TECHNICAL GUIDELINE
FOR
LAND TRAFFIC
NOISE IMPACT ASSESSMENT

TECHNICAL GUIDELINE FOR LAND TRAFFIC NOISE IMPACT ASSESSMENT [AS AT 1 JUL 16]

Purpose

This technical guideline serves to provide general reference for acoustic consultants and Qualified Persons (QPs) to prepare land traffic Noise Impact Assessment (NIA) for designated projects. A typical NIA would take about 1-2 months to complete and sufficient time should be catered for consultants /QPs to carry out NIA. It was developed by National Environment Agency (NEA) in consultation with the Institute of Engineers Singapore (IES), Environmental Engineering Society of Singapore (EESS) and National University of Singapore (NUS).

2 This technical guideline will be reviewed and updated by NEA in consultation with the relevant government agencies and professional association regularly to take into account changing circumstances.

Scope

3 This technical guideline consists of the following parts.

(i) **PART 1** – Land traffic Noise Impact Assessment on **new** residential and noise sensitive developments located in close proximity to **existing** land traffic noise sources/hotspots (e.g. expressways/major arterial roads/MRT tracks); and

(ii) **PART 2** – Land traffic Noise Impact Assessment on **existing** residential and noise sensitive developments located in close proximity to **new** transport-related developments (e.g. expressway/major arterial roads/MRT tracks/bus interchanges/ bus depots), inclusive of the expansion of existing transport-related infrastructures.

PART 1

4 This Part would focus on the land traffic Noise Impact Assessment on **new** residential and noise sensitive developments located in close proximity to **existing** land traffic noise sources/hotspots (e.g. expressways/major arterial roads/MRT tracks).

5 New residential and noise sensitive developments located within 70m[1] from the land traffic noise sources/hotspots (e.g. expressways/major arterial roads/MRT tracks) would be subjected to the requirement to carry out land traffic Noise Impact Assessment if any parts of the new residential and noise sensitive developments are within the line of sight from the land traffic noise sources/hotspots.

6 Waiver of the requirement to carry out land traffic Noise Impact Assessment could be requested from National Environment Agency and could be granted on a case-by-case basis. For example, a proposed development, which will be totally shielded off from the traffic by another existing development, could apply for waiver to carry out Noise Impact Assessment.

7 The Noise Impact Assessment should cover the following:

(i) Understanding the existing noise environment and establishing the baseline condition;
(ii) Prediction of the noise impact on the residential and noise sensitive developments;
(iii) Assessment of the noise impact on the residential and noise sensitive developments;
(iv) Establishing of the need for mitigation measures to meet NEA's noise requirement; and
(v) Verification of the effectiveness of the mitigation measures if mitigation measures are needed as in (iv).

8 The International Standard for Assessment of Environmental Noise ISO 1996 "Acoustics – Description and Measurement of Environmental Noise" is the principal standard referred to for environmental noise assessment. It is divided into 2 parts:

ISO 1996-1:2016:	Basic quantities and assessment procedures
ISO 1996-2 2007:	Determination of environmental noise levels

Understanding the existing noise environment and establishing the baseline condition

9 This section covers the purposes for which baseline noise levels are required, the means of determining them and the factors that influence the method used. It also sets out a systematic approach to presenting the baseline information.

[1] The distance is calculated from road reserve line or MRT 1st reserve line, whichever is nearer to the development plot, to the boundary line of the development plot.

10 The objective is to enable an acoustic consultants and Qualified Persons (QPs) to prepare the baseline information to an appropriate level of detail for the assessment. The section is structured as follows:

(i) Definition and purpose of baseline; and
(ii) Determining the baseline.

Baseline Definition and Purpose

11 Baseline noise refers to the noise environment in an area that is affected by the land traffic noise sources (e.g. expressways/major arterial roads/MRT tracks). The baseline noise levels measured will be relevant within 12 months in which the assessment is carried out and these baseline noise levels may be referred to as existing (or current).

12 The existing baseline noise levels can serve several purposes in the assessment process:

(i) They provide a context for the existing noise levels which could impact the proposed residential and noise sensitive developments;
(ii) They may demonstrate that the existing noise environment is already unsatisfactory;
(iii) They serve as an important data for projecting the future noise levels that would impact the proposed residential and noise sensitive developments.
(iv) They serve as information for better understanding the impact the residential and noise sensitive developments would be subjected to; and
(v) They provide data to be used to calibrate the noise prediction models.

Determining the Baseline

13 The noise meters use to measure the noise levels would need to comply with the standards specified in the International Electro-technical Commission Publication 651 (Type 1) and Publication 804 (Type 1), or any other comparable standards. It should have a recent (annual/biennial) traceable calibration and checked in the field before and after any measurements by the use of an acoustic calibrator with a recent (annual) traceable calibration. If the calibration level at the end of the survey reefs by more than +/- 1 dB, then the survey should be repeated.

14 The principal noise index to be recorded will generally be the LAeq, T, the A-weighted equivalent continuous level averaged over a specified time period, T (the sampling interval). This time period must be specified for the measurement result to be meaningful. Most modern instrumentation will provide different exponential time weightings and noise measurements are to be conducted with the fastest time weighting.

15 The typical environmental noise measurement parameters are as follows:

L_{AeqT} The average noise level during the measurement period (T), which includes all noise events. The L_{Aeq} has been found to correlate with human tolerance of noise.

L_{A90} The noise level exceeded for 90% of the time. Commonly used to describe steady background noise at a location.

L_{A10} The noise level exceeded for 10% of the time. Commonly used to describe traffic noise.

L_{Amax} The instantaneous maximum sound level measured during the sample period

L_{Amin} The minimum sound pressure measured during the sample period

16 Typically noise measurements are to taken in "free field". It should be taken at 10m from the road shoulder and at least 3.5m from any facade. The microphone should be at a height of 1.2 - 1.5m above the ground. If the minimum of 3.5m from any facade is not possible, the microphone should be 1m from any façade and a facade reflection correction of -3 dBA should be applied.

17 Measurements are best avoided when raining or wind > 5m/s. Windshield shall be used during measurements at all times. The monitoring result shall be excluded from the analysis when the wind > 5m/s or there are heavy rain.

18 Representative sampling intervals should be selected and justified. Normally, a sampling interval of 15 minutes shall be used and noise assessment should be carried out during both peak (8-9am & 6-7pm) and off-peak hours. These may need to be supplemented with shorter or longer sampling intervals in certain cases. Ideally, sampling over different days and at different times during the day will help to ensure that the survey is statistically representative. Where noise emissions are relatively unsteady, a series of measurements should be undertaken over a typical period of 4 hours during daytime and over a minimum of 2 hours during evening and night-time, particularly for larger facilities with numerous external noise sources.

19 It is essential to ensure that sufficient measurement points are identified to provide representative noise data on the land traffic noise sources/ hotspots. The measurement points should be selected such that there exists at least one assessment point able to represent the noise level at each affected façade of the proposed residential and noise sensitive developments for mitigated and unmitigated scenarios.

20 The existing baseline noise measurement report shall contain:

(i) The manufacturer, model type and serial number of the sound level meter, calibrator and microphone used;
(ii) The windshield and other microphone attachments used;
(iii) The date the equipment was last calibrated to a traceable standard;
(iv) A statement of on-site calibration before and after the measurements;
(v) The frequency weighting networks and meter responses used;
(vi) A description of the measurement site and of the range of sound sources including the type of sound;
(vii) A map of the measurement site showing the locations of the measurement positions;
(viii) Details of the intervening ground between sources and measurement positions and the presence of barriers;
(ix) The time and date of the measurement;

(x) A description of the meteorological conditions;
(xi) The background noise level e.g. L_{A90} (where practicable);
(xii) The names of the person/s that undertook the survey and drafted the survey report; and
(xiii) Tabular values and graphical presentations of the measured and rated noise levels for each measurement period.

Prediction of the noise impact on the residential and noise sensitive developments

21 Noise levels at a receiver point can be calculated or predicted. Noise prediction is typically carried out as part of the noise impact assessment process. Prediction shall be made using proprietary noise modelling software (such as SoundPLAN, Cadna or equal) that is in accordance with, for example CRNT (Calculation of Road Traffic Noise) and any equivalent standards relevant to MRT train noise emission. Consultants / QPs should state clearly the standards adopted in the noise prediction.

22 For buildings within the 70m and facing land traffic noise sources (e.g. expressways/major arterial roads/MRT tracks), the vertical facade noise propagation contours from the lowest to the highest habitable floors shall be presented. In addition, horizontal contours of the worst affected floor / unit shall be presented to assess the noise dispersion. The noise contours shall take into account the effects of reverberant noise due to reflections from other blocks within the development and existing buildings in the close proximity, if any.

23 The predicted data of noise modelling tools should be validated using measured data to ensure that modelling tools are applicable in Singapore's context. The accuracy of the noise modelling tools should not exceed 3 dBA and the accuracy of the noise modelling tools shall be taken into consideration during the assessment of the noise impact and being used as the correction factor.

Assessment of the noise impact on the residential and noise sensitive developments

24 The noise levels of the new residential and noise sensitive development shall comply with the following NEA's noise requirement:

(i) The noise levels at any façade of the buildings[2] of the new residential and noise sensitive development shall not exceed the noise level of 67 dBA (Leq 1hr); and
(ii) The indoor noise level shall not exceed the noise level of 57 dBA (Leq 1hr) under natural ventilation.

25 This is based on the assumption that there will be a reduction of 10 dBA for the minimum statutory requirement[3] for natural ventilation in accordance Building Control Regulation.

[2] The façade of the buildings refer to façade of noise-sensitive rooms such as bedrooms, living rooms, study rooms, etc. It is not applicable to façade of kitchen, toilets, storeroom, yard which are not noise-sensitive.
[3] Natural ventilation shall be provided by means of one or more openable windows or other openings with an aggregate area of not less than 5% of the floor area of the room or space required to be ventilated as stated under V6 of the BCA Approved Document - Acceptable Solutions.

26 The assessment shall show the noise impact on the new residential and noise sensitive development and identify the locations or areas within the residential and noise sensitive developments, if any, which are unable to comply with the above noise requirements.

Establishing of the need for mitigation measures to meet NEA's noise requirement

27 For better noise management, developers shall first review the layout design of the development such as the building orientation, locating less noise-sensitive buildings like multi-storey carparks fronting the road, and adopting designs that are less sensitive to traffic noise to shield the traffic noise. After reviewing the layout design of the development, if the assessment shows that the noise levels at certain locations or areas within new residential and noise sensitive development are unable to comply with the noise requirement stipulated in Para 24 (i) and (ii), mitigation measures shall be taken.

28 When aiming to reduce the effects of land traffic noise on people, it is important to consider the:

(i) Noise sources;
(ii) Transmission path; and
(iii) Noise Recipient.

29 Land traffic noise levels usually decrease with increasing distance from the source because of geometrical spreading of the noise energy over a bigger surface and absorption of the noise by the atmosphere and by the ground. Normally, noise mitigation measures at source are considered as the preferred option. However, there is a limit to the decibel reduction at source for land traffic noise and mitigation measures should also be taken along transmission path and noise recipients' end for decibel reduction. Mitigation measures along transmission path, mainly barriers, can achieve additional reduction of noise levels. The sound insulation at recipients' end is the final barrier to the potentially intruding effects of noise.

30 The assessment shall show the types of mitigation measure to be taken within the residential and noise-sensitive developments for each identified locations or areas which are unable to comply with the above noise requirements. The assessment shall also address how the mitigation measures would meet the requirements, including the technical specification of these mitigation measures, the standards that these mitigation measures could meet, and the expected reduction in decibel levels of these mitigation measures. Horizontal and vertical noise contours shall be presented to show the noise levels at the critical building facades with and without the noise mitigation measures.

Verification of the effectiveness of the mitigation measures if mitigation measures are needed

31 After the completion of the installation of these mitigation measures, a post development measures should be conducted to verify the effectiveness of the mitigation measures and to ensure that the noise levels of the new residential and noise sensitive development shall comply with the following NEA's noise requirement.

32 Similar to the baseline monitoring, the noise meters use to measure the noise levels would need to comply with the standards specified in the International Electro-technical Commission Publication 651 (Type 1) and Publication 804 (Type 1), or any other comparable standards. It should have a recent (annual) traceable calibration and checked in the field before and after any measurements by the use of an acoustic calibrator with a recent (annual) traceable calibration.

33 The principal noise index to be recorded will generally be the LAeq, T, the A-weighted equivalent continuous level averaged over a specified time period, T (the sampling interval). This time period must be specified for the measurement result to be meaningful. Most modern instrumentation will provide two different exponential time weightings – 'fast' (with a nominal exponential-time constant of 125 milliseconds) and 'slow' (nominal exponential time constant of 1 second). Fast, is generally the preferred time-weighting, especially for statistical data and for variable noise levels.

34 For the façade noise level, the noise level should be taken at 1m from the façade wall.

35 For indoor noise level, the noise level should be taken from the centre of the rooms such as living room, bed rooms, etc with windows or balcony door opened. The microphone should be at a height of 1.2 - 1.5m above the floor. Vacant room is reverberant and results in build-up of reverberant noise and echo. For representative measurement, the room should be furnished or be filled with absorptive materials. The amount of absorptive material will be determined by the Reverberation Time (RT) in the room. The typical reverberation time will be 0.5 seconds for residential. A reverberation test can be carried out according to ISO 3382, using interrupted or impulse method to verify that optimum absorption material has been placed.

36 A comparison should be made between the predicted noise level with mitigation measures and the post development measurements to verify the effectiveness of the mitigation measures. Further mitigation measures would be needed if the post development measurements showed that the noise levels for the new residential and noise-sensitive developments are unable to comply with the requirement.

PART 2

37 This Part would focus on the land traffic Noise Impact Assessment on **existing** residential and noise sensitive developments located in close proximity to **new** transport-related developments (e.g. expressway/major arterial roads/MRT tracks/bus interchanges/ bus depots), inclusive of the expansion of existing transport-related infrastructures.

38 New transport-related developments (e.g. expressway/major arterial roads/MRT tracks/bus interchanges/ bus depots), inclusive of the expansion of existing transport-related infrastructures located within 70m[4] from the residential and noise sensitive developments would be subjected to the requirement to carry out land traffic Noise Impact Assessment.

39 Waiver of the requirement to carry out land traffic Noise Impact Assessment could be requested from National Environment Agency and could be granted on a case-by-case basis. For example, a proposed development, which will be totally shielded off from the traffic by another existing development, could apply for waiver to carry out Noise Impact Assessment.

40 The Noise Impact Assessment should cover the following:

(i) Understanding the existing noise environment and establishing the baseline condition;
(ii) Prediction of future noise level which might be generated;
(iii) Prediction of the noise impact on the residential and noise sensitive developments;
(iv) Assessment of the noise impact on the residential and noise sensitive developments;
(v) Establishing of the need for mitigation measures to meet NEA's noise requirement; and
(vi) Verification of the effectiveness of the mitigation measures if mitigation measures are needed as in (v).

41 The International Standard for Assessment of Environmental Noise ISO 1996 "Acoustics – Description and Measurement of Environmental Noise" is the principal standard referred to for environmental noise assessment. It is divided into 2 parts:

ISO 1996-1 2016:	Basic quantities and assessment procedures
ISO 1996-2 2007:	Determination of environmental noise

Understanding the existing noise environment and establishing the baseline condition

42 This section covers the purposes for which baseline noise levels are required, the means of determining them and the factors that influence the method used. It also sets out a systematic approach to presenting the baseline information.

[4] The distance is calculated from road reserve line or MRT 1st reserve line, whichever is nearer to the development plot, to the boundary line of the development plot.

43 The objective is to enable an acoustic consultants and Qualified Persons (QPs) to prepare the baseline information to an appropriate level of detail for the assessment. The section is structured as follows:

(i) Definition and purpose of baseline; and
(ii) Determining the baseline.

Baseline Definition and Purpose

44 Baseline noise refers to the noise environment in an area which may include the noise from the current land traffic noise sources. The baseline noise levels measured will be relevant within 12 months in which the assessment is carried out and these baseline noise levels may be referred to as existing (or current).

45 The existing baseline noise levels can serve several purposes in the assessment process:

(i) They provide a context for the existing noise levels that the residential and noise sensitive developments are subjected to;
(ii) They may demonstrate that the existing noise environment is already unsatisfactory;
(iii) They serve as an important data for projecting the future noise levels that would impact the residential and noise sensitive developments;
(iv) They serve as information for better understanding the impact the residential and noise sensitive developments would be subjected to; and
(v) They provide data to be used to calibrate the noise prediction models

Determining the Baseline

46 The noise meters use to measure the noise levels would need to comply with the standards specified in the International Electro-technical Commission Publication 651 (Type 1) and Publication 804 (Type 1), or any other comparable standards. It should have a recent (annual/biennial) traceable calibration and checked in the field before and after any measurements by the use of an acoustic calibrator with a recent (annual) traceable calibration. If the calibration level at the end of the survey reefs by more than +/- 1 dB, then the survey should be repeated.

47 The principal noise index to be recorded will generally be the LAeq, T, the A-weighted equivalent continuous level averaged over a specified time period, T (the sampling interval). This time period must be specified for the measurement result to be meaningful. Most modern instrumentation will provide different exponential time weightings and noise measurements are to be conducted with the fastest time weighting.

48 The typical environmental noise measurement parameters are as follows:

L_{AeqT} The average noise level during the measurement period (T), which includes all noise events. The L_{Aeq} has been found to correlate with human tolerance of noise.

L_{A90} The noise level exceeded for 90% of the time. Commonly used to describe steady background noise at a location.

L_{A10} The noise level exceeded for 10% of the time. Commonly used to describe traffic noise.

L_{Amax} The instantaneous maximum sound level measured during the sample period

L_{Amin} The minimum sound pressure measured during the sample period

49 As the residential and noise sensitive developments are likely to be impacted by the noise from the land transport infrastructures, it is critical to establish the existing noise level at these developments. The noise level should be taken at both the façade and the indoor of these residential and noise sensitive developments.

50 Typically noise measurements are to taken in "free field". For the façade noise level, the noise level should be taken at 1m from the façade wall. For indoor noise level, the noise level should be taken from the centre of the rooms such as living room, bed rooms, etc with windows or balcony door opened. The microphone should be at a height of 1.2 - 1.5m above the floor.

51 If there is existing road, noise level should also be taken at 10m from the road shoulder, if any, and at least 3.5m from any facade. The microphone should be at a height of 1.2 - 1.5m above the ground. If the minimum of 3.5m from any facade is not possible, the microphone should be 1m from any façade and a facade reflection correction of -3 dBA should be applied. If not, noise level should also be taken at 10m from the proposed road shoulder.

52 Measurements are best avoided when raining or wind > 5m/s. Windshield shall be used during measurements at all times. The monitoring result shall be excluded from the analysis when the wind > 5m/s or there are heavy rain.

53 Representative sampling intervals should be selected and justified. Normally, a sampling interval of 15 minutes shall be used and noise assessment should be carried out during both peak (8-9am & 6-7pm) and off-peak hours. These may need to be supplemented with shorter or longer sampling intervals in certain cases. Ideally, sampling over different days and at different times during the day will help to ensure that the survey is statistically representative. Where noise emissions are relatively unsteady, a series of measurements should be undertaken over a typical period of 4 hours during daytime and over a minimum of 2 hours during evening and night-time, particularly for larger facilities with numerous external noise sources.

54 If there is existing road, the traffic condition is to be established during the sampling intervals for the prediction of the future noise level which might be generated. The traffic condition would include the following:

(i) Category of the road;
(ii) Traffic volume in number of vehicles per hour;
(iii) Travelling Speed of the vehicles;
(iv) Percentage of heavy vehicles such as buses, heavy good vehicles more than 3.5 tonnes, etc;
(v) Road gradient; and

(vi) Type of road surface.

55 It is essential to ensure that sufficient measurement points are identified to provide representative noise data for establishing the baseline noise level. The measurement points should be selected such that there exists at least one assessment point able to represent the noise level at each affected façade of the residential and noise sensitive developments. As the residential and noise sensitive developments are mainly high rise buildings, it is also essential to establish the vertical noise pattern of the residential and noise sensitive developments. It would be recommended for noise measurements to be taken for every 5 floors.

56 The existing baseline noise measurement report shall contain:

(i) The manufacturer, model type and serial number of the sound level meter, calibrator and microphone used;
(ii) The windshield and other microphone attachments used;
(iii) The date the equipment was last calibrated to a traceable standard;
(iv) A statement of on-site calibration before and after the measurements;
(v) The frequency weighting networks and meter responses used;
(vi) A description of the measurement site and of the range of sound sources including the type of sound;
(vii) A map of the measurement site showing the locations of the measurement positions;
(viii) Details of the intervening ground between sources and measurement positions and the presence of barriers;
(ix) The time and date of the measurement;
(x) A description of the meteorological conditions;
(xi) The background noise level e,g, L_{A90};
(xii) The names of the person/s that undertook the survey and drafted the survey report;
(xiii) Tabular values and graphical representations of the measured and rated noise levels for each measurement period; and
(xiv) Traffic conditions for each measurement period, if applicable.

Prediction of future noise level which might be generated

57 In order for the noise impact assessment to be robust, the predicted land traffic noise levels must be the values expected at the relevant time. It should take into consideration the vehicular population growth rate and the recommended assessment year. The current vehicle population growth rate is 0.5% in Singapore and the recommended assessment year is 15 years from assessment years adopted internationally. Consultants / QPs are to consult LTA on the future noise levels prediction under Singapore's context.

Prediction of the noise impact on the residential and noise sensitive developments

58 Noise levels at a receiver point can be calculated or predicted. Noise prediction is typically carried out as part of the noise impact assessment process. Prediction shall be made using proprietary noise modelling software (such as SoundPLAN,

Cadna or equal) that are in accordance with, for example CRNT (Calculation of Road Traffic Noise) and any equivalent standards relevant to MRT train noise emission. Consultants / QPs should state clearly the standards adopted in the noise prediction.

59 For buildings within the 70m and facing land traffic noise sources (e.g. expressways/major arterial roads/MRT tracks), the vertical facade noise propagation contours from the lowest to the highest habitable floors shall be presented. In addition, horizontal contours of the worst affected floor / unit shall be presented to assess the noise dispersion. The noise contours shall take into account the effects of reverberant noise due to reflections from other blocks within the development and existing buildings in the close proximity, if any.

60 The predicted data of noise modelling tools should be validated using measured data to ensure that modelling tools are applicable in Singapore's context. The accuracy of the noise modelling tools should not exceed 3 dBA and the accuracy of the noise modelling tools shall be taken into consideration during the assessment of the noise impact and being used as the correction factor.

Assessment of the noise impact on the residential and noise sensitive developments

61 The occupants of the existing residential and noise sensitive developments would likely be used to their current living environment and it would be difficult for them to accept the increase in environmental noise due to new transport-related developments (e.g. expressway/major arterial roads/MRT tracks/bus interchanges/ bus depots), inclusive of the expansion of existing transport-related infrastructures. Hence, it is recommended that the perceived environmental noise at the existing residential and noise sensitive development should not be worse off after the construction of the new transport-related developments. The difference between the predicted noise level and the baseline noise level should be kept within 3 dBA.

62 In the circumstances that Para 61 could not be met, the predicted noise level at the existing residential and noise sensitive developments shall comply with the following NEA's noise requirement:

(i) The noise levels at any façade of the buildings[5] of the new residential and noise sensitive development shall not exceed the noise level of 67 dBA (Leq 1hr); and
(ii) The indoor noise level shall not exceed the noise level of 57 dBA (Leq 1hr) under natural ventilation (if noise measurements could be carried out within existing premises).

63 This is based on the assumption that there will be a reduction of 10 dBA for the minimum statutory requirement[6] for natural ventilation in accordance Building Control Regulation.

[5] The façade of the buildings refer to façade of noise-sensitive rooms such as bedrooms, living rooms, study rooms, etc. It is not applicable to façade of kitchen, toilets, storeroom, yard which are not noise-sensitive.
[6] Natural ventilation shall be provided by means of one or more openable windows or other openings with an aggregate area of not less than 5% of the floor area of the room or space required to be ventilated as stated under v6 of the BCA Approved Document - Acceptable Solutions.

64 The assessment shall show the noise impact on the existing residential and noise sensitive developments and identify the locations or areas within the residential and noise sensitive developments, if any, which are unable to comply with the above noise requirements.

Establishing of the need for mitigation measures to meet NEA's noise requirement

65 If the assessment shows that the noise levels at certain locations or areas within residential and noise sensitive development are unable to comply with the noise requirement stipulated in Para 61, Para 62 (i) and (ii), mitigation measures shall be taken.

66 When aiming to reduce the effects of land traffic noise on people, it is important to consider the:

(iv) Noise sources;
(v) Transmission path; and
(vi) Noise Recipient.

67 Normally, noise mitigation measures at source are considered as the preferred option. New transport-related developments (e.g. expressway/major arterial roads/MRT tracks/bus interchanges/ bus depots), inclusive of the expansion of existing transport-related infrastructures, shall ensure that mitigation measures are in place for decibel reduction.

68 There is a limit to the decibel reduction at source for land traffic noise and mitigation measures should also be taken along transmission path and noise recipients' end for decibel reduction. Mitigation measures along transmission path, mainly barriers, can achieve additional reduction of noise levels. The sound insulation at recipients' end is the final barrier to the potentially intruding effects of noise. However, this may not be possible for existing residential and noise sensitive developments.

69 The assessment shall show the types of mitigation measure to be taken at new transport-related developments, the transmission paths and recipients' end. The assessment shall also address how the mitigation measures would meet the requirements in Para 61 and 62, including the technical specification of these mitigation measures, the standards that these mitigation measures could meet, and the expected reduction in decibel levels of these mitigation measures.

Verification of the effectiveness of the mitigation measures if mitigation measures are needed

70 After the completion of the installation of these mitigation measures, a post development measures should be conducted to verify the effectiveness of the mitigation measures and to ensure that the noise levels at the existing residential and noise sensitive development shall meet the requirements in Para 61 and 62.

71 Similar to the baseline monitoring, the noise meters use to measure the noise levels would need to comply with the standards specified in the International Electro-technical Commission Publication 651 (Type 1) and Publication 804 (Type 1), or any other comparable standards. It should have a recent (annual) traceable calibration and checked in the field before and after any measurements by the use of an acoustic calibrator with a recent (annual) traceable calibration.

72 The principal noise index to be recorded will generally be the LAeq, T, the A-weighted equivalent continuous level averaged over a specified time period, T (the sampling interval). This time period must be specified for the measurement result to be meaningful. Most modern instrumentation will provide two different exponential time weightings – 'fast' (with a nominal exponential-time constant of 125 milliseconds) and 'slow' (nominal exponential time constant of 1 second). Fast, is generally the preferred time-weighting, especially for statistical data and for variable noise levels.

73 For the façade noise level, the noise level should be taken at 1m from the façade wall.

74 For indoor noise level, the noise level should be taken from the centre of the rooms such as living room, bed rooms, etc with windows or balcony door opened. The microphone should be at a height of 1.2 - 1.5m above the floor. Vacant room is reverberant and results in build-up of reverberant noise and echo. For representative measurement, the room should be furnished with absorptive materials. The amount of absorptive material will be determined by the Reverberation Time (RT) in the room. The typical reverberation time will be 0.5 seconds for residential. A reverberation test can be carried out according to ISO 3382, using interrupted or impulse method to verify that optimum absorption material has been placed.

75 A comparison should be make for between the predicted noise level with mitigation measures and the post development measurements to verify the effectiveness of the mitigation measures. Further mitigation measures would be needed if the post development measurements showed that the noise levels at the existing residential and noise-sensitive developments are unable to meet the requirements in Para 61 and 62.

References

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(iii) Technical Guidelines for Noise Impact Assessment, Ministry of Environmental Protection (MEP), China (1995)
(iv) Traffic Impact Assessment Guide, Alberta Infrastructure and Transportation, Canada (March 2005)
(v) Road Traffic Noise Impact Assessment Guidance Note, Environmental Protection Department, Hong Kong (December 2005)
(vi) Calculation of Road Traffic Noise (CRTN), Department of Transport, Welsh Office, UK (1998)
(vii) Environmental Noise, Consultnet.ie