

*Environmental Noise Limits
and Control*



Department of Environment
Ministry of Natural Resources and Environment
Malaysia



FOREWORD

The Department of Environment hereby published 3 sets of documents to provide guidance on acceptable noise limits for various types of land use and human activities. ***The Planning Guidelines for Environmental Noise Limits and Control*** provide noise acceptance criteria for quantitative assessment of noise to define disturbance or otherwise. ***The Guidelines for Noise Labeling and Emission Limits of Outdoor Sources*** prescribes comprehensive methodology to measure and report noise emission from outdoor sources. ***The Planning Guidelines for Vibration Limits and Control*** gives vibration acceptance criteria for quantitative assessment of vibration.

It is hoped that these document could serve as useful guide to planners and decision makers at the state and local level as well as other organization, bodies and agencies involved or having responsibilities in the design and/or approval of town planing, infrastructure development, etc. so as to reduce the potential impact of noise affecting public health or causing annoyance or disturbance. Continuing efforts to improve the content and structures of these guidelines based upon feedback from users will be made from time to time.

In the publication of these documents, I would like with sincere appreciation to acknowledge the valuable expert contribution of the University of Technology Malaysia, in particular Prof. Dr. Mohd Salman Leong Bin Abdullah, the relevant agencies and all individuals in providing the necessary and relevant inputs, comments and recommendations towards the successful completion of the documents.

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THE PLANNING GUIDELINES FOR ENVIRONMENTAL NOISE LIMITS AND CONTROL

TABLE OF CONTENTS

TITLE	PAGE
1.0 Scope	3
2.0 Purpose	3
3.0 Legislative Background	3
4.0 Noise Limits	4
5.0 Noise Measurements	6
6.0 Monitoring Point(s)	7
7.0 Noise Severity And Impact Assessment	7
8.0 Noise And Planning	8
9.0 Noise Control	9

LIST OF ANNEXES

TITLE	PAGE
Annex A - Schedule of permissible sound levels	10
Annex B - Procedures for measurement of noise immission level	15
Annex C - Procedures for assessment of community annoyance response	21
Annex D - Code of practice to minimize noise disturbance	23
Annex E - Statutory instruments, standards and other guidance	27
Glossary	30

1.0 Scope

- 1.1 This document presents guidance and recommendations for
 - (a) specifying noise limits in the environment for the protection of the public from excessive noise;
 - (b) procedures on environmental noise measurements and impact assessment;
 - (c) noise parameters for the assessment of different noise sources; and
 - (d) noise abatement through planning and control.
- 1.2 For the purpose of these guidelines, definitions used are consistent with those given in ISO 1996/1, BS 661, and BS 3015. A glossary of definitions is also included in this document.
- 1.3 These guidelines present noise acceptance criteria upon which a quantitative assessment of noise could be made. This eliminates subjective judgment of parties involved, ambiguity in defining a disturbance, and places the assessment of a noise source on a measurement basis.

2.0 Purpose

- 2.1 The purposes of these guidelines are:
 - (a) for planning purposes, typically by project proponents, local authorities, and consultants;
 - (b) to be used in noise impact assessments, and pre- and post EIA compliance verification;
 - (c) in quantifying a noise disturbance on a quantitative manner; and
 - (d) to offer an introductory treatise in environmental noise control.

3.0 Legislative Background

- 3.1 Section 23 under The Environmental Quality Act 1974 stipulates that : “No person shall, unless licensed, emit or cause or permit to be emitted any noise greater in volume, intensity or quality in contravention of the acceptable conditions specified under section 21.”

- 3.2 Approval of projects subjected to Environmental Impact Assessment (EIA) procedures and requirements usually include maximum permissible noise limits at the affected areas that must be complied with during the construction phase and/or operation of the project.
- 3.3 The Department of Environment in these guidelines present recommendations upon which acceptable noise limits could be specified. In instances of new noise sources or projects, compliance to these limits may be made mandatory using legislative instruments available to the Department of Environment, and other authorities (Local Authorities, City Halls, etc).
- 3.4 Prior to these guidelines as presented here, acceptable limits had been set based on “Guidelines for Siting and Zoning of Industries”,and “Guidelines an Application for Permission to Install Generator Sets”. These current guidelines supercedes noise limits set in the above documents; and presents a comprehensive and unambiguous manner upon which noise could be measured and assessed against the prescribed standards for all applications.

4.0 Noise Limits

- 4.1 Noise limits may be set based on either of the following, depending on circumstances:
- (a) an absolute limit based on the average level of noise which should not be exceeded in a specified time period;
 - (b) a relative limit based on the permitted increase in noise level with respect to the background level.
- 4.2 These limits may either be a single value over the relevant time periods, or different values for day and night. It may also be appropriate to set an evening value where the noise source lends itself to such control. The setting of an absolute limit is often desirable, but would require care in noise monitoring and assessment to ensure that unrelated or extraneous noises (which will increase the measured noise level) do not influence the assessment.
- 4.3 Relative limits in general are not appropriate where the permitted increase in noise over background is substantial, for example 15 dB or more. Because background noise varies during the day, the background noise level determined should be representative of a typical quiet period during the working day.
- 4.4 Acceptance limits for noise should be consistent with the environmental noise climate that currently exists at a location -such that an adverse impact on the environment and affected property are avoided, and at the same time maintain a reasonable balance with physical development and/or activities.
- 4.5 Recommended maximum permissible sound levels as measured at the real property boundary, and assessed under the respective land use, are given in [Annex A](#).
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- 4.6 Under normal circumstances, these sound levels shall apply to outdoor locations at the real property boundary of the receiver (typically residential areas, or other noise sensitive area). This shall include assessment of sound levels from road traffic, railways and other noise source(s). In instances of industrial noise sources in an industrial zone, the sound level shall be at the property boundary of the industrial site or plant under assessment.
- 4.7 Schedule 1 of Annex A prescribes maximum permissible sound level (L_{Aeq}) by receiving land use for planning purposes and new development. These limits should be used for new industrial, commercial or housing areas; and/or development affecting such areas. Such limits are deemed to be a requisite in protecting public health and welfare with an adequate margin of safety.
- 4.8 For new development (industrial, transportation: roads, rails) in areas of existing high environmental noise climate, the maximum permissible sound level (L_{Aeq}) at the receiver locations should not be higher than noise limits prescribed in Schedule 2. This schedule presents an absolute limit for the noise level L_{Aeq} based on the existing ambient percentile index L_{90} plus an allowable noise increment.
- 4.9 In instances where the existing noise climate (L_{Aeq}) is higher than the planning values of Schedule 1; or when the noise limits ($L_{Aeq} = L_{90} + \text{Factor}$) prescribed in Schedule 2 are lower than the existing noise climate, an acceptance criteria based on maintaining a noise level similar to the existing noise climate (existing L_{Aeq}) may be more appropriate. This acceptance criterion is tabulated in Schedule 3.
- 4.10 Recommended limiting sound levels (L_{Aeq}) from road traffic for proposed new roads and/or redevelopment of existing roads are given in Schedule 4.
- 4.11 Recommended limiting sound levels (L_{Aeq}) from railways including transit trains for new development or re-alignments are given in Schedule 5. A maximum permissible instantaneous maximum sound pressure levels for the transient pass-by noise is also stipulated. This is the single event maximum instantaneous noise limit permissible for the entire measurement duration.
- 4.12 Due to the intrusive but temporal nature of construction noise, maximum permissible sound levels (statistical centile L_{90} , L_{10} , and maximum instantaneous sound pressure level) for construction, maintenance and demolition works should be observed. These limits are stipulated in Schedule 6. Assessment of the L_{10} and L_{max} levels are generally intended for impulsive or fluctuating noise sources (for example piling, pneumatic tools, etc).

5.0 Noise Measurements

5.1 Measurements of noise levels are often necessary for any of the following purpose:

- (a) assessing the existing noise climate.
- (b) assessing compliance to noise limits for noise limits for noise source(s) and/or project development.
- (c) assessing environmental impact and potential community response.

5.2 Noise measurements usually include the following:

- (a) background (ambient) sound pressure levels at a receiver location(s) and/or at the real property boundary of a noise source(s). These may be undertaken at a location(s) prior to a project development. It could also be undertaken in the absence of the noise source(s) (example with a plant or facility not operating).
- (b) sound pressure levels at a receiver location (s) and/or at the real property boundary of a noise source with the plant or facility operating and/or completion and operation of a project (highway, transit trains, industrial plant, etc.).
- (c) sound pressure levels of each noise source as may be required to evaluate the contribution of each source.

5.3 Noise measured indoors may also be undertaken, but is usually not desirable for environmental impact assessments of project development or noise source(s) unless otherwise required by prior conditions or assessment requirements. Measurement indoors is governed by the severity of noise source, the sound insulation properties of the building, and acoustic characteristics of the interior space.

5.4 Procedures for measurement of sound levels in the environment and noise source(s) severity assessment as described in [Annex B](#) should be used. Guidance on the use and selection of an appropriate noise measurement parameter (indices) and sampling methods are also given in [Annex B](#).

- 5.5 Because noise vary over time and have different characteristics, several indices are available to describe noise levels. The equivalent continuous noise level over a time period T ($L_{Aeq,T}$) is the preferred general purpose index for environmental noise. For road traffic noise $L_{A10,18h}$ is still widely used; and to describe background noise $L_{A90,T}$ is appropriate.
- 5.6 To describe the sound insulation of a component of a building envelope (e.g. window) the acoustic rating R_w (BS 5821: Part 3: 1984) is appropriate. It is more difficult to specify the insulation of the whole building envelope because the value depends on different insulation values for the various building elements such as windows, walls and roof structure, as well as the type of noise source and its location.

6.0 Monitoring point(s)

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

7.0 Noise Severity and Impact Assessment

- 7.1 Noise could be assessed against an absolute numerical noise limit (as proposed in [Annex A](#)), or alternatively assessed based on the relative increase of the noise levels with respect to a background noise level.
- 7.2 Assessment of noise levels against a noise limit is fairly straight forward, as it merely requires comparison of the measured noise level against the permissible sound pressure levels. Assessment of the impact of a noise level in the environment, and the anticipated community response to the noise could also be made by evaluating the magnitude by which the assessed noise level exceeds the existing ambient sound level.
- 7.3 The use of ISO-R 1996 Acoustics – “Assessment of Noise with Respect to Community Response” are recommended for community annoyance response evaluation. Procedures as adopted from ISO-R 1996 are described in [Annex C](#).

8.0 Noise and Planning

- 8.1 The impact of noise should be considered in the planning of a project development, and in general be guided by these Guidelines.
- 8.2 For the purpose of the consideration of noise in planning, the following information may reasonably require:
- (i) the existing daytime and night-time (L_{Aeq}) equivalent sound levels for a representative sample of locations, existing noise zones; identification of the major sources of sound;
 - (ii) any projected or proposed new or expanded sources of sound which may affect exposure of the site during three years following completion of the project and the projected future daytime and night-time (L_{Aeq}) equivalent sound levels; projected noise contours; and changes to existing noise zones at the site resulting from these new or expanded sources;
 - (iii) where applicable, plans for noise attenuation measures on the site and/or of the structure proposed to be built, and the amount of sound attenuation anticipated as a result of these measures.
- 8.3 The Project Proponent and any other Person(s) who would operate or cause to operate equipment, plant, process or activity with noise generation should undertake all reasonable measures to control the source of, or limit exposure to, noise. Such measures should be proportionate and reasonable, and may include one or more of the following:
- (a) land use compatibility: proposed operations shall be compatible with designated land use;
 - (b) layout : adequate distance between source and noise-sensitive neighbours, building or area; the usage and designation of buffer zones shall be in accordance to Planning Guidelines issued by the Department of Environment from time to time; screening by barriers, (natural, man-made or otherwise) and other buildings;
 - (c) engineering measures: reduction of sound at point of generation, containment of noise generated by adequate design of building envelope, and protection of adjacent noise-sensitive buildings by sound insulation or screening of the buildings;
 - (d) administrative measures: limiting the operating time of noise source(s); restricting the activities and ensuring acceptable sound emission limits of noise source.
- 8.4 In instances where noise would be potential concern, the Project Proponent and/or parties responsible for the noise source or emissions should undertake sound propagation predictions to the environment using acoustic modelling techniques and/or algorithms such that the impact of noise could be assessed. The parameters used in the analysis shall include but are not limited to sound power level emissions (actual or estimated), directivity factors, ground effects, distance, meteorological influences, and transmission path

9.0 Noise Control

- 9.1. The Project Proponent, and/or any other occupier of any industrial or trade premises, construction sites, and/or person(s) responsible for excessive sound generation should use the “best practical means” to minimise the sound generation and reduce its propagation to the environment.
- 9.2 Excessive sound generation is deemed to occur when noise levels above the noise limits prescribed in these Guidelines are exceeded. “Best practical means” in the context of these guidelines, shall include but not limited to:-
- (i) the size, design and inherent operation characteristics of the plant, equipment, process or activity;
 - (ii) the adjustment of operational parameters to limit the intensity of sound emissions,
 - (iii) the selection and usage of low sound power levels equipment;
 - (iv) the provision if necessary, and appropriate use of sound attenuators, acoustic plenum, and other acoustic filtering devices;
 - (v) the provision if necessary, and appropriate use of acoustic enclosures and other sound enclosing devices;
 - (vi) the provision if necessary, and appropriate use of screening barriers (man-made, natural or otherwise);
 - (vii) the proper conduct and adequate supervision of operation; and
 - (viii) regular and efficient maintenance of plant and control equipment.
- 9.3 In instances of high noise severity, the Department of Environment at its discretion may make it mandatory for the Project Proponent and/or noise source originator or person(s) responsible for the excessive sound generation to institute measures for reducing sound levels to comply with limits as prescribed in these Guidelines.

ANNEX A SCHEDULE OF PERMISSIBLE SOUND LEVELS

SCHEDULE 1

MAXIMUM PERMISSIBLE SOUND LEVEL (L_{Aeq}) BY RECEIVING LAND USE FOR PLANNING AND NEW DEVELOPMENT

Receiving Land Use Category	Day Time 7.00 am - 10.00 pm	Night Time 10.00 pm - 7.00 am
Noise Sensitive Areas, Low Density Residential, Institutional (School, Hospital), Worship Areas.	50 dBA	40 dBA
Suburban Residential (Medium Density) Areas, Public Spaces, Parks, Recreational Areas.	55dBA	45 dBA
Urban Residential (High Density) Areas, Designated Mixed Development Areas (Residential - Commercial).	60 dBA	50 dBA
Commercial Business Zones	65 dBA	55 dBA
Designated Industrial Zones	70 dBA	60 dBA

SCHEDULE 2**MAXIMUM PERMISSIBLE SOUND LEVEL (L_{Aeq}) OF NEW DEVELOPMENT
(ROADS, RAILS, INDUSTRIAL) IN AREAS OF EXISTING
HIGH ENVIRONMENTAL NOISE CLIMATE**

Receiving Land Use Category	Day Time 7.00 am - 10.00 pm	Night Time 10.00 pm - 7.00am
Noise Sensitive Areas, Low Density Residential	$L_{90} + 10$ dBA	$L_{90} + 5$ dBA
Suburban and Urban Residential Areas	$L_{90} + 10$ dBA	$L_{90} + 10$ dBA
Commercial, Business	$L_{90} + 10$ dBA	$L_{90} + 10$ dBA
Industrial	$L_{90} + 10$ dBA	$L_{90} + 10$ dBA

L_{90} is the measured ninety percentile sound level for the respective time period of the existing areas of interest in the absence of the proposed new development.

SCHEDULE 3**MAXIMUM PERMISSIBLE SOUND LEVEL (L_{Aeq}) TO BE MAINTAINED AT THE EXISTING
NOISE CLIMATE**

Existing Levels	New Desirable Levels	Maximum Permissible Levels
L_{Aeq}	L_{Aeq}	$L_{Aeq} + 3$ dBA

SCHEDULE 4***LIMITING SOUND LEVEL (L_{Aeq}) FROM ROAD TRAFFIC (FOR PROPOSED NEW ROADS AND/OR REDEVELOPMENT OF EXISTING ROADS)***

Receiving Land Use Category	Day Time 7.00 am - 10.00 pm	Night Time 10.00 pm - 7.00 am
Noise Sensitive Areas Low Density Residential Areas	55 dBA	50 dBA
Suburban Residential (Medium Density)	60 dBA	55 dBA
Urban Residential (High Density)	65 dBA	60 dBA
Commercial, Business	70 dBA	60 dBA
Industrial	75 dBA	65 dBA

SCHEDULE 5***LIMITING SOUND LEVEL (L_{Aeq}) FOR RAILWAYS INCLUDING TRANSITS
(FOR NEW DEVELOPMENT AND RE-ALIGNMENTS)***

Receiving Land Use Category	Day Time 7.00 am - 10.00 pm	Night Time 10.00 pm - 7.00 am	L_{max} (Day & Night)
Noise Sensitive Areas Low Density Residential Areas	60 dBA	50 dBA	75 dBA
Suburban and Urban Residential Areas	65 dBA	60 dBA	80 dBA
Commercial, Business	70 dBA	65 dBA	80 dBA
Industrial	75 dBA	65 dBA	NA

SCHEDULE 6

MAXIMUM PERMISSIBLE SOUND LEVELS (PERCENTILE L_N AND L_{MAX}) OF CONSTRUCTION, MAINTENANCE AND DEMOLITION WORK BY RECEIVING LAND USE

Receiving Land Use Category	Noise Parameter	Day Time 7.00 am - 7.00 pm	Evening 7.00 pm - 10.00 pm	Night Time 10.00 pm - 7.00 am
Residential (Note 2 **)	L_{90}	60 dBA	55 dBA	* (Note 1)
	L_{10}	75 dBA	70 dBA	*
	L_{max}	90 dBA	85 dBA	*
Commercial (Note 2 **)	L_{90}	65 dBA	60 dBA	NA
	L_{10}	75 dBA	70 dBA	NA
Industrial	L_{90}	70 dBA	NA	NA
	L_{10}	80 dBA	NA	NA

NOTES

*1. At these times the maximum permissible levels as stipulated in the Schedule 1 for the respective residential density type shall apply. This may mean that no noisy construction work can take place during these hours.

**2. A reduction of these levels in the vicinity of certain institutions such as schools, hospitals mosque and noise sensitive premises (apartments, residential dwellings, hotel) may be exercised by the local authority or Department of Environment.

Where the affected premises are noise sensitive, the limits of the Schedule 1 shall apply.

3. In the event that the existing ambient sound level (L_{90}) without construction, maintenance and demolition works is higher than the L_{90} limit of the above Schedule, the higher measured ambient L_{90} sound level shall prevail. In this case, the maximum permissible L_{10} sound level shall not exceed the Ambient L_{90} level + 10 dBA, or the above Schedule L_{10} whichever is the higher.

4. NA = Not Applicable.

ANNEX B

PROCEDURES FOR MEASUREMENT OF NOISE IMMISSION LEVELS

1.0 Measurement equipment.

- 1.1 The measurement shall be made with a precision sound level meter which complies with the requirements of the IEC Publications 60651, 60804 and 61672 or thereafter, for the type of meters in Class 1.
- 1.2 The "A" weighting network, and "fast" time weighting response shall be used for sound pressure level measurements for equivalent Leq and statistical centile readings.
- 1.3 Measurement for statistical centile levels (L_{10} , L_{90}) and maximum instantaneous level (L_{max}) shall be made using a sound level meter installed with statistical analysis functions, or alternatively computed from continuously monitored instantaneous sound pressure levels using data acquisition system for the stipulated time period.
- 1.4 Measurement for blasting and other explosion related activities shall be made using linear weighting network (dB Linear) for a peak value ("peak" time constant setting) with a "maximum hold" function of the sound level meter.
- 1.5 Other supplementary measurement(s) of impulsive sound, for the purpose of reporting and record keeping, shall be measured using an "impulse" time weighting response.
- 1.6 If a graphic level recorder is used the recorder shall be set with a writing speed which most closely approximates the "fast" time weighting response (for example, a writing speed of 100mm/s for a chart width of 50 mm).
- 1.7 The calibration of sound level meter shall be checked and adjusted according to the manufacturer's instructions or with a standard sound source (for example a pistonphone) at the beginning and at the end of each series of measurements. If the errors of the sound level meter obtained from these calibrations deviates by more than 1dB during a series of measurements, the measured result shall be considered invalid.
- 1.8 A wind shield approved by the microphone manufacturer shall be used. Measurements cannot normally be made if the wind speed exceeds 5m/s at the microphone position. For continuous remote monitoring, the wind speed shall be monitored concurrently with the sound levels.

2.0 Measurement locations.

- 2.1 Measurements for noise immision as propagated to the environment by a sound source shall be made at locations along or adjacent the real property boundary of the sound source, and/or at the receiver location.
- 2.2 Measurements shall be made at all strategic locations representative of the entire real property boundary, and at all locations affecting the community. These shall include but are not limited to locations at closest proximity to the sound source(s) affected by the noise of these source(s).
- 2.3 Measurements shall be made outdoors at 1.2 to 1.5 m above the ground and, practical, at least 3.5m from walls, buildings or other sound reflecting structures. When circumstances dictate, measurements may be made at greater heights and closer to the wall (for example 0.5 m in front of an open window) and these special conditions indicated in the measurement records.
- 2.4 Care shall be taken to avoid influence on the result from other unwanted sound signals, for example noise from wind on the microphone of the measuring equipment, noise from electrical interference or noise from extraneous sources.
- 2.5 When the noise source is distant, the measured sound level may depend significantly on the climatic conditions. It is recommended that extreme climatic conditions be avoided. A typical value and an indication of the range of variation shall be obtained.

3.0 Measurement methods and parameters

- 3.1 Various methods of noise measurements and noise parameters are described in the annex. The method to be selected in a particular case will depend on the temporal variations of noise level, on the resources available and on the time period over which the noise is to be measured.
- 3.2 Sampling methods can be divided into three broad categories; and the selection of the method deemed most appropriate is dependent on the purpose and accuracy required of the monitoring.

(a) Continuous day night sampling

This procedure involves the continuous sampling of instantaneous sound pressure level for the entire duration of a day (0700 to 2200 hours) and/or night (2200 to 0700 hours) to obtain the day time $L_{Aeq\ day, 15h}$ and night time $L_{Aeq\ night, 9h}$.

Data sampling can be undertaken in a continuous mode (non-stop) for the entire day/night time period using an integrated sound level meter, or sampled continuously on an hourly basis and repeated continuously over the hours to obtain the $L_{Aeq, 1h}$ levels, and the L_{Aeq} day and L_{Aeq} night computed from the hourly $L_{Aeq, 1h}$ noise level/time profile.

This procedure can be undertaken with a permanent monitoring station (but requires care to ensure that extraneous noise source unrelated to the events monitored do not influence the results); or undertaken manually.

(b) Regular sampling repeated over a hourly basis

This procedure involves the continuous sampling of instantaneous sound pressure level over a designated duration (for example 5 to 20 minutes) repeated over every hour. This procedure in essence limits data sampling over a shorter period of time per hour, thereby permitting measurements to be undertaken at more positions. Uncertainty and errors in the L_{Aeq} values are therefore inevitable.

(c) 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).

- 3.3 The size of possible errors in estimates of L_{Aeq} 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. The Table below 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 building sites but may not be applicable for large sites where there are very wide fluctuations in noise level (e.g. for some types of piling).

Estimation of daily L_{Aeq} according to sampling technique

Sampling techniques	Daily L_{Aeq} estimated within (95%) confidence
	dB(A)
5 min every 1h	± 2.5
20 min every 1h	± 1.5
Single 20 min sample	$\pm 5^*$
Single 60 min sample	$\pm 3^*$

Source: BS 5228 Part 1: 1984

* These figures assume that measurements are only taken when the site is working normally (e.g. not during meal breaks).

- 3.4 For compliance verification and record keeping, the sampling period should be continuous to cover the entire twenty four hour day cycle to obtain the respective day time, evening and night time noise levels.
- 3.5 For preliminary EIA and/or evaluation of continuous sound sources, a sampling period of not less than 20 minutes for each hour period to be repeated hourly over the day/evening/night to obtain an hourly profile, and thereafter the computed L_{eq} is acceptable. This approximation is not acceptable for transient impulsive sound source(s) typical in construction sites or activities.
- 3.6 Measurements for equivalent sound levels (L_{eq}) and statistical centile levels (L_{10} , L_{90} , and including L_{max}) shall be undertaken with continuous sampling for the entire time period of interest, i.e. day time, evening, and night time.

4.0 Number and duration of measurements

- 4.1 At least three measurements should be carried out at each measuring location.

For continuous monitoring over a complete 24 hours cycle (for day and night time L_{Aeq}) a single continuous 24 hours measurement per measuring location is often acceptable if the noise source generation at the day of measurement is deemed representative of the source(s).

- 4.2 The measurements shall be considered valid if the range of three measurements made immediately one after the other is not greater than 2 dB for steady state noise.

The arithmetic mean value given by these measurements shall constitute the result.

- 4.3 For transient or impulsive noise, the highest L_{max} value as obtained shall be taken as the maximum instantaneous level occurring over the period of measurement. It is however recommended that repeat measurements be undertaken where feasible to confirm repeatability of this reading.

- 4.4 For compliance verification and record keeping the measurements should be undertaken by the Project Proponent for every day for a minimum of two weeks.

- 4.5 In the interest of protection of public, including abatement for community annoyance response, the Department of Environment may at its discretion require permanent or semi-permanent long term monitoring for sound to be undertaken by person(s) responsible for excessive noise generation consistent with the period or duration the sound source(s) may be in operation or anticipated to be a nuisance.

5.0 Noise mapping

- 5.1 For the purpose of assessment and planning approval, noise mapping in the form of noise zones is usually required. Noise zones should clearly show sound level with respect to the location of the site and sound source(s).

- 5.2 Noise zones may be obtained and presented in sound level ranges of 5 dBA L_{Aeq} increment (for example 40-45 dBA, 45-50 dBA, etc.).

- 5.3 The mapping of noise zones without the influence of the noise source(s) under evaluation should be obtained, and compared with noise zones with the subsequent contribution of the above said noise source(s).

- 5.4 Detailed noise contours for further assessment may be required as and when necessary.

6.0 Record keeping

6.1 The following information should be recorded and kept for record purposes.

- (a) The measured values of L_{Aeq} and, where appropriate $L_{pA, max}$ or L_{10}, L_{90} , 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 may have adversely affected the reliability or accuracy of the measurements.
- (d) Plans of the site and neighbourhood showing position of plant, associated buildings and notes of site activities during monitoring period(s).
- (e) Notes on weather conditions, including, where possible, wind speed/direction, temperature, relative humidity, presence of precipitation, etc.

ANNEX C

PROCEDURES FOR ASSESSMENT OF COMMUNITY ANNOYANCE RESPONSE

- 1.0 These procedures as prescribed herein are intended to assess sound with respect to community annoyance response, and are in general guided by the International Organisation for Standardisation ISO R 1996 Acoustics - "Assessment of Noise with Respect to Community Response".
- 2.0 The sound level of the offending sound source(s) shall be measured (or estimated as the case may be for a new project development, process or activity). The equivalent "A" weighted fast response sound level (L_{eq}) shall be used for quantifying the sound emission of the source. Normalisation for peak factor associated with impulsive sound, spectrum character for tonal content of the sound, and duration of the Table 1 shall be undertaken. The normalised sound level (as corrected for the characteristic features of the sound) yields the rating sound level (L_r).
- 3.0 The noise criterion of the receiver (community) shall be taken as the existing ambient sound level at the real property boundary of interest in the absence of the offending sound source(s) but shall include prevailing environmental noise sources prior to the introduction of the new sound source(s). The existing ambient sound level is defined as the mean minimum sound level at this location and time (in the absence of the noise which is alleged to be offending), and shall be taken as the ninety percentile (L_{90}) "A" weighted fast response level. The L_{90} levels for day time, night time (and evening time) period shall be so quantified.
- 4.0 Exceedance of the rating sound level (L_r) above the noise criterion (L_{90}) is computed as $L_r - L_{90}$ dBA. This exceedance quantifies anticipated impact and community reaction to the offending sound source(s), and is tabulated in Table 2.

TABLE 1 - Corrections to the measured (or predicted) sound level in dB (A)

Characteristic features of the sound		Correction dB(A)
Peak factor	Impulsive noise (e.g. from piling)	+5
Spectrum character	Audible tone components present (e.g. whine)	+5
Duration of the sound as a percentage of the relevant time period	Between :	
	100 and 56	0
	56 and 18	-5
	18 and 6	-10
	6 and 1.8	-15
	1.8 and 0.6	-20
	0.6 and 0.2	-25
	Less than 0.2	-30

TABLE 2 - Anticipated community response to noise

Amount in dB(A) by which the rating sound level L _r exceeds the noise criterion	Anticipated community response	
	Impact	Description
0	None	No observed reaction
5	Little	Sporadic complaints
10	Medium	Widespread complaints
15	Strong	Threats of community action
20	Very Strong	Vigorous community action

ANNEX D

CODE OF PRACTICE TO MINIMISE NOISE DISTURBANCE

- 1.0 No person should unreasonably make, continue, or cause to be made or continued, any noise disturbance. Lawful non-commercial public speaking and public assembly activities conducted on any public space or public right-of-way are exempted.
- 2.0 In the context of these Guidelines, noise disturbance shall mean any sound which:
 - (i) endangers or injures the safety or health of human or animals; or
 - (ii) annoys or disturbs a reasonable person of normal sensitivities; or
 - (iii) endangers or intrudes onto personal or real property boundary; or
 - (iv) exceeds the existing ambient equivalent A-weighted sound level (L_{Aeq}) by 10 dBA during the day time, and/or 5 dBA during the night time; or
 - (v) exceeds the sound level limits as prescribed herein in these Guidelines.

3.0 Construction

Project Proponents or any other Person(s) should not operate or permit the operation of any tools or equipment used in construction, maintenance, or demolition work:

- (a) Between the hours of 10.00 p.m. and 7.00 a.m. the following day on weekdays or at any time on weekends or public holidays, such that the sound therefrom creates a noise disturbance across a residential real property boundary or within a noise sensitive zone, except for emergency work of public service, and utilities.
- (b) At any other time such that the sound level at or across real property boundary exceeds the stipulated maximum permissible sound levels as defined in the Second Schedule of Annex A for the daily period of operation.
- (c) The use of low noise (and vibration) generation equipment, process or activity shall be required in noise sensitive areas.
- (d) Procedures for noise control in accordance to BS 5228: Part 1 (Noise Control on Construction and Open Sites: Part 1 Code of Practice for Basic Information and Procedures for Noise Control) should be used.

4.0 Industrial Sites

- (a) Project Proponents and any other Person(s) should not operate or permit the operation of equipment or facilities in an industrial site such that noise levels exceed the maximum permissible limits as prescribed in the Guidelines.
- (b) Equipments or facilities located outdoor, exhaust, discharge vents, ventilation openings which generate excessive noise should be fitted with sound attenuators, enclosures or barriers as deemed appropriate.

5.0 Transportation

- (a) Project Proponents of new highways, road re-development or expansion, and rail or transit trains system(s) should minimize noise intrusion to residential areas and noise sensitive premises with alignments offering the maximum possible buffer zones and/or natural shielding.
- (b) In urban or suburban areas where a meaningful buffer zone is not possible, or/and when noise immission to affected receivers exceed maximum permissible limits as prescribed in the Guidelines the use of shielding (man made or natural barriers) may be required. Man made barriers should be aesthetically compatible with the surroundings.

6.0 Loudspeakers and Sound Reinforcement Systems

- (a) Sound amplified system, public address system, or similar device should not be used between the hours of 10:00 p.m. and 7:00 a.m. the following day, such that the sound therefrom creates a noise disturbance across a residential real property boundary or within a noise sensitive zone.
- (b) Sound amplified systems used in conjunction with mosques and other places of religious worship shall be exempted.

7.0 Radios, television sets, musical instruments and other devices

The operation or playing of any radio, television, phonograph, musical instrument, sound amplifier, or similar device which produces, reproduces, or amplifies sound should not be:

- (a) in such a manner as to create a noise disturbance across a real property boundary or within a noise sensitive zone, except for activities open to the public and for which a permit has been issued by the appropriate licensing authority;
-

- (b) in such a manner as to create a noise disturbance at 15 meters from such device, when operated in or on a motor vehicle on a public right-of-way or public space, or in a boat on public waters;
- (c) in such a manner as to create a noise disturbance to any person other than the operator of the device, when operated by any passenger on a common carrier.

8.0 Entertainment noise

Person(s) who organise, or operate a business or permit the hosting of activities, within their private property or public right of way, should ensure that these activities would not create a noise disturbance from their entertainment and recreational activities which result in sound levels exceeding maximum permissible limits as prescribed in these Guidelines.

9.0 Street Vendors

The offer for sale, to purchase or sell anything by shouting or outcry within any residential or commercial area when licensed by the appropriate licensing authority should not be between the hours of 7.00 a.m. and 10.00 p.m., or in such a manner as to cause a noise disturbance.

10.0 Loading and unloading

Person(s) when licensed by the local authority should not load, unload, open, close or engage in activities related to other handling of goods, cargo, boxes, crates, containers, building materials, garbage or similar objects between the hours of 10.00 p.m. and 7.00 a.m. the following day, or in such a manner as not to cause a noise disturbance across a residential real property boundary or within a noise sensitive zone.

11.0 Stationary non-emergency signaling devices

- (a) The sounding of any electronically-amplified signal from any stationary bell, chime, siren, whistle, or similar device, intended primarily for non-emergency purposes, from any place, should not be more than 5 minutes in any hourly period.
- (b) Devices used in conjunction with places of religious worship are exempted.

12.0 Emergency signaling devices

- (a) The sounding the outdoors of any fire, burglar, or civil defense alarm, siren, whistle or similar stationary emergency signaling device for testing, except for emergency purposes, should occur at the same time of day each time such a test is performed, but not before 8.00 a.m. or after 10.00 p.m. Any such testing should use only the minimum cycle test time. In no case should such test time exceed 60 seconds.
- (b) The sounding of any exterior burglar or fire alarm or any motor vehicle burglar alarm should automatically terminate within 5 minutes of activation.

13.0 Explosives, firearms, and similar devices

Person(s) unless duly authorised by law or carrying out legitimate duties as an armed personnel should not use or fire explosives, firearms, or similar devices which create impulsive sound so as to cause a noise disturbance across a real property boundary or on a public space or right-of-way.

14.0 Domestic power tools

The operation of any mechanically powered, or otherwise, saw, drill, sander, grinder, lawn or garden tool, or similar device used outdoors in residential areas should not be between the hours of 10.00 p.m. and 7.00 a.m. the following day, or cause a noise disturbance across a residential real property boundary.

15.0 Vehicle or motorboat repairs and testing

Activities relating to the repair, rebuilding, modification or testing any motor vehicle, motorcycle, or motorboat should not cause a noise disturbance across a residential real property boundary or within a noise sensitive zone.

16.0 Low frequency noise

- (a) Project Proponent or industrial plant operators should not operate or cause to be operated on private property any source of sound in such a manner as to create a low frequency noise disturbance.
 - (b) A low frequency noise disturbance is deemed to occur if the sound immission level measured at the real property boundary with a linear (non-weighted) scale exceeds the "A"-weighted scale level by 30 dB or more.
-

ANNEX E

STATUTORY INSTRUMENTS, STANDARDS AND OTHER GUIDANCE

1.0 The Environmental Quality Act

Under the Environmental Quality Act, 1974 (Amendment), 1985, there are several provisions that could be utilized to control and abate the noise pollution problems. The following are statements of the Environmental Quality Act, 1974.

(a) Section 21

The Minister, after consultation with the Council, may specify the acceptable conditions for the emission of noise into any area, segment or element of the environment and may set aside any area, segment or element of the environment within which the emission is prohibited or restricted.

(b) Section 23

1. No person shall, unless licensed, emit or cause or permit to be emitted any noise greater in volume, intensity or quality in contravention of the acceptable conditions specified under section 21.
2. Any person who contravenes subsection (1) shall be guilty of an offence and shall be liable to a fine not exceeding five thousand ringgit or to imprisonment for a period not exceeding one year or to both and to a further fine not exceeding five hundred ringgit a day for every day that the offences is continued after a notice by the Director General requiring him to cease the act specified therein has been served upon him.

(c) Section 48A

The Director General or any other officer duly authorized by him, has the power to test and prohibit use of vehicle.

(d) Section 51

The Minister after consultation with the Council may make regulations for or with respect to:

- (f) prohibiting the use of any equipment, facility, vehicle, or ship capable of causing pollution or regulating the construction, installation or operation thereof so as to prevent or minimize pollution, and
- (j) defining objectionable noise and prescribing standards for tolerable noise.

(e) Environmental Quality (Motor Vehicle Noise) Regulation, 1987

This regulation stipulates permissible noise emission from motor vehicles as measured in accordance to procedures stated here in the regulations.

2.0 Guidelines for Siting and Zoning of Industries by Department of Environment Malaysia

The existing guidelines only give daytime and night-time noise limits based on maximum sound levels according to category of industries. This is insufficient because internationally accepted noise indices being used worldwide are based on A-weighted continuous equivalent sound level, L_{Aeq} .

3.0 Local Government Act 1976

The Local Government Act 1976 and the various Town Board Enactment also contain provisions enabling due action to be taken against, including prosecution of owners or occupiers of premises, whether public or private, emitting noise that are deemed to be a nuisance. For the purpose of quantifying the acceptable noise levels, limits based on the best judgment of these Authorities had been used. Noise limits to be used by these Authorities could now be base on these Guidelines.

4.0 Minor Offences Ordinance 1953

Minor Offences Ordinance 1953 prohibits noise after 11.00 p.m., and the police are empowered to act forthwith on complains. Annoyance and nuisance could be assessed based on procedures presented in this guideline.

5.0 Civil Aviation Act 1969

Under the Civil Aviation Act, aircraft and airport authorities are absolved from paying compensation for nuisance noise only if the aircraft and airport authorities are operated in conformance with international civil aviation procedures.

6.0 The Factories and Machinery (Noise Exposure) Regulations 1989

The Regulations came into force on February 1, 1989. It was formulated under the Factories and Machinery Act, 1967, aimed at minimizing workers exposure to noise in their working environment. These Regulations stipulate maximum allowable noise limits in the workplace, and worker's allowable noise exposure dosage.

7.0 ISO 1996 – Assessment of Environmental Noise

- 7.1 ISO 1996 “Acoustics – Description and Measurement of Environmental Noise” is a central standard within environmental noise assessment, acting as a reference work on the subject. It is divided into 3 parts:
- (i) ISO 1996 Part 1 1982: Basic quantities and procedures
 - (ii) ISO 1996 Part 2 1987: Acquisition of data pertinent to land use (amended 1998)
 - (iii) ISO 1996 Part 3 1987: Application to noise limits
- 7.2 It defines the basic terminology including the central Rating Level parameter and describes best practices for assessing environmental noise.

8.0 ISO 9613 – Prediction of Environmental Noise

- 8.1 ISO 9613 “Acoustics – Attenuation of Sound during Propagation Outdoors” is divided into 2 parts:
- (i) ISO 9613 Part 1 1993: Calculation of the absorption of sound by the atmosphere
 - (ii) ISO 9613 Part 2 1996: General method of calculation
- 8.2 It defines an octave-based calculation method based on point sources with a defined sound power level. Line sources can be built up with point sources.

9.0 BS 5228: Part 1 1984

- 9.1 Noise control on construction and open sites. Part 1: Code of practice for basic information and procedures for noise control.
- 9.2 BS 5228 Part 1 gives recommendations for basic methods of noise control relating to construction sites and other open sites where having work activities and operation are carried out.

GLOSSARY

“commercial area/zone” means designated area/zone as approved or gazetted by the local authority under the relevant act, regulations, rules and by-laws made thereunder for the purpose of business, trading, financial, commercial and other similar activities.

“community” means the body of people gathered or living in the same locality.

“construction” means any site preparation, assembly, erection, substantial repair, alteration, refurbishment, renovation or similar action, but excluding demolition, for or of public or private rights-of-way, structures, utilities or similar property.

“dB (A)” means the decibel unit of measurement of sound level corrected to the “A” weighted scale.

“decibel (dB)” means a unit of measurement of sound level equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure of 20 micropascals.

“demolition” means any dismantling, intentional destruction or removal of structures, utilities, public or private right-of-way surfaces, or similar property.

“emergency work” means any work performed for the purpose of preventing or alleviating the physical trauma or property damage threatened or caused by an emergency.

“equivalent A-weighted sound level (L_{Aeq})” means the constant sound level that, in a given situation and time period, conveys the same sound energy as the actual time-varying A-weighted sound. For the purpose of these Guidelines, the day time L_{Aeq} is the equivalent A-weighted sound level for the day time period of 7.00 am to 10.00 pm (0700 to 2200 hours) and the night time L_{Aeq} is the equivalent A-weighted sound level for the night time period of 10.00 pm to 7.00 am (2200 to 0700 hours).

“impulsive sound” means sound of short duration, usually less than one second, with an abrupt onset and rapid decay. Examples of sources of impulsive sound are explosions, drop hammer or driven impacts, and the discharge of firearms.

“industrial area” means a designated area as approved or gazetted by the local authority for the purpose of siting industrial, manufacturing or processing plants, factories or facilities.

“licensing authority” means the local authority or state agencies or agents of the State that grants licence, approval or similar permission for a specific activity.

“local authority” means the local planning authorities, agencies, or agents of the State as defined in the Town and Country Planning Act, 1976 and such rules, regulations and by-laws made thereunder. These include City Halls, City Councils, Municipal Councils, Town Council and District Councils.

“mixed development area” means designated area as approved or gazetted by the local authority under the relevant act, regulations, rules and by-laws made thereunder, permitting business, commercial, trading or similar activities, together with residential uses.

“noise sensitive area or zone” means low density residential areas, schools, hospitals, and nursing homes, places of worship, religious buildings and courts of law.

“pure tone” means any sound which can be distinctly heard as a single pitch or a set of single pitches. A pure tone exist if the one-third octave band sound pressure level in the band with the tone exceeds the arithmetic average of the sound pressure levels of the two contiguous one-third octave bands by 5 dB for centre frequencies of 500 Hz and above, and by 8 dB for centre frequencies between 160 and 400 Hz, and by 15 dB for centre frequencies less than or equal to 125 Hz.

“real property boundary” means an imaginary line along the ground surface, and its vertical extension, which separates the real property owned by one person from that owned by another person, but not including intra-building real property divisions, as delineated in the land title appearing in the Certificate of Title.

“residential area” means a designated area as approved or gazetted by the local authority for the purpose of human dwellings and residence. “low density residential areas” is defined as areas with a population of less than 75 persons per acre; “suburban residential (medium density) areas” is defined as areas with a population of 75 to 200 persons per acre; and “urban residential (high density) areas” is defined as areas with a population exceeding 200 persons per acre.

“rms sound pressure” means the square root of the time averaged square of the sound pressure, denoted as P_{rms} .

“sound attenuator” or **“sound dissipative device”** means an acoustic filtering device for the attenuation of sound energy for airborne sound as transmitted to the atmosphere or surroundings of an equipment or sound source; such as muffler as used for engines exhausts, and silencer for air distribution equipment or enclosures.

“sound emission” means sound as emitted or discharged from a sound source(s).

“sound immission” means sound as propagated onto and received by a receiver from source(s) external to the receiver or real property boundary.

“sound level” means the weighted sound pressure level obtained by the use of a sound level meter and frequency weighting network, such as A, B, or C as specified for sound level meters. If the frequency weighting employed is not indicated, the linear non-weighting level shall apply.

“sound pressure level” means 20 times the logarithm to the base 10 of the ratio of the RMS sound pressure to the reference pressure of 20 micropascals. The sound pressure level is denoted L_p or SPL and is expressed in decibels.



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*Noise Labeling and Emission
Limits of Outdoor Sources*



Department of Environment
Ministry of Natural Resources and Environment
Malaysia



FOREWORD

The Department of Environment hereby published 3 sets of documents to provide guidance on acceptable noise limits for various types of land use and human activities. *The Planning Guidelines for Environmental Noise Limits and Control* provide noise acceptance criteria for quantitative assessment of noise to define disturbance or otherwise. *The Guidelines for Noise Labeling and Emission Limits of Outdoor Sources* prescribes comprehensive methodology to measure and report noise emission from outdoor sources. *The Planning Guidelines for Vibration Limits and Control* gives vibration acceptance criteria for quantitative assessment of vibration.

It is hoped that these document could serve as useful guide to planners and decision makers at the state and local level as well as other organization, bodies and agencies involved or having responsibilities in the design and/or approval of town planing, infrastructure development, etc. so as to reduce the potential impact of noise affecting public health or causing annoyance or disturbance. Continuing efforts to improve the content and structures of these guidelines based upon feedback from users will be made from time to time.

In the publication of these documents, I would like with sincere appreciation to acknowledge the valuable expert contribution of the University of Technology Malaysia, in particular Prof. Dr. Mohd Salman Leong Bin Abdullah, the relevant agencies and all individuals in providing the necessary and relevant inputs, comments and recommendations towards the successful completion of the documents.

DATO' HAJAH ROSNANI IBARAHIM

Director General

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THE GUIDELINES FOR NOISE LABELING AND EMISSION LIMITS OF OUTDOOR SOURCES

TABLE OF CONTENTS

TITLE	PAGE
1.0 Scope	3
2.0 Purpose	3
3.0 Legislative Background	3
4.0 Use Of Noise Labeling Information	4
5.0 Noise Emission Limits	5
6.0 Noise Labeling	6
7.0 Measurement Procedures	7

LIST OF ANNEXES

TITLE	PAGE
Annex A - Schedule of permissible sound emission levels	8
Annex B - Noise label stating the sound power and sound pressure level	12
Annex C - Supplementary notes on measurement conditions for specific machines	14
Annex D - Method to determine airborne sound emission of outdoor noise sources (piling operations and sound reinforcement systems)	17
Annex E - Statutory instruments, standards and other guidance	22
Glossary	25

1.0 Scope

- 1.1 This document presents guidance and recommendations for
- (a) specifying noise emission levels and noise labeling requirements;
 - (b) procedures for measurement and labeling of noise emission of outdoor noise sources; and
 - (c) noise parameters for the description of noise emission of outdoor noise sources.
- 1.2 For the purpose of these Guidelines, definitions used are consistent with those given in ISO 3740:1980, ISO 3746: 1979, ISO 3744: 1994, ISO 7574-3: 1985, and the European Community Council Directives on noise labeling. A glossary of definitions is also included in this document.
- 1.3 These Guidelines present a comprehensive and unambiguous manner upon which noise emission from outdoor noise sources could be measured and reported.

2.0 Purpose

- 2.1 The purposes of these guidelines are:
- (a) to present a uniform method in the measurement and labeling of outdoor noise sources; and
 - (b) to prescribe recommended maximum permissible sound emission levels for a variety of outdoor noise sources for the protection of the public from excessive noise.

3.0 Legislative Background

- 3.1 Section 23 under the Environmental Quality Act 1974 stipulates that: *“No person shall, unless licensed, emit or cause or permit to be emitted any noise greater in volume, intensity or quality in contravention of the acceptable conditions specified under Section 21.”*
- 3.2 The Environmental Quality (Motor Vehicle Noise) Regulation 1987 of the Environmental Quality Act 1974 stipulates permissible noise emission from motor vehicles, and procedures for the measurement of such noise emission.

- 3.3 The Department of Environment in these Guidelines present recommendations upon which acceptable noise emission limits and noise labeling could be specified for outdoor noise sources. These noise sources are for construction and industrial equipment commonly used outdoors. Sound emission from outdoor sound systems is also included. Noise emission from motor vehicles are however not included here as this is enforced under the Motor Vehicle Noise Regulation 1987.
- 3.4 Prior to the guidelines as presented here, acceptable noise limits at the property boundary are recommended for generator sets in the “Guidelines an Application for Permission to Install Generator Sets”. These Guidelines herein, and the Planning Guidelines For Environmental Noise Limits and Control supercede noise limits set in the above document.

4.0 Use of Noise Labeling Information

4.1 Noise labeling information is used to:

- (i) caution project proponents and/or users and purchasers about the noise emission level of equipment and outdoor work activities, and help them to compare or select quieter machines;
- (ii) enable project proponents and users of machines or originator of activities to plan noise control strategies including plant layout, to protect the general public and workers against exposure to excessive noise;
- (iii) give advance notice to project proponent and users of machine that noise level in the environment should be monitored when new machines or equipment are introduced; and
- (iv) warn machines operators that they may be exposed to excessive noise, and hence should wear hearing protectors.

4.2 The intention of defining an acceptable noise emission limit is to:

- (i) control excessive noise generation at source for the protection of the public from excessive noise pollution;
 - (ii) encourage the use of quieter machines and/or implement noise reduction measures on outdoor noise source.
-

5.0 Noise Emission Limits

- 5.1 Noise emission limits may be set based on either of the following, depending on the type of noise source:
- (a) an absolute limit based on the sound power levels of the machine or equipment;
 - (b) an absolute limit based on the sound pressure levels of the activity or work process measured at a receptor location.
- 5.2 The recommended maximum permissible sound emission levels for various noise sources are given in Annex A.
- 5.3 The recommended maximum sound power level of airborne noise for power generators, as measured in accordance to procedures set out in these Guidelines should not exceed levels as prescribed in Schedule 1.
- 5.4 The recommended maximum sound power level of airborne noise for excavators, dozers and loaders, as measured in accordance to procedures set out in these Guidelines should not exceed levels as prescribed in Schedule 2.
- 5.5 The recommended maximum sound power level of airborne noise for powered hand held concrete breakers and picks, as measured in accordance to procedures set out in these Guidelines should not exceed levels as prescribed in Schedule 3.
- 5.6 The recommended maximum sound power level of airborne noise for compressors, as measured in accordance to procedures set out in these Guidelines should not exceed levels as prescribed in Schedule 4.
- 5.7 The recommended maximum sound power level of airborne noise for tower cranes, as measured in accordance to procedures set out in these Guidelines should not exceed levels as prescribed in Schedule 5.
- 5.8 The recommended maximum sound power level of airborne noise for welding generators, as measured in accordance to procedures set out in these Guidelines should not exceed levels as prescribed in Schedule 6.
- 5.9 The recommended maximum sound power level of airborne noise for cooling towers, as measured in accordance to procedures set out in these Guidelines should not exceed levels as prescribed in Schedule 7.
- 5.10 The recommended maximum sound pressure level of airborne noise for piling operations as measured in accordance to procedures set out in these Guidelines should not exceed environmental noise levels as prescribed in Schedule 8.

- 5.11 The maximum permissible sound pressure levels for sound reinforcement systems operated outdoors, typically for outdoor concerts, cultural or musical performances, stage shows and theme parks as measured under the conditions set out in these Guidelines should not exceed levels as prescribed in [Schedule 9](#) at the stipulated measurement locations.
- 5.12 Sound power levels of equipment, not stipulated herein in these Guidelines under [Schedule 1 to 8](#) used outdoors in residential or noise sensitive areas should not result in sound pressure levels at the real property boundary exceeding the recommended maximum permissible levels given in the Planning Guidelines for Environmental Noise Limits and Control.
- 5.13 This in particular relates to all types of industrial and domestic fans, blowers, air conditioning, and condensing units. Lawn mowers and other household appliances are exempted from these Guidelines.

6.0 Noise Labeling

- 6.1 Machine tested in accordance with the guidelines prescribed herein should bear a clear and permanent mark (label) indicating the sound power level, in dB (A) referenced to 1 pW, guaranteed by the manufacturer, assembler, distributor and supplier of the machine. An example of a suitable and recommended label is given in [Annex B](#).
- 6.2 The Department of Environment strongly encourages person(s) manufacturing, assembling, distributing, selling and hiring construction and industrial equipment, and any other machines used outdoors to conduct sound emission measurements, and to label the sound emission in accordance to these Guidelines.
- 6.3 The Department of Environment under its condition of the EIA Approval may at its sole discretion require project proponents and/or person(s) using construction and industrial equipment, and other machines used outdoors to comply with maximum permissible sound emission levels as recommended in the Guideline.
- 6.4 The Department of Environment may also require that such sound emission measurements be carried out by an independent testing authority at the costs of project proponent or person(s) responsible.
- 6.5 Local authority may require organizers, promoters or owners of concerts, outdoor performances, theme parks and other outdoor activities with sound reinforcement systems, as a condition in its granting of license(s) for such activities, to comply with maximum permissible sound pressure levels as recommended in [Schedule 9](#). The local Authority may further require these organizers, promoters or owners to conduct sound emission measurements at their own costs by an independent testing authority.
-

7.0 Measurement Procedures

- 7.1 The determination of sound power levels, as required in the noise labeling, shall in general be undertaken in accordance to recommendations of:
- a) ISO 3740: 1980 Acoustics – Determination of sound power levels of noise sources – Guidelines for the use of basic standards and for the preparation of noise test codes.
 - b) ISO 3744: 1994 Acoustics – Determination of sound power levels of noise sources using sound pressure – Engineering method in an essentially free field over a reflecting plane.
 - c) ISO 3746: 1995 Acoustics – Determination of sound power levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane.
- 7.2 Sound power levels determination in accordance to ISO 3744 (engineering method) is recommended for noise labeling purpose. Sound power levels determined in accordance to ISO 3745 (precision method) is equally acceptable.
- 7.3 The verification of sound power levels at site may be undertaken in accordance to ISO 3746 (survey method).
- 7.4 Further guidance and reference to any other available ISO standards that are specific for selected machines and equipment may be necessary. A list of such current ISO standards (relating to outdoor or industrial noise sources) is listed in [Annex E](#).
- 7.5 Additional supplementary notes on operating conditions and references to European Community Council Directives for specific machines or equipment are given in [Annex C](#).
- 7.6 Sound measurement instrumentations, acoustic qualification tests of the testing environment, and accuracy of test results shall be guided by the relevant ISO Acoustic Standards as listed in Paragraph 25 above.
- 7.7 Sound pressure level measurements for piling operations shall be undertaken in accordance procedures given in [Annex D](#), and supplementary notes attached therein.
- 7.8 Sound pressure level measurements for sound reinforcement systems applicable for outdoor concerts, performance, stage and theme parks shall be undertaken in accordance to procedures given in [Annex D](#), and supplementary notes attached therein.

ANNEX A SCHEDULE OF PERMISSIBLE SOUND EMISSION LEVELS

SCHEDULE 1

MAXIMUM PERMISSIBLE SOUND POWER LEVELS OF POWER GENERATORS

Electric power (kVA)	Sound power level in dB (A)/1 pW
$P \leq 2$ kVA	102
$2 \text{ kVA} < P \leq 8$ kVA	100
$8 \text{ kVA} < P \leq 240$ kVA	100
$P > 240$ kVA	100

SCHEDULE 2

MAXIMUM PERMISSIBLE SOUND POWER LEVELS OF EXCAVATORS, DOZERS AND LOADERS

Net installed power in kW	Sound-power level in dB (A)/1pW
≤ 70	106
$> 70 \leq 160$	108
$> 160 \leq 350$	118
> 350	118
- hydraulic and rope-operated excavators	112
- other earth-moving machines	113

SCHEDULE 3**MAXIMUM PERMISSIBLE SOUND POWER LEVELS OF
POWERED HAND HELD CONCRETE BREAKERS AND PICKS**

Mass of appliance (m) in kg	Sound-power level in dB (A)/1pW
m < 20 kg	108
20 kg ≤ m ≤ 35 kg	111
m > 35 kg and appliance with an internal-combustion engine incorporated	114

SCHEDULE 4**MAXIMUM PERMISSIBLE SOUND POWER LEVELS OF COMPRESSORS**

Standardised nominal air flow Q in m³/min	Sound-power level in dB (A)/1pW
Q ≤ 5 kg	100
5 < Q ≤ 10	100
10 < Q ≤ 30	102
Q > 30	104

SCHEDULE 5**MAXIMUM PERMISSIBLE SOUND POWER LEVELS OF TOWER CRANES**

	Sound-power level in dB (A)/1pW
Lifting mechanism	100
Energy generator	See Schedule 1 (power generators according to the power generated)
Assembly comprising lifting mechanism and energy generator	Highest values of the two components

SCHEDULE 6**MAXIMUM PERMISSIBLE SOUND POWER LEVELS OF WELDING GENERATORS**

Nominal maximum welding current in amps (A)	Sound-power level in dB (A)/1pW
Not greater than 200 A	101
Greater than 200 A	100

SCHEDULE 7**MAXIMUM PERMISSIBLE SOUND POWER LEVELS OF COOLING TOWERS**

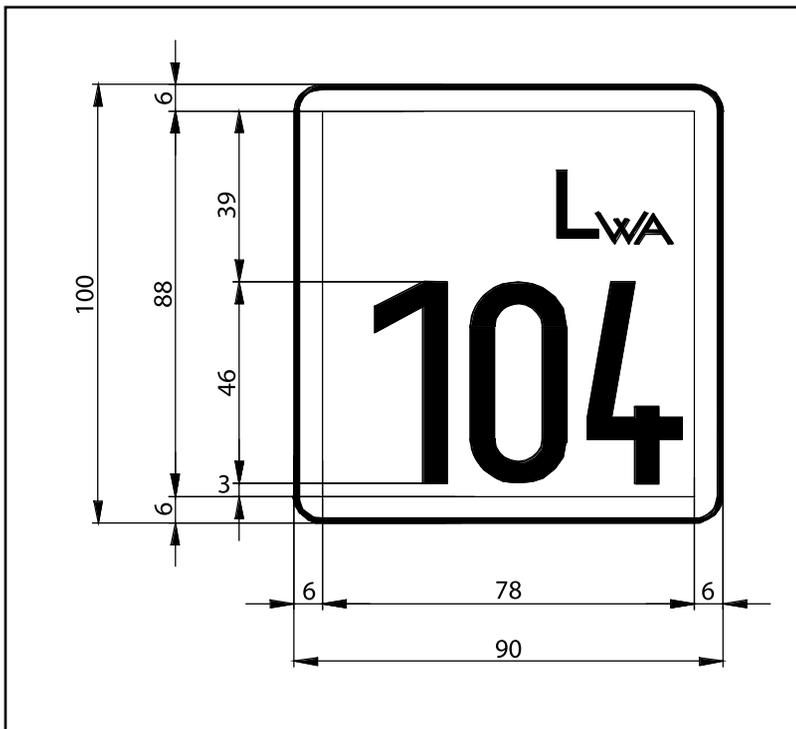
Fan Power in kW	Sound-power level in dB(A)/1pW
< 60 kW	105
> 60 kW	108

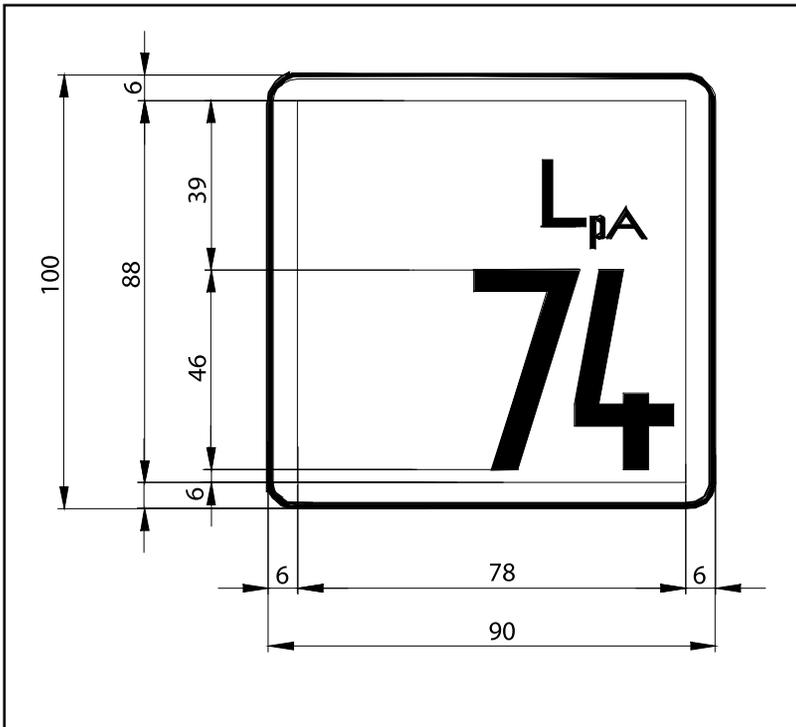
SCHEDULE 8**MAXIMUM PERMISSIBLE SOUND PRESSURE LEVELS FROM PILING OPERATIONS**

At Real Property Boundary. For Receiving Land Use Category	Noise Parameter	Sound Pressure Level (dBA)
Residential	L ₉₀	60
	L ₁₀	75
	L _{max}	90
Commercial	L ₉₀	65
	L ₁₀	75
Industrial	L ₉₀	70
	L ₁₀	80

SCHEDULE 9**MAXIMUM PERMISSIBLE SOUND PRESSURE LEVELS FOR SOUND REINFORCEMENT SYSTEMS (APPLICABLE FOR OUTDOOR CONCERTS, PERFORMANCE, STAGE AND THEME PARKS)**

Location	Noise Parameter, dB (A)			
	L_{eq}	L₁₀	L₉₀	L_{max}
At Stage, Pavilion (At Source)	95	98	90	105
At Audience	85	88	80	95

ANNEX B**NOISE LABEL STATING THE SOUND POWER AND SOUND PRESSURE LEVEL****(a) Sound Power Level, dB (A)**



(b) Sound Pressure Level, dB (A) at Machine Operator's position

ANNEX C

SUPPLEMENTARY NOTES ON MEASUREMENT CONDITIONS FOR SPECIFIC MACHINES

The acoustic parameter describing airborne sound emission of machines in these Guidelines is basically based on sound power levels. The determination of sound power levels shall generally be based on procedures laid out in the ISO standards, and in particular ISO 3740, ISO 3744 and ISO 3746. Supplementary procedures and/or provisions unique to specific machines may be appropriate to ensure uniformity of operating conditions upon which the sound power levels are rated. These procedures and/or provisions are described herein.

1.0 Power generators

- (a) The power generator shall operate at a steady speed, with a current flow through a non-inductive resistance equal to three-quarters of the unit power load in kW defined on the basis of the nominal power in kVA, taking into account the power factor ($\cos \phi$).

Skid-mounted power generators shall be placed on supports 0.40m high, unless otherwise required by the manufacturer's conditions of installations.

- (b) Additional guidance is given in the European Community Council Directive 84/536/EEC.

2.0 Excavators, dozers, loaders

- (a) Sound power determination of earth moving equipment shall be guided by ISO 6393, ISO 6394 and ISO 6395, and the European Community Council Directive 86/662/EEC.
- (b) In the event that airborne noise emissions under conventional working conditions are required, the dynamic test method of measurements is preferred (ISO 6395, ISO 6396, and Annex II of Directive 86/662/EEC).

3.0 Powered hand held concrete breakers and picks

- (a) The concrete breakers and picks shall be fitted out for normal use coupled during the test to a tool embedded in a cube-shaped concrete block placed in a concrete pit sunk into the ground. This concrete test block characteristics, supports of the concrete breakers and picks shall be in accordance to Annex 1 of Directive 84/537/EEC.

The compressor supplying compressed air to the concrete breakers and picks shall be acoustically shielded; and the noise emission of the compressor separately rated as prescribed in this regulation (see Item 4(a) of this Section below).

- (b) Additional guidance is given in European Community Council Directive 84/537/EEC.

4.0 Compressors

- (a) During testing, no tools shall be coupled to the compressor. At each measuring point, the noise level of release and escape of air from the external lines coupled to the air outlet valves of compressors shall be more than 10 dB lower than the noise level of the compressor.
- (b) Air volume flow rate of the compressor shall be measured by means of circular air venturi nozzles under critical flow conditions as prescribed in Annex 1 of Directive 84/533/EC. Alternative air volume flow rate measurement methods with a $\pm 2.5\%$ accuracy are also acceptable.
- (c) Additional guidance is given in European Community Council Directive 84/533/EEC.

5.0 Tower Cranes

- (a) Measurements shall be carried out at ground level. The measuring surface to be used for the ground-level test shall be a hemisphere. The centre of the hemisphere shall be the vertical projection on the flat reflecting surface of the geometric centre of the frame of the lifting mechanism of the energy generator or of the two combined.
- (b) Additional guidance is given in European Community Council Directive 84/534/EEC.

6.0 Welding generators

- (a) The welding generator shall operate in accordance to manufacturer's recommendations and recommendation laid down in ISO/R700-1968 at its nominal speed producing the nominal welding current through a resistance.
- (b) Additional guidance is given in European Community Council Directive 84/535/EEC.

7.0 Cooling towers

- (a) The measurement surface for sound power determination of cooling towers shall include measurement points for air intake and discharge.
 - (b) The cooling tower shall operate in accordance to manufacturer's recommendations at rated capacity of the cooling tower under load.
-

ANNEX D

METHOD TO DETERMINE AIRBORNE SOUND EMISSION OF OUTDOOR NOISE SOURCES (PILING OPERATIONS AND SOUND REINFORCEMENT SYSTEMS)

1.0 Purpose

The purpose of this procedure is to determine the sound emitted from piling operations and from all categories of sound reinforcement systems used outdoors.

2.0 Scope

- (a) This method is applicable to any type of piling operations in construction sites, etc., and from sound electronically amplified or reproduced from musical instruments, human voice and other sound reproduction materials.
- (b) Due to the diversely different nature of the above noise sources, supplementary notes are given for measuring conditions specific for the noise source.

3.0 Measuring instruments

3.1 Measuring apparatus

- (a) The measurement shall be made with a precision sound level meter which comply with the requirements of the IEC Publication 651, first edition 1979 or thereafter, for the type of meters in Class 1.
- (b) If, for any measurement, instruments other than a precision sound level meter or combinations of instruments, such as integrators are used, all the specifications of such instruments shall comply with the relevant requirements of IEC Publication 651, first edition 1979. Use of a microphone with cable shall comply with IEC Publication 651, first edition 1979, and calibrated for free field measurement.

3.2 Inspection of the measuring apparatus

- (a) Before the tests, the acoustic properties of the entire apparatus (measuring instruments including microphone and cable) shall be checked by means of calibrated sound source with an accuracy of at least 0.5 dB (e.g. a piston phone). The apparatus shall be checked again immediately after each series measurements.

3.3 Weighting network

- (a) Use shall be made of an A-weighting network meeting the requirements of IEC publication 179, 1973, second edition, or thereafter.
- (b) The above on-the-spot checks shall be supplemented by more thorough calibrations to be carried out at least once a year in a specially equipped laboratory or standards institution (e.g. SIRIM).

3.4 Statistical analysis

The sound level meter or combinations of instruments, such as real time analysers, shall be fitted with statistical analysis functions to derive statistical centile sound pressure levels (ten percentile level L_{10} , ninety percentile level L_{90}), the maximum instantaneous sound pressure level L_{max} , and equivalent sound pressure level L_{Aeq} over the prescribed measuring time period.

4.0 Measuring condition for sound emissions from piling operations

4.1 Piling operations

- (a) Measurements shall be undertaken for the duration of the piling operation of a single pile length under worst case conditions of ground penetration rated at the operational impact energy per blow fitted with the operational dolly.
- (b) Measurements shall be repeated to cover different soil conditions and/or source receiver distances.

4.2 Measurement site

Measurements for operations from piling machines shall be carried out at ground level at the real property boundary of the receiver.

5.0 Measuring conditions for sound emission from sound reinforcement systems

5.1 Operation of all loudspeakers and sound amplification equipment

- (a) With an intent of evaluating actual operational conditions, all sound amplification equipment shall be operational, and all loudspeakers activated (i.e. patched into the sound reinforcement system).
- (b) The entire sound reinforcement system(s) which forms the integral sound sources to be tested shall be operated with the actual operation media of sound reproduction or reinforcement (i.e. live band music, human voice, pre-recorded media, etc. as the case may be).
- (c) All electronic gain control settings (sound intensity, volume control etc.) of the power amplifiers, mixing consoles, line outputs, etc. shall be at the full operational levels.
- (d) The sound sources (loudspeakers clusters, stage frontal loudspeakers, monitor speakers, etc.) shall be installed in its normal operational location and orientation on site.
- (e) The results of a measurement shall be valid only for the combination tested.

5.2 Measurement locations

Measurements shall be undertaken at the stage, pavilion and source location, including main loudspeaker clusters (at distance not less 3 metre); and at the audience or public areas (as the case may be).

6.0 Measurement

6.1 Measurement of the acoustic properties of the measuring site

The environment conditions at the measuring site shall be checked before measurements are carried out. The following factors shall be checked:

- (a) extraneous and other activity noise unrelated to the noise source of interest;
- (b) wind interference;
- (c) operating conditions such as temperature, humidity, barometric pressure.

Corrections for extraneous noise shall be undertaken if and only if this noise is deemed not representative of the site (for example construction activities).

6.2 Measurement of sound pressure levels (L_{Aeq} , L_{max} , L_{10} , L_{90})

- (a) Continuous noise monitoring of the sound emissions of the noise source over the complete duration of the sound source generation shall be undertaken. For practical convenience, monitoring in regular time period segments (e.g. hourly segments repeated over different time period) is also acceptable.
- (b) Statistical analysis of the instantaneous sound pressure levels over the monitoring period shall be undertaken to obtain the statistical centile levels of L_{10} (ten percentile level) and L_{90} (ninety percentile level). The maximum instantaneous level L_{max} over the monitoring period shall also be noted.
- (c) The equivalent A weighted sound pressure level L_{Aeq} over the monitoring time period shall also be measured.

7.0 Data to be reported

The following information shall be compiled and recorded in a report concerning all measurements made with respect to these Guidelines.

7.1 Sound sources under test

- (a) Piling operations
 - Description of piling method or system, and/or type of piles;
 - Pile depth(s) for which noise levels were measured; and
 - Soil condition.
- (b) Sound Reinforcement System
 - Description of the sound reinforcement system under test, including rated power output of sound amplification devices, and loudspeaker ratings;
 - Operating conditions of the sound reinforcement systems (gain control settings, line inputs - voice, music, live band, etc.);
 - Location and elevation of sound sources (loudspeakers, including remote distributed loudspeakers) and its proximity to adjoining properties.

7.2 Acoustic environment

- (a) Description of the measuring site; diagram showing the location of sound sources and any reflecting or screening surfaces on the measuring site;
- (b) Meteorological conditions.

7.3 Instrumentation

- (a) Equipment used for the measurements, including the name of the equipment, type, serial number and name of manufacturer;
- (b) Method used to calibrate the measuring equipment in accordance with 3.2.

7.4 Acoustic data

- (a) Equivalent "A" weighted sound pressure level (L_{Aeq}) for the time period of measurement;
- (b) A-weighted statistical centile levels L_{10} and L_{90} the time period of measurement;
- (c) Maximum instantaneous sound pressure level (L_{max}) for the time period of measurement;
- (d) Measurement time duration.

ANNEX E

STATUTORY INSTRUMENTS, STANDARDS AND OTHER GUIDANCE

1.0 Statutory instruments

Environmental Quality Act 1974.

2.0 ISO Standards

- (a) ISO 1680–1:1986 Acoustics – Test code for the measurement of airborne noise emitted by rotating electrical machinery – Part 1: Engineering method for free-field conditions over a reflecting plane
- (b) ISO 1680–2:1986 Acoustics – Test code for the measurement of airborne noise emitted by rotating electrical machinery – Part 2: Survey method
- (c) ISO 2151:1972 Measurement of airborne noise emitted by compressor/prime mover-units intended for outdoor use (To be replaced by future ISO 3989 of TC 43)
- (d) ISO 4412–1:1991 Hydraulic fluid power – Test code for determination of airborne noise levels – Part 1: Pumps
- (e) ISO 4412-2: 1991 Hydraulic fluid power – Test code for determination of airborne noise levels – Part 2: Motors
- (f) ISO 4412-3: 1991 Hydraulic fluid power – Test code for determination of airborne noise levels – Part 3: Pumps – Method using a parallelepiped microphone array
- (g) ISO 4872:1978 Acoustics – Measurement of airborne noise emitted by construction equipment intended for outdoor use – Method for determining compliance with noise limits
- (h) ISO 5131:1983 Acoustics – Tractors and machinery for agriculture and forestry – Measurement of noise at the operator’s position – Survey method
- (i) ISO/DIS 5131 Acoustics – Tractors and machinery for agriculture and forestry – Measurement of noise at the operator’s position – Survey method (Revision of ISO 5131:1982)

- (j) ISO 6191:1988 Acoustics – Measurement of sound pressure levels of gas turbine installations for evaluating environmental noise – Survey method
- (k) ISO 6393:1985 Acoustics – Measurement of airborne noise emitted by earth-moving machinery – Method for determining compliance with limits for exterior noise – Stationary test condition
- (l) ISO 6394:1985 Acoustics – Measurement of airborne noise emitted by earth-moving machinery – Operator’s position – Stationary test condition
- (m) ISO/DIS 6394 Acoustics – Measurement at the operator’s position of noise emitted by earth-moving machinery – Stationary test conditions
- (n) ISO 6395:1988 Acoustics – Measurement of exterior noise emitted by earth-moving machinery – Dynamic test conditions
- (o) ISO 6396:1992 Acoustics – Measurement at the operator’s position of noise emitted by earth-moving machinery – Dynamic test conditions
- (p) ISO 6798:1995 Reciprocating internal combustion engines – Measurement of emitted airborne noise – Engineering method and survey method
- (q) ISO 7182:1984 Acoustics – Measurement at the operator’s position of airborne noise emitted by chain saws
- (r) ISO 7216:1992 Acoustics – Agricultural and forestry wheeled tractors and self-propelled machines – Measurement of noise emitted when in motion
- (s) ISO 7917:1987 Acoustics – Measurement at the operator’s position of airborne noise emitted by brush saws.
- (t) ISO/DIS 8528 – 10 Reciprocating internal combustion engine driven alternating current generating sets – Part 10: measurement of airborne noise by the enveloping surface method
- (u) ISO 9207:1995 Manually portable chain-saws with internal combustion engine – Determination of sound levels – Engineering method (grade 2)
- (v) ISO/DIS 10302 Acoustics – Method for the measurement of airborne noise emitted by small air-moving devices
- (w) ISO 10494:1993 Gas turbines and gas turbines sets – Measurement of emitted airborne noise – Engineering/survey method

- (x) ISO 10884:1995 Manually portable brush-cutters and grass-trimmers with internal combustion engine – Determination of sound power levels – Engineering method (Grade 2)
- (y) ISO 11094:1991 – Acoustics – Test code for the measurement of airborne noise emitted by power lawn movers, lawn tractors, lawn and garden tractors, professional mowers and lawn and garden tractors with mowing attachments]

3.0 EEC DIRECTIVES

- (a) Council directive 78/1015/EEC of 19 December 1978 on the approximation of the laws of the Member States relating to the determination of the noise emission of construction plant and equipment.
- (b) Council Directive 84/533/EEC of 17 September 1984 on the approximation of the laws of the Member States relating to the permissible sound power level of compressors.
- (c) Council Directive 84/534/EEC of 17 September 1984 on the approximation of the laws of the Member States relating to the permissible sound power level of tower cranes.
- (d) Council Directive 84/535/EEC of 17 September 1984 on the approximation of the laws of the Member States relating to the permissible sound power level of welding generators.
- (e) Council Directive 84/536/EEC of 17 September 1984 on the approximation of the laws of the Members States relating to the permissible sound power level of power generators.
- (f) Council Directive 84/537/EEC of 17 September 1984 on the approximation of the laws of the Member States relating to the permissible sound power level of powered hand-held concrete-breakers and picks.
- (g) Council Directive 84/538/EEC of 17 September 1984 on the approximation of the laws of the Member States relating to the permissible sound power level of lawnmowers.
- (h) Council Directive 86/594/EEC of 1 December 1986 on airborne noise emitted by household appliances.
- (i) Council Directive 86/662/EEC of 22 December 1986 on the limitation of noise emitted by hydraulic excavators, rope-operated excavators, dozers, loaders and excavator-loaders.

GLOSSARY

“airborne noise emission”

means the “A”-weighted sound power level, L_{WA} , or SWL, emitted by the noise source expressed in decibels (dB) with reference to the sound power of one picowatt (1pW), and transmitted by the air.

“background noise”

means any noise recorded at the measuring points which are not generated by the sound source.

“compressor”

means any motor-driven device for circulating and compressing air other than the following two categories of device: fans, i.e. devices producing air circulation at a positive pressure of not more than 1.1 atmospheric pressure; and vacuum pumps, i.e. devices or appliances for extracting air from an enclosed space at a pressure not exceeding atmospheric pressure.

“dozers”

means self-propelled wheeled or crawler machines fitted in front with a blade which serves primarily to displace or spread materials.

“equivalent A-weighted sound level (L_{Aeq})”

means the constant sound level that, in a given situation and time period, conveys the same sound energy as the actual time-varying A-weighted sound.

“excavator”

(hydraulic or rope-operated) means machine combining a self-propelled undercarriage with an upper structure which can swivel through more than 360°. The machine excavates, lifts, carries and dumps material by moving a boom, an arm and bucket (as is the case with a face shovel or a backhoe) or a bucket controlled by the winding gear (as is the case with a drag-line or a clamshell).

“excavator-loader”

means self-propelled wheeled or crawler machine, designed to be fitted with a loading bucket at the front and an excavating arm at the rear as original equipment. The loading bucket loads, raises, transports and dumps material by combining its own movements with those of the machine. The excavating arm excavates raises and dumps material by movements of the boom, arm and bucket.

“extraneous noise”

means the noise resulting from background noise and parasitic noise.

“household appliance”

means any machine, portion of a machine or installation manufactured principally for use in dwellings, including cellars, garages and other outbuildings, in particular household appliances for upkeep, cleaning purposes, preparation and storage of foodstuffs, production and distribution of heat and cold, air conditioning, and other appliances used for non-commercial purposes;

“impulsive sound”

means sound of short duration, usually less than one second, with an abrupt onset and rapid decay. Without prejudice to the foregoing, examples of sources of impulsive sound shall include but not limited to pile drivers, drop hammer or driven impacts and explosions.

“lawnmower”

means all motorised equipment appropriate for the upkeep by cutting, by whatever method, of areas under grass used for recreational, decorative or similar purposes.

“loader”

means self-propelled wheeled or crawler machine fitted in front with a bucket. The machine loads, raises, transports and dumps material by combining its own movements and those of the bucket.

“machine”

means device, equipment or parts of equipment and installation, mechanically or electrically driven or otherwise, as used for any forms of work. This includes construction plant equipment, and all forms of equipment used outdoors.

“measuring surface”

means a hypothetical surface surrounding the sound source and on which sound measurement points are arranged.

“person”

means any individual, association, partnership, firm, society or corporation, and includes any officer, employee, department, agency or instrumentality of a State.

“power generator”

means any device comprising a motor unit driving a rotary generator producing continuous electrical power.

“real property boundary”

means an imaginary line along the ground surface, and its vertical extension, which separates the real property owned by one person from that owned by another person, but not including intra-building real property divisions, as delineated in the land title appearing in the Certificate of Title.

“sound or noise emission”

means sound as emitted or discharged from a sound source(s).

“sound immission”

means sound as propagated onto and received by a receiver from source(s) external to the receiver or real property.

“sound power”

means the acoustic energy emission radiated by a sound source, expressed in unit of Watts (W).

“sound power level”

means 10 times the logarithm to the base 10 of the ratio of the sound power to the reference power of 1 pW. The sound power level is denoted L_W or SWL and is expressed in decibels. The sound power level expressed in dB (A) is denoted as L_{WA} or SWL (A).

“sound pressure”

means the instantaneous difference between the actual pressure and the average or barometric pressure at a given point in space, as produced by sound energy.

“sound pressure level”

means 20 times the logarithm to the base 10 of the ratio of the RMS sound pressure to the reference pressure of 20 micropascals. The sound pressure level is denoted L_p or SPL, and is expressed in decibels.

“sound reinforcement systems”

means any electronic or similar devices which produces, reproduces or amplifies sound.

“sound source”

means the machine, equipment, installation including its sub-components, sound reinforcement systems including loudspeakers, and other sources from which sound originates.

“tower crane”

means a power-driven lifting appliance which when in use, consists of a vertical tower with a jib fitted to the upper part; is equipped with means for raising and lowering suspended loads and for horizontal movement of such loads by variation of load-lifting radius and/or by slewing and/or by traveling of the complete appliance; is designed to be able to be removed when the work for which it was erected has been completed.

“welding generator”

means any rotary device which produces a welding current.



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*Vibration Limits and Control
in the Environment*



Department of Environment
Ministry of Natural Resources and Environment
Malaysia



FOREWORD

The Department of Environment hereby published 3 sets of documents to provide guidance on acceptable noise limits for various types of land use and human activities. ***The Planning Guidelines for Environmental Noise Limits and Control*** provide noise acceptance criteria for quantitative assessment of noise to define disturbance or otherwise. ***The Guidelines for Noise Labeling and Emission Limits of Outdoor Sources*** prescribes comprehensive methodology to measure and report noise emission from outdoor sources. ***The Planning Guidelines for Vibration Limits and Control*** gives vibration acceptance criteria for quantitative assessment of vibration.

It is hoped that these document could serve as useful guide to planners and decision makers at the state and local level as well as other organization, bodies and agencies involved or having responsibilities in the design and/or approval of town planing, infrastructure development, etc. so as to reduce the potential impact of noise affecting public health or causing annoyance or disturbance. Continuing efforts to improve the content and structures of these guidelines based upon feedback from users will be made from time to time.

In the publication of these documents, I would like with sincere appreciation to acknowledge the valuable expert contribution of the University of Technology Malaysia, in particular Prof. Dr. Mohd Salman Leong Bin Abdullah, the relevant agencies and all individuals in providing the necessary and relevant inputs, comments and recommendations towards the successful completion of the documents.

DATO' HAJAH ROSNANI IBARAHIM

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**THE PLANNING GUIDELINES FOR VIBRATION LIMITS AND CONTROL
IN THE ENVIRONMENT**

TABLE OF CONTENTS

TITLE	PAGE
1.0 Scope	3
2.0 Purpose	3
3.0 Legislative Background	3
4.0 Vibration Limits	4
5.0 Vibration Measurements	5
6.0 Monitoring Point(s)	6
7.0 Vibration Severity And Impact Assessment	6
8.0 Vibration And Planning	7
9.0 Vibration Reduction	8

LIST OF ANNEXES

TITLE	PAGE
Annex A - Schedule of recommended vibration limits	9
Annex B - Procedures for the measurement of vibration	16
Annex C - Code of practice to minimise vibration disturbance	19
Annex D - Statutory instruments, standards and other guidance	22
Glossary	23

1.0 Scope

- 1.1 This document presents guidance and recommendations for:
- (a) specifying vibration limits in the environment, including buildings, for the protection of the public from excessive vibration;
 - (b) procedures for environmental vibration measurements and impact assessment;
 - (c) vibration parameters for the assessment of different vibration sources; and
 - (d) abatement of excessive vibration through planning and control.
- 1.2 For the purpose of these Guidelines, definitions used are consistent with those given in ISO 2631, BS 6472 and DIN 4150. A glossary of definitions is also included in this document.
- 1.3 These guidelines present vibration acceptance criteria upon which a quantitative assessment of vibration could be made. This eliminates subjective judgment of parties involved, ambiguity in defining a disturbance, and places the assessment of a vibration source on a measurement basis.

2.0 Purpose

- 2.1 The purposes of these guidelines are:
- (a) for planning purposes, typically by project proponents, local authorities, and consultants;
 - (b) to be used in vibration impact assessments, and pre- and post EIA compliance verification;
 - (c) in quantifying a vibration disturbance on a quantitative manner; and
 - (d) to offer an introductory treatise in environmental vibration control.

3.0 Legislative Background

- 3.1 Approval of projects subjected to EIA procedures and requirements usually include maximum permissible vibration limits at affected receptors that must be complied with during the construction phase and/or operation of the project.

- 3.2 The Department of Environment in these guidelines present recommendations upon which acceptable vibration limits could be specified. In instances of new vibration sources or projects, compliance to these limits may be made mandatory using legislative instruments available to the Department of Environment, and other authorities (Local Authorities, City Halls, etc).
- 3.3 There are no prior guidelines for vibration stipulated by the Department of Environment. These Guidelines are intended to present a comprehensive and unambiguous manner upon which vibration could be measured and assessed against the prescribed standards for all applications.

4.0 Vibration Limits

- 4.1 Vibration limits may be set based on either of the following vibration parameter:
- (a) an absolute limit based on the vibration in a particular designated direction which should not be exceeded;
 - (b) an absolute limit based on the vectorial sum of instantaneous vibration in three orthogonal axes (termed the peak particle velocity of the vibration) which should not be exceeded.
- 4.2 The governing limits are depended on the repetitive nature and duration of the vibration (continuous, short term or single event).
- 4.3 For human response and annoyance evaluation, limits may be set for different period of the day (day and night).
- 4.4 It is often necessary to establish by measurements the existing ambient vibration levels in the absence of the offending source; and the contribution and severity of the offending source could be assessed with certainty against the existing ambient conditions.
- 4.5 Vibration acceptance could be assessed against the following criteria:
- (a) potential structural damage in buildings;
 - (b) human response and annoyance; and
 - (c) re-radiated structure-borne noise.
- 4.6 Recommended vibration limits to minimize structural damage risk in buildings, and for human response and annoyance assessment are given in Annex A of these Guidelines.
-

- 4.7 Structural damage from vibration are inter-related and inter-dependent on numerous factors. These include, but are not limited to, factors related to structural design and integrity of the building, materials, quality of construction and workmanship, age of building, forcing frequency content, duration and amplitude of the vibration source. There is a statistical probability relating to potential structural damage. The recommended limits do not guarantee absence of damage, but reduce its probability of occurrence. The vibration limits as prescribed in these Guidelines are therefore offered as guidance only.
- 4.8 Schedule 1 prescribes recommended limits (vibration velocity peak levels in the frequency range 10 to 100 Hz) for potential structural damage in buildings from steady state vibrations.
- 4.9 Under normal circumstances, steady state vibration should not exceed the upper limit defined as "caution level" in Schedule 1.
- 4.10 Vibration level exceeding limits for "major damage" as prescribed in Schedule 1 is usually an issue of serious concern where structural damage may be likely.
- 4.11 Recommended limits for short-term vibrations (as measured at foundation or plane of floor slabs), as classified in accordance to the type of structure are given in Schedule 2.
- 4.12 Recommended limits for peak particle velocity for ground vibration from single event impulsive excitation (such as blasting and explosion) not exceeding 3 occurrences per day are given in Schedule 3.
- 4.13 Schedule 4 stipulates acceptable road traffic induced vibration in buildings, based on types of building foundation.
- 4.14 Recommended vibration limits for human response and annoyance for steady state continuous vibration and short-term within building are given in Schedule 5, and Schedule 6 respectively. These limits are categorised according to receiving land use and period of the day. These limits are based on multipliers of the human perception threshold (designated as "Curve 1" as defined in ISO 2631 and BS 6472).

5.0 Vibration Measurements

- 5.1 Measurements of vibration are often necessary for any of the following purpose:
- (a) assessing the existing vibration climate;
 - (b) assessing compliance to vibration limits for vibration generation source(s) and/or project development; or
 - (c) assessing environmental impact and potential community response.

5.2 Vibration measurements shall usually include the following:

- (a) background (ambient) vibration levels at a receiver location(s) and/or at the real property boundary of a source(s). These may be undertaken at locations prior to a project development. It could also be undertaken in the absence of the source(s) operating (for example with a plant not operating, or without construction activities).
- (b) vibration levels at a receiver location(s) and/or at the real property boundary of a source with the plant operating, construction in progress, and/or completion and operation of a project (transit trains, industrial plant, etc.).
- (c) vibration characteristics of each source as may be required to evaluate the contribution of each source.

5.3 Vibration measured indoors may be undertaken outdoors or indoors on building floor slabs or foundation as the case may be.

5.4 Procedures for measurement of vibration in the environment and vibration source(s) severity assessment as described in [Annex B](#) shall be used. Guidance on the use and selection of an appropriate vibration measurement parameter and sampling methods are also given in [Annex B](#).

6.0 Monitoring point(s)

6.1 The vibration assessment should normally be at the nearest building and/or locations; and the best position for the monitoring point(s) would often be on the floor slab or foundation. Monitoring points should be accessible to all parties concerned.

7.0 Vibration Severity and Impact Assessment

7.1 Vibration could be assessed against an absolute numerical vibration limit (as proposed in the Schedules of [Annex A](#)), and/or assessed based on the increase of the vibration levels with respect to the ambient level without the offending source.

7.2 Assessment of vibration levels against an acceptance limit is fairly straight forward, as it merely requires comparison of the measured level against the permissible levels.

7.3 Further guidance is given in BS 6472: 1992 ([Appendix A](#)) on human response and annoyance for different receivers and duration of vibration exposure.

- 7.4 Buildings which exhibit evidence of threshold damage (defined as visible cracking in non-structural members) as a result of excessive vibration should be investigated. These could include building structural inspection, and vibration monitoring if this damage is suspected to be vibration induced.
- 7.5 In the event of vibration levels exceeding the minor or major damage limits for potential structural damage to buildings as prescribed in Schedule 1 of Annex A, further investigations, which include the determination and evaluation of stresses in building structural members, and long term structural integrity monitoring, should be undertaken. The reduction of the vibration generation or origin at source may also be necessary.

8.0 Vibration and Planning

- 8.1 The impact of vibration should be considered in the planning of a project development; and in general be guided by these Guidelines.
- 8.2 For the purpose of the consideration of vibration in planning, the following information may reasonably require:
- (i) the existing vibration levels in the community, including identification of the major sources of vibration generation.
 - (ii) any projected or proposed new or expanded sources of vibration which may affect exposure of the site.
 - (iii) where applicable, plans for vibration reduction measures.
- 8.3 The Project Proponent and any other Person(s) who would operate or cause to operate equipment, plant, process or activity with vibration generation should undertake all reasonable measures to control the source of, or limit exposure to vibration. Such measures should be proportionate and reasonable, and may include one or more of the following:
- (a) Layout: adequate distance between source and vibration-sensitive neighbours, building or area. The usage and designation of buffer zones shall be in accordance to guidelines issued by the Department of Environment from time to time;
 - (b) Engineering measures: reduction of vibration at point of generation with the use of alternative methods, reduction of energy input for impactive activities, containment of vibration generated, and protection of adjacent vibration sensitive buildings by appropriate engineering measures; and
 - (c) Administrative measures: limiting the operating time of vibration source(s); restricting the activities and ensuring acceptable vibration generation limits of vibration source.

- 8.4 The Project Proponent and/or parties who undertakes construction, piling, drilling, excavation, demolition works, blasting and other construction related activities shall be required to inform the local authority in good time the nature of the proposed works and method statements to ensure that excessive vibration are not generated.
- 8.5 Person(s) responsible for the development, and operations of roads and highways should undertake all reasonable precautionary mitigation measures such that road traffic induced vibrations within buildings are not to exceed acceptable levels as prescribed in Schedule 4 of Annex A.

9.0 Vibration Reduction

- 9.1 The Project Proponent, and/or occupier of any industrial or construction sites, and/or person(s) responsible for excessive vibration generation should use the “best practical means” to minimise the vibration generation and reduce its propagation to the environment.
- 9.2 Excessive vibration generation is deemed to occur when vibration levels above the recommended vibration limits as prescribed in these Guidelines are exceeded. “Best practical means” in the context of these Guidelines, should include but not limited to:
- (i) the size, design and inherent operation characteristics of the device, plant, process or activity;
 - (ii) the adjustment of operational parameters including reduction of energy input (per blow or cycle for piling for example) to limit the intensity of vibration generation;
 - (iii) the selection and usage of alternative methods with low vibration generation;
 - (iv) the provision of and appropriate use of vibration isolators, and attenuation dampers;
 - (v) the provision if necessary and appropriate use of vibration transmission structural breaks;
 - (vi) the proper conduct and adequate supervision of operation; and
 - (vii) regular and efficient maintenance of plant and control equipment.
- 9.3 In instances of excessive vibration severity, the Department of Environment at its discretion may make it mandatory for the Project Proponent and/or vibration source originator or person(s) responsible for the excessive vibration generation to institute measures for reducing vibration levels to comply with recommended limits as prescribed in these Guidelines.
-

ANNEX A

SCHEDULE OF RECOMMENDED VIBRATION LIMITS

SCHEDULE 1

RECOMMENDED LIMITS FOR DAMAGE RISK IN BUILDINGS FROM STEADY STATE VIBRATION

Damage Description	Vertical Vibration Peak Velocity v_{\max} , [mm/s] (0 to Peak) (10 - 100 Hz)
Safe	Less Than 3
Caution Level (Damage Not Necessary Inevitable)	3 to 5
Minor Damage	5 to 30
Major Damage	More Than 30

(Source: ISO DP 4688: 1975)

SCHEDULE 2

RECOMMENDED LIMITS FOR DAMAGE RISK IN BUILDINGS FROM SHORT TERM VIBRATION

Type of Structure	Vibration Velocity v_i [mm/s] at foundation (as defined by the respective rating curves of Figure 1)	Vibration Velocity v_i [mm/s] at plane of floor of uppermost full storey (all frequencies)
Industrial buildings and buildings of similar design	Curve C	40
Commercial building, dwelling and buildings of similar design and/or use	Curve B	15
Structures that, because of their particular sensitivity to vibration, do not correspond to those listed above, or of great intrinsic value (e.g. residential houses, or buildings that are under preservation order)	Curve A	8

(Source: DIN 4150/3)

SCHEDULE 3

RECOMMENDED LIMITS FOR DAMAGE RISK IN BUILDINGS FROM SINGLE EVENT IMPULSIVE EXCITATION *

Type of Structure	Ground Vibration Peak Particle Velocity v_{\max} [mm/s]	
	At low frequency < 40 Hz	At high frequency >40 HZ
Industrial buildings and buildings of similar design	40	50
Commercial building, dwelling and buildings of similar design and/or use	20	50
Structures that, because of their particular sensitivity to vibration, do not correspond to those listed above, or of great intrinsic value (e.g. residential buildings, or buildings that are under preservation order)	12	50

* Single event impulsive excitation not exceeding 3 occurrences per day.

(Adapted from DIN 4150/3, and Swiss Standard for Vibration Damage to Buildings).

SCHEDULE 4

ACCEPTABLE ROAD TRAFFIC INDUCED VIBRATIONS IN BUILDINGS

Type of Building and Foundation	Recommended Vertical Velocity Limit, v_{\max} [mm/s]
- Especially sensitive buildings, and buildings of cultural and historical value	1
- Newly built buildings, and/or foundation of a foot plate (spread footings)	2
- Buildings on cohesion piles	3
- Building on bearing piles or friction piles	5

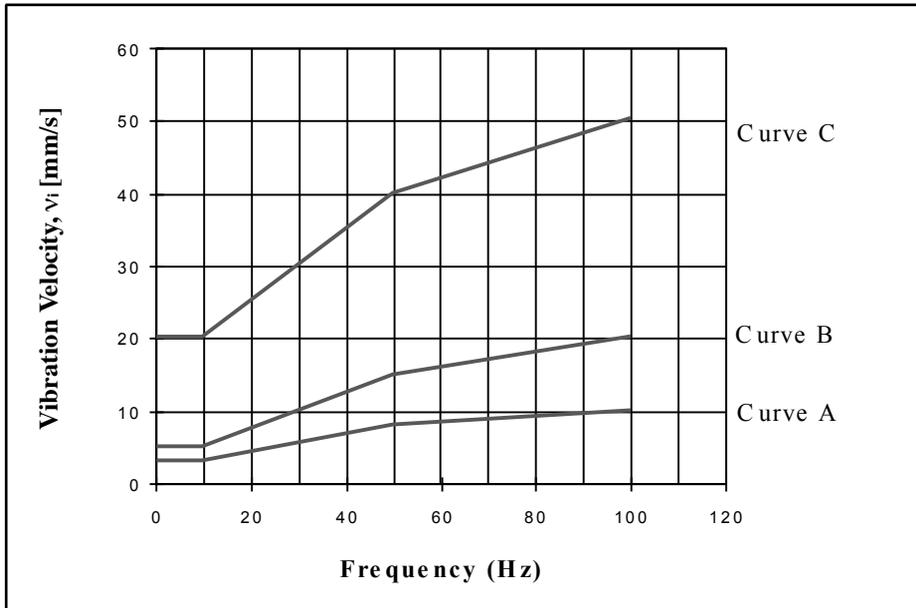


FIGURE 1
Foundation Vibration Velocity Limiting Values for Vectorial Sum of Vibration Levels in Three Orthogonal Axes.

SCHEDULE 5

RECOMMENDED LIMITS FOR HUMAN RESPONSE AND ANNOYANCE FROM STEADY STATE VIBRATIONS

Receiving Land Use Category	Day Time 7.00 am - 10.00 pm	Night Time 10.00 pm - 7.00 am
Vibration Sensitive Areas	Curve 1	Curve 1
Residential	Curve 2 to Curve 4	Curve 2
Commercial, Business	Curve 4 to Curve 8	Curve 4
Industrial	Curve 8 to Curve 16	Curve 8 to Curve 16

SCHEDULE 6

RECOMMENDED LIMITS FOR HUMAN RESPONSE AND ANNOYANCE FROM SHORT TERM VIBRATIONS

Receiving Land Use Category	Day Time 7.00 am - 10.00 pm	Night Time 10.00 pm - 7.00 am
Vibration Sensitive Areas	Curve 1	Curve 1
Residential	Curve 8 to Curve 16	Curve 4
Commercial, Business	Curve 16 to Curve 20	Curve 16 to Curve 20
Industrial	Curve 32	Curve 32

The above stipulated curves are defined in Figure 2 and 3. The base Curve 1 is based on the vibration perception threshold for human response as defined by BS 6472:1992 and ISO 2631. The designated numbers of subsequent curves are multiplying factors of the base curve.

(Source: ISO 2631 and BS 6472)

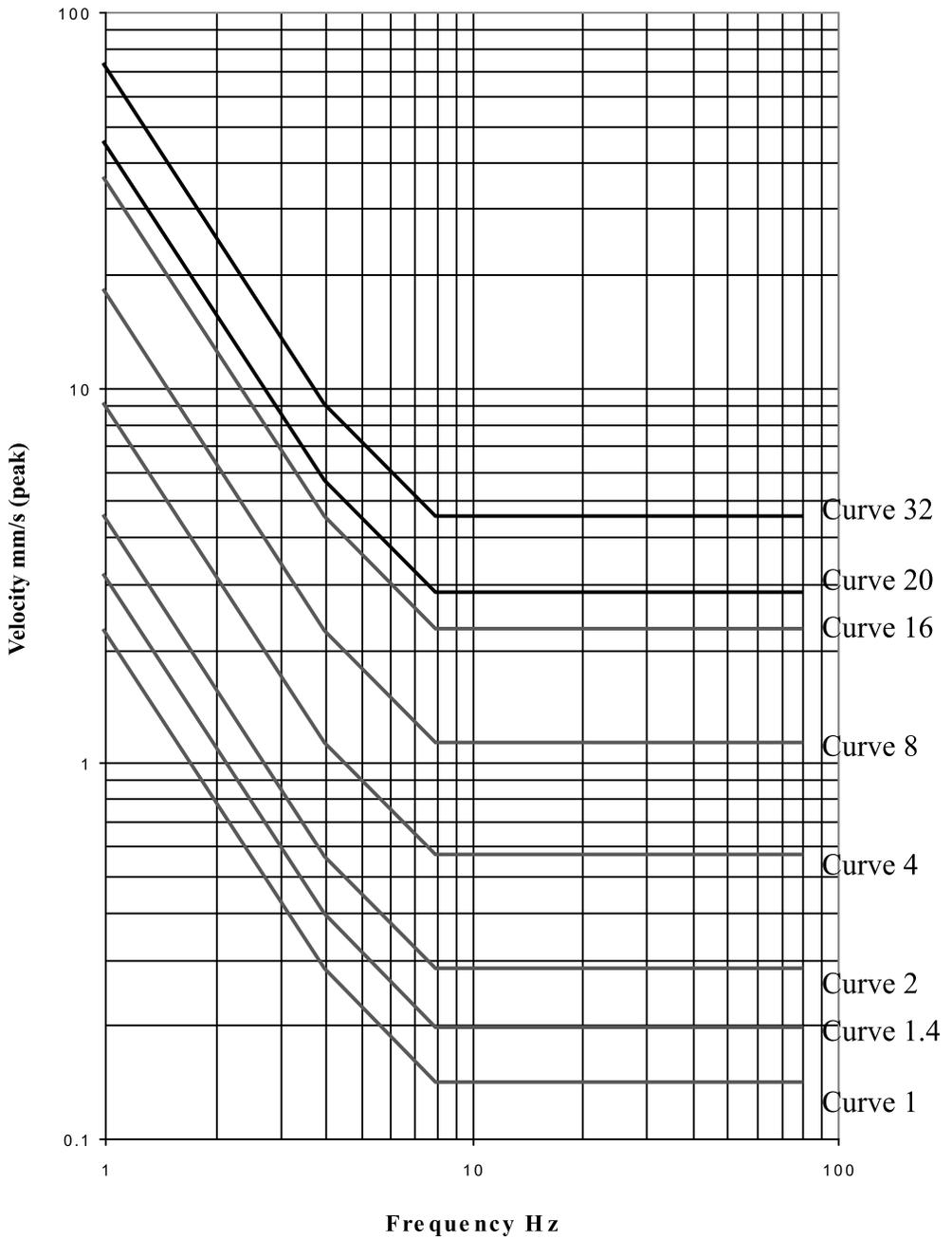


FIGURE 2. Building vibration z-axis curves for peak velocity

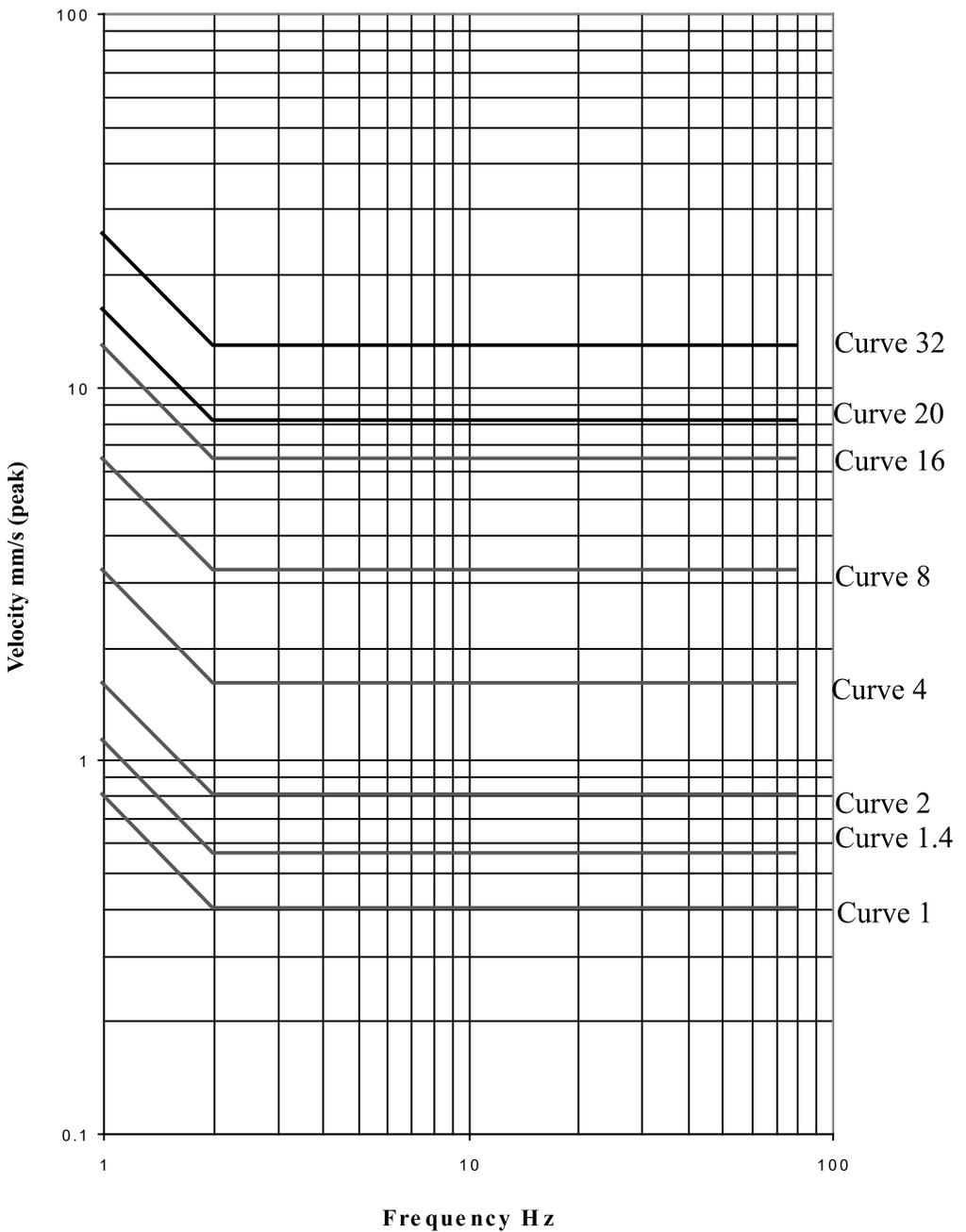


FIGURE 3. Building vibration x- and y-axis curves for peak velocity

ANNEX B

PROCEDURES FOR THE MEASUREMENT OF VIBRATION IN THE ENVIRONMENT

1.0 Measurement equipment

- 1.1 Vibration measuring equipment shall consist of the following parts: a transducer or pick-up sensor, an amplifying device, an amplitude or level indicator or recorder, and/or signal analyser. Where appropriate, filters (low pass, high pass) should be included to limit the frequency range of the equipment and to apply the recommended filters to the input signal.
- 1.2 Vibration transducers shall be in compliance to IEC Publication 184, and auxiliary equipment (amplifiers, frequency selective equipment and carrier systems) in compliance to IEC Publication 222.
- 1.3 Vibration frequency analysers or signal analysers (of either type based on instrumentation hardware, or software digital signal processor) with one third octave filter sets or narrow band FFT (fast Fourier transform) bandwidth, shall be used for vibration frequency analysis in the frequency range 1 to 100 Hz minimum.
- 1.4 Proprietary specialist instrumentation for single or multiple event impulsive vibration excitation monitoring and data recording with equivalent accuracy to vibration measurement equipment as stipulated herein may also be used. Such equipment shall be used in accordance to the manufacturer's instructions.
- 1.5 All vibration measuring equipment shall be properly calibrated in accordance with current standards and thereafter, or recommendations governing the calibration of such equipment in accordance to the equipment manufacturer's instructions.

2.0 Measurement locations

- 2.1 Measurements of vibration in general shall normally be taken on a building structural surface supporting a human body; and in instances of ground vibration or measurements at a real property boundary, may have to be made outside the structure, or on some surface other than points of entry to the human subject.

- 2.2 When measuring vibration at the foundation, the transducers for the three axes of vibration shall be placed close to one another in the lowest storey of the building under investigation, either on the foundation of the outer wall or in the outer wall, or in recesses in the outer wall. For buildings having no basement, the point of measurement shall lie no more than 0.5 m above ground level. Measuring points shall preferably be located on the side of the building facing the source of excitation. Vibration as a function of time shall be measured for the x, y and z directions, with one direction of measurement being parallel to one of the side walls of the building. In the case of buildings of large ground area, measurements shall be taken simultaneously at several points.
- 2.3 In addition to measurements taken at the foundation and to those at the uppermost storey, the vertical axis vibration of floors, where necessary measured approximately at the centre of the floor area, shall be included in the evaluation.
- 2.4 When measuring the x and y axes vibration of the floor of the uppermost full storey, the transducers shall be placed in, or close to, the outer masonry. They shall be set up in the x and y directions; one direction of measurement shall be parallel to one of the side walls of the building.
- 2.5 Measurement for blasting and other explosions related impulsive vibration excitation, if measured outside buildings, shall preferably be measured on a hard surface on ground as close to the property of interest or at real property boundary as the case may be. Transducers may be buried in the ground if no such hard surface is available.

3.0 Measurement Type and Parameters

- 3.1 Building vibration, and measurements for assessment of human response and annoyance shall be measured in vibration velocity or acceleration terms. The recommended vibration limits as given in these Guidelines are based on vibration velocity.
- 3.2 Single event impulsive vibration excitation shall be measured in terms of peak particle velocity. Peak particle velocity should preferably be measured simultaneously in the three orthogonal x, y, z axes; and the vectorial sum v_i computed based on the instantaneous values v_x , v_y , and v_z . When a multiple channel analyzer is not available, a conservative estimate of the vectorial sum v_i may be computed from single (or dual) channel measurements of v_x , v_y , and v_z . Such an assumption should be reported accordingly.
- 3.3 The maximum value v_{\max} is measured in a designated single direction, and shall be in a direction normal to a wall or a particular plane of interest.
- 3.4 Real time frequency domain measurements (in one third octaves or narrow bandwidth) may be undertaken to obtain the vibration frequency spectrum for evaluation in accordance to these Guidelines.

- 3.5 Measurements and/or data recording of unfiltered time histories of vibration may also be undertaken from which any desired data reduction for frequency analysis and the rms total value may be determined.
- 3.6 Vibration measurements shall be undertaken within a frequency range of 1 Hz to 100 Hz minimum.
- (a) In the event of any occurrence of vibration response at frequency higher than 100 Hz, supplementary measurements up to at least the second harmonics of these higher order frequencies shall be undertaken.
- (b) In the event that extraneous signal noise (such as cable or electrical noise) unrelated to the vibration measurement is deemed to influence the measurements, a high-pass filter with a value greater than 1 Hz but not more than 10 Hz may be used. In this instance the person undertaking the measurement and analysis must conclusively validate no vibration response components of significance up to this cut-off frequency of the high pass filter.
- 3.7 Measurements for steady state vibration shall be measured with peak or rms-weighted averaging over the duration of measurement period of interest, and with an averaging sample until such time the vibration readings are repeatable to within 95% confidence limits.
- 3.8 Measurements for short-term vibrations and single event impulsive vibration excitation shall be measured on peak hold levels over the duration of measurement period of interest.

4.0 Period of measurement

- 4.1 Measurements in general shall be undertaken over the duration of operation of the device(s), process or activity which results in vibration generation to obtain a fair representation and record keeping of actual vibrations generated.
- 4.2 In instances of vibration monitoring for potential structure damage concern in buildings, and for compliance record keeping arising from construction, maintenance, demolition or excavation works, and blasting, the measurement should be continuous or reported over regular period the entire duration of these activities. A time chart recording for this period is recommended. Monitoring prior to the commencement of these activities is also required to establish existing ambient levels.
- 4.3 Hourly measurements of not less than 20 minutes sampling repeated over the entire day (daytime and night time) for human annoyance and response shall be acceptable for initial screening of vibration annoyance. The sampling must however include period(s) of vibration generation activities. Continuous monitoring over a complete 24-hour cycle may be required in the event that human annoyance and response are of concern, and for confirmation of compliance to these Guidelines.

ANNEX C

CODE OF PRACTICE TO MINIMISE VIBRATION DISTURBANCE

1.0 Vibration Disturbance

Under normal circumstances, Project Proponent, and/or any other Person(s) who would operate or cause to operate equipment, plant process or activity should not unreasonably make, continue, or cause to be made or continued, any vibration disturbance. In the context of these Guidelines, vibration disturbance shall mean any vibration which:

- (i) endangers or injures the safety or health of human or animals; or
- (ii) annoys or disturbs a reasonable person of normal sensitivities; or
- (iii) endangers personal or public property; or
- (vi) exceeds the vibration limits as prescribed herein in these Guidelines.

2.0 Construction

Project Proponent and/or other Person(s) should not operate or permit the operation of any tools or equipment used in construction, maintenance, or demolition work:

- (a) Between the hours of 10.00 p.m. and 7.00 a.m. the following day on weekdays or at any time on weekends or public holidays, that creates a vibration disturbance across a residential real property boundary or within a vibration sensitive zone, except for emergency work of public service, and utilities.
- (b) At any other time, the vibration levels resulting from construction work activities or equipment, plant or process at or across real property boundary should not exceed the recommended acceptable vibration limits as defined in the respective Schedules of Annex A for the daily period of operation.
- (c) The use of low vibration (and vibration) generation equipment, process or activity shall be required in vibration sensitive areas.

- (d) The use of low impact piling methods and/or alternative piling methods (bore piles, micropiles for example) are preferred over conventional impact hammer piling methods.
- (e) Recommendations for vibration control in accordance to BS 5228: 1992 (Noise Control on Construction and Open Sites: Part 4 Code of Practice for Noise and Vibration Control Applicable to Piling Operations) shall be used.

3.0 Industrial Sites

- (a) Project Proponent and/or other Person(s) should not operate or permit the operation of equipment or facilities in an industrial site such that vibration propagated to the adjacent community results in vibration levels exceeding the maximum recommended limits as prescribed in the Guidelines.

4.0 Transportation

- (a) Project Proponents of new highways, road re-development or expansion, and rail or transit trains system(s) should minimize vibration intrusion to residential areas and vibration sensitive premises, and with alignments offering the maximum possible buffer zones, and natural or man-made attenuation.
- (b) In urban or suburban areas where a meaningful buffer zone is not possible, or/and when vibration immission to affected receivers exceed maximum recommended limits as prescribed in the Guidelines, the use of vibration attenuating or isolation materials, or structural breaks shall be required.
- (c) For railway tracks (trains of all type: LRT, commuter, electric rail, passenger, cargo, etc) that are located in close vicinity or adjacent residential, or built up areas and/or any vibration sensitive areas, the use of tracks vibration isolation are recommended. These include floating track slabs, ballast mats, undersleeper pads, and resilient track fasteners.

5.0 Explosions

No person unless duly authorized by law or carrying out legitimate duties shall use explosives, or results in an explosion which create a vibration disturbance across a real property boundary or on a public space or right-of-way.

6.0 Buildings

- (a) All reasonable and precautionary measures for the safe occupancy of a building must be taken by the Person(s) responsible for or in control of the building, and/or other Person(s) responsible or permit the operation of any equipment, plant, process or work activity within the building.
- (b) All mechanical and electrical equipment (building services equipment, manufacturing or production equipment, and any other rotating or reciprocating equipment), or any other facilities with rotation or reciprocating dynamic motion that results in moderate to significant dynamic excitation or motion of structures, including floor slabs, when installed within buildings should be mounted with suitable vibration isolation systems or devices. Such systems or devices include elastomeric or rubber pads, steel spring isolators, or pneumatic isolators. The use of matching inertia blocks is recommended.

7.0 Low frequency vibration

- (a) Industrial plants or process that result in low frequency noise, and consequently perceivable as low frequency vibration and/or resulting in vibration of lightweight building elements or structures, should be located away from noise and vibration sensitive areas.
- (b) The design and implementation of appropriate attenuating elements or devices within the discharge or emission points (exhaust stacks, blowout points, etc) of the low frequency noise source should be included in all new or retrofitted installation in proximity to residential and noise and vibration sensitive areas.

ANNEX D

STATUTORY INSTRUMENTS, STANDARDS AND OTHER GUIDANCE

1.0 Statutory instruments

Environmental Quality Act 1974.

2.0 Standards

- (a) ISO 2631-1: 1985 – Evaluation of human exposure to whole-body vibration-Part 1: General requirements.
- (b) ISO 2631-2:1989 – Evaluation of human exposure to whole-body vibration – Part 2: Continuous and shock-induced vibrations in buildings (1 to 80 Hz).
- (c) ISO 2631-3: 1985 – Evaluation of human exposure to whole-body vibration – Part 3: Evaluation of exposure to whole-body z-axis vertical vibration in the frequency range 0.1 to 0.63 Hz.
- (d) ISO 8041: 1990 – Human response to vibration – Measuring instrumentation.
- (e) BS 6472: 1992 – Guide to Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz).
- (f) BS 5228: 1992 – Noise control on construction and open sites – Part 4: Code of practice for noise and vibration control applicable to piling operations.
- (g) DIN 4150 – Part 3: Structural vibration in buildings.
- (h) ANSI S3.29: 1983 – Guide to the evaluation of human exposure to vibration in buildings.

GLOSSARY

“community”

means the body of people gathered or living in the same locality.

“impulsive vibration excitation”

means vibration which has a rapid build-up to a peak followed by a damped decay which may or may not involve several cycle of vibration, and is generally associated with single event occurrence such as blasting and explosions.

“local authority”

means the local planning authorities or agents of the State as defined in the Town and Country Planning Act, 1976 and such rules, regulations and by-laws made there under. For the purpose of these Regulations, this shall include City Halls, City Councils, Municipal Councils, Town Councils and District Councils.

“major damage”

means serious weakening of the structure with large cracks or shifting of foundations, bearing walls, or major settlement resulting in distortion or weakening of the superstructure.

“real property boundary”

means an imaginary line along the ground surface, and its vertical extension, which separates the real property owned by one person from that owned by another person, but not including intra-building real property divisions, as delineated in the land title appearing in the Certificate of Title.

“residential area”

means a designated area as gazetted by the local authority for the purpose of human dwellings and residence.

“short term vibration”

means a vibration which is impulsive or transient in nature but are repeated periodically (but not necessarily at equal time period) over a duration of time, and is generally associated with repetitive impactive events such as piling and hammer blows.

“steady state vibration”

means a vibration which continues uninterrupted for a period of time of assessment.

“threshold damage”

means visible cracking in non-structural members such as partitions, facings and plaster walls.

“vibration”

means an oscillatory motion of solid bodies of deterministic or random nature described by displacement, velocity, or acceleration with respect to a given reference point.

“vibration perception threshold”

means the minimum ground-or structure-borne vibrational motion necessary to cause a normal person to be aware of the vibration by such direct means as, but not limited, sensation by touch or visual observation of moving objects.

“vibration sensitive area”

means area where the absence of vibration is deemed necessary for the functional usage of the space, with requirements for the vibration level to be significantly below the human vibration perception threshold. These spaces include but are not limited to hospitals, operating theatres, precision laboratories, residential dwellings.

“vibration velocity v_i ”

means the vectorial sum of the instantaneous values of the vibration velocity in the three axis (x, y, z). This is computed from $v_i = \sqrt{(v_x^2 + v_y^2 + v_z^2)}$.

“x axis”

means the orthogonal axis in the forward facing direction of a building or standing person.

“y axis”

means the orthogonal axis in the transverse direction (at right angle to the x axis) of a building or standing person.

“z axis”

means the orthogonal axis in the vertical direction (orthogonal to the floor plane containing the x and y axes) of a building or standing person.



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