Interim Guideline

Operational Railway Noise and Vibration

Government Supported Transport Infrastructure

March 2019

Queensland Government

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1 Overview

This interim guideline is a standard which provides assessment criteria for operational noise and vibration emissions generated by rolling stock operating on a railway or railway tracks on other rail infrastructure. The guideline also provides guidance on appropriate measurement and modelling methodologies to be used when preparing a noise and/or vibration assessment report for rolling stock operating on a railway, or railway tracks on other rail infrastructure. This guideline is an interim document to provide guidance to industry until a formal code of practice is developed. Once developed, the code of practice will also be a standard and will form a volume within the department's *Transport Noise Management Code of Practice*. Currently the Code of Practice is structured into two volumes being:

- Volume 1: *Road Traffic Noise*
- Volume 2: *Construction Noise and Vibration*.

1.1 Aim of the interim guideline

This guideline aims to demonstrate the Queensland Department of Transport and Main Roads (the department) compliance with its General Environmental Duty defined in Section 319 of the *Environmental Protection Act* (1994) with respect to environmental harm and nuisance. Overall, the department has an obligation to reduce the adverse environmental impacts of government supported transport infrastructure. For rolling stock noise and vibration emissions this requires reasonable and practicable measures to be implemented to prevent or minimise environmental harm and nuisance from operational activities.

This interim guideline is a standard (Section 9(b) of the *Transport Infrastructure Act* (1994)) that includes criteria and guidance for government supported transport infrastructure (as defined in Schedule 6 of the *Transport Infrastructure Act*).

Compliance with this interim guideline is mandatory for government supported transport infrastructure activities which constitute Upgrading Existing Railway or New Railway.

Compliance with this interim guideline is optional for activities which constitute Existing Railway.

1.2 Scope of the interim guideline

The scope of this interim guideline is limited to the assessment of operational noise and vibration impacts onto sensitive land uses from rolling stock operating on a railway or railway tracks on other rail infrastructure.

This guideline does not relate to noise and vibration generated due to the construction or maintenance of transport infrastructure or construction, maintenance or operation of light rail transport infrastructure. This guideline also does not relate to noise and vibration aspects of the development application process of land adjacent to rail transport infrastructure or other rail infrastructure.

1.3 Application of the interim guideline

This interim guideline is to be used by a railway manager, government entity or other responsible party in the planning and assessment of the operational rolling stock aspects of New Railway and Upgrading Existing Railway projects and may also be used for management of Existing Railway. It outlines an assessment process which may be used for planning of projects or strategic planning to address existing issues.

This interim guideline provides a consistent framework for the identification and assessment of operational noise and vibration generated by rolling stock operating on a railway or railway tracks on other rail infrastructure.

Noise and vibration criteria are provided for operational impacts from rolling stock to reduce environmental impacts by ensuring all reasonable and practicable mitigation measures are considered.

2 Interim criteria

2.1 Sensitive land uses

Sensitive land uses have the potential to be impacted by rolling stock noise and vibration. Sensitive land uses may include:

- accommodation activities (including caretaker's accommodation, community residence, dual occupancy, dwelling house, dwelling unit, home-based business, multiple dwelling, nature-based tourism, non-resident workforce accommodation, relocatable home park, residential care facility, resort complex, retirement facility, rooming accommodation, rural workers' accommodation, short term accommodation and tourist park)
- educational establishments (including primary and secondary schools, colleges, technical institutes, universities or other educational institutions)
- child care centres (including crèches, early childhood centres, kindergartens and preschools)
- health care services (including medical centres, health clinics, surgeries and other medical institutions)
- hospitals
- community uses (including courts of law, art galleries, community halls, libraries and museums)
- places of worship
- offices
- a protected area, or an area identified under a conservation plan as a critical habitat or an area of major interest under the *Nature Conservation Act* 1992
- a public park or gardens that is open to the public (whether or not on payment of a fee) for use other than for sport or organised entertainment (passive recreation only).

2.2 Criteria

Noise and vibration criteria are defined for the following categories:

- Operational rolling stock airborne noise:
  - New Railway
  - Upgrading Existing Railway
  - Existing Railway.

- Operational rolling stock groundborne noise and vibration:
  - New Railway
  - Upgrading Existing Railway.

It should be noted that rolling stock groundborne noise and vibration mitigation is best considered at the design phase for New Railway or Upgrading Existing Railway projects and the development application stage for sensitive land uses (covered by the department's *Development Affected by Environmental Emissions from Transport Policy* document). Therefore, groundborne noise and vibration criteria are not provided for an Existing Railway.

When considering the potential noise and vibration impacts an assessment should consider the measurement and/or prediction for the opening / existing year rolling stock as well as a 10 year horizon (where data is available for future activities).

For New Railway or Upgrading Existing Railway projects, if the operational noise or vibration criterion levels are measured or predicted to be exceeded at sensitive land uses, mitigation measures should be considered on rail corridor land, commercial corridor land or future railway land with the aim to reduce the noise and vibration levels to meet criteria, where reasonable and practicable.

In the Existing Railway environment, the Railway Manager should implement a strategy that seeks to reduce airborne rolling stock noise exposure at sensitive land uses over time. The strategy should be based on the following considerations as a minimum:

- available reasonable and practicable noise mitigation options
- available funding
- Railway Manager's ranking of noise impact for affected sensitive land uses within their rail network in Queensland.

The Existing Railway noise criteria and strategy provide guidance for a Railway Manager to reduce adverse environmental impacts associated with operational rolling stock activities.

2.2.1 Operational airborne noise criteria

Rolling stock airborne noise criteria for sensitive land uses for New Railway, Upgrading Existing Railway and Existing Railway are provided in Table 2.2.1. The criteria include both Single Event Maximum (SEM) and time average noise level (L_{Aeq} (24 hour) or L_{Aeq} (12 hour)). If the criteria are exceeded, reasonable and practicable mitigation options should be implemented.

The use of rolling stock horns as a warning device are excluded from compliance with airborne noise criteria due to public safety obligations.

Table 2.2.1 - Airborne noise criteria

Type	Sensitive Land Use	Location	External Operational Railway Noise Criteria, dB(A) (1)		
			Single Event Maximum (SEM)	**L_{Aeq} (24 hour)**	**L_{Aeq} (12 hour)**
New Railway	Accommodation activities Educational establishments Child care centres Health care services Hospitals Community uses Places of worship Offices	All facades	≤ 82 (facade corrected)	≤ 60 (facade corrected)	-
		Outdoor spaces for passive recreation Outdoor education area Outdoor play area (2)	≤ 79 (free field)	-	≤ 57 (free field)
Upgrading Existing Railway OR Existing Railway	Accommodation activities Educational establishments Child care centres Health care services Hospitals Community uses Places of worship Offices	All facades	≤ 87 (facade corrected)	≤ 65 (facade corrected)	-
		Outdoor spaces for passive recreation Outdoor education area Outdoor play area (2)	≤ 84 (free field)	-	≤ 62 (free field)

Note:

1. The facade corrected noise measurement / calculation / prediction height shall be 1.5 m above Finished Floor Level (FFL) or mid window height, whichever is the higher, for each storey of the building (1.0 m in front of the most exposed facade). Otherwise, the receptor heights shall be assumed at 1.8 m and 4.6 m above the building platform level for the ground and first floors respectively. A height of 0.5 m below the eaves' height is also acceptable. For free field criteria, the noise measurement / calculation / prediction height shall be 1.5 m above the ground level.
2. For outdoor educational, outdoor play and passive recreational areas greater than 2000 m², the criterion level is to be achieved for a minimum 2000 m². For areas less than 2000 m², the criterion level shall be achieved for the whole area. All available relevant information about the provision and future use of the outdoor educational or passive recreational areas should be considered.

2.2.2 Operational groundborne noise criteria

Groundborne noise (structureborne noise or regenerated noise) is the noise radiated into a room caused by structural vibration, for example due to underground rail operations. Groundborne noise has significant low frequency components and tends to be more noticeable compared with airborne noise at the same A-weighted level. Groundborne noise criteria in buildings are relevant at sensitive land uses where the level of groundborne noise is likely to be greater than airborne noise (e.g. in buildings above rail tunnels where the airborne noise is masked by the tunnel).

Rolling stock groundborne noise criteria for sensitive land uses for New Railway and Upgrading Existing Railway are provided in Table 2.2.2. If the criteria are exceeded, reasonable and practicable mitigation options should be implemented.

Table 2.2.2 - Groundborne Noise Criteria

Type	**Sensitive Land Use**	**Internal Groundborne Noise Criteria**	
		Use Period (1)	**SEM_S dB(A)**
New Railway OR Upgrading Existing Railway (2)	Accommodation activities	Daytime	≤ 40
		Evening \ Night time	≤ 35
	Educational establishments Child care centres Health care services Hospitals	While in use	≤ 35
	Community uses (excluding a court of law) Places of worship Offices		≤ 40
	Court of Law (court rooms)		≤ 30
	Court of Law (court reporting and transcript areas, Judges' chambers)		≤ 35

Note:

1. Daytime – 7 am to 6 pm, Evening – 6 pm to 10 pm, Night time 10 pm to 7 am.
2. Mitigation of groundborne noise criteria as part of Upgrading Existing Railway applies only to new / refurbished infrastructure.

Some institutions / facilities, such as concert halls, TV studios, recording studios, auditoriums and theatres, may require specific acoustic performance in order to operate successfully. If these facilities are potentially affected by groundborne rolling stock noise, then consultation with the affected parties should be conducted to determine a reasonable and practicable approach to mitigation.

2.2.3 Operational groundborne vibration criteria

Rolling stock vibration criteria for sensitive land uses for New Railway and Upgrading Existing Railway are provided in Table 2.2.3. If the criteria are exceeded, reasonable and practicable mitigation options should be implemented.

Table 2.2.3 - Groundborne Vibration Criteria

Type	Sensitive Land Use	Internal Groundborne Vibration Criteria	
		Use Period (1)	**Vibration Dose Value (VDV) m/s$^{1.75}$**
New Railway OR Upgrading Existing Railway (2)	Accommodation activities	Daytime	≤ 0.20
		Evening	
		Night time	≤ 0.13
	Educational establishments Child care centres Health care services Hospitals Community uses Places of worship Offices	While in use	≤ 0.40 (all areas)
			≤ 0.10 (critical areas)

Note:

1. Daytime – 6 am to 6 pm, Evening – 6 pm to 10 pm, Night time 10 pm to 6 am.
2. Mitigation of groundborne vibration criteria as part of Upgrading Existing Railway applies only to new/refurbished infrastructure.

Where the buildings include sensitive instruments and electronics, vibration criteria for New Railway or Upgrading Existing Railway projects should be established through discussion with the manufacturer, supplier or operator of the sensitive equipment. Reference may also be made to previous experience or, if appropriate published sources such as *Vibration control design of high technology facilities* (Ungar *et al*, 1990).

3 Measurement

Section 3 describes the methods and standards required by the interim guideline when conducting measurements of noise and vibration from rolling stock. If alternative measurement methods are proposed they should be documented and justified within the assessment report.

Measurements should be conducted at selected locations during typical 'worst case' conditions (e.g. typical maximum operating conditions) which are representative of the identified relevant sensitive land uses. This limits the required number of measurements to a practical level.

3.1 Noise measurement

3.1.1 Instrumentation

Sound level meters used for the purposes of noise measurement should be Type 1 or Class 1, complying with the requirements of AS 1259.1 & 2-1990 or IEC 61672 respectively. Measurements conducted using octave and third octave band filters should comply with the Class 1 requirements of IEC 61260.

Other measurement equipment, such as data recorders or statistical analysers, may be used in conjunction with a sound level meter, provided that the overall accuracy of the measurement system is not less than that which would be acceptable for a Class 1 sound level meter.

3.1.2 Calibration

Sound level meters and any other sound measurement equipment should be calibrated by a National Association of Testing Authorities (NATA) certified calibration laboratory at intervals of preferably 12 months, but not exceeding two years.

Calibrated reference sound sources used to check calibration in the field ('sound level calibrators') should be recalibrated at least once a year.

A field check of instrument calibration (including any attached measurement equipment) should be made using a calibrated reference sound source, before and after each set of measurements. Where a discrepancy equal to or greater than 1 dB is measured between consecutive checks, any measurements in the interval between the two checks shall be considered invalid.

Notwithstanding this, where instrumentation will be unattended and used for an extended period at the same site (for example, 'noise logging') care should be taken to ensure that field checks of calibration are made at appropriate intervals by considering the reliability and stability of the measurement instrument or system.

The difference between sound level meter reading and calibrated reference level must be noted during each field calibration check. If, during a field check of instrument calibration, the sound level meter reading differs from the calibrated reference level, then any measurements taken in the interval since calibration was last checked should be adjusted accordingly.

3.1.3 Airborne noise measurement

Noise measurements should be conducted generally with the sound level meter set to A weighting and fast response and with a compliant windscreen fitted to the sound level meter microphone. Unless specified, noise level measurements should be presented to a single decimal place with the appropriate units specified (for example, 61.2 dB(A)).

It is important to note that for any measurement the instrumentation must be properly protected from unintended vibration or electromagnetic interference. As a general rule, when conducting noise measurements in the vicinity of vibratory plant or other sources of vibration, it is essential to ensure that the equipment is located in a stable position and properly isolated from obvious sources of vibration. Non-shielded cabling should not be used for the purpose of noise measurement.

Noise measurement should be conducted as follows:

a) Noise measurements for buildings generally must be taken 1 m from the facade of the sensitive land uses and 1.5 m above floor level. Free field measurements may be acceptable. A facade correction of 2.5 dB(A) should be added to free field measurements to determine facade corrected noise levels.

b) Measurements for open space should generally be taken at a height of 1.5 m above ground level.

c) Unattended rail noise monitoring should be conducted over a minimum of two day period, preferably on highest trafficked days. Freight train events, if occurring, must be captured in the monitoring.

d) It is recommended that attended noise monitoring should be conducted for no less than 4 hours during the period when unattended monitoring is taking place. Extraneous noise should be noted during attended monitoring. The attended monitoring should encompass all

train types utilising the track (especially freight, if present). The results from attended and unattended monitoring should be compared and addressed. They should generally agree with each other. Otherwise, additional noise measurement may be required.

- *If the corridor includes a single track then audio recordings of unattended passbys may be used in place of attended measurements.*

e) The Single Event Maximum (SEM) from trains should be calculated based on one of the following options (which should be clearly explained in the assessment report):

- *If the number of single events due to train passing is greater than or equal to 15 over a given 24 hour period, the SEM is the arithmetic average of maximum levels of the highest 15 events.*
- *If the number of single events due to train passing is less than 15 over a given 24 hour period, the SEM is the arithmetic average of maximum levels of all the events.*

f) Across all the days of monitoring, the highest SEM level shall be reported and assessed as determined in accordance with (e) above. For example, over a two day / 48 hour period, there will be two SEM levels. The highest dB(A) value of these two SEM levels is to be reported and assessed.

g) The L_{Aeq} (24 hour) / L_{Aeq} (12 hour) must be derived from the minimum two day monitoring results. The method used to calculate these levels should be clearly documented in the report. This should include the assumed number of passenger / freight events, the relevant characteristics of passbys and the method used to identify and remove extraneous noise events. The highest L_{Aeq} (24 hour) and L_{Aeq} (12 hour) levels shall be reported and assessed.

If meteorological influences may affect the measured noise levels, a portable weather station should be collocated with noise measurements. The portable weather station should be placed to limit the effects of obstructions and capable of measuring the following:

- temperature
- humidity
- rainfall
- wind speed and direction (anemometer should be located 2.0 m ± 0.2 m above ground).

Weather conditions can substantially affect the quality and accuracy of noise measurements. The primary weather conditions that affect noise measurements are wind and rain. For rail noise measurements, the maximum acceptable values of these conditions are as follows:

- average hourly wind speed up to 3 m/s
- rainfall up to 0.3 mm/h.

Noise measurements conducted during an hourly period which do not meet the above maximum acceptable values or where adversely affected by extraneous noise should be discarded. Once discarded, it should be determined whether the remaining measurement data are sufficient to adequately calculate the required noise descriptors. Where insufficient measurement data remains, further measurement will be required.

Where noise measurements are conducted to determine source reference noise levels, they may be conducted, where relevant, in accordance with AS 2377-*2002 Acoustics – Methods for the Measurement of Railbound Vehicle Noise*.

3.1.4 Groundborne noise measurement

Groundborne noise measurement and reporting should be conducted using methodologies in accordance with the provisions of ISO 14837-1.

The SEMS is the groundborne noise assessment descriptor. It should be measured inside sensitive land use buildings to determine the internal noise impacts.

A Class 1 sound level meter set to A weighting and slow response should be used for groundborne noise measurement.

The measurement for this purpose should meet the following requirements:

- The microphone should be placed at least 1 m from walls or other major reflecting surfaces and 1.5 m from windows. The presence of furnishings or other reflective surfaces, which may result in shielding or scattering of the noise, should also be considered.
- The microphone should be 1.2 m to 1.5 m above the floor.
- All windows, doors and other openings to the room should be closed.

In some situations, it may not be possible to measure the groundborne noise levels directly with a sound level meter due to the presence of extraneous noise. In these situations, measurement of groundborne vibration levels inside a room may provide an estimate of the groundborne noise level. If this method is adopted all assumptions should be stated.

3.2 Vibration measurement

Instrumentation used for vibration monitoring should be of sufficient sensitivity to allow comparison with the criteria specified in Section 2.2.3. Measurements should be conducted at sensitive land uses in accordance with:

- BS 6472-1:2008 *Guide to evaluation of human exposure to vibration in buildings Part 1: Vibration sources other than blasting*, and
- BS EN ISO 8041 *Human response to vibration – Measuring instrumentation*.

While standards may state detailed requirements, the following sections provide general requirements for calibration, instrumentation performance and coupling to substrate.

3.2.1 Instrumentation

Vibration measurement should be conducted using accelerometers in a triaxial transducer arrangement in accordance with BS 6472-1:2008. The transducers should be arranged orthogonally, so that each of the three component vibration accelerations and corresponding VDV can be measured. For all measurements the particular transducer orientation should be properly recorded and documented, both with respect to the source and to the surface on which it is fixed.

The instrumentation selected should have a frequency range meeting the assessment requirements. The weighting factors for acceleration from BS 6472-1:2008 should be used.

3.2.2 Calibration

Testing and calibration of accelerometers and other vibration measurement instrumentation should be conducted by a NATA certified calibration laboratory at intervals of at least 24 months (or less where required by the standard). Calibration will also be required following modification (e.g. use of another transducer) or repair that might affect the performance of the instrument.

In addition to the above, field calibration (in-situ checking) is required to ensure that the equipment is functioning within the required performance specification. These calibrations should be carried out immediately before and after measurements are made.

3.2.3 Coupling to substrate

To ensure the vibration measurement accuracy it is critical to maintain effective and secure coupling of the transducers to the ground, building foundations, other structural elements or substrates on which measurement is undertaken. Coupling should be provided as required in BS EN ISO 8041.

The preferred coupling method depends on site conditions. Where there is a rigid surface (for example, concrete or rock), adhesive or mechanical bonding can be used. Where the surface is soil the transducer can be embedded or fixed to an embedded mount (where allowed by the standard). If measurements are repeated at the same location an embedded mount may be particularly justified for consistency of results.

Coupling with soil spikes in soft conditions may lead to exaggerated measurements and is not recommended.

4 Modelling

4.1 Airborne noise

Section 4 provides guidance on the requirements and methodologies for modelling of operational rolling stock noise. The use of a computer noise model enables the consideration of multiple noise sources, receptors and propagation conditions.

Rail noise modelling is part of a rail noise assessment and should represent a typical ‘worst case’ (e.g. typical maximum operating conditions). Model predictions may be supported by measurements (e.g. model verification) to determine impacts.

It should be noted that whilst all noise measurements should be reported to a single decimal place, all noise model predictions should be rounded to the nearest integer.

Noise prediction requires consideration of:

- Locations of all noise sensitive land uses that may be affected by rolling stock. Typically, this includes receptors up to 150 m from the noise source and consider the following:
    - The receptor height used for prediction should be 1.5 m above the finished floor level/s. In the case of multi-level buildings, all floor levels are to be assessed.
    - The receptor height used for free field prediction should be 1.5 m above the ground level.
    - For approved residential allotment reconfigurations where the finished floor level is not known, the receptor heights should be assumed at 1.8 m and 4.6 m above an assumed building pad level, for the ground and first floors (first and second storey) respectively. It is essential that both low and high-set residential buildings be considered in the assessment.

    - All facade corrected predictions should be reported at 1 m from the facade and include a facade correction of + 2.5 dB.

- Number, speed and type of rolling stock (existing and 10 year horizon, where data is available for future activities).
- Expected noise emissions in the form of sound power levels (L_w) (or sound pressure level (L_p) at distance) from rolling stock (passenger and freight). Noise emissions from rolling stock should also include the selected correction factors utilised in the algorithm (e.g. Kilde 67/130 algorithm ΔL_1 and ΔL_2 correction factors). These should be considered as part of the train type model corrections and represent the measured levels.
- Model correction factors for track type (e.g. jointed), track radius, bridges, switches and crossings.
- Noise attenuation due to distance, ground and air absorption, screening effects of topography, buildings, temporary or permanent noise barriers.
- Variations in the noise level due to the effects of sound reflection and situations such as propagation over water (where considered by the algorithm).
- Meteorological effects including wind speed and direction as well as atmospheric stability (where required by the algorithm).

This information is typically used within a computer noise modelling package supported by a suitable algorithm.

4.1.1 Modelling algorithms

Commercial noise modelling software relies on the implementation of various algorithms which have been produced by various international bodies. To provide the most accurate assessment against all types of airborne noise criteria in Table 2.2.1, the methodology needs to be verified for Queensland situations and be capable of producing both the Single Event Maximum and L_{Aeq} (12 hour) / L_{Aeq} (24 hour) noise descriptors.

To date in both Single Event Maximum Level and L_{Aeq} cases, only the Kilde 67/130 methodology has been verified by Queensland Rail for the types of freight and passenger rolling stock (both diesel and electric powered) used in Queensland as well as propagation conditions found in Queensland. The verification process did, however, identify the need to incorporate track feature adjustments from the German Schall03 method (as listed in Table 4.1.1) as input to the Kilde 67/130 predictions. Accordingly, the track feature adjusted Kilde 67/130 methodology is currently the only accepted methodology for use in Queensland.

Other methodologies may be considered to be acceptable if they can predict noise levels within ± 2 dB(A) of either measured levels and/or those predicted by the corresponding Kilde 67/130 at representative locations. This applies in both the cases of Single Event Maximum Level and L_{Aeq} levels. For the purposes of this comparison, the number of representative locations will be dependent on what wheel track interaction noise sources are being assessed relative to Table 4.1.2 and the terrain. Verification of other methodologies should be documented within a verification report which outlines all assumptions, data and results.

4.1.2 Noise source data

It is preferable to measure noise emission data for rolling stock traffic. Measurement of airborne noise should be conducted as presented in Section 3. Where measurements of existing rail noise are not possible / required reference may be made to verified Queensland network or manufacturer supplied rail noise source levels.

Wheel track interaction (track feature) corrections should be applied to the passenger and freight consist (not freight locomotive, which is dominated by power unit / exhaust) source levels to account for various track configurations as presented in Table 4.1.2.

Table 4.1.2 - Wheel track interaction corrections

Source	Type	Correction, dB
Track type	Jointed track	+3
	Continuously welded rail	0
Crossings/ Switches	Level crossings (at a 10 m section of track for each crossing)	+5
	Switch (at a 10 m section of track for each switch)	+6
Bridge	Concrete bridges and viaducts with parapets	+1
	Concrete bridges and viaducts without parapets	+3.5
	Steel bridge with concrete parapets	+4
	Steel bridge with box or lattice girders	+9
	Wooden bridge	+5
	Unknown	+6
Track curvature	Curve radii < 300 m	+8
	Curve radii > 300 m and < 500 m	+3

Note: These corrections are additive unless confirmed by adequate measurements.

4.1.3 Source characteristics

The default noise source heights used in modelling should be as follows:

- locomotive engines – 4.0 m above top of railway track
- passenger and freight train consist – 0.5 above top of railway track.

It should be noted that some commercial modelling packages may already include a default 0.5 m above top of rail. This should be considered when allocating source heights.

Modelled noise source heights may be revised based on adequate measurements or manufacturer data.

Modelled train speeds should be based on existing and proposed sign posted speeds. It is noted that model verification may use an alternative speed where confirmed by adequate measurements.

4.1.4 Model verification

Measurements can be made where possible to determine existing noise exposure from rolling stock. This information can be used to verify a project noise model where adequate emission data is unavailable (i.e. base noise emission data has not been consistently verified across the wider Queensland network).

Source emissions (including octave bands where required by the algorithm), measured levels and calculated levels should be tabulated including any other information that is to be used in the calculation of SEM and L_{Aeq} (12 hour) / L_{Aeq} (24 hour).

Differences between the measured and calculated noise levels should be discussed within the report. Any under-prediction of the noise model should be quantified, and the value used to correct the model predictions (i.e. include a positive correction to the model results).

Generally, a noise model will be considered verified if the calculated noise level is within ± 2 dB(A) of the measured noise level. Verification should be conducted for both the SEM and L_{Aeq} noise levels.

4.2 Groundborne noise and vibration

This interim guideline does not present a preferred approach for the modelling of groundborne noise and vibration. The assessment should document the selected approach and its adequacy to represent typical 'worst case' conditions (e.g. typical maximum operating conditions) within the noise and vibration assessment report.

5 Reporting

A rolling stock noise and vibration assessment report should adequately document and present all the data inputs, measurement and modelling methodologies, assumptions and assessment results, and attenuation strategies / options considered as part of the assessment.

Reporting of operational rolling stock noise and vibration assessments should include the following as a minimum:

- Project details including classification with respect to New Railway, Upgrading Existing Railway and Existing Railway.
- Details of any noise and vibration measurements including the measurement method / standard.
- Adopted noise and vibration prediction methods and their general assumptions. Where the project includes tunnel portals/openings the assessment report should detail how tunnel portals are considered and their impact of the predicted noise levels.
- Details of noise sources included in the predictions:
    - source sound power level / pressure level information (e.g. SEM, L_{Aeq}) with octave bands where required by the algorithm
    - the number and type of train
    - modelling parameters (e.g. height of source above tracks, length of train, speed, etc.)
    - model correction factors for train types and wheel track interactions
    - details of verification where required as per Section 4.1.4.
- Details of all sensitive land uses (i.e. existing and approved development), including specifically the receptor height in relation to local ground level.
- Sensitive land use criteria as presented in Section 2.2.
- Assumptions made regarding facade reflections and reflections from other surfaces local to the receptors.

- Details of all terrain data used in the modelling.
- Details of any buildings, structures, walls, bunds or noise barriers considered to be significant and included in the modelling process. This should include specifically height relative to local ground level.
- Assumptions made in relation to ground cover (hard ground, soft ground, etc.). This should include specifically any areas where propagation over water would occur for significant distances.
- Meteorological data used in the modelling, where required by the algorithm.
- Noise and vibration prediction results tabulated and presented graphically as contours for sensitive land uses.
- Comparison of measured and predicted noise and vibration levels with criteria.
- Details of all reasonable and practicable noise and vibration mitigation options recommended for the project. Where noise barriers are proposed the barrier location and heights should be clearly reported.

Noise and/or vibration assessments and reporting should be conducted by a suitably qualified acoustic professional who should, as a minimum, be a Member of the Australian Acoustical Society (MAAS). If a professional engineering service (as defined by the *Professional Engineers Act* 2002) is conducted during the assessment and report, the report will need to be certified by a Registered Professional Engineer of Queensland (RPEQ).

For departmental projects noise and vibration assessment reports should be prepared by or overseen by Registered Professional Engineer of Queensland (RPEQ) with relevant experience.

6 Glossary

Term	Definition
Accommodation activities	Refer to Schedule 24 of the Planning Regulation 2017
Caretaker's accommodation	Refer to Schedule 24 of the Planning Regulation 2017
Child care centre	Refer to Schedule 24 of the Planning Regulation 2017
Commercial corridor land	Refer to Schedule 6 of the *Transport Infrastructure Act* 1994
Community residence	Refer to Schedule 24 of the Planning Regulation 2017
Community use	Refer to Schedule 24 of the Planning Regulation 2017
Critical area	Critical areas within Health care services and hospitals. Includes hospital operating theatres and precision laboratories where sensitive operations are occurring.
Dual occupancy	Refer to Schedule 24 of the Planning Regulation 2017
Dwelling house	Refer to Schedule 24 of the Planning Regulation 2017
Dwelling unit	Refer to Schedule 24 of the Planning Regulation 2017
Educational establishments	Refer to Schedule 24 of the Planning Regulation 2017
Environmental harm	Refer to Schedule 4 of the *Environmental Protection Act* 1994
Environmental nuisance	Refer to Schedule 4 of the *Environmental Protection Act* 1994

Term	Definition
Existing Railway	Rolling stock activities on Rail Corridor Land or Commercial Corridor Land governed by an existing Railway Manager lease.
Facade corrected	An external position affected by reflecting surfaces which influence the sound pressure level. Taken as a minimum of 1.2 m above ground level and 1.0 m from the closest reflecting plane (e.g. building facade).
Future railway land	Refer to Schedule 6 of the *Transport Infrastructure Act* 1994
Free field	An external position where there are no reflecting surfaces, other than the ground, close enough to influence the sound pressure level. Taken as a minimum of 1.2 m above ground level and 3.5 m from the closest reflecting plane (e.g. building facade).
General environmental duty	Refer to Schedule 4 of the *Environmental Protection Act* 1994
Government supported transport infrastructure	Refer to Schedule 6 of the *Transport Infrastructure Act* 1994
Groundborne noise (structureborne noise or regenerated noise)	Unwanted sound that has part of its transmission path through the ground.
Groundborne vibration	Vibration that has part of its transmission path through the ground.
Health care service	Refer to Schedule 24 of the Planning Regulation 2017
Home-based business	Refer to Schedule 24 of the Planning Regulation 2017
Hospital	Refer to Schedule 24 of the Planning Regulation 2017 (Patient care areas).
L_{Aeq}	The time average A-weighted sound level having the same total energy as the time varying sound being measured.
L_{Aeq} (12 hour)	The time average A-weighted sound level having the same total energy as the time varying sound being measured between the 12 hours between 6:00 am to 6:00 pm.
L_{Aeq} (24 hour)	The time average A-weighted sound level having the same total energy as the time varying sound being measured between the 24 hours between 12 midnight to 12 midnight.
L_{AFmax}	The maximum A-weighted noise level of a passby event, measured using the Fast response setting.
L_{ASmax}	The maximum A-weighted noise level of a passby event, measured using the Slow response setting.
Lease	Refer to Schedule 6 of the *Transport Infrastructure Act* 1994
Light rail transport infrastructure	Refer to Schedule 6 of the *Transport Infrastructure Act* 1994
Multiple dwelling	Refer to Schedule 24 of the Planning Regulation 2017
Nature-based tourism	Refer to Schedule 24 of the Planning Regulation 2017
New Railway	Proposed operational rolling stock activities on Future Railway Land.
Non-resident workforce accommodation	Refer to Schedule 24 of the Planning Regulation 2017
Office	Refer to Schedule 24 of the Planning Regulation 2017
Other rail infrastructure	Refer to Schedule 6 of the *Transport Infrastructure Act* 1994

Term	Definition
Outdoor education area	An outdoor area intended for use for the training or teaching of persons. Does not include playgrounds or outdoor sport and recreational areas.
Outdoor play area	An unenclosed area located outside the external walls of a building. Only includes playgrounds / play areas in a child care centre or educational establishment.
Patient care area	A part of a health care building normally used for the treatment, care, accommodation, recreation, dining and holding of patients including a ward area and treatment area (*Building Code of Australia*).
Passby	A noise event representing the sound pressure level experienced at a reference measuring position as rolling stock passes.
Passive recreation area	An area used for passive recreation such as a park, playground, or walking track. Does not include drainage reserves / channels, landscape buffer strips or environmental / conservation areas / corridors. Excludes private open space.
Places of worship	Refer to Schedule 24 of the Planning Regulation 2017
Private open space	Includes outdoor areas associated with accommodation and used for recreational or social activities such as a swimming pool, barbeque area, tennis court or children's play area but does not include outdoor areas designed to serve a specific service function for the building such as driveways, car parks, utility areas and walkways.
Rail transport infrastructure	Refer to Schedule 6 of the *Transport Infrastructure Act* 1994
Rail corridor land	Refer to Schedule 6 of the *Transport Infrastructure Act* 1994
Railway	Refer to Schedule 6 of the *Transport Infrastructure Act* 1994
Railway Manager	Refer to Schedule 6 of the *Transport Infrastructure Act* 1994
Railway Manager	Lease means a Lease between the Department and a Railway Manager.
Railway Operator	Refer to Schedule 6 of the Transport Infrastructure Act 1994
Relocatable home park	Refer to Schedule 24 of the Planning Regulation 2017
Residential care facility	Refer to Schedule 24 of the Planning Regulation 2017
Resort complex	Refer to Schedule 24 of the Planning Regulation 2017
Retirement facility	Refer to Schedule 24 of the Planning Regulation 2017
Rolling stock	Refer to Schedule 6 of the *Transport Infrastructure Act* 1994
Rooming accommodation	Refer to Schedule 24 of the Planning Regulation 2017
Rural workers' accommodation	Refer to Schedule 24 of the Planning Regulation 2017
Sensitive land use	A location which may be affected by transport noise and/or vibration where there is an existing land use listed in Section 2.1 or an approved development application for land uses listed in Section 2.1.
Short term accommodation	Refer to Schedule 24 of the Planning Regulation 2017
Single event maximum (SEM)	The arithmetic average of L_{AFmax} levels from the highest 15 single events (i.e. rolling stock passby) over a given 24 hour period.

Term	Definition
Single event maximum slow (SEMs)	The arithmetic average of L_{ASmax} levels from the highest 15 single events (i.e. rolling stock passby) during a Use Period within a 24 hour period.
Sound pressure level (SPL)	The local root-mean-square pressure variation from ambient for a sound, usually expressed on a logarithmic decibel scale referenced to a level of 20 microPascals.
Tourist park	Refer to Schedule 24 of the Planning Regulation 2017
Train	Refer to Schedule 6 of the *Transport Infrastructure Act* 1994
Upgrading Existing Railway	Where changes to infrastructure governed by an existing Railway Manager Lease are required to or directed to be assessed under the Railway Manager Lease, for rolling stock noise and vibration impacts onto sensitive land uses and the changes to the infrastructure are forecast to increase: • The existing rolling stock noise level at a sensitive land use (refer Table 2.2.1 for sensitive land uses) by: o ≥ 3 dB(A) for SEM, OR o ≥ 2 dB(A) for L_{Aeq} (24 hour) or L_{Aeq} (12 hour). OR • The existing rolling stock groundborne noise or vibration level at a sensitive land use to a level above the criteria nominated in Table 2.2.2 or Table 2.2.3 respectively. OR Where changes to infrastructure and/or changes to rolling stock activities on Rail Corridor Land and/or Commercial Corridor Land governed by an existing Railway Manager Lease are required as a result of, and incidental to, a New Railway project and the changes are forecast to increase: • The existing rolling stock noise level at a sensitive land use (refer Table 2.2.1 for sensitive land uses) by: o ≥ 3 dB(A) for SEM, OR o ≥ 2 dB(A) for L_{Aeq} (24 hour) or L_{Aeq} (12 hour). OR • The existing rolling stock groundborne noise or vibration level at a sensitive land use to a level above the criteria nominated in Table 2.2.2 or Table 2.2.3 respectively.
Vibration Dose Value (VDV)	As determined according to BS 6472-1:2008.
Ward area	A part of a patient care area for resident patients. It may contain areas for accommodation, sleeping, associated living and nursing facilities (*Building Code of Australia* / *National Construction Code*).

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