Noise and Vibration Measurements of the ACELA

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Noise Measurements

- Single microphone at 100 ft. (30 m)
  - 4 ft. (1.2 m) AGL
  - 11.5 ft. (3.5 m) ATOR

- Array Configurations
  - Linear Horizontal: High, Mid, Low
  - Linear Vertical: High, Low
  - “X”- High: 32 cm, 16 cm
  - “X”- Low: 8 cm
Noise vs. Speed

High Speed Train Noise Measurements
100 ft from track centerline

- CELLA at TTC
- X2000 on NEC
- ICE on NEC
Noise vs. Speed

ACELA Noise Measurements
100 ft from track centerline

Lmax, fast (dBA)

Speed (mph)
Single Microphone at 100 ft.
Low Horizontal Linear Array
Low “X-Array”
Low Vertical Array
Low Vertical Array with ACELA
Rail Roughness Measurement
Vibration - Source/Path/Receiver

- Soil Vibration
- Propagation Path
- Structural Vibration
- Radiated Sound
Vibration Concepts

- Vibration velocity measured in RMS inches/sec
- \( L_v [\text{dB}] = 20 \log_{10} \left( \frac{\text{RMS vib. Velocity}}{1 \mu \text{in/sec}} \right) \)
- \( L_v = \text{Train Force} + \text{Ground Propagation Characteristics} \)
- \( L_v [\text{dB}] = \text{FD}[\text{dB}] + \text{TM}[\text{dB}] \)
## Typical Vibration Velocity Levels

<table>
<thead>
<tr>
<th>Human/Structural Response</th>
<th>VELOCITY LEVEL*</th>
<th>Typical Sources (50 ft from source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold, minor cosmetic damage to fragile buildings</td>
<td>100</td>
<td>Blasting from construction projects</td>
</tr>
<tr>
<td>Difficulty with tasks such as reading a VDT screen</td>
<td>90</td>
<td>Bulldozers and other heavy tracked construction equipment</td>
</tr>
<tr>
<td>Residential annoyance, infrequent events (e.g., commuter rail)</td>
<td>80</td>
<td>High speed rail, upper range</td>
</tr>
<tr>
<td>Residential annoyance, frequent events (e.g., rapid transit)</td>
<td>70</td>
<td>Rapid transit, upper range</td>
</tr>
<tr>
<td>Limit for vibration sensitive equipment. Approx. threshold for human perception of vibration</td>
<td>60</td>
<td>High speed rail, typical</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>Bus or truck over bump</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bus or truck, typical</td>
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<tr>
<td></td>
<td></td>
<td>Typical background vibration</td>
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</tbody>
</table>

* RMS Vibration Velocity Level in V/ft relative to 10^{-6} inches/second
Ballast Mat – Dynamic Engineering
Ballast Mat – Clouth (23mm & 15 mm)
Vibration Propagation Test
Measurement Site
Vibration Measurement Procedure

- One “Reference” measurement site between Zone 2 and Zone 3
- Additional measurement at each mitigation zone
- Acela vibration measured at 5 speeds
  - 50 mph
  - 75 mph
  - 100 mph
  - 125 mph
  - 150 mph
Vibration Results

• ISO-Rail minimally effective

• Ballast mats marginally effective
  • On soft foundation

• Under-tie pads most effective