GUIDEBOOK FOR BEST ENVIRONMENTAL PRACTICES

NOISE CONTROL AT LTA SITES

Land Transport Authority

We Keep Your World Moving

Published by Land Transport Authority

Enquiries can be directed to LTA Safety Division

Acknowledgements

The Land Transport Authority (LTA) would like to thank the National Environment Agency (NEA) for their invaluable contribution and support in producing this guidebook.

Special thanks also go out to all staff who have provided constructive feedback and suggestions.

Lastly, a big thank you to all our contractors for their continuous support and efforts in maintaining an environmentally friendly site.

Land Transport Authority

ENVIRONMENTAL POLICY STATEMENT

LTA is committed to nurture its staff to care and protect our environment. We incorporate environmental protection in our strategic decisions and conduct our business in a manner that balances the environmental and economic needs of the communities in which we operate.

We will:

- Comply fully with all relevant environmental legislation and regulations and meet or exceed good environmental practices;
- Work with our partners i.e., transport operators, contractors, suppliers, interest groups and other government agencies in a concerted effort to operate in an environmentally responsible manner;
- Create a cleaner and greener environment by making continuous efforts to be energy-efficient and to practice Reduce, Reuse and Recycle; and
- Monitor, evaluate and continually improve our environmental management practices to ensure efficient use of the limited resources.

Chew Hock Yong
Chief Executive

Date: 1 September 2010

Contents

List of Acronyms

dB	Decibel
dB(A), dBA	A-weighted decibels
DCM	Deep Cement Mixing
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
kHz	Kilohertz
Leq	Equivalent Continuous Sound Level
$L_{p(A)}$	Sound Power Level at receiver's end
LTA	Land Transport Authority
$L_{w(A)}$	Sound Power Level at source
m	Metre
NEA	National Environment Agency
NMP	Noise Management Plan
NSR	Noise Sensitive Receivers
PH	Public Holidays
PR	Public Relation
PRO	Public Relation Officer
R	Distance from source to receiver's end
SMS	Short Message Service
SPL	Sound Power Level

Chapter 1
Basic Acoustics

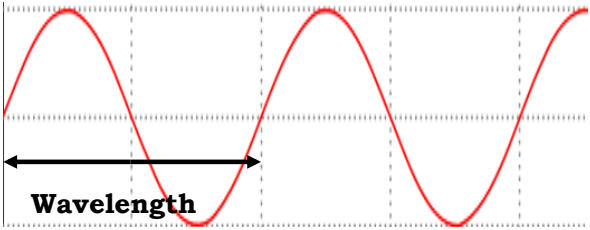
1.1 Definition of Noise pollution

"Noise pollution is sound at excessive levels that may be detrimental to human health"

- Organisation for Economic Co-operation and Development, 2008

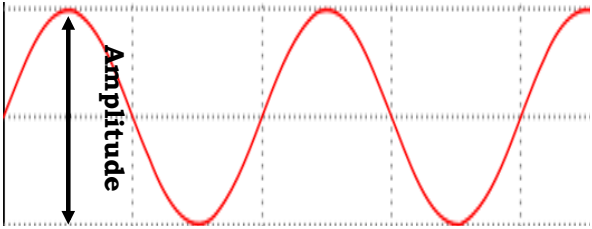
1.2 Wavelength

Wavelength is determined by the distance between any point on the wave and the equivalent point of the next phase.



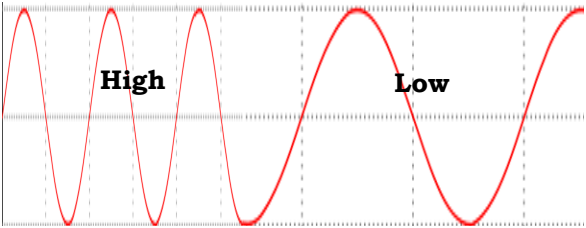
1.3 Amplitude

Amplitude of a wave is its strength or power of a noise signal and is often the “height” of a wave when viewed on a graph. The higher the amplitude, the higher the volume would be.



1.4 Frequency

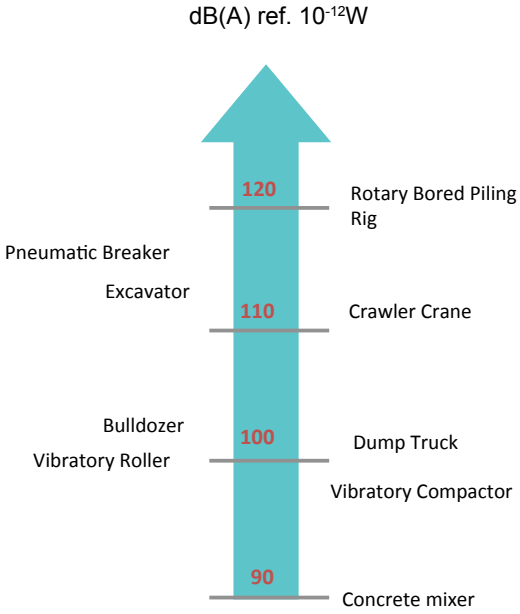
Frequency of a wave is the number of times the wavelength occurs in one second. It is measured in kilohertz (kHz) or cycles per second. Higher frequencies are interpreted as higher pitch.



1.5 Decibels

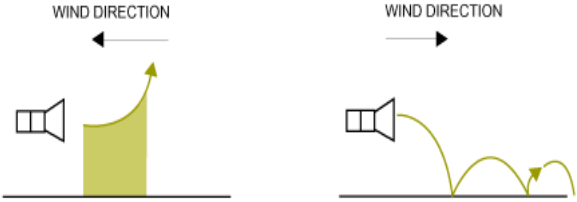
A unit (dB) used to measure the power of a signal, such as an electrical signal or sound, relative to some reference level. As a measure of sound intensity, a zero-decibel reference is stipulated to be the lowest level audible to the human ear.

1.6 Typical A-weighted Sound Power Levels from Construction Equipment



Source: CP 49: 1988

1.7 Behaviour of Noise in Windy Conditions



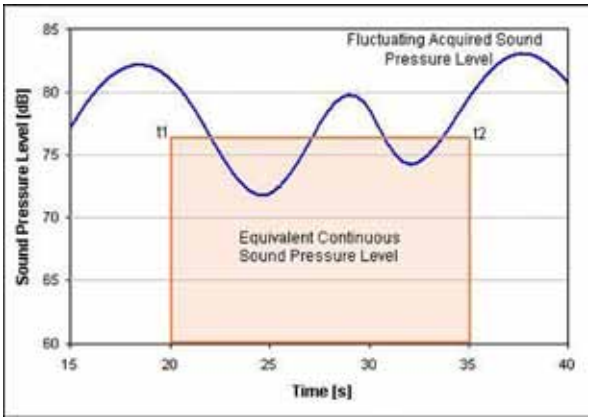
Source: http://citysoundproofing.com/environ.html

Noise travelling in the direction of wind will propagate further than expected while noise travelling against direction of wind will propagate lesser than expected.

1.8 Equivalent Continuous Sound Level (Leq)

The definition of Leq is the measure used to express the average sound level (typically expressed in dBA) over a given period of time.

Therefore “Leq 5 mins” is the average sound level measured over 5 minutes etc.



Source:
http://digital.ni.com/public.nsf/allkb/FCE0EC0A6B193A028625722E006DE298

Chapter 2
Introduction to Noise Management on site

Effective management of noise pollution helps to maintain a good living environment for all.

As LTA continues to deliver more rail and road networks, construction sites are increasingly located in close proximity to residential, hospital, heath care and school buildings. It is vital for contractors and LTA project teams to adopt a holistic approach towards noise management.

This guidebook will introduce 5 steps that will help to achieve good noise management on site.

Step 1 outlines the legislation and other regulatory requirements that relates to the control of noise pollution on site.
This will be covered in Chapter 3.

Step 2 assists in identifying the various Noise Sensitive Receivers (NSR) and noise sources from construction activities. This will be covered in Chapter 4 & 5.

Step 3 demonstrates means of managing and mitigating noise from construction activities.
This will be covered in Chapter 6 & 7.

Step 4 summarises the process of noise monitoring required before and during construction works.
This will be covered in Chapter 8.

Step 5 highlights different ways of effective communication and emphasises the importance of establishing good relationship with stakeholders.
This will be covered in Chapter 9.

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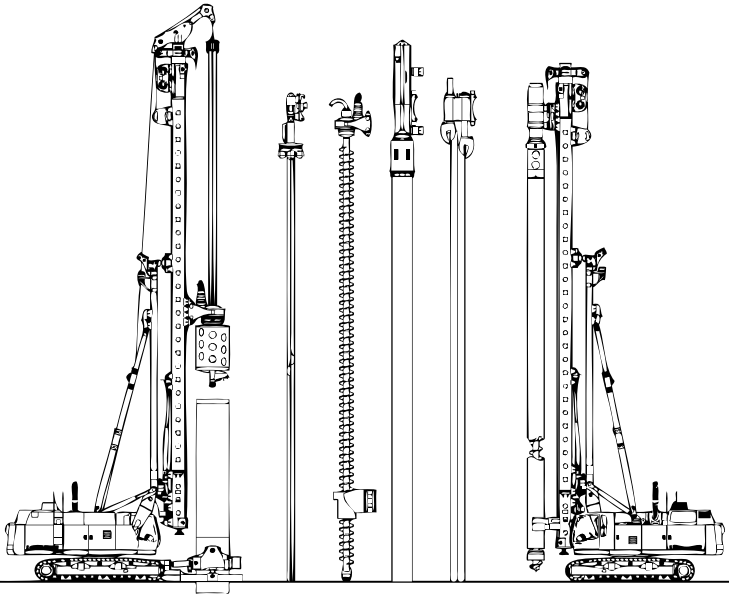
Step 1: Meeting Regulatory and Other Requirements



Chapter 3
Regulatory and Other Requirements

3.1 Permissible Construction Noise Limits

For Worksites within 150m from Existing Residential Premises

For Monday to Saturday:

Types of affected buildings	7am - 7pm	7pm – 10pm	10pm – 7am
(a) Hospital, schools, institutions of higher learning, homes for aged sick, etc.	60 dBA (Leq* 12 hrs)	50 dBA (Leq 12 hrs)	
	75 dBA (Leq 5 mins)	55 dBA (Leq 5 mins)	
(b) Residential buildings located less than 150m from the construction site	75 dBA (Leq 12 hrs)	65 dBA (Leq 1 hr)	55 dBA (Leq 1 hr)
	90 dBA (Leq 5 mins)	70 dBA (Leq 5 mins)	55 dBA (Leq 5 mins)
(c) Buildings other than those in (a) and (b) above	75 dBA (Leq 12 hrs)	65 dBA (Leq 12 hrs)	
	90 dBA (Leq 5 mins)	70 dBA (Leq 5 mins)	

* Equivalent continuous noise level over the specified period, i.e. 5 mins, 1 hr or 12 hrs.

Chapter 3
Regulatory and Other Requirements

Note: Only applicable for sites given approval by NEA to work on Sundays/PH only.

Types of affected buildings	7am - 7pm	7pm – 10pm	10pm – 7am
(a) Hospital, schools, institutions of higher learning, homes for aged sick, etc.	60 dBA (Leq* 12 hrs)	50 dBA (Leq 12 hrs)	
	75 dBA (Leq 5 mins)	55 dBA (Leq 5 mins)	
(b) Residential buildings located less than 150m from the construction site	75 dBA (Leq 12 hrs)	-	-
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	90 dBA (Leq 5 mins)	70 dBA (Leq 5 mins)	

* Equivalent continuous noise level over the specified period, i.e. 5 mins, 1 hr or 12 hrs.

Chapter 3
Regulatory and Other Requirements

No Work Rule on Sundays and Public Holidays

On top of the permissible noise limits, NEA has also mandated a prohibition of work on Sundays and Public Holidays (PH) for construction sites located within 150m away from residential premises and noise sensitive premises.

The requirements are as follows:

a) Site Established* from 1 Sep 2010
No work allowed from 10.00pm on Sat/eve of PH to 10.00am on Sun/PH

b) Site Established* from 1 Sep 2011
No work allowed from 10.00pm on Sat/eve of PH to 7.00am on the following Mon/day after the PH

* - Establishment of site is based on the BCA Permit to Commence Structural Works

3.1.1 Correction Factor

The adjusted value for the maximum permissible noise level shall be obtained by adding the correction factor (in the table shown below) to either:

a. The maximum permissible noise level (shown in the previous tables) **or**

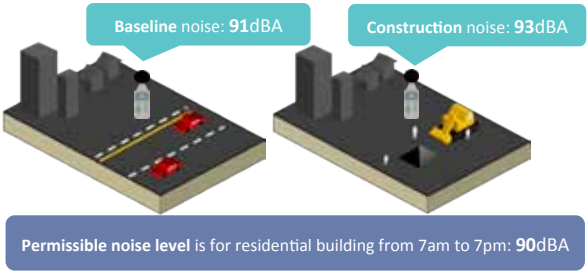
b. The baseline noise level.

Whichever is higher of the 2 noise levels.

Difference between 2 noise levels in decibels (A)	Correction factor in decibels (A)
Below 2	3
2 to less than 4	2
4 to less than 10	1
10 and above	0

Chapter 3
Regulatory and Other Requirements

Adjusted Permissible Noise Level Using Correction Factor (Working Example)



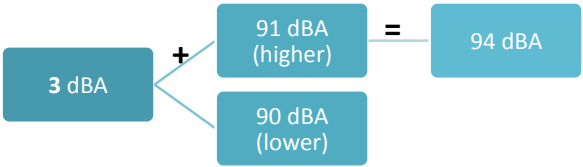
Difference between **baseline noise** and **permissible noise level**,

91 − 90 = 1 dBA

Using the **Correction Factor Table**, difference of 1dBA gives you a correction factor of **3dBA**.

Chapter 3
Regulatory and Other Requirements

Add the correction factor to either baseline noise level or prescribed permissible noise level. Whichever is higher.



As adjusted permissible noise level is now **94 dBA**. Construction noise level of 93 dBA still complies with the regulation.

Chapter 3
Regulatory and Other Requirements

3.1.2 Penalties for Exceeding Permissible Limits

- The maximum fine for violating the permissible noise limits will be up to $40,000 for court prosecutions

- The penalty for a continuing offence after conviction will be $1,000 for every day the offence is continued

Chapter 3
Regulatory and Other Requirements

3.2 CP 49:1998 Code of Practice for Noise Control on Construction and Demolition Sites

This section shall only highlight the salient points, for full details, please refer to CP 49.

At Planning Stage

- Consider processes, machineries and equipment required for different phases of operations
- Reduce noisy operations wherever feasible
- Noisy operations should start in the late morning and end by early afternoon
- Wherever possible, choose quieter techniques/ methods
- Expected level of construction noise should be determined

Chapter 3
Regulatory and Other Requirements

At Design Stage

- Identify NSRs
- Consider site layout to limit noise propagation
- Apply noise restriction if any
- Preferred off-site vehicle routes should be established to avoid NSRs

At Tender Stage

- Provision for noise control and monitoring should be included in tender documents
- Tenderer is expected to use best practicable means to minimise noise and satisfy himself of being able to comply with the permissible limits before submitting a tender

Chapter 3
Regulatory and Other Requirements

During Works

- Contractors should have a programme of works taking into account the site layout to minimise noise
- Implement specific measures to mitigate noise
- Adopt the use of quieter plant and equipment
- Ensure that all machineries are working properly
- Plan the hours of work and consider the effects on the neighbourhood and persons working on site
- Regularly monitor noise levels on site

Chapter 3
Regulatory and Other Requirements

3.3 LTA General Specifications

General Requirements (February 2013 Edition)

This section shall only highlight the salient points, for full details, please refer to Annex A-F: Environmental Considerations of LTA General Specifications.

General

- Contractors shall appoint an acoustic consultant to prepare a noise management plan (NMP)

- Prior to the commencement of any construction activities and major diversion works, the Contractor shall carry out a pre-construction baseline noise monitoring for a duration of 1 week. The survey period shall include at least a weekday and a weekend

- NMP shall make reference to the Environmental Impact Assessment (EIA), be site-specific and in accordance to the respective construction phases

- NMP shall be submitted for acceptance before implementation of mitigation measures, which includes the use of full acoustic enclosures to the affected worksites

Chapter 3
Regulatory and Other Requirements

- NSRs must be identified
- Noisy plant, equipment and methods producing excessive noise will not be allowed to be used on site
- LTA has the right to stop any noisy activities during the school examination periods if work is in the vicinity of affected educational institutions
- It is the Contractor's responsibility to ensure that all machinery/equipment are maintained and operating to the standards indicated in their respective specifications

Chapter 3
Regulatory and Other Requirements

Noise Measurement

- The Contractor shall provide competent and qualified personnel and suitable equipment for measurements and recordings of noise levels

- Noise measurements will be required for buildings within 150m from the boundary of the construction site

- Measurements shall be carried out 1m away from the nearest façade of the building facing the site and readings shall be taken from at least 3 different levels at least 1.5m above grade without any obstruction/obstacles in direction of measurement

- Continuous noise monitoring shall be carried out for works within vicinity of NSRs

- At any time during the contract period as directed by the Engineer and after the project is completed and opened to traffic, the noise survey or part of it shall be repeated to establish any change in the noise levels

Chapter 3
Regulatory and Other Requirements

Noise Control

- All machinery and plant must be sound reduced prior to entering the site
- Contractor shall use power supplied by PowerGrid whenever possible
- No piling works will be allowed from 10pm to 7am unless both machinery and method are of a quiet nature
- Full length noise barriers must be at least 10m in height or break the line of sight from receiver to noise source. Noise barriers shall be erected at site boundaries facing NSRs
- Slurry treatment plants and launch shafts shall be housed within a full acoustic enclosure
- Noisy activities must be barricaded with portable sound barriers/panels
- All machinery in operation must have their covers properly shut at all times
- All plant/machinery/equipment must be pasted with a weather-proof sticker clearly indicating its noise emission level (at source) under normal operating condition

Chapter 3
Regulatory and Other Requirements

- Noise barriers should be erected before any work commences if the site is within proximity to residences and/or sensitive buildings or as directed by the Engineer

- Preparation for traffic diversion should be carried out during the day and portable acoustic panels/ enclosure must be deployed for such works

- The Contractor shall commit sufficient effort and time into public relation works to establish good rapport with the community. Such activities shall be subject to the Authority's approval

3.4 NEA requirements

Submissions

At the start of a project, the following submissions shall be drafted and sent to NEA for their concurrence.

The submissions include:

i. Proposed adjusted noise limits[1]
ii. Construction NMP[2]

Subsequently, a presentation of the contract's NMP for NEA's concurrence will be required. This is to be carried out before commencement of works, start of a construction phase or change of site location.

Updates

For each project, LTA and Contractors' management shall meet NEA on an annual basis or as and when required to :

- Update NEA on upcoming works
- Inform residents that they may be potentially affected by noise
- Implement intended mitigation measures

1. Refer to Chapter 6.2 for method for measuring baseline noise level
2. Refer to Chapter 6 for guidelines on writing an NMP

Chapter 3
Regulatory and Other Requirements

Inspections

Joint inspections (ad-hoc) by LTA and NEA will be carried out once every 2 months or as and when required for NEA officers to appreciate the site conditions and assess the adequacy of measures implemented.

Emergency and Scheduled Road Works occurring at night

For Scheduled Road Works, the following shall be carried out:

I. Notification shall be sent out to NEA call centre at least one week before planned works
II. Public relation (PR) works carried out for nearby residences informing them of upcoming works
III. Noise mitigating measures, such as noise barriers, to be erected to minimise noise disturbance

Chapter 3
Regulatory and Other Requirements

For Emergency works, the following shall be carried out:

I. Notification shall be made to NEA call centre before commencement works
II. Public relation (PR) works carried out for nearby residences informing them of upcoming works
III. Install noise mitigating measures as and when available and reasonable

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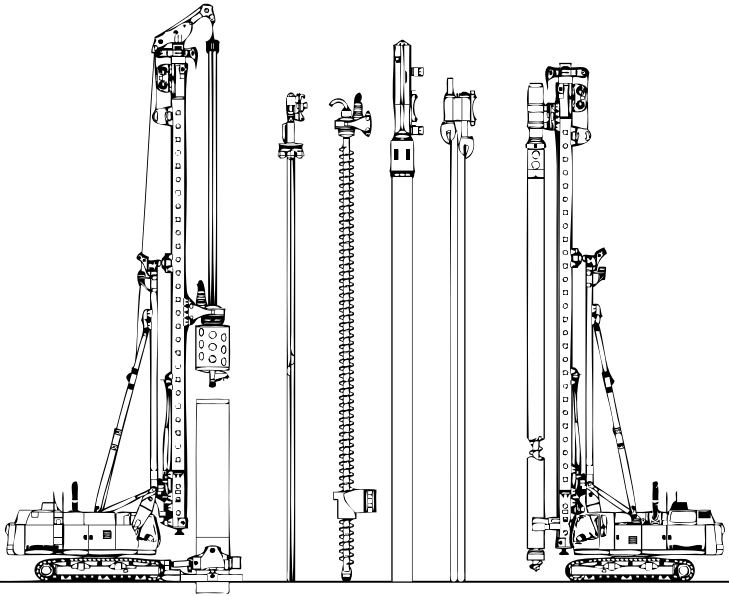
Step 2: Identification of Noise Sensitive Receivers & Noise Sources



Chapter 4
Noise Sensitive Receivers

4.1 Noise Sensitive Receivers

Below are some examples of NSRs that are adjacent to some of LTA's construction site:

Residential premises located less than 150m from construction site

C935: Located close to residential building

Hospitals

C920 & C921: Located near KKH

Chapter 4
Noise Sensitive Receivers

Homes for the aged, sick, etc

ER368: Located near to Ju Eng Home for Senior Citizens

Source: http://web.singnet.com.sg/~thamwong/project.html

Places of Worship

C923: Located in close proximity to a church

Chapter 4
Noise Sensitive Receivers

Schools, Institutes of higher learning

C918: In the boundaries of Hwa Chong Institution

Public Libraries

C925A: Located near to a public library

Source: http://static.panoramio.com/photos/iw-thumbnail/20191930.jpg

Chapter 4
Noise Sensitive Receivers

Commercial Areas

C922: Located near UE Bizhub East commercial building

Hotels and Serviced Apartments

C936: Located near to Hotel Rendezvous

Chapter 4
Noise Sensitive Receivers

Other noise sensitive receivers to take note:

Association of the Visually Handicapped

Chapter 5
Noise Sources on Construction Sites

5.1 Overview of Noise Sources on Construction Sites

A typical construction site has equipments and work processes that generate noise.

The following table shows a general guide to the risk of annoyance of different levels of loudness of noise and the type of noise generated by these noise sources. Noise levels taken at source.

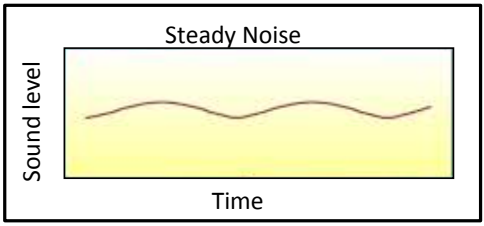
Noise Output / Type of noise	High	Medium	Low
Steady Noise	HIGH	MEDIUM	LOW
Fluctuating Noise	HIGH	MEDIUM	LOW
Impact/Impulse Noise	HIGH	HIGH	MEDIUM

Noise Output	General definition
High	Predicted noise levels are more than 3 dB above the statutory limits
Medium	Predicted noise levels are up to 3 dB above the statutory limits
Low	Predicted noise levels are below or at statutory limits

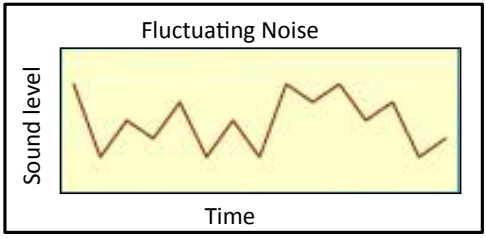
Source: ERM, 2012

Chapter 5
Noise Sources on Construction Sites

Steady Noise is noise with negligibly small fluctuations of level and has frequencies evenly distributed throughout the audible range. E.g. Noise from generator set, ventilation fans, mechanical hacking etc.

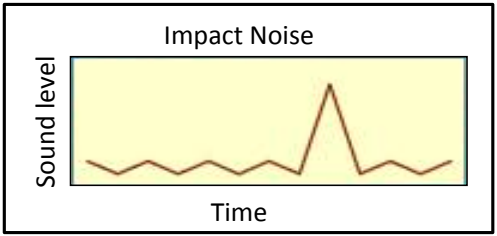


Fluctuating noise is noise whose level varies continuously and to an appreciable extent. It consists of a wide mixture of frequencies. E.g. Noise from vehicle movements, deep cement mixing (DCM) machines and overall construction noise.



Chapter 5
Noise Sources on Construction Sites

Impact or Impulse Noise is noise defined as a transient sound of duration of less than one second which may be repeated after a delay of more than one second. E.g. Noise from spinning and locking of bucket of bore piling machine, hammering of rebar cages etc.



Source: http://www.mom.gov.sg/Documents/safety-health/Guidelines-for-Noise-Control-Vibration-Part2.pdf

Chapter 5
Noise Sources on Construction Sites

5.2 Noisy Plants and Equipments

The following are some examples of common plants and equipment found in LTA construction sites and the type of noise they emit.

Contractors should pay particular attention to plants and equipments with risk of annoyance labeled as high (red), they are to be shielded or located away from NSRs as much as possible.

Chapter 5
Noise Sources on Construction Sites

High Risk of Annoyance

- High noise output
- Steady noise source

Old generator sets

High Risk of Annoyance

- High noise output
- Fluctuating noise source

Power packs

Chapter 5
Noise Sources on Construction Sites

High Risk of Annoyance

- High noise output
- Steady noise source

Ventilation fans

Medium Risk of Annoyance

- Medium noise output
- Steady noise source

Idling vehicles

Chapter 5
Noise Sources on Construction Sites

Medium Risk of Annoyance

- Medium noise output
- Steady noise source

Desanding plant

Medium Risk of Annoyance

- Medium noise output
- Fluctuating noise source

Old machinery

Chapter 5
Noise Sources on Construction Sites

5.3 Noisy Operations & Work Processes

Certain construction operations and methods generate high noise output that is of intermittent nature. These types of noise are also known as impact/impulse noise.

Contractors should pay particular attention to such operations as they are the reasons behind most complaints. Such operations and work processes are best scheduled in the day and to be accompanied with appropriate noise mitigation measures at all times.

The following are some examples of common construction work operations and their respective risk of annoyance.

Chapter 5
Noise Sources on Construction Sites

High Risk of Annoyance

- High noise output
- Impact/Impulse noise source

Mechanical hacking works

High Risk of Annoyance

- Medium noise output
- Fluctuating noise source

Diaphragm wall works

Chapter 5
Noise Sources on Construction Sites

High Risk of Annoyance

- High noise output
- Impact/Impulse noise source

Bored piling works

High Risk of Annoyance

- High noise output
- Impact/Impulse noise source

Demolition works

Chapter 5
Noise Sources on Construction Sites

High Risk of Annoyance

- High noise output
- Fluctuating noise source

Installation/Extraction of sheet piles

High Risk of Annoyance

- High noise output
- Fluctuating noise source

Installation/Extraction of casings

Chapter 5
Noise Sources on Construction Sites

Medium Risk of Annoyance

- Low noise output
- Impact/Impulse noise source

Washing bays

Medium Risk of Annoyance

- Medium noise output
- Fluctuating noise source

Deep cement mixing works

Chapter 5
Noise Sources on Construction Sites

Medium Risk of Annoyance

- Medium noise output
- Fluctuating noise source

Concreting works

Low Risk of Annoyance

- Low noise output
- Fluctuating noise source

Vehicular movement

Chapter 5
Noise Sources on Construction Sites

5.4 Noisy Parts of Machinery

The following are some examples of noisy parts of machinery that can cause annoyance to nearby stakeholders if not addressed.

Machinery parts that produces noise at a high risk of annoyance (red), they are to be rectified or sent for maintenance as soon as possible. Mufflers or acoustic panels should be considered to be installed at noisy parts if noise persists after rectification.

Chapter 5
Noise Sources on Construction Sites

High Risk of Annoyance

- High noise output
- Steady noise source

Noise emission outlet

High Risk of Annoyance

- High noise output
- Steady noise source

Opened compartment cover

Chapter 5
Noise Sources on Construction Sites

High Risk of Annoyance

- High noise output
- Steady noise source

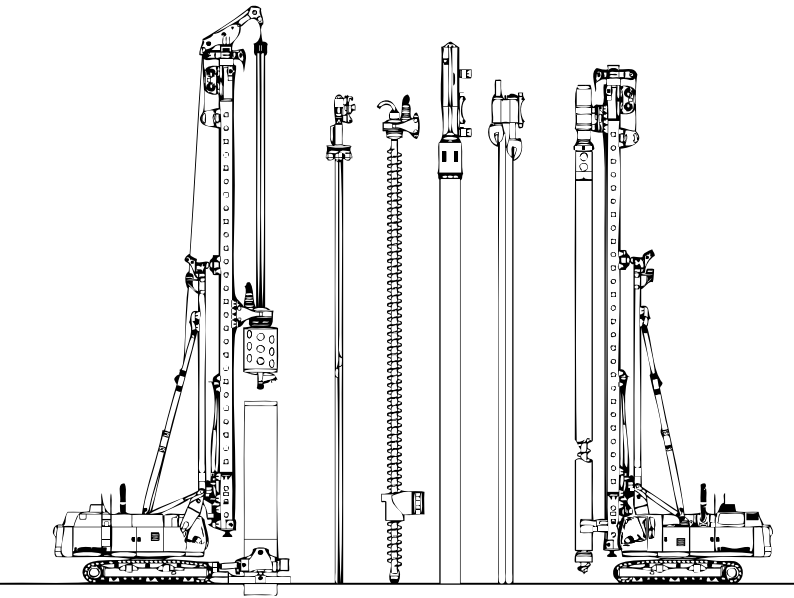
Reverberating cover

Medium Risk of Annoyance

- Medium noise output
- Fluctuating noise source

Poor maintenance of joints

Step 3: Management and Mitigation

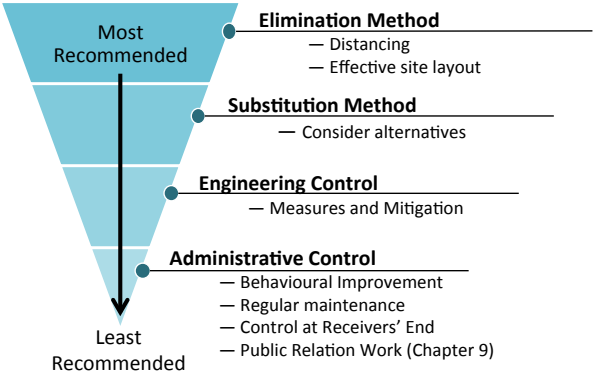


Chapter 6
Noise Management Plan

6.1 Overview and Strategies for an Effective Noise Management Plan

The NMP is designed to help contractors estimate the noise impact and plan measures to ensure compliance with the construction permissible noise limits and to reduce noise nuisance to NSRs.

For an effective NMP, efforts for the reduction of noise shall be apportioned in the following order.

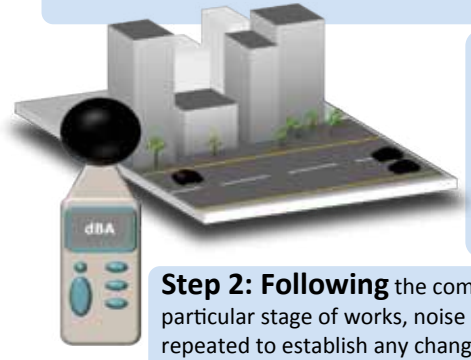


Last but not least, all these should be compiled to an NMP to be submitted. Details refer to Appendix 1&2.

6.2 Overview of Baseline Noise Study

Prior to the commencement of work, pre-construction noise monitoring shall be carried out to establish the baseline noise level for the site.

Step 1: Pre-construction baseline noise monitoring to be carried out for **7 days** (i.e. Monday to Sunday).



Take note:
Acoustic Consultant to take measurements and recordings of noise levels.

Step 2: Following the completion of a particular stage of works, noise survey is to be repeated to establish any change in the noise levels.

Step 3: Continuous noise monitoring shall be carried out for works within vicinity of NSRs throughout the project.

Chapter 6
Noise Management Plan

Step 4: Adjustment of permissible noise limits

Based on the baseline obtained, the acoustic consultant may recommend a set of proposed adjusted noise limits, which are to be submitted to NEA for approval.

The proposed adjusted noise limits shall be segregated into the follow time frames:

7am-7pm	7pm-10pm	10pm-12am	12am-7am

6.3 Site Planning (Elimination Method)

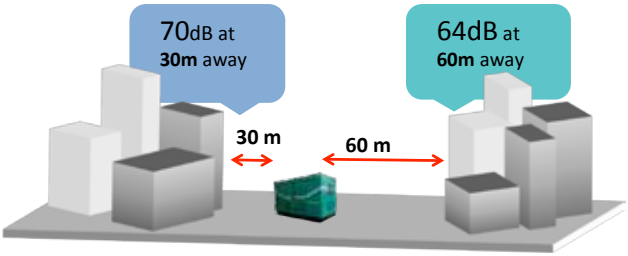
3 items to consider when planning your site.

1. Referring but not limited to the recommendations in the Environmental Impact Assessment (EIA),
   - Identify the types of noise sensitive receivers (NSR) near to your site
   - Establish the methods of construction taking into consideration quieter alternatives
   - Establish the types of machinery to be used, giving a preference to new over older machines
2. Plan your site layout such that minimal disturbance reaches the NSRs
3. Schedule noisy activities to be carried out in the day

6.3.1 Distancing

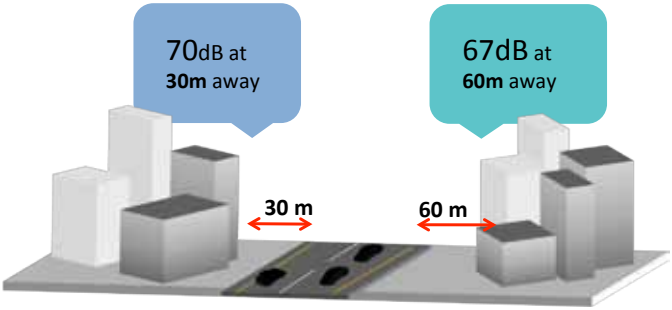
If there are no space constraints on site, distancing provides a free means of reducing noise. The reduction in noise levels depends primary on:

i. type of noise source and
ii. distance between noise source and receiver.



Point Source

Generally, every doubling of distance for a point source (e.g generator set) will reduce noise at the receiver's end by approximately 6dB.



Linear Source

Whereas, every doubling of distance for a linear source (e.g moving traffic) will reduce noise at the receiver's end by approximately 3dB.

6.3.2 Site Layout

Make use of structures on site to act as a form of noise barrier.

Rows of silos placed before receivers aid in mitigating construction noise

Placing noisy plant behind large objects also helps in reducing noise

Source:
http://www.streetdirectory.com/stock_images/travel/simg_show/12826430520298/1/lasalle_college_of_the_arts/

Chapter 6
Noise Management Plan

Plan vehicular access routes to ensure minimal disturbance to the nearby premises.

Control speed of moving vehicles to reduce noise

Speeding vehicles pose a threat to safety and generate both dust and excessive noise

Chapter 6
Noise Management Plan

Site washing bays and vehicular access located away from NSRs

Sudden jets of water are a form of intermittent noise that can startle residents, especially at night

Chapter 6
Noise Management Plan

Paved vehicular access route provides for a smoother drive

Muddy ground surface requires revving of engines which in turn produces noise

Chapter 6
Noise Management Plan

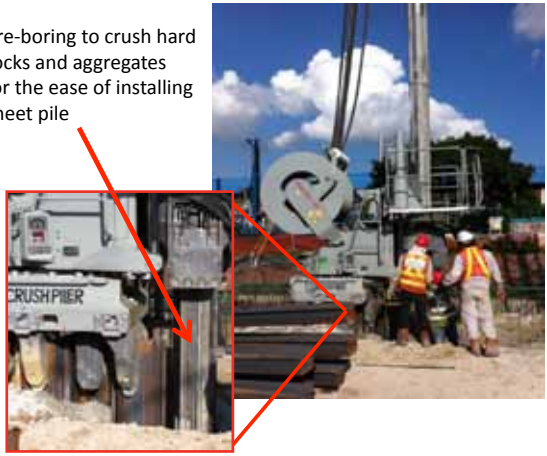
Designate a storage area and ensure proper stacking of materials

Retrieval and “dumping” of materials in a messy storage area creates noise

6.4 Consider Alternatives (Substitution Method)

Consider the use of quieter machinery and methods of construction in your planning. For activities that are inherently noisy, try to schedule them in the day.

Pre-boring to crush hard rocks and aggregates for the ease of installing sheet pile



Use of quieter alternatives such as a silent piler for installing sheet piles

Chapter 6
Noise Management Plan

Traditional method of using vibro- hammer generates loud noise and ground vibration

Casing rotator used as a quieter alternative to bore piling works

6.5 Mitigation Measures (Engineering Control)

6.5.1 At Source

Mitigation of noise at source is the most effective way to reduce noise pollution. It thus makes sense to deploy the measures below as much as possible.

Use sound-reduced machinery

Sound-proof generator set

Sound-proof welding set

Welding set with noise level verified on-site and displayed

Chapter 6
Noise Management Plan

Avoid the use of old machinery

Old excavators

Old air compressors

Chapter 6
Noise Management Plan

By adding a layer of acoustic material to metal sheets such as machinery cover can help to reduce reverberating noise

Chapter 6
Noise Management Plan

By placing vibrating units on isolators such as a coil of spring can reduce noise generated by vibration

Noise shield around rotary head

Chapter 6
Noise Management Plan

For machines that are not yet sound-reduced, install noise panels at noise emission outlets

Panels installed at noise emission outlets should be longer or curved at the end to shield off angles that allow noise to escape

Chapter 6
Noise Management Plan

Noise panels are closely aligned in order to effectively reduce engine noise from source

Missing noise panels will allow noise generated from machinery to escape

Chapter 6
Noise Management Plan

Noise Shield for Pile Driving Hammer

Rubber Padding on boom frame to avoid sharp noise when wire ropes hit against it

Chapter 6
Noise Management Plan

Cantilever noise barrier to shield noise generated from ventilation fans

Acoustic material is not closely aligned to effectively reduce noise generated from ventilation fans

Chapter 6
Noise Management Plan

Boring rig with butterfly bucket to reduce noise generated from the spinning and locking of bucket head

6.5.2 Using Enclosures

Enclosures also offer a good way of noise reduction by minimising outlets where noise can escape from. Thus a full enclosure is more effective than a partial enclosure. The choice of using which depends on several factors such as:

- Mobility of noisy plant/ equipment
- Operational method of plant/ equipment
- Availability of noise panels
- Whether personnel are required to work within the enclosure
- Location of noisy plant/ equipment
- Cost of installing the enclosure

Chapter 6
Noise Management Plan

Partial enclosures if used, should be oriented such that openings are facing away from NSRs and if there's no roof ,it should not be placed below any tall residential buildings

Housing of small motor units

Chapter 6
Noise Management Plan

Using full enclosure for housing of generator set

Access to enclosed generator set should remained closed when not in use

Chapter 6
Noise Management Plan

Noisy parts of cranes are enclosed using noise panels

Chapter 6
Noise Management Plan

Noise enclosures for D-wall machine

Chapter 6
Noise Management Plan

Noise enclosures for desanding plant

Chapter 6
Noise Management Plan

Noise enclosure for launch shaft

6.5.3 At Transmission Path

Noise barriers deployed this way are usually placed in between the noise source and receiver to force noise to travel over a greater distance and/or be absorbed by the acoustic materials, thus decreasing in loudness by the time it reaches the receiver.

Install noise barriers on top and along the length of hoardings where required

Noise barriers should be installed before any construction work starts

Chapter 6
Noise Management Plan

Absence of noise barriers means NSRs will receive direct noise impact from construction work

Noise barriers are installed once site hoardings are up

Chapter 6
Noise Management Plan

Use of double-layer noise barrier to reduce noise along transmission path

As much as possible, noise barriers should block the line of sight of low-rise NSRs

Chapter 6
Noise Management Plan

Noise barriers erected on top of site gate

Noise barrier panels mounted on site gate

Chapter 6
Noise Management Plan

Noise curtain may be used to replace traditional stiff noise panels to act as perimeter noise barrier if the site is located in very close proximity to NSRs

Chapter 6
Noise Management Plan

Portable noise barriers can be used at the face of operations for noisy activities

Portable noise barriers should be placed in front of the noise emission source

Chapter 6
Noise Management Plan

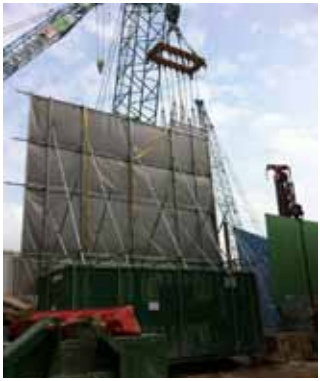
Portable noise barriers should follow noisy operations and not remain in the previous location

Portable noise barriers used to shield noisy parts of machinery for scheduled road works at night

Chapter 6
Noise Management Plan

Use of air-inflatable noise barrier to shield noisy activities

Alternatives to noise panels used to shield noise from construction site.



Acoustic curtain used as portable noise barriers to shield noisy diaphragm wall activities

Chapter 6
Noise Management Plan

Position noisy generators behind a row of noise barriers

Do not place noisy generators with their noise emission outlets facing NSRs

Noise Mitigation Measures at Transmission Path:
Portable air-inflated noise barriers used at the face of operations for diaphragm wall activities

Using of Enclosures:
Noise enclosure used to block noise from noisy part of machinery

Chapter 6
Noise Management Plan

6.6 Procedures, Awareness and Training (Administrative Control)

6.6.1 Behavioural Improvement

In order to reduce high pitch noise which could cause generate annoyance in the nearby residents, simple techniques can be employed to reduce such noises.

Wrap one of the resonance head with cloth to reduce high pitch noise

Wrap hammers with cloth to reduce tonal noise generated from the knocking of rebars

Chapter 6
Noise Management Plan

Make use of rubber mallets in place of hammers while working at night

Educate workers to lay rebar down properly instead of dropping them from a standing position

Chapter 6
Noise Management Plan

Remind drivers not to leave their engines idling when not in use

Remind machine operators not to exert more power than necessary during operations

Chapter 6
Noise Management Plan

Conduct briefing for workers on the correct methods of handling of machine/material/working methods and personal conduct in order to reduce noise generated on site

6.6.2 Regular maintenance

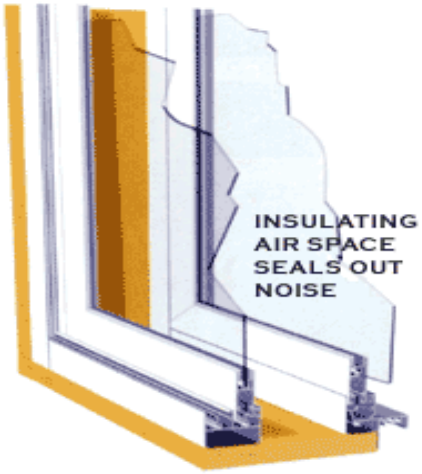
Machinery should be regularly maintained by certified personnel

6.6.3 At Receivers' End

Adhering acoustic materials to the windows and doors of NSRs to reduce noise transmitted indoors

Planting trees at NSRs do not actually reduce noise much but they provide a psychological soothing effect

Chapter 6
Noise Management Plan



Installing double-glazed glass at NSRs could be an option for commercial businesses, such as hotels. However, if intended for residential premises, do consider factors such as cost of installing double-glazed glass and loss of natural ventilation. Additional expenses may also be incurred due to installation of air-conditioner units and their operating cost.

Chapter 7
Basic Principles of Using Noise Barriers

7.1 Orientation

The side of noise barrier with louvers shall face the noise source.

The flat side of the noise barrier should be facing the noise recipient.

Chapter 7
Basic Principles of Using Noise Barriers

7.2 Alignment

Noise panels must be closely aligned in order to be efficient.

Misaligned panels will allow noise to seep through gaps.

Chapter 7
Basic Principles of Using Noise Barriers

7.3 Acoustic Properties of Materials

Material	Thickness mm	Surface Density kg/m^2	Transmission Loss * (TL) dB
Polycarbonate	8-12	10-14	30-33
Acrylic [Poly-Methyl-Meta- Acrylate (PMMA)]	15	18	32
Concrete Block 200x200x400 light weight	200	151	34
Dense concrete	100	244	40
Light concrete	150	244	39
Light concrete	100	161	36
Brick	150	288	40
Steel, 18 ga	1.27	9.8	25
Steel, 20 ga	0.95	7.3	22
Steel, 22 ga	0.79	6.1	20
Steel, 24 ga	0.64	4.9	18
Aluminium Sheet	1.59	4.4	23
Aluminium Sheet	3.18	8.8	25
Aluminium Sheet	6.35	17.1	27
Wood	25	18	21
Plywood	13	8.3	20
Plywood	25	16.1	23
Absorptive panels with polyester film backed by metal sheet	50-125	20-30	30-47

* Values assuming no openings or gaps in the barriers.

Source:
http://www.epd.gov.hk/epd/english/environmentinhk/noise/guide_ref/design_barriers_content2.html

The values listed in the table is meant to be estimates only. For noise reduction, the maximum value that can be achieved theoretically is approximately 20dB.

Chapter 7
Basic Principles of Using Noise Barriers

7.4 Efficiency

% area occupied by leaks	Transmission Loss without leaks at 500 Hz			
	10dB*	15dB*	20dB*	25dB*
	reduction in transmission loss, dB			
50	10+	15+	20+	25+
25	10	15	20	25
13	8	12	17	22
6	5	10	14	19
3	4	7	11	16
1.5	2	5	9	13
0.78	1	3	6	10
0.39	1	2	4	8
0.20	0	1	3	5
0.10	0	1	1	4
0.05	0	0	1	2

Source: http://www.epd.gov.hk/epd/english/environmentinhk/noise/guide_ref/design_barriers_content2.html

The above table shows you the relationship between gaps and effectiveness of noise barriers. The area shaded in darker colour indicates a detectable loss in efficiency of the noise barriers as a result of the corresponding percentage area occupied by leaks.

7.5 Dimensions

Noise panels must be considerably longer than the length of building they are trying to shield

Noise barriers should be built higher for better performance

However, thoughts need to be given to structural and wind load requirements

Chapter 7
Basic Principles of Using Noise Barriers

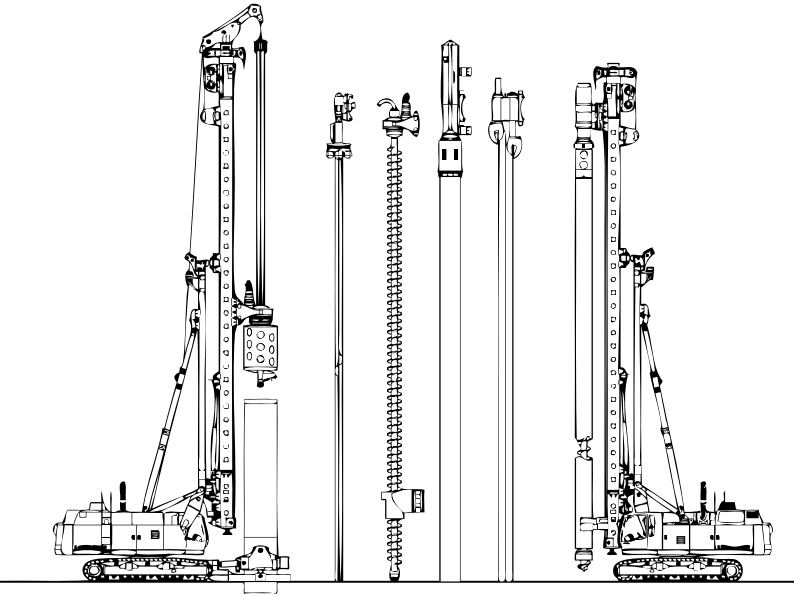
7.5 Dimensions

To overcome structural and wind load, tall noise barriers may be supported on I-beams.
The arrangement reduces the tie-back area required

Example of high noise barriers built to shield residents in low-rise buildings from noise

The general rule of thumb when using noise barriers, is to break the line of sight of the source from the receiver.

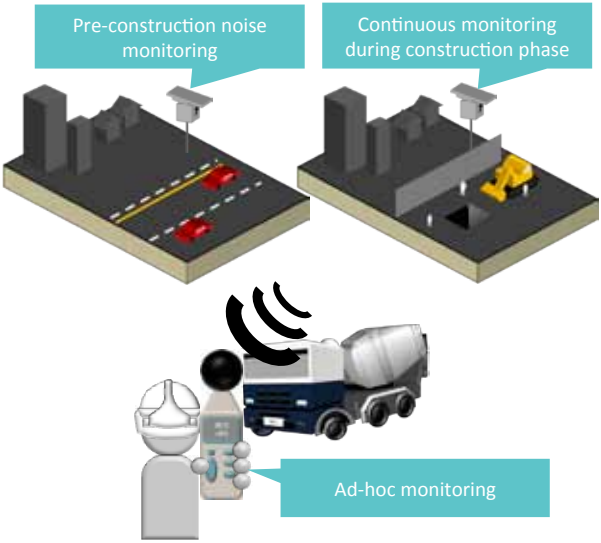
Step 4: Noise Monitoring



Chapter 8
Noise Monitoring

8.1 Noise monitoring

There are 3 types of noise monitoring which should be carried out:



Note: Images are for illustration purposes only

Chapter 8
Noise Monitoring

8.2 Noise Meters

Noise monitoring must be carried out using a Type 1 noise meter conforming to the IEC 61672 (BS EN 61672), IEC 60651 (BS EN 60651) or IEC 60804 (BS EN 60804) standards or other equivalent standards.

The monitoring instrument should comprise of:

- An integrating-averaging sound level meter set to frequency weighting A
- A sound exposure level meter
- A sound level meter set to frequency-weighting A and time-weighting S
- A data logger for sampling the running value of A-weighted sound pressure level
- A statistical distribution analyser for sampling running value of A-weighted sound pressure level

Chapter 8
Noise Monitoring

8.3 Pre-construction Noise Monitoring

Baseline noise levels shall be established according to method stated in Chapter 6.2.

Noise Simulation of the existing environment shall also be carried out to determine the noise level experienced by the surrounding NSRs. Appropriate noise mitigation measures may then be applied to reduce noise levels to within permissible limits.

8.4 Continuous monitoring during construction phase

Continuous noise monitoring must be carried out for the entire duration of the project as long as there are any NSRs within 150m from the construction site. This form of permanent noise monitoring must be located at the nearest affected building and its location must be acknowledged by the relevant authority.

Noise meters shall be located 1m away from the nearest façade of the building facing the site, 1.5m above at-grade level without any obstructions/obstacles in the direction of measurement.

Noise meter located in front of public library

Chapter 8
Noise Monitoring

For tall buildings such as a HDB block, it is recommended that the location for noise monitoring be located at least 3 different levels of the building. (1st storey, intermediate storey and top storey).

This system shall be equipped with a SMS “alert” feature to send out alerts when permissible limits are exceeded.

8.5 Ad-hoc monitoring

Ad-hoc noise monitoring must be carried out by competent personnel whenever work progresses into the night, weekends or during noisy operations. Once noise levels are approaching permissible limits, the person-in-charge of site should be notified so that additional measures can be adopted to reduce disturbance to the nearby NSRs.

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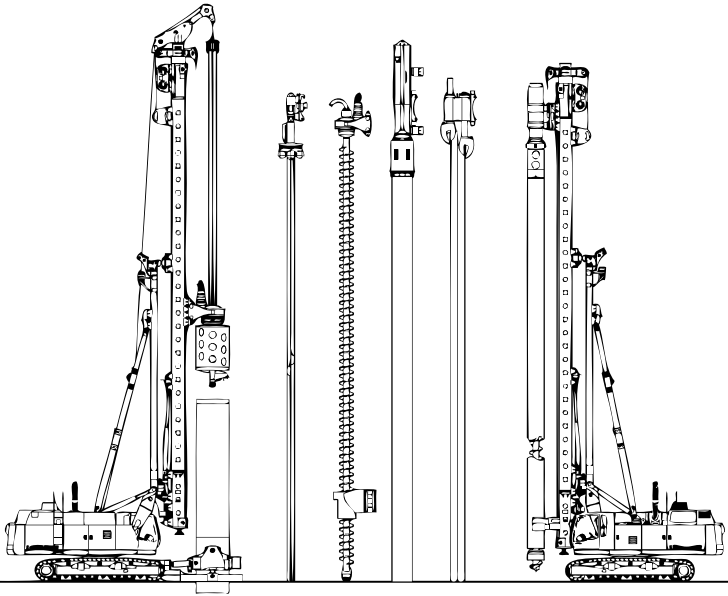
Step 5: Community Engagement



Chapter 9
Public Relations Work

9.1 Overview of Public Relations Work

The integration of public relations as part of an overall noise management strategy is growing in importance today. As a person's acceptance of noise level is dependent on an individual's tolerance, it is important to include public relation works together with the use of engineering technologies.

Good public relation works would:

- Allow public to better understand our works
- Gain and build public's trust
- Open up communication channels
- Allow faster resolution of problems

Below are some situations that could decrease the public's trust and their tolerance level to noise:

- Where there is originally low ambient noise level
- Intermittent, impulsive, startling noise
- Low frequency noise that causes vibrations in any parts of the building structure
- Any changes/ fluctuation in noise patterns
- Noise created at time nearing/ during rest hours

Chapter 9
Public Relations Work

9.2 Examples of Public Relations Work

Organise regular community bonding/ information sharing sessions with the residents & grassroots

Regular publication of newsletters to keep residents informed on our development

Chapter 9
Public Relations Work

Inform the relevant authority in advance of any anticipated night works

Discuss noise mitigation with the relevant authority before the commencement of works

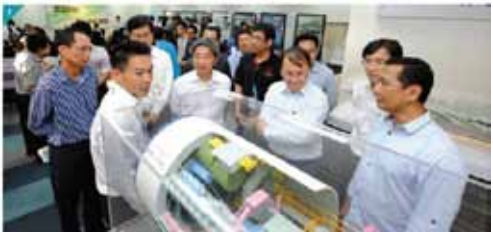
Distribute circulars to residents and stakeholders in advance of any anticipated night works

Chapter 9
Public Relations Work

Carry out engagement with schools and institutions of higher learning

Making use of multimedia resources to engage stakeholders

Chapter 9
Public Relations Work



Project information centre for engagement of stakeholders

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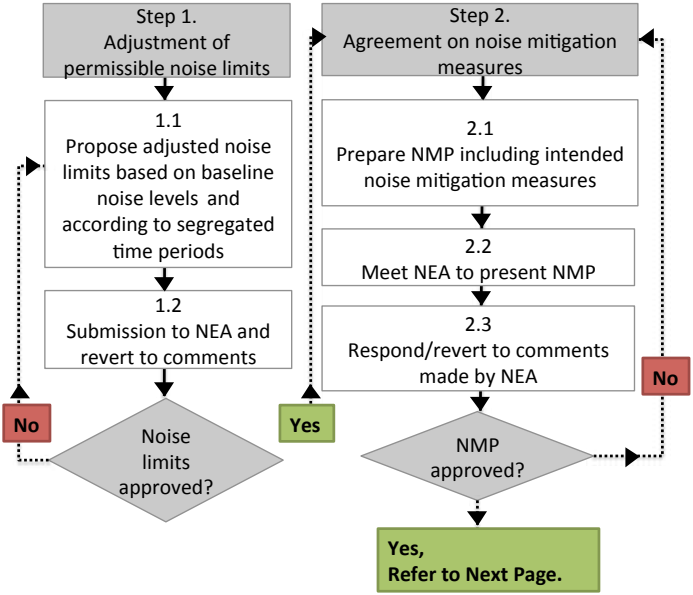
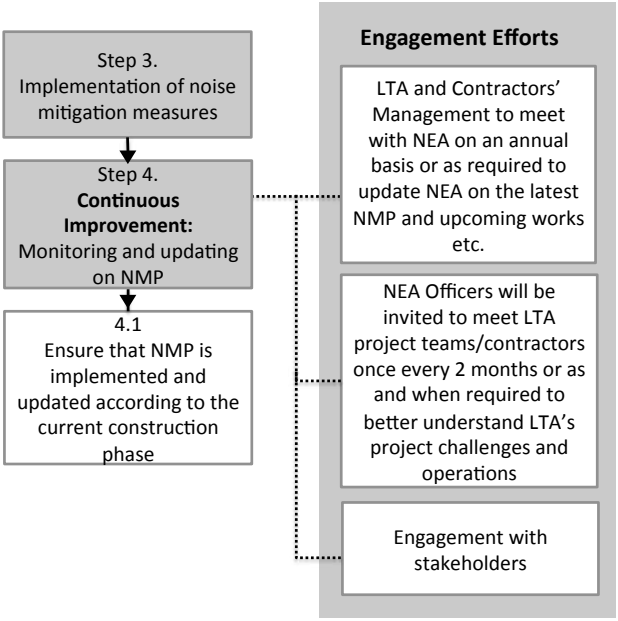
Appendix 1
Flowchart for the Process on Noise Management



Appendix 1
Flowchart for the Process on Noise Management



Appendix 2
Format of report for Noise Management Plan

Report format of a Noise Management Plan

At the start of the project, the contractor shall submit to LTA and NEA a Noise Management Plan. The NMP shall contain but not limited to the following sections.

1. Project information and relevant contact numbers
2. Baseline noise monitoring and locations of noise meters
3. Adjusted permissible noise limits
4. Identification of nearby sensitive premises
5. Site layout with locations of equipment
6. Schedule of work demonstrating consideration of noisy activities
7. List of powered equipment and their noise emission levels
8. Noise assessment including total anticipated noise emission levels
9. Noise mitigation measures with estimated noise reduction levels
10. Public relations strategies
11. Supporting documents (i.e. site map, photographs, equipment certificates etc)

Appendix 3
Useful Information

It is possible to estimate the sound power level (SPL) at the receiver's end using this theoretical formula:

$$L_{p(A)} = L_{w(A)} - 20 \log_{10} R - 8$$

where:
$L_{p(A)}$ = SPL at receiver's end dB(A)
$L_{w(A)}$ = SPL at source dB(A) and
R = distance from source to receiver's end (metres)

This calculation assumes that:

- Sound is radiated uniformly in all directions
- Terrain is that of a flat, open ground
- No obstacle between source and receiver
- Do not take into consideration effect of reflected sound from building facade

Appendix 3
Useful Information

A list of estimated SPL at receiver's end has been calculated for your convenience and is meant to serve only as a guide:

SPL at source dB (A)	Estimated SPL dB(A) at a distance R from source					
	R=20m	R=30m	R=40m	R=50m	R=60m	R=70m
80	46.0	42.5	40.0	38.0	36.4	35.1
81	47.0	43.5	41.0	39.0	37.4	36.1
82	48.0	44.5	42.0	40.0	38.4	37.1
83	49.0	45.5	43.0	41.0	39.4	38.1
84	50.0	46.5	44.0	42.0	40.4	39.1
85	51.0	47.5	45.0	43.0	41.4	40.1
86	52.0	48.5	46.0	44.0	42.4	41.1
87	53.0	49.5	47.0	45.0	43.4	42.1
88	54.0	50.5	48.0	46.0	44.4	43.1
89	55.0	51.5	49.0	47.0	45.4	44.1

Appendix 3
Useful Information

SPL at source dB (A)	Estimated SPL dB(A) at a distance R from source					
	R=20m	R=30m	R=40m	R=50m	R=60m	R=70m
90	56.0	52.5	50.0	48.0	46.4	45.1
91	57.0	53.5	51.0	49.0	47.4	46.1
92	58.0	54.5	52.0	50.0	48.4	47.1
93	59.0	55.5	53.0	51.0	49.4	48.1
94	60.0	56.5	54.0	52.0	50.4	49.1
95	61.0	57.5	55.0	53.0	51.4	50.1
96	62.0	58.5	56.0	54.0	52.4	51.1
97	63.0	59.5	57.0	55.0	53.4	52.1
98	64.0	60.5	58.0	56.0	54.4	53.1
99	65.0	61.5	59.0	57.0	55.4	54.1

Appendix 3
Useful Information

SPL at source dB (A)	Estimated SPL dB(A) at a distance R from source					
	R=20m	R=30m	R=40m	R=50m	R=60m	R=70m
100	66.0	62.5	60.0	58.0	56.4	55.1
101	67.0	63.5	61.0	59.0	57.4	56.1
102	68.0	64.5	62.0	60.0	58.4	57.1
103	69.0	65.5	63.0	61.0	59.4	58.1
104	70.0	66.5	64.0	62.0	60.4	59.1
105	71.0	67.5	65.0	63.0	61.4	60.1
106	72.0	68.5	66.0	64.0	62.4	61.1
107	73.0	69.5	67.0	65.0	63.4	62.1
108	74.0	70.5	68.0	66.0	64.4	63.1
109	75.0	71.5	69.0	67.0	65.4	64.1

Appendix 3
Useful Information

SPL at source dB (A)	Estimated SPL dB(A) at a distance R from source					
	R=20m	R=30m	R=40m	R=50m	R=60m	R=70m
110	76.0	72.5	70.0	68.0	66.4	65.1
111	77.0	73.5	71.0	69.0	67.4	66.1
112	78.0	74.5	72.0	70.0	68.4	67.1
113	79.0	75.5	73.0	71.0	69.4	68.1
114	80.0	76.5	74.0	72.0	70.4	69.1
115	81.0	77.5	75.0	73.0	71.4	70.1
116	82.0	78.5	76.0	74.0	72.4	71.1
117	83.0	79.5	77.0	75.0	73.4	72.1
118	84.0	80.5	78.0	76.0	74.4	73.1
119	85.0	81.5	79.0	77.0	75.4	74.1

Appendix 3
Useful Information

SPL at source dB (A)	Estimated SPL dB(A) at a distance R from source					
	R=20m	R=30m	R=40m	R=50m	R=60m	R=70m
120	86.0	82.5	80.0	78.0	76.4	75.1
121	87.0	83.5	81.0	79.0	77.4	76.1
122	88.0	84.5	82.0	80.0	78.4	77.1
123	89.0	85.5	83.0	81.0	79.4	78.1
124	90.0	86.5	84.0	82.0	80.4	79.1
125	91.0	87.5	85.0	83.0	81.4	80.1
126	92.0	88.5	86.0	84.0	82.4	81.1
127	93.0	89.5	87.0	85.0	83.4	82.1
128	94.0	90.5	88.0	86.0	84.4	83.1
129	95.0	91.5	89.0	87.0	85.4	84.1

Appendix 3
Useful Information

Pre-construction phase

Please score using the maximum marks given as a guide.

No.	Pre-Construction Phase	Scores
1	Noise sensitive receivers near my site have been identified	3
2	We have considered the use of quieter construction methods	3
3	We have considered the use of sound-reduced and/or newer machinery	3
4	We have scheduled noisy activities to be carried out in the day whenever possible	3
5	We have engaged an ECO as well as a PRO	2
6	Pre-construction noise monitoring was carried out continuously for a week	3
7	Noisy equipment are sited at a distance from the NSRs	3
8	Large structures/ natural barriers on site are used as noise barriers	2
9	There is a speed limit for vehicles moving through our site	2
10	Vehicular access route is paved	2
11	Washing bays and vehicular access points are sited away from NSRs where possible	2
12	There is a proper stacking system for storage and rebar work areas	2
	Total score	**/30**

Appendix 3
Useful Information

Score Results

Total possible marks for this section = 30 marks

If your score falls in the range of:	Status	Remarks
< 15	Poor	You have to put more thoughts into your site planning. A quiet site requires a good site layout and provisions for noise mitigation measures and quieter machinery to effectively reduce noise.
15 - 25	Average	You probably have considered most of the elements in achieving a quieter site. Try improving by extending the considerations to more activities and machinery.
> 25	Excellent	Well done! You have thought through all major work activities and machinery needed for your work. Just remember to implement them when construction works commence!

Appendix 3
Useful Information

Construction phase

No.	Construction Phase	Scores
1	Noise barriers are installed immediately after site hoardings are up	5
2	Noisy machinery are fitted with noise panels at the side	5
3	Loose attachments on the machine have been secured or removed	3
4	Stationary equipment are housed in enclosures	5
5	Covers of machinery are kept closed when in operation	3
6	Idling vehicles have their engines switched off	3
7	Machinery are serviced regularly	5
8	Portable noise barriers are used at face of noisy operations and are redeployed as the work progresses	5
9	Machine operators and workers have been briefed on quieter working techniques	5
10	Noise barriers installed are able to break the line of sight between noise source and receiver	5
11	A Type 1 Noise meter conforming to IEC/ BS EN 60651/60804 or equivalent standards is used for monitoring purpose	3
12	Monitoring is carried out at the nearest affected NSR	5
13	Exact location of monitoring has been acknowledged by the relevant authority	5
14	Ad-hoc monitoring is carried out for night works	3
	Total	**/60**

Appendix 3
Useful Information

Score Results

Total possible marks for this section = 60 marks

If your score falls in the range of:	Status	Remarks
< 30	Poor	There are inadequate noise mitigation measures on site. Try identifying and put up noise barriers for noisy machinery/ operations and work areas.
30 - 50	Average	There should already be noise barriers and some sound-reduced machinery on site. You can improve by actively identifying noisy works/ machinery and enforcing good practices on site.
> 50	Excellent	Well done! You have good noise mitigation and practices on site. Keep up your good work!

Appendix 3
Useful Information

Community Engagement: Construction phase

No.	Public Relations Work	Scores
1	Community bonding/ information sharing sessions have been planned	2
2	Circulars were sent out to affected residents in advance of night work and there are periodic publication to keep residents updated	2
3	The relevant authority has been informed in advance of any night work	2
4	Hotlines and communication channels are made available for residents feedback	2
5	There is an investigation team looking into feedback and getting back to the resident	2

Appendix 3
Useful Information

Score Results

Total possible marks for this section = 10 marks

If your score falls in the range of:	Status	Remarks
< 5	Poor	Public relation works will help strengthen the existing measures you have on site. Do practice good public relation works in managing public expectations.
5 - 7	Average	You have sufficient public relation works in place. However there is still room for improvement.
> 7	Excellent	Keep up the good work! Continuous engagement of the public and relevant authorities will help you to keep your mitigation measures in check.

References

Legal and other requirements

1. Environmental Protection and Management Act
2. Environmental Protection and Management (Control of Noise at Construction Sites) Regulations.
3. CP 49: 1998 Code of Practice for Noise Control on construction and demolition sites

LTA Contractual Specification

1. Annex A-g: Environmental Considerations of the General Specifications (February 2013 Edition)

Websites

1. http://www.nonoise.org
2. http://www.catseyeservices.com/Handbooks/cd/references/references.htm
3. http://www.epd.gov.hk/epd/english/environmentinhk/noise/noise_maincontent.html
4. http://citysoundproofing.com/
5. http://www.noisenet.org
6. http://www.techniconacoustics.com/acoustics-101/glossary