

**TECHNICAL GUIDELINE ON BOUNDARY NOISE LIMITS FOR AIR
CONDITIONING AND MECHANICAL VENTILATION SYSTEMS IN NON-
INDUSTRIAL BUILDINGS
(2nd Edition 2018)**

1. Scope

This guideline sets out the maximum boundary noise emission limits for air conditioning and mechanical ventilation systems in non-industrial buildings.

The adoption of the guideline would help minimise noise nuisance from such sources. It was developed by NEA in consultation with the industry associations [i.e. Singapore Institute of Architects (SIA), Institute of Engineers Singapore (IES), the Association of Consulting Engineers Singapore (ACES), the Singapore Contractor Association Ltd (SCAL)], the academia [i.e. National University of Singapore (NUS)] and the government agencies [Building and Construction Authority (BCA), Urban Redevelopment Authority (URA)].

Qualified Persons may use the Guideline for reference in their specification, design and installation of air conditioning and mechanical ventilation systems in non-industrial buildings.

2. Definitions

For the purpose of this Guideline, the following definitions apply:

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|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Air-conditioning | – The process of treating air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the requirements of the conditioned space. |
| Mechanical Ventilation | – The process of supplying or removing air to or from a building or part thereof by mechanical means or devices. |

- Non-industrial building – Any permanent or temporary building or structure used for the purposes of trade, business or commerce and includes any shopping complex, financial institution, office tower, hotel, educational institution, hospital, transport infrastructures, community infrastructure, sport and recreational infrastructure but does not include any factory and residential premises.
- Noise Sensitive Premises – Any premises used for purposes that require peace and quiet and includes any nature reserves, health care facilities, educational institution, place of worship, library and court of law.
- Residential Premises – Any premises used for residential purposes.
- Commercial Premises /Others – Any premises used for the purposes of trade, business or commerce and include any shopping complex, offices and hotel but does not include any factory premises.
- Factory Premises – Any premises used for any industrial or manufacturing purposes, and includes any repair or processing workshop, and warehouse, but does not include any construction sites¹.
Note: ¹ Please refer to the Environmental Protection and Management (Control of Noise at Construction Sites) for the definition of a construction site.

3. Boundary Noise Limits

The noise level from the air conditioning or mechanical ventilation system should not exceed the following boundary noise limits subject to applicable correction factors as per paragraphs 5 and 6.

Type of affected premises	Boundary noise limits (reckoned as the equivalent continuous noise level over 15 minutes) in decibels (dBA)		
	Day 7 am to 7 pm	Evening 7 pm to 11 pm	Night 11 pm to 7 am
(a) Noise Sensitive Premises	60	55	50
(b) Residential Premises	65	60	55
(c) Other premises (Other than those in (a) and (b))	70	65	60

Note:

- (i) If the affected premise is a mixed-use development comprising both commercial and residential, the more stringent residential noise limits should apply.
- (ii) Qualified Persons should make reference to the latest URA master plan at URA website (<https://www.ura.gov.sg>) to verify the intended uses of adjacent premises. The more stringent noise limits should be used when the current and intended land uses differ.

4. Measurement Points

For equipment installed at ground level, the noise measurements should be made at the site boundary. For equipment that is installed above ground level e.g. at roof-top, the noise measurements should be taken at least 1m from the noise source and at the same height as the equipment. The noise level shall be computed for a point that is at the site boundary and at the same height as the equipment. The locations for noise measurements are at **Annex 1**. The methodology/example of the computation to be used is at **Annex 2**.

5. Background Noise Correction Factor

The adjusted value for the maximum permissible noise limit shall be obtained by adding the correction factor corresponding to the difference between the

maximum permitted level and the background noise level, set out in the Table below, to the higher of the 2 noise levels.

Difference between 2 noise levels in decibels (A)	Correction factor in decibels (A)
(a) Below 2	3
(b) 2 to less than 4	2
(c) 4 to less than 10	1
(d) 10 and above	Nil

6. 'Modifying Factor' Adjustments

Where a noise source contains certain characteristics, such as tonality, impulsiveness, intermittency, irregularity or dominant low frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same level and a penalty of 5 dBA shall be added for each of the following characteristics, up to a maximum of 10 dBA, in accordance with **Annex 3**.

On the other hand, some sources may cause less annoyance where only a single event occurs for a limited duration. The adjustments for duration are also given in **Annex 3**.

7. Type of Sound Level Meter

Measurement of noise levels for the purpose of this Guideline shall be carried out with a calibrated integrating sound level meter which complies with the standards specified in the International Electrotechnical Commission Publication 61672 (Type 1) and Publication 804 (Type 1), or any other comparable standards.

8. Design Considerations

The following points provide general guidance in the design of mechanical ventilation system(s) for the proposed development:

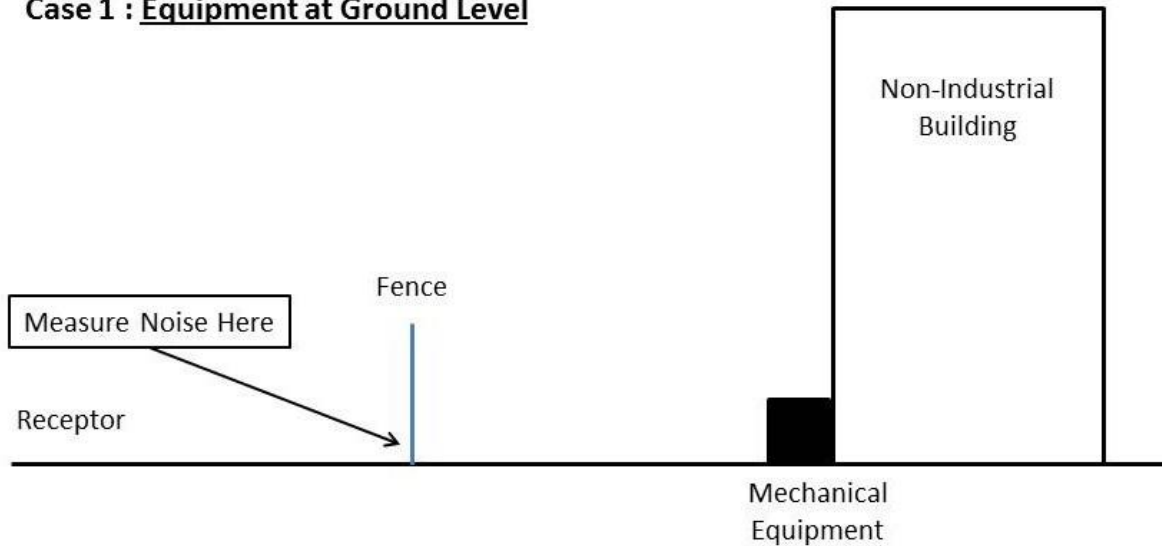
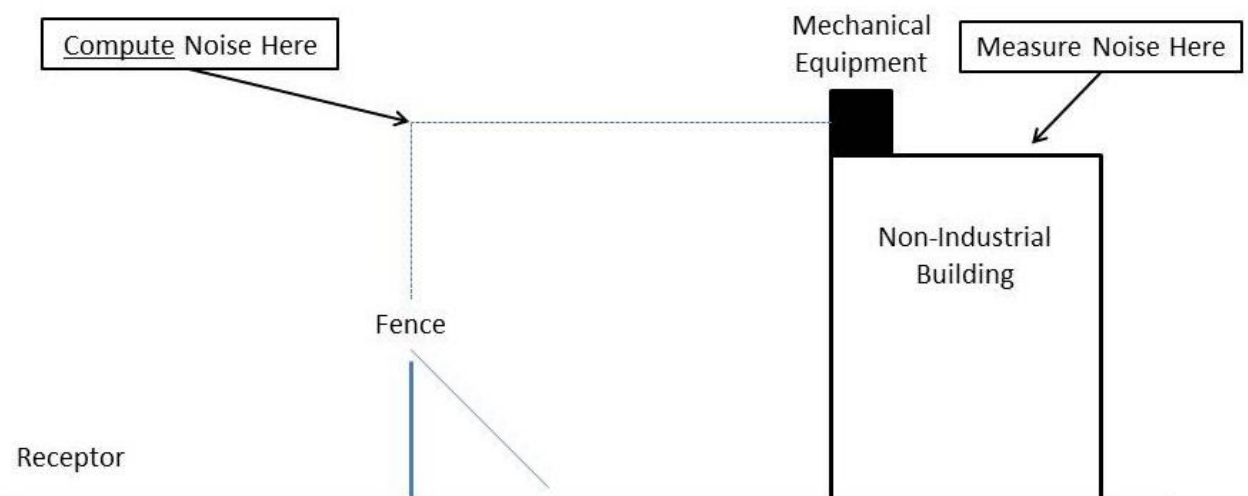
- (a) All mechanical ventilation exhaust outlets, in particular bin centre, kitchen and carpark exhaust outlets, should avoid facing directly immediate and nearby residential units, and common circulation areas within the development, where technically feasible.
- (b) All mechanical ventilation exhaust outlets, in particular bin centre, kitchen and carpark exhaust outlets, should avoid facing directly walkways outside the development, residential units and any common areas of the adjacent developments, where technically feasible.

9. References

Environmental Protection and Management (Boundary Noise Limits for Factory Premises) Regulations, 2008, National Environment Agency, Singapore

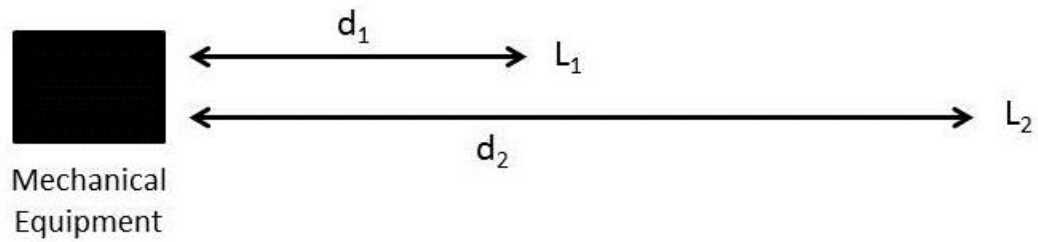
New South Wales Industrial Noise Policy, Jan 2000, New South Wales Environment Protection Authority, Australia

LOCATION FOR NOISE MEASUREMENT

Case 1 : Equipment at Ground Level**Case 2 : Equipment above Ground Level****Note:**

- a) If noise barrier is installed, noise measurements are to be carried out at least 1m behind the noise barrier and at its mid-height.
- b) If it is not practical to measure at 1m away from mechanical ventilation outlet, the noise measurements should be taken farther away from the outlet within the site boundary [and apply a correction factor for the additional distance accordingly (refer to Annex 2)].

COMPUTATION OF NOISE LEVELS



The noise level measured at distance d_1 is L_1 (in dBA).

The computed noise level at distance d_2 is L_2 (in dBA).

$$L_2 = L_1 - 20 \log (d_2/d_1)$$

'MODIFYING FACTOR' ADJUSTMENTS***Definitions to support the modifying factor corrections***

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|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tonal noise | - Containing a prominent frequency and characterised by a definite pitch. |
| Low-frequency noise | - Containing major components within the low frequency range (20Hz-250Hz) of the frequency spectrum. |
| Impulsive noise | - Having a high peak of short duration or a sequence of such peaks. |
| Intermittent noise | - The level suddenly drops to that of the background noise several times during the assessment period, with a noticeable change in noise level of at least 5 dB. |
| Adjustment for duration | - Applied where a single event noise is continuous for a period of less than two and a half hours in any 24-hour period. The acceptable noise level may be increased by the adjustment shown in <i>Table 1.2</i> . This adjustment is designed to account for unusual and one-off events, and does not apply to regular high-noise levels that occur more frequently than once per day. |
| Maximum adjustment | - The maximum correction to be applied to the criteria or the measured level where two or more modifying factors are present. The maximum adjustment is 10 dBA where the noise contains two or more modifying factors (excluding the duration correction). |

Table 1.1 – Modifying Factor Corrections

Factor	Assessment / measurement	When to apply	Correction ¹	Comments
Tonal noise ³	One-third octave or narrow band analysis	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: <ul style="list-style-type: none"> ▪ -5 dB or more if the centre frequency of the band containing the tone is above 400 Hz ▪ -8 dB or more if the centre frequency of the band containing the tone is 160 to 400 Hz inclusive ▪ -15 dB or more if the centre frequency of the band containing the tone is below 160 Hz 	5 dB ²	Narrow-band Frequency Analysis (preferably Fast Fourier Transform (FFT) analysis) to be carried out according to ISO1996-2 Acoustics-Description, measurement and assessment of environmental noise – Part 2: Determination of environmental noise levels.
Low frequency noise	Measurement of C-weighted and A-weighted level	Measure/assess C- and A- weighted levels over same time period. Correction to be applied if the difference between the two levels is 15 dB or more noise	5 dB ²	C-weighting is designed to be more responsive to low-frequency
Impulsive noise	A-weighted fast response and impulse response	If difference in A-weighted maximum noise levels between fast response and impulse response is greater than 2 dB (ms)	Apply difference in measured levels as the correction, up to a maximum of 5 dB	Characterised by a short rise time of 35 milliseconds and decay time of 1.5s

Factor	Assessment / measurement	When to apply	Correction ¹	Comments
Intermittent noise		Level varies by more than 5 dB	5 dB	Adjustment to be applied for night-time only .
Duration	Single-event noise duration may range from 1.5 min to 2.5 h	One event in any 24-hour period	0 to –20 dBA	The acceptable noise level may be increased by an adjustment depending on duration of noise.(see <i>table 1.2</i>)
Maximum adjustment	Refer to individual modifying factors	Where two or more modifying factors are indicated	Maximum correction of 10 dBA ² (excluding duration correction)	

Note:

- (i) Corrections to be added to the measured or predicted levels.
- (ii) Where a source emits tonal and low-frequency noise, only one 5-dB correction should be applied if the tone is in the low-frequency range. If FFT is used for analysis, the correction (penalty) is to be quantified according to the audibility calculation (Please refer to ISO 1996-2, DIN 45681, Joint Nordic Method, or equivalent reference for audibility calculation).
- (iii) Please note that air-conditioning compressors, bifurcated kitchen exhaust and axial fans could cause tonal noise.

Table 1.2 – Adjustments for duration

Duration of noise (one event in any 24 hour period)	Increase in acceptable noise level, dBA	
	Daytime and evening (7 am to 11 pm)	Night-time (11 pm to 7 am)
1.0 to 2.5 hrs	2	Nil
15 mins to 1 hr	5	Nil
6 mins to 15 mins	7	2
1.5 mins to 6 mins	15	5
Less than 1.5 mins	20	10