Noise and Vibration

Stephen Cawser
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Basics of sound and vibration

Scope of Environmental Statement

• Methodology
• Criteria
• Assessment results

Overall noise and vibration significance
Basics of Sound and Vibration
What is sound?

Sound is an oscillatory motion of the air

- Caused by vibrating surfaces
- Propagated by wave motion
- Received by the ear

Sound decays with distance due to:

- Geometrical spreading
- Absorption
- Barriers
Sound Measurement

Sound is measured in decibels ‘dB’

- Range of audible sound is very large

Perception of sound is not linear

- Use ‘A-weighting’ to account for this

- Universally applied in environmental noise
Perception of sound levels

Decibel scale is a logarithmic ratio based on a reference

- Positive value represents a value bigger than the reference
- Negative value represents a value smaller than the reference
- +10dB is a doubling of perceived loudness
- +3dB is a noticeable change in time varying sound
- +1dB is a noticeable change in a steady sound
Context of sound levels

In environmental noise, reference is threshold of perception

Typical sound levels are shown using the ‘thermometer’ on the right:
Environmental Sound Indices

To account for variation in sound levels, we use ‘equivalent continuous sound level’ or $L_{eq}$

- Average sound level
- State the time period for the average

Maximum sound levels can be used

Statistical indicators can also be used

- $L_{A10}$ is used for road traffic noise
What is vibration?

Oscillation of solids and structures

Decays with distance through:

• Geometrical spreading
• Absorption and damping
Vibration Perception

Vibration is perceived through hands, feet, whole body

Human perception requires use of weightings
Vibration Assessment Indices

Effects on people assessed using Vibration Dose Value (VDV)
• Cumulative representation of vibration exposure

Effects on buildings assessed using Peak Particle Velocity (PPV)
• Used to assess likelihood of damage
Environmental Statement
Environmental Statement

Assessment of noise and vibration effects given in ES and ES Addendum (Chapter 6)

The purpose of an ES is to:

• Assess likely environmental effects

• Based on best available information available at time
Scope of Noise and Vibration Assessment

The ES Chapter 6 contains assessment of:

- Construction noise
- Construction vibration
- Operational noise from trams
- Operational vibration from trams
- Operational noise from changes to road traffic
- Cumulative operational noise (trams + road traffic)
Methodology

Methodology of environmental assessment:

• Identify noise and vibration sensitive receptors
• Define assessment criteria
• Determine baseline situation
• Assess likely effects
  • Predict noise and vibration levels
  • Determine significance
• Mitigation (if required)
• Residual effects (significance after application of mitigation)
Magnitude of Impact

Impact is the physical quantity measured.

<table>
<thead>
<tr>
<th>Change in Noise Level dB(A)</th>
<th>Magnitude of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Change</td>
</tr>
<tr>
<td>≤ 1</td>
<td>Negligible</td>
</tr>
<tr>
<td>&gt;1 - ≤3</td>
<td>Low</td>
</tr>
<tr>
<td>&gt;3 - ≤5</td>
<td>Medium</td>
</tr>
<tr>
<td>&gt; 5</td>
<td>High</td>
</tr>
</tbody>
</table>

Table 6.9 Criteria for Assessment of Changes in Existing Ambient Noise Levels due to the Operation of the Trams
Significance of Effects

Effects are what an impact means for a receptor

<table>
<thead>
<tr>
<th>Sensitivity of Receptor</th>
<th>Magnitude of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Negligible</td>
</tr>
<tr>
<td>High</td>
<td>Minor</td>
</tr>
<tr>
<td>Medium</td>
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<td>Negligible</td>
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</table>
Impacts and Effects Example

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<th>Sensitivity of Receptor</th>
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<tr>
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<tr>
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<td>Negligible</td>
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<td>Negligible</td>
<td>Negligible</td>
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</tbody>
</table>
ES Noise Assessment
Construction Noise Criteria

Based on guidance in British Standards

- BS 5228-1:2009+A1:2014 for residential properties
- BS 8233:2014 for other building uses
- Dependent on existing ambient noise levels

Assessed as $L_{Aeq}$ over 10 hour working day

- Standard construction site working hours (08:00-18:00)
Operational Noise Criteria

Based on a change in noise level ($L_{Aeq,18hr}$ for trams, $L_{A10,18hr}$ for road traffic)

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<tr>
<td>&gt;5</td>
<td>High</td>
</tr>
</tbody>
</table>
Noise and Vibration Receptors

Chosen receptors for ES assessments

Cover all land uses adjacent to route
Baseline Noise Levels

Baseline measurement locations

Supplemented by modelling of existing road traffic noise
Measurements used to check road traffic model
Construction Noise Predictions

Based on likely construction activities and programme

Predictions carried out according to BS 5228-1:2009+A1:2014

Assessment incorporates a number of impact avoidance measures

- Best practice for construction sites
- Implemented through the CoCP

Significant effects likely at some locations for some activities

- Temporary and reversible impacts
- Not for full duration of construction
Construction Noise Mitigation

CoCP requires the production of an Environmental Management Plan

• Noise and Vibration Management Plan would form part of this

ES suggested additional mitigation in the form of:

• Use of localised screening around plant and equipment

This is in addition to the best practice measures outlined in impact avoidance measures
Operational Noise from Trams

Predictions carried out to the requirements of Calculation of Railway Noise (CRN) methodology

For the majority of locations, noise from trams less than existing ambient noise levels

Exceptions are where TPL runs adjacent to quiet façade of a building

Noise levels no more than exist on other façades

Not significant - no mitigation required
Noise from Changes to Road Traffic

Prediction methodology uses Calculation of Road Traffic Noise (CRTN)

• Guidance from Design Manual for Roads and Bridges (DMRB)

Based on data from transport assessment

Changes in road traffic noise calculated for each building façade individually

Impacts are calculated and significance identified

No significant effects identified at chosen receptors

Not significant - no mitigation required
Cumulative Operational Noise

Moderate adverse noise effect identified at one location – receptor R4

- Loss of attenuation from demolished buildings
- Additional tram noise

Better information for ES Addendum

- Revisions in ES Addendum changed this to minor adverse

Not significant - no mitigation required
ES Vibration Assessment
Construction Vibration Criteria - People

Construction vibration assessed in terms of peak particle velocity (PPV)

Table 6.6 Guidance on Effects of Construction Vibration Levels - Annoyance

<table>
<thead>
<tr>
<th>Vibration Level ( \text{ppv mms}^{-1} )</th>
<th>Description of Effect</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.3</td>
<td>Vibration is unlikely to be perceptible in even the most sensitive situations for most vibration frequencies associated with construction.</td>
<td>Negligible</td>
</tr>
<tr>
<td>0.3 to 1</td>
<td>Increasing likelihood of perceptible vibration in residential environments.</td>
<td>Minor</td>
</tr>
<tr>
<td>1 to 10</td>
<td>Increasing likelihood of complaint in residential environments, but can be tolerated at the lower end of the scale if prior warning and explanation has been given to residents.</td>
<td>Moderate</td>
</tr>
<tr>
<td>&gt;10</td>
<td>Vibration is likely to be intolerable for any more than a very brief exposure to a level of 10 mms(^{-1}).</td>
<td>Major</td>
</tr>
</tbody>
</table>
Construction Vibration Criteria - Buildings

Assessed in terms of peak particle velocity (PPV)

<table>
<thead>
<tr>
<th>Continuous Vibration Level, PPV mms⁻¹</th>
<th>Damage Risk</th>
<th>Significance of Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Tends to zero</td>
<td>Negligible</td>
</tr>
<tr>
<td>7.5</td>
<td>Cosmetic</td>
<td>Minor</td>
</tr>
<tr>
<td>15</td>
<td>Minor</td>
<td>Moderate</td>
</tr>
<tr>
<td>30</td>
<td>Major</td>
<td>Major</td>
</tr>
</tbody>
</table>
Operational Vibration Criteria

Significance of VDV from BS 6472:2008

<table>
<thead>
<tr>
<th>Vibration level (VDV ms-1.75)</th>
<th>BS 6472 Rating</th>
<th>Significance of effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day (07:00 – 23:00)</td>
<td>Adverse comment is not expected</td>
<td>Negligible</td>
</tr>
<tr>
<td>Night (23:00 – 07:00)</td>
<td>Low probability of adverse comment</td>
<td>Minor</td>
</tr>
<tr>
<td>&lt; 0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2 - 0.4</td>
<td>Adverse comment possible</td>
<td>Moderate</td>
</tr>
<tr>
<td>0.4 - 0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 0.8</td>
<td>Adverse comment probable</td>
<td>Major</td>
</tr>
<tr>
<td>&gt; 0.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Construction Vibration Assessment


Empirical methods for predicting vibration

Not significant - no mitigation required
Operational Vibration from Trams

Prediction method is empirically based on measurements on Metrolink

- Evaluation of source levels and propagation effects

Vibration Dose Values fall in to ‘adverse comment not expected’ category of BS 6472:2008 at all receptors

Not significant - no mitigation required
Residual Effects

Construction noise – significant adverse
• Temporary and reversible
• Mitigation reduces effect, but still potentially significant

Construction vibration – negligible

Operational tram noise – negligible

Operational tram vibration - negligible

Operational road traffic noise – minor adverse

Combined operational noise – negligible to moderate adverse
Proposed Additional Mitigation

Concerns raised by ITV Studios regarding a number of noise sources

In response to this, the following additional mitigation proposed:

• Construction works outside of filming times, where necessary
• Operational restriction on routine use of tram warning horn
• Implementation of friction modifier to mitigate curving noise