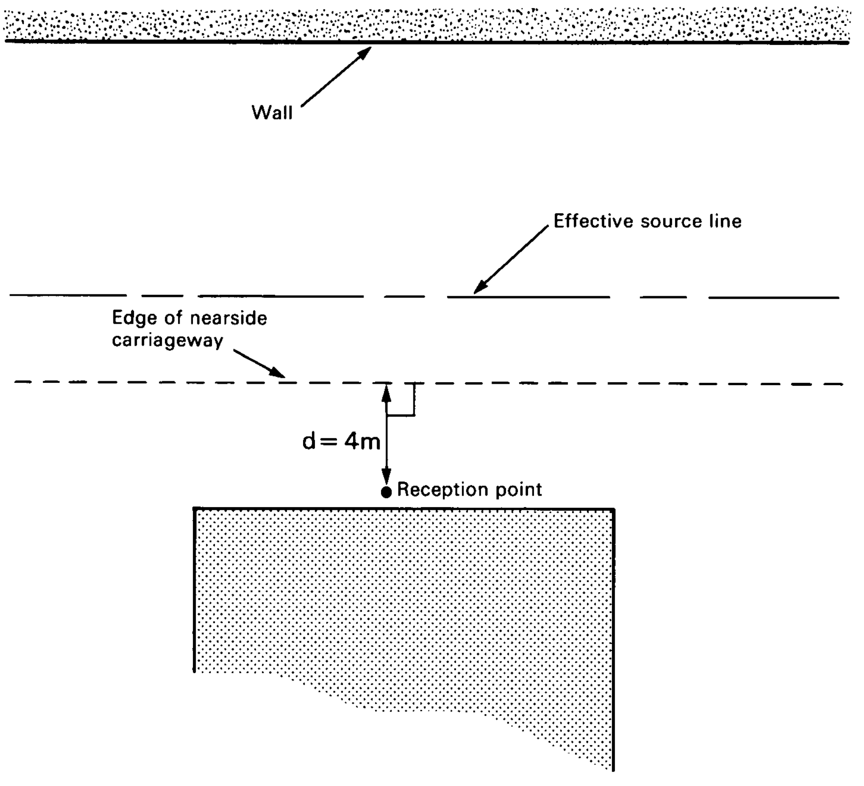
STAGE 5. OVERALL NOISE LEVEL: There is only one road segment which contributes to the overall noise level.

Basic Noise Level dB(A)	81.7
Propagation Correction dB(A)	−7.0
Site Layout Correction dB(A)	−5.2
Overall Noise Level dB(A)	69.5

Rounding to the nearest whole number:

Predicted value of L_{10} (18-hour) is 70 dB(A)

Annex 14 LOW TRAFFIC FLOW ROAD AFTER THE OPENING OF A BY-PASS



ANNEX 14. LOW TRAFFIC FLOW ROAD AFTER THE OPENING OF A BY-PASS

OBJECT: To predict the change in the L_{10} (18-hour) value at a reception point 1m from the facade and 4m above the ground due to the opening of a by-pass.

STAGE 1. SEGMENT ROAD SCHEME: In both the 'before' and 'after' situations only the noise from traffic on the road outside the house is significant. The noise from traffic on the by-pass in the 'after' situation is negligible due to its distance away from the site.

STAGE 2. BASIC NOISE LEVEL: The road is a single carriageway with an impervious surface. For both the 'before' and 'after' situations the traffic speed was measured and found to be less than 75 km/h and therefore a surface correction is required (para 16.1). The road has zero gradient.

	BEFORE	AFTER
Traffic flow Q veh/18-hour day	16000	1500
Traffic speed V km/h	40	50
Heavy vehicles p %	15	2
Gradient G %	0	0
Road surface	Impervious	

	BEFORE	AFTER
Chart 3 L_{10} (18-hour) dB(A)	71.1	60.9
Chart 4 correction dB(A)	+0.7	−2.0
Chart 6 correction dB(A)	0	0
correction dB(A)	−1.0	−1.0
Basic Noise Level dB(A)	70.8	57.9

STAGE 3. PROPAGATION: Propagation is unobstructed and the intervening ground is flat and there are no front gardens. The proportion of soft ground is less than 10% and no Chart 8 correction is required (I=0), see para 20.4.

	BEFORE	AFTER
Shortest horizontal distance d m	4	4
Height relative to source h m	3.5	3.5
Average height of propagation H m	2.25	2.25
Absorbent ground cover I	0	0
Barrier path difference δ m		

	BEFORE	AFTER
Chart 7 correction dB(A)	+2.1	+2.1
Chart 8 correction dB(A)	0	0
Chart 9 correction dB(A)	0	0
Propagation Correction dB(A)	+2.1	+2.1

STAGE 4. SITE LAYOUT: A facade correction is required (para 26.1). A wall 2m high runs along the opposite side of the traffic stream and a reflection correction is required, para 26.2.

	BEFORE	AFTER
Facade		
Opposite facade angle θ' deg.	180	180
Angle of view segment θ deg.	180	180

	BEFORE	AFTER
correction dB(A)	+2.5	+2.5
reflection correction dB(A)	+1.5	+1.5
Chart 10 correction dB(A)	0	0
Site Layout Correction dB(A)	+4.0	+4.0

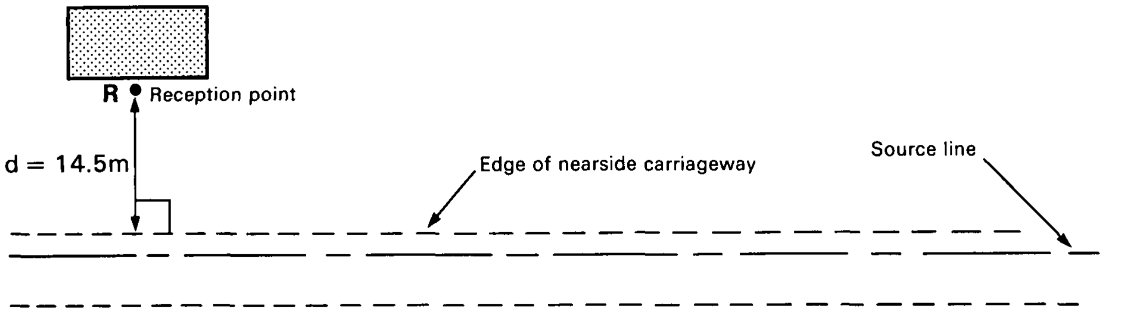
STAGE 5. COMPARING NOISE LEVELS: The traffic flow in the 'after' situation is less than 4000 veh/18-hr day and the shortest slant distance is less than 30m, a low traffic flow correction is required, para 30, Chart 12. D = 3.625 and C = 0.375.

	BEFORE	AFTER
Basic Noise Level dB(A)	70.8	57.9
Propagation Correction dB(A)	+2.1	+2.1
Site Layout Correction dB(A)	+4.0	+4.0
Chart 12 Low Traffic Flow Correction dB(A)	0	−1.7
Overall Noise Level dB(A)	76.9	62.3

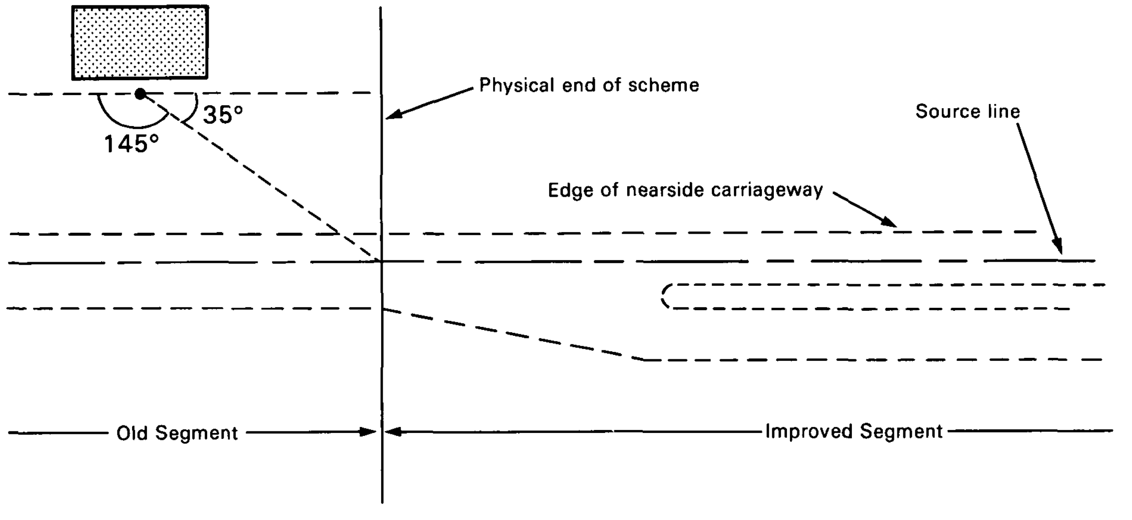
Predicted change in the L_{10} (18-hour) value = 76.9 − 62.3 = 14.6 dB(A)

Annex 15. END OF SCHEME

EXISTING SITUATION



FUTURE SITUATION



N.B. The central reservation for the improved segment is less than 5m wide and therefore both carriageways are considered to act as a single road and are treated in the calculation as a single segment.

ANNEX 15. END OF SCHEME

OBJECT: To predict the change in noise level L_{10} (18-hour) at a facade due to a road improvement scheme and to check entitlement under the Noise Insulation Regulations.

STAGE 1. SEGMENT ROAD SCHEME: The procedure is to calculate the existing noise level to give the prevailing noise level and then to calculate the maximum noise level within the 15 year period to give the relevant noise level. For the existing situation the prevailing noise level arises from a single road segment whilst, for the relevant noise level prediction, two segments are identified; the old segment, and the improved segment.

STAGE 2. BASIC NOISE LEVEL: In this example the percentage of heavy vehicles is estimated to remain unchanged whilst the future mean speed on the new selection is increased from 50 to 60 km/h and the flow increased from 15,000 to 25,000 veh/18-hour day. The road surface is impervious and, as the speeds are less than 75 km/h, a surface correction is required (para 16.1). The road has zero gradient.

	EXISTING SITUATION	FUTURE	
		OLD	IMPROVED
Traffic flow Q veh/18-hour day	15000	25000	25000
Traffic speed V km/h	50	50	60
Heavy vehicles p %	20	20	20
Gradient G %	0	0	0
Road surface	Impervious		

	EXISTING SITUATION	FUTURE	
		OLD	IMPROVED
Chart 3 L_{10} (18-hour) dB(A)	70.9	73.1	73.1
Chart 4 correction dB(A)	+2.0	+2.0	+2.6
Chart 6 correction dB(A)	0	0	0
correction dB(A)	−1.0	−1.0	−1.0
Basic Noise Level dB(A)	71.9	74.1	74.7

STAGE 3. PROPAGATION: For both the existing and future situations propagation is unobstructed. As the nearside kerbline remains unchanged the distance correction remains unchanged. It is estimated that the percentage of absorbent ground is greater than 90% and therefore I = 1, (para 20.4) In other cases it may be necessary to adopt a different distance from nearside kerb to take into account change in road width as, for example, has occurred on the opposite side of this road.

	EXISTING SITUATION	FUTURE	
		OLD	IMPROVED
Shortest horizontal distance d m	14.5	14.5	14.5
Height relative to source h m	3.5	3.5	3.5
Average height of propagation H m	2.25	2.25	2.25
Absorbent ground cover I	1	1	1

	EXISTING SITUATION	FUTURE	
		OLD	IMPROVED
Chart 7 correction dB(A)	−1.3	−1.3	−1.3
Chart 8 correction dB(A)	−0.9	−0.9	−0.9
Propagation Correction dB(A)	−2.2	−2.2	−2.2

STAGE 4. SITE LAYOUT: A facade correction is required (para 26.1). There are no substantial buildings on the far side of the road and therefore no further correction for reflection is required (para 26.2).

	EXISTING SITUATION	FUTURE	
		OLD	IMPROVED
Facade			
Opposite facade angle θ′ deg.	0	0	0
Angle of view segment θ deg.	180	145	35

	EXISTING SITUATION	FUTURE	
		OLD	IMPROVED
correction dB(A)	+2.5	+2.5	+2.5
reflection correction dB(A)	0	0	0
Chart 10 correction dB(A)	0	−0.9	−7.1
Site Layout Correction dB(A)	+2.5	+1.6	−4.6

STAGE 5. COMBINING NOISE LEVELS:

	EXISTING SITUATION	FUTURE	
		OLD	IMPROVED
Basic Noise Level dB(A)	71.9	74.1	74.7
Propagation Correction dB(A)	−2.2	−2.2	−2.2
Site Layout Correction dB(A)	+2.5	+1.6	−4.6
Prevailing Noise Level dB(A)	72.2		
Future Noise Contributions dB(A)		73.5	67.9
Chart 11 Relevant Noise Level dB(A)		74.6	

In this case there is entitlement under the 1975 Regulations (para 6), viz:

(i) RNL (rounded to the nearest whole number = 75 dB(A)) ⩾ 68 dB(A)

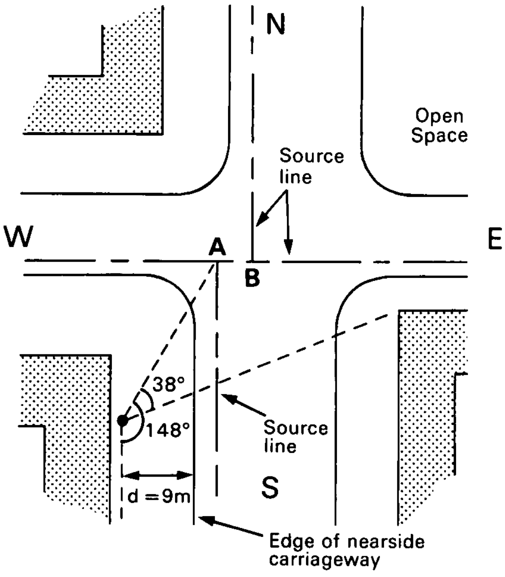
(ii) RNL – PNL, (74.6 − 72.2 = 2.4 dB(A)) ⩾ +1.0 dB(A)

(iii) RNL – 'Old', (74.6 − 73.5 = 1.1 dB(A)) ⩾ +1.0 dB(A)

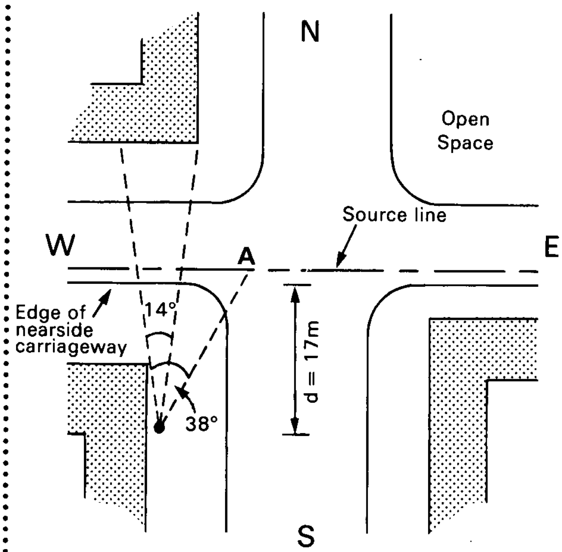
The example above illustrates that entitlement under the Regulations generally extends only a comparatively short distance beyond the end of scheme. In fact, by calculating for several different distances it was established, in this case, that entitlement extended some 28m beyond the physical end of the scheme.

Annex 16. EXAMPLES OF ROAD JUNCTIONS

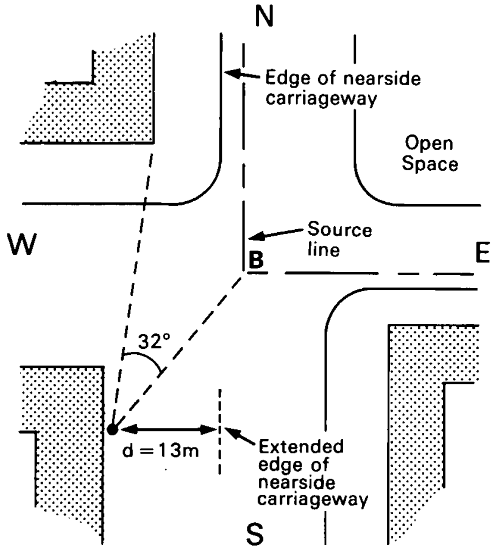
a) Light-controlled road junction



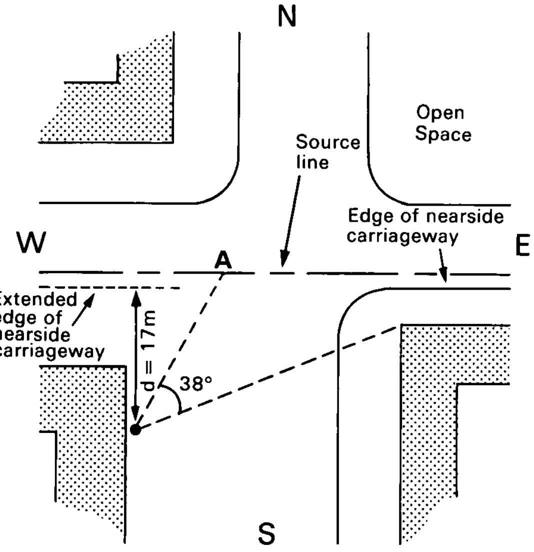
(i) Segment S: d = 9m
Angle of view = 148°
Angle of reflection = 148° −38° = 110°



(ii) Segment W: d = 17m
Angle of view = 38°
Angle of reflection = 14°



(iii) Segment N: d = 13m
Angle of view = 32°
No reflecting facade opposite traffic stream



(iv) Segment E: d = 17m
Angle of view = 38°
No reflecting facade opposite traffic stream

ANNEX 16. EXAMPLES OF ROAD JUNCTIONS.

(a) A light-controlled road junction.

OBJECT: To predict the value of L_{10} (18-hour) at a reception point 1m from a facade and 4m above ground in the vicinity of a light-controlled road junction.

STAGE 1. SEGMENT ROAD SCHEME: In this example, the effective source lines for junction arms S and N are extended to intersect the source line WE at A and B respectively. Each arm of the junction is then treated as a separate segment as illustrated. NB Point A is chosen as the boundary between the W and E segments rather than B as this leads to a marginally higher overall noise level (see para 33). For this example the contribution to the overall noise level from road segments screened by buildings is assumed negligible.

STAGE 2. BASIC NOISE LEVEL: In the region of the junction the estimated speed for traffic on that class of road is adopted rather than the actual speed of traffic crossing the junction. As the estimated traffic speed is less than 75 km/h a surface correction is required (para 16.1).

	SEGMENT			
	S	W	N	E
Traffic flow Q veh/18-hour day	20000	12000	10000	18000
Traffic speed V km/h	60	60	50	60
Heavy vehicles p %	15	12	10	15
Gradient G %	0	0	0	0
Road surface	Impervious			

	SEGMENT			
	S	W	N	E
Chart 3 L_{10} (18-hour) dB(A)	72.1	69.9	69.1	71.7
Chart 4 correction dB(A)	+1.9	+1.4	+0.2	+1.9
Chart 6 correction dB(A)	0	0	0	0
correction dB(A)	−1.0	−1.0	−1.0	−1.0
Basic Noise Level dB(A)	73.0	70.3	68.3	72.6

STAGE 3. PROPAGATION: For all segments propagation is unobstructed and the intervening ground is pavement.

	SEGMENT			
	S	W	N	E
Shortest horizontal distance d m	9	17	13	17
Height relative to source h m	3.5	3.5	3.5	3.5
Average height of propagation H m				
Absorbent ground cover I				
Barrier path difference δ m				

	SEGMENT			
	S	W	N	E
Chart 7 correction dB(A)	+0.2	−1.9	−1.0	−1.9
Chart 8 correction dB(A)	0	0	0	0
Chart 9 correction dB(A)	0	0	0	0
Propagation Correction dB(A)	+0.2	−1.9	−1.0	−1.9

STAGE 4. SITE LAYOUT: For all segments a facade correction is required (para 26.1). Segments S and W require a reflection correction for facades opposite the traffic stream but no correction is required for segments N and E as there are no facades on the opposite side of the road (para 26.2).

	SEGMENT			
	S	W	N	E
Facade				
Opposite facade angle θ′ deg.	110	14	0	0
Angle of view segment θ deg.	148	38	32	38

	SEGMENT			
	S	W	N	E
correction dB(A)	+2.5	+2.5	+2.5	+2.5
reflection correction dB(A)	+1.1	+0.6	0	0
Chart 10 correction dB(A)	−0.9	−6.8	−7.5	−6.8
Site Layout Correction dB(A)	+2.7	−3.7	−5.0	−4.3

STAGE 5. COMBINING NOISE LEVELS:

	SEGMENT			
	S	W	N	E
Basic Noise Level dB(A)	73.0	70.3	68.3	72.6
Propagation Correction dB(A)	+0.2	−1.9	−1.0	−1.9
Site Layout Correction dB(A)	+2.7	−3.7	−5.0	−4.3
Noise Contribution dB(A)	75.9	64.7	62.3	66.4
Chart 11 Combined Noise Level dB(A)	76.8			

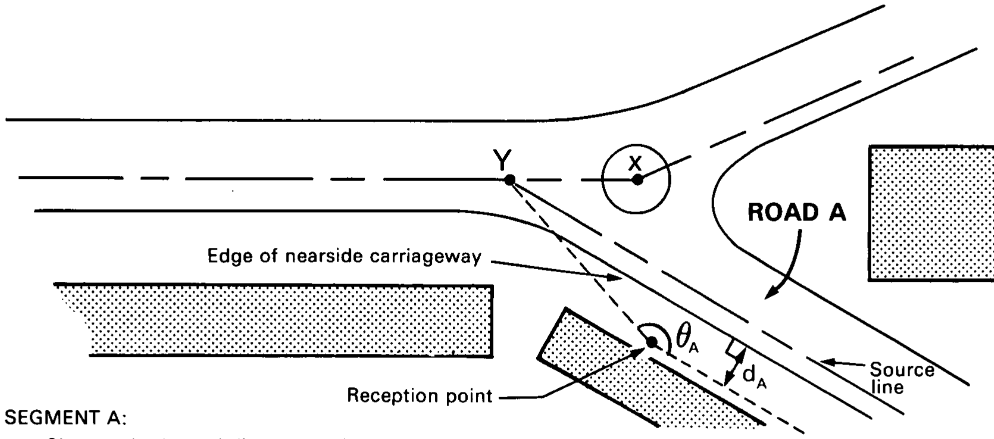
Rounding to the nearest whole number:

Predicted value of L_{10} (18-hour) is 77 dB(A)

NB This example shows that the major contribution to the overall predicted noise level comes from the noise segment which actually passes the reception point, the correction for angle of view generally reducing the significance of the other segments in the calculation. The combined contribution to the overall noise level from segments W, E and N is only 0.9 dB(A).

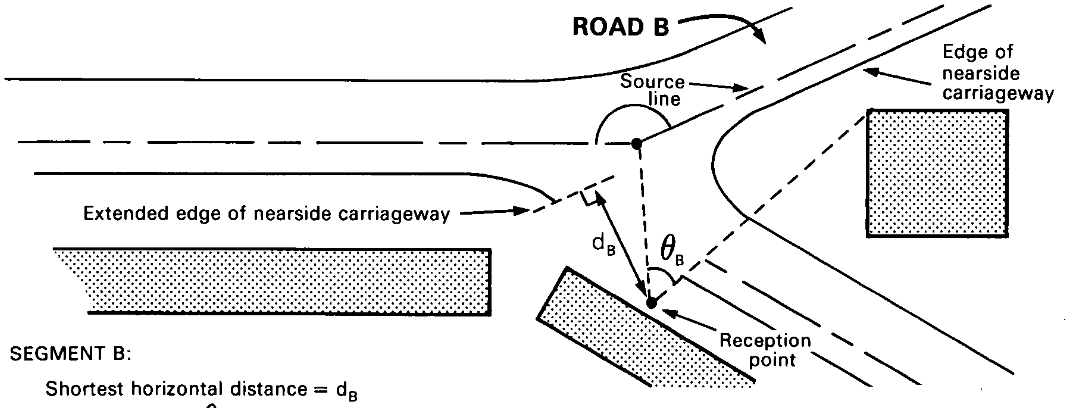
Annex 16. EXAMPLES OF ROAD JUNCTIONS.

(b) A roundabout



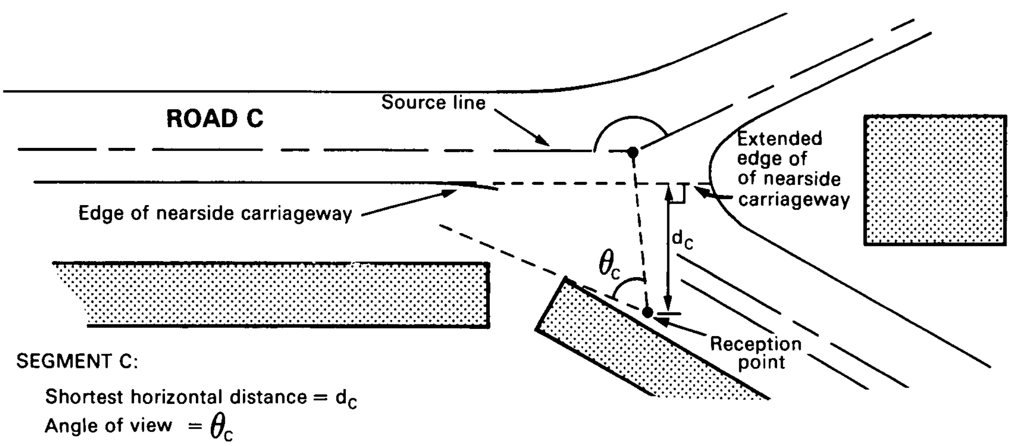
(i) SEGMENT A:

Shortest horizontal distance = d_A
Angle of view = θ_A
N.B. A reflection correction for the facade on the opposite side of the traffic stream is required.



(ii) SEGMENT B:

Shortest horizontal distance = d_B
Angle of view = θ_B



(iii) SEGMENT C:

Shortest horizontal distance = d_C
Angle of view = θ_C

ANNEX 16. EXAMPLES OF ROAD JUNCTIONS

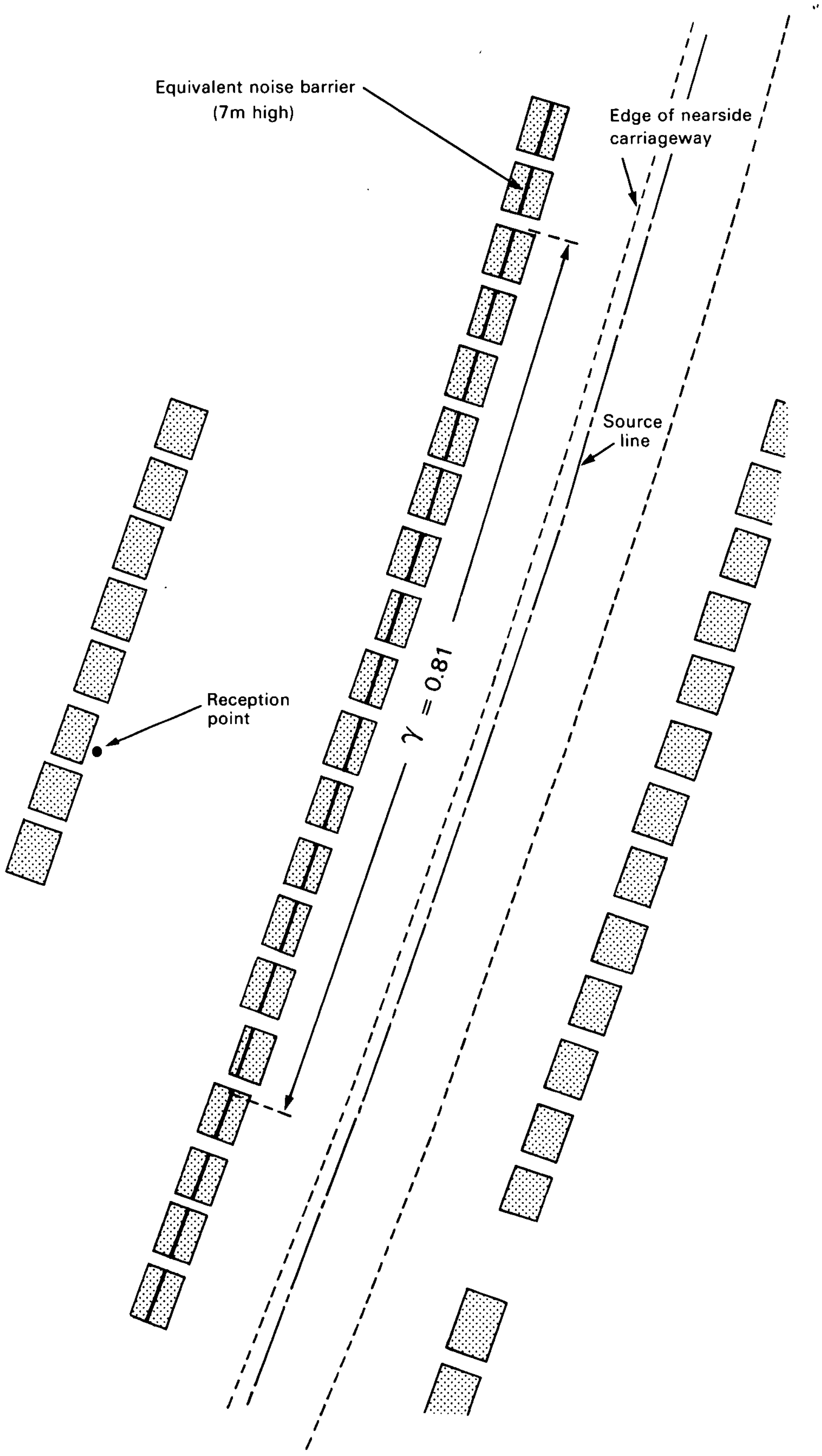
(b) A roundabout.

A similar procedure as described in (a) is applied when dealing with roundabouts. The presence of the roundabout can be ignored and the road segments determined by extending the source line of B and C to intersect at X and the source line of A to intersect C at Y. The segment angle θ_A, θ_B and θ_C are defined by the points of intersection of the source lines and the presence of buildings. It will be noted that source line B could have been extended to intersect source line A producing a slightly different configuration and slightly different segment angles. In practice the configuration leading to the highest overall noise level should be chosen. In most cases it will be necessary merely to maximise the segment angle defining the most important road segment. In this case, assuming similar traffic conditions for each road, it is likely to be the source line of road A.

Having defined the segment angles, each arm of the junction is treated separately, the estimated speed for traffic on the class of road is adopted rather than the actual speed of traffic on the roundabout.

NB In order to calculate the distance correction using Chart 7 it may be required to extend the edge of the nearside carriageway to calculate the shortest horizontal distance d as is the case for road segments B and C in the example.

Annex 17. NOISE LEVEL BEHIND FIRST ROW OF HOUSES



ANNEX 17. NOISE LEVEL BEHIND FIRST ROW OF HOUSES

OBJECT: To predict the value of L_{10} (18-hour) at 1m from the facade and 4m above the ground located behind a fairly uniform row of houses fronting onto a main road.

STAGE 1. SEGMENT ROAD SCHEME: The angle of view of the road scheme is 180°. As the row of houses screening the reception point is uniform the road scheme can be treated as two segments. The correction to the angle of view of the screened segment (1) is determined along a representative section of the centre of the road scheme and estimated to be $\gamma = 0.81$, giving an angle of view of 180 x 0.81 = 146°. Therefore the unscreened segment (2) has angle of view of 180 − 146 = 34° (see para 34.1).

STAGE 2. BASIC NOISE LEVEL: The road surface is impervious and the traffic speed (measured) is less than 75 km/h so a surface correction is required (para 16.1).

	SEGMENT 1	SEGMENT 2
Traffic flow Q veh/18-hour day	65000	65000
Traffic speed V km/h	65	65
Heavy vehicles p %	19	19
Gradient G %	0	0
Road surface	Impervious	

	SEGMENT 1	SEGMENT 2
Chart 3 L_{10} (18-hour) dB(A)	77.2	77.2
Chart 4 correction dB(A)	+2.8	+2.8
Chart 6 correction dB(A)	0	0
correction dB(A)	−1.0	−1.0
Basic Noise Level dB(A)	79.0	79.0

STAGE 3. PROPAGATION: For the screened segment (1) the ridge of the houses is taken as the position of the equivalent barrier and is estimated to be 7m high and 25.5m from the edge of the nearside carriageway. For the unscreened segment (2) the intervening ground is flat and predominantly gardens (>90%). Therefore the value of I=1 and the average height of propagation, H, determined along the segment bisector = 1/2 (3.5 + 1) = 2.25m.

	SEGMENT 1	SEGMENT 2
Shortest horizontal distance d m	79	79
Height relative to source h m	3.5	3.5
Average height of propagation H m		2.25
Absorbent ground cover I		1
Barrier path difference δ m	0.729	

	SEGMENT 1	SEGMENT 2
Chart 7 correction dB(A)	−7.9	−7.9
Chart 8 correction dB(A)	0	−4.4
Chart 9 correction dB(A)	−14.3	0
Propagation Correction dB(A)	−22.2	−12.3

STAGE 4. SITE LAYOUT: A facade correction is required (para 26.1). Also a reflection correction is required as there are houses on the opposite side of the traffic stream. As these houses are uniform and similar to those screening the reception point the reflection correction
$= \gamma \times 1.5 = 1.2$ dB(A) (see para 34.2).

	SEGMENT 1	SEGMENT 2
Facade		
Opposite facade γ	0.81	0.81
Angle of view segment θ deg.	146	34

	SEGMENT 1	SEGMENT 2
correction dB(A)	+2.5	+2.5
reflection correction dB(A)	+1.2	+1.2
Chart 10 correction dB(A)	−0.9	−7.2
Site Layout Correction dB(A)	+2.8	−3.5

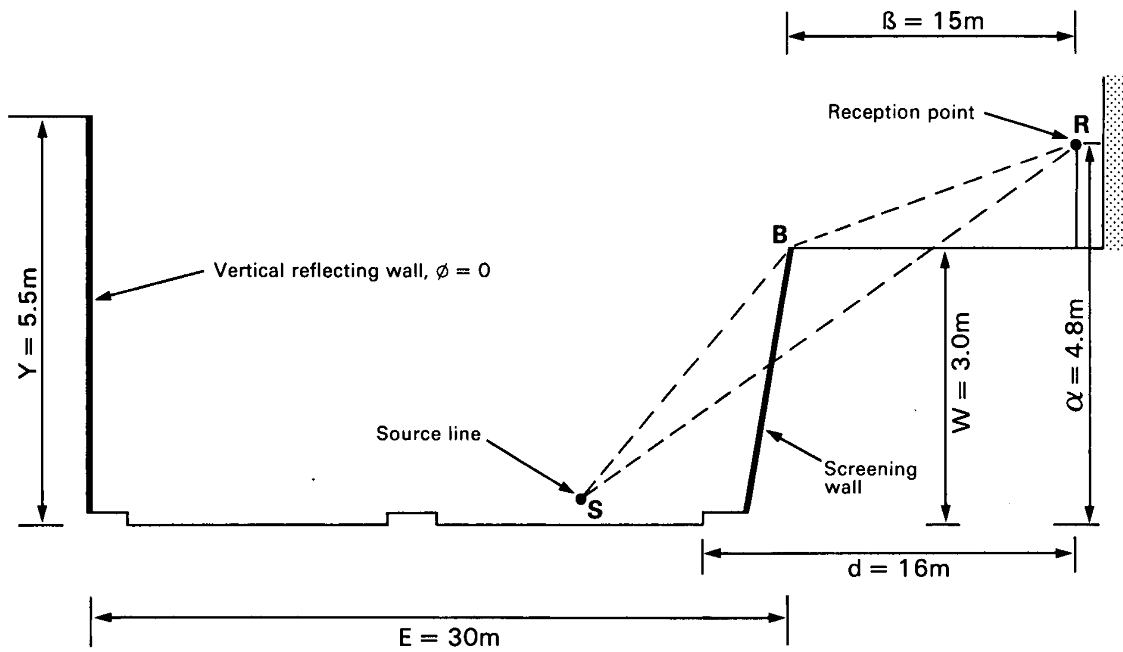
STAGE 5. COMBINING NOISE LEVELS:

	SEGMENT 1	SEGMENT 2
Basic Noise Level dB(A)	79.0	79.0
Propagation Correction dB(A)	−22.2	−12.3
Site Layout Correction dB(A)	+2.8	−3.5
Noise Contribution dB(A)	59.6	63.2
Chart 11 Combined Noise Level dB(A)	64.8	

Rounding to the nearest whole number:

Predicted value of L_{10} (18-hour) is 65 dB(A)

Annex 18. SCREENING DUE TO A ROAD IN A RETAINED CUT



N.B. $Y \geqslant W$ and $\alpha \geqslant W$ therefore $\Delta_1 = W = 3.0$

α = 4.8m

ß = 15.0m

E = 30.0m

Y = 5.5m

W = 3.0m

∅ = 0°

ANNEX 18. SCREENING DUE TO A ROAD IN A RETAINED CUT

OBJECT: To illustrate the procedure for predicting the potential barrier correction and containment effects for a road in a retained cut.

STAGE 1. SEGMENT ROAD SCHEME: For the purpose of this example it can be assumed that the section of retained cut subtends an angle of 120° at the reception point. This segment constitutes the total angle of view of the road and is, therefore, the only segment to be considered.

STAGE 2. BASIC NOISE LEVEL: The road is subject to a speed limit of 70 mph with an estimated traffic speed of 108 km/h. The road has zero gradient and no correction ΔV is required. As the traffic speed is greater than 75 km/h and the road surface is impervious, a surface correction is not required.

Traffic flow Q veh/18-hour day	25000	Chart 3 L_{10} (18-hour) dB(A)	73.1
Traffic speed V km/h	108	Chart 4 correction dB(A)	+6.1
Heavy vehicles p %	20		
Gradient G %	0	Chart 6 correction dB(A)	0
Road surface	Impervious	correction dB(A)	0
		Basic Noise Level dB(A)	79.2

STAGE 3. PROPAGATION: Propagation is obstructed by the screening wall of the retained cut. The path difference (δ = SB + BR − SR, see diagram opposite) is calculated and the potential barrier correction is found using Chart 9. The distance correction is found using Chart 7.

Shortest horizontal distance d m	16	Chart 7 correction dB(A)	−1.7
Height relative to source h m	4.3		
Average height of propagation H m		Chart 8 correction dB(A)	0
Absorbent ground cover I			
Barrier path difference δ m	0.287	Chart 9 correction dB(A)	−11.6
		Propagation Correction dB(A)	−13.3

STAGE 4. SITE LAYOUT: A facade correction is required (para 26.1) together with a correction for reflection from the farside retaining wall, see para 36.1, where in this example:–

$\Delta_1 = 3$
$\Delta_2 = 0.488$ Chart 13
$\Delta_3 = 0.037$ Chart 13
$\Delta_4 = 1.0$ Chart 14
$\Delta_5 = 1.0$ Chart 15

The correction for reflection = $[1.5 + (\Delta_2 - \Delta_3)\{1 + \Delta_5(\Delta_1 - 1)\}]\Delta_4 = +2.9$ dB(A)

Facade		correction dB(A)	+2.5
Farside retaining wall		reflection correction dB(A)	+2.9
Angle of view segment θ deg.	120	Chart 10 correction dB(A)	−1.8
		Site Layout Correction dB(A)	+3.6

STAGE 5. OVERALL NOISE LEVEL: There is only one road segment which contributes to the overall noise level.

Basic Noise Level dB(A)	79.2
Propagation Correction dB(A)	−13.3
Site Layout Correction dB(A)	+3.6
Overall Noise Level dB(A)	69.5

Rounding to the nearest whole number:

Predicted value of L_{10} (18-hour) is 70 dB(A)

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Appendix AP2.5

Noise Policy Statement for England

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Noise Policy Statement for England (NPSE)

March 2010

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Department for Environment Food and Rural Affairs

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Noise Policy Statement for England

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

1.2 The Government recognises that the effective management of noise requires a co-ordinated and long term approach that encompasses many aspects of modern society.

1.3 The aim of this document is to provide clarity regarding current policies and practices to enable noise management decisions to be made within the wider context, at the most appropriate level, in a cost-effective manner and in a timely fashion.

1.4 The document seeks to clarify the underlying principles and aims in existing policy documents, legislation and guidance that relate to noise. It has been developed following discussions with stakeholders regarding the effects on the noise environment of current policies and practices.

1.5 This Noise Policy Statement for England (NPSE) should apply to all forms of noise including environmental noise, neighbour noise and neighbourhood noise. The NPSE does not apply to noise in the workplace (occupational noise).

1.6 This Noise Policy Statement for England (NPSE) sets out the long term vision of Government noise policy:

Noise Policy Vision

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

1.7 This long term vision is supported by the following aims:

Noise Policy Aims

Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:

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

1.8 The vision and aims of NPSE should be interpreted by having regard to the set of shared UK principles that underpin the Government's sustainable development strategy.

Guiding principles of sustainable development

Ensuring a Strong Healthy and Just Society – Meeting the diverse needs of all people in existing and future communities, promoting personal wellbeing, social cohesion and inclusion, and creating equal opportunity for all.

Using Sound Science Responsibly – Ensuring policy is developed and implemented on the basis of strong scientific evidence, whilst taking into account scientific uncertainty (through the precautionary principle) as well as public attitudes and values.

Living Within Environmental Limits – Respecting the limits of the planet's environment, resources and biodiversity – to improve our environment and ensure that the natural resources needed for life are unimpaired and remain so for future generations.

Achieving a Sustainable Economy – Building a strong, stable and sustainable economy which provides prosperity and opportunities for all, and in which environmental and social costs fall on those who impose them (polluter pays), and efficient resource use is incentivised.

Promoting Good Governance – Actively promoting effective, participative systems of governance in all levels of society – engaging people's creativity, energy and diversity.

Source: Securing the future – delivering UK sustainable development strategy, HM Government, March 2005.

Noise Policy Statement for England
Explanatory Note

Why do we need a Noise Policy Statement for England (NPSE)?

2.1 Noise is an inevitable consequence of a mature and vibrant society. For some the noise of city life provides a desirable sense of excitement and exhilaration, but for others noise is an unwanted intrusion that adversely impacts on their quality of life, affecting their health and well being.

2.2 The management of noise has developed over many years as the types and character of noise sources have altered and as people's attitude to noise has changed. The Noise Abatement Act came into law in 1960 and the Report from the Committee on the Problem of Noise was published in 1963 (the Wilson report). Since then, examples of noise management can be found in many areas including reducing noise at source; the use of the land use and transport planning systems, compensation measures, the statutory nuisance and licensing regimes and other related legislation.

2.3 Furthermore, the broad aim of noise management has been to separate noise sources from sensitive noise receivers and to 'minimise' noise. Of course, taken in isolation and to a literal extreme, noise minimisation would mean no noise at all. In reality, although it has not always been stated, the aim has tended to be to minimise noise 'as far as reasonably practical'. This concept can be found in the Environmental Protection Act 1990, where, in some circumstances, there is a defence of 'best practicable means' in summary statutory nuisance proceedings.

2.4 By describing clear policy vision and aims the NPSE provides the necessary clarity and direction to enable decisions to be made regarding what is an acceptable noise burden to place on society.

What types of noise are addressed by the Noise Policy Statement for England?

2.5 The intention is that the NPSE should apply to all types of noise apart from noise in the workplace (occupational noise). For the purposes of the NPSE, "noise" includes:

- "environmental noise" which includes noise from transportation sources;
- "neighbour noise" which includes noise from inside and outside people's homes; and
- "neighbourhood noise" which includes noise arising from within the community such as industrial and entertainment premises, trade and business premises, construction sites and noise in the street.

What will the Noise Policy Statement for England achieve?

2.6 The application of the NPSE should mean that noise is properly taken into account at the appropriate time. In the past, the opportunity for the cost effective management of noise has often been missed because the noise implications of a particular policy, development or other activity have not been considered at an early enough stage.

2.7 In addition, the application of the NPSE should enable noise to be considered alongside other relevant issues and not to be considered in isolation. In the past, the wider benefits of a particular policy, development or other activity may not have been given adequate weight when assessing the noise implications.

2.8 In the longer term, the Government hopes that existing policies could be reviewed (on a prioritised basis), and revised if necessary, so that the policies and any noise management measures being adopted accord with the vision, aims and principles of the NPSE.

How should the Noise Policy Statement for England be used?

2.9 Noise management is a complex issue and at times requires complex solutions. Unlike air quality, there are currently no European or national noise limits which have to be met, although there can be specific local limits for specific developments. Furthermore, sound only becomes noise (often defined as 'unwanted sound') when it exists in the wrong place or at the wrong time such that it causes or contributes to some harmful or otherwise unwanted effect, like annoyance or sleep disturbance. Unlike many other pollutants, noise pollution depends not just on the physical aspects of the sound itself, but also the human reaction to it. Consequently, the NPSE provides a clear description of desired outcome from the noise management of a particular situation.

2.10 The guiding principles of Government policy on sustainable development, (paragraph 1.8), should be used to assist in its implementation. The development of further principles specifically to underpin implementation of noise management policy will be kept under review as experience is gained from the application of the NPSE.

What does the vision of the Noise Policy Statement for England mean?

2.11 There are several key phrases within the NPSE vision and these are discussed below.

"***Health and quality of life"***

2.12 The World Health Organisation defines health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity, and recognises the enjoyment of the highest attainable standard of health as one of the fundamental rights of every human being.

2.13 It can be argued that quality of life contributes to our standard of health. However, in the NPSE it has been decided to make a distinction between 'quality of life' which is a subjective measure that refers to people's emotional, social and physical well being and 'health' which refers to physical and mental well being.

2.14 It is recognised that noise exposure can cause annoyance and sleep disturbance both of which impact on quality of life. It is also agreed by many experts that annoyance and sleep disturbance can give rise to adverse health effects. The distinction that has been made between 'quality of life' effects and 'health' effects recognises that there is emerging evidence that long term exposure to some types of transport noise can additionally cause an increased risk of direct health effects. The Government intends to keep research on the health effects of long term exposure to noise under review in accordance with the principles of the NPSE.

“***Promote good health and good quality of life”***

2.15 This statement expresses the long term desired policy outcome, but in the use of “promote” and “good” recognises that it is not possible to have a single objective noise-based measure that is mandatory and applicable to all sources of noise in all situations.

“***Effective management of noise”***

2.16 This concept confirms that the policy applies to all types of “noise” (environmental, neighbour and neighbourhood) and that the solution could be more than simply minimising the noise.

“***Within the context of Government policy on sustainable development”***

2.17 Sustainable development is a core principle underpinning all government policy. For the UK Government the goal of sustainable development is being pursued in an integrated way through a sustainable, innovative and productive economy that delivers high levels of employment and a just society that promotes social inclusion, sustainable communities and personal wellbeing. The goal is pursued in ways that protect and enhance the physical and natural environment, and that use resources and energy as efficiently as possible.

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

What do the aims of the Noise Policy Statement for England mean?

2.19 There are several key phrases within the NPSE aims and these are discussed below.

“*Significant adverse” and “adverse”*

2.20 There are two established concepts from toxicology that are currently being applied to noise impacts, for example, by the World Health Organisation. They are:

NOEL – No Observed Effect Level

This is the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise.

LOAEL – Lowest Observed Adverse Effect Level

This is the level above which adverse effects on health and quality of life can be detected.

2.21 Extending these concepts for the purpose of this NPSE leads to the concept of a significant observed adverse effect level.

SOAEL – Significant Observed Adverse Effect Level

This is the level above which significant adverse effects on health and quality of life occur.

2.22 It is not possible to have a single objective noise-based measure that defines SOAEL that is applicable to all sources of noise in all situations. Consequently, the SOAEL is likely to be different for different noise sources, for different receptors and at different times. It is acknowledged that further research is required to increase our understanding of what may constitute a significant adverse impact on health and quality of life from noise. However, not having specific SOAEL values in the NPSE provides the necessary policy flexibility until further evidence and suitable guidance is available.

The first aim of the Noise Policy Statement for England

Avoid significant adverse impacts on health and quality of life from environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.

2.23 The first aim of the NPSE states that significant adverse effects on health and quality of life should be avoided while also taking into account the guiding principles of sustainable development (paragraph 1.8).

The second aim of the Noise Policy Statement for England

Mitigate and minimise adverse impacts on health and quality of life from environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.

2.24 The second aim of the NPSE refers to the situation where the impact lies somewhere between LOAEL and SOAEL. It requires that all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development (paragraph 1.8). This does not mean that such adverse effects cannot occur.

The third aim of the Noise Policy Statement for England

Where possible, contribute to the improvement of health and quality of life through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.

2.25 This aim seeks, where possible, positively to improve health and quality of life through the pro-active management of noise while also taking into account the guiding principles of sustainable development (paragraph 1.8), recognising that there will be opportunities for such measures to be taken and that they will deliver potential benefits to society. The protection of quiet places and quiet times as well as the enhancement of the acoustic environment will assist with delivering this aim.

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Appendix AP2.6

BS 8233:2014

Guidance on sound insulation and noise reduction for buildings

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BSI Standards Publication

Guidance on sound insulation and noise reduction for buildings

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NOTE 5 If relying on closed windows to meet the guide values, there needs to be an appropriate alternative ventilation that does not compromise the facade insulation or the resulting noise level.

If applicable, any room should have adequate ventilation (e.g. trickle ventilators should be open) during assessment.

NOTE 6 Attention is drawn to the Building Regulations [30, 31, 32].

NOTE 7 Where development is considered necessary or desirable, despite external noise levels above WHO guidelines, the internal target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved.

If there is noise from a mechanical ventilation system, the internal ambient noise levels should be reported separately with the system operating and with it switched off. If the room contains items such as fridges, freezers, cookers and water heaters, these should be turned off during measurement. Shorter measurement periods such as $L_{\text{Aeq, 1 hour}}$ may be used by agreement, provided the selected shorter measurement period is shown to be representative of the entire night or day period.

7.7.3 Living accommodation

7.7.3.1 Regulatory framework

The sound insulation between adjoining dwellings is controlled by the Building Regulations [30, 31, 32], which require reasonable standards of insulation for certain walls, floors, and stairs. As the Building Regulations have been devolved in Scotland, Wales and Northern Ireland, the appropriate national regulations should be consulted, together with their supporting documents:

- England: Approved Document E [1];
- Wales: Approved Document E [1];
- Scotland: Section 5 of the Technical Handbook [33];
- Northern Ireland: Technical Booklets G and G1 [34].

7.7.3.2 Design criteria for external noise

For traditional external areas that are used for amenity space, such as gardens and patios, it is desirable that the external noise level does not exceed 50 dB $L_{\text{Aeq},T}$, with an upper guideline value of 55 dB $L_{\text{Aeq},T}$ which would be acceptable in noisier environments. However, it is also recognized that these guideline values are not achievable in all circumstances where development might be desirable. In higher noise areas, such as city centres or urban areas adjoining the strategic transport network, a compromise between elevated noise levels and other factors, such as the convenience of living in these locations or making efficient use of land resources to ensure development needs can be met, might be warranted. In such a situation, development should be designed to achieve the lowest practicable levels in these external amenity spaces, but should not be prohibited.

Other locations, such as balconies, roof gardens and terraces, are also important in residential buildings where normal external amenity space might be limited or not available, i.e. in flats, apartment blocks, etc. In these locations, specification of noise limits is not necessarily appropriate. Small balconies may be included for uses such as drying washing or growing pot plants, and noise limits should not be necessary for these uses. However, the general guidance on noise in amenity space is still appropriate for larger balconies, roof gardens and terraces, which might be intended to be used for relaxation. In high-noise areas, consideration should be given to protecting these areas by screening or building design to achieve the lowest practicable levels. Achieving levels of 55 dB $L_{Aeq,T}$ or less might not be possible at the outer edge of these areas, but should be achievable in some areas of the space.

7.7.3.3 Internal planning

To minimize disturbance from internally generated noise:

a) services should be kept away from bedrooms;

b) special attention should be given when locating stairs next to noise-sensitive rooms, such as bedrooms, to prevent disturbance by footsteps;

c) special attention should be given when locating bedrooms near the lift and circulation areas, with less sensitive rooms being used as buffers.

NOTE Compatibility between rooms of adjacent dwellings can be assisted by handing and stacking identical dwelling plans.

Where it is necessary to locate bedrooms adjacent to stairs (other than stairs used for fire escape) or lifts, precautions should be taken where practical to minimize noise transfer.

7.7.3.4 Noise levels from lifts in living accommodation

7.7.3.4.1 General

The maximum recommended noise levels within the living accommodation due to lift operation should not exceed the values given in Table 5. These criteria relate to the highest noise levels during any part of the lift cycle and with any occupancy level between zero and the recommended maximum number of people in a car.

The values in Table 5 should be regarded as upper guideline values and every effort should be made in the design of the lift systems and components to minimize noise and vibration at source such that lower levels result in practice.

Table 5 **Noise levels from lifts in living accommodation**

Room	Maximum noise level (dB $L_{Amax,F}$)
Bedroom	25
Living room	30
Other areas	35

NOTE These figures relate solely to lift noise levels and do not account for any other noise sources. These values include noise from the lifts irrespective of the transmission mechanism, i.e. they include both airborne and structure-borne noise.

The lift motor and associated equipment should be installed on suitable anti-vibration mountings to prevent the transmission of excessive vibration and/or structure-borne noise to any parts of the living accommodation.