Noise and Vibration Measurements for the DCTA Stadler DMU

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INTRODUCTION

- A noise and vibration test program was conducted for the Stadler Model GTW 2/6 Diesel Multiple Unit (DMU) diesel-electric articulated rail vehicle.

- The DMU vehicles operate on the Denton County Transportation Authority (DCTA) A-Train system.

- The test program was conducted in Lewisville, Texas during December of 2012.

- The objective was to document wayside noise and ground-borne vibration levels from the DMU for application to projects with plans to use similar vehicles (e.g. DART Cotton Belt and FWTA TEX Rail).
DCTA Stadler DMU Test Train

Fully-equipped Stadler GTW 2/6 consisting of two 134-ft. long articulated vehicles weighing 161,500 lb. ea. (AW0)
Noise Measurement Methodology

- **Measurement Microphones** – located at 50 ft. and 100 ft. from the test track center line

- **Constant Speed Tests** – runs in each direction at constant speeds of 15, 30, 45 and 60 mph

- **Acceleration Tests** – runs in each direction accelerating at full throttle from 0 to 30 mph

- **Deceleration Tests** – runs decelerating from 30 to 0 mph, simulating a normal station stop

- **Stationary Tests** – tests of stationary vehicles at low and high idle speeds
Noise and Vibration Test Location
A-Weighted Noise Measurement Results

<table>
<thead>
<tr>
<th>Measurement Condition</th>
<th>Speed (mph)</th>
<th>Sound Level at 50 feet(^1) (dBA)</th>
<th>SEL at 50 feet (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>2-Car Train</td>
</tr>
<tr>
<td>Constant Speed Test</td>
<td>15</td>
<td>69</td>
<td>79</td>
</tr>
<tr>
<td>Constant Speed Test</td>
<td>30</td>
<td>75</td>
<td>82</td>
</tr>
<tr>
<td>Constant Speed Test</td>
<td>45</td>
<td>79</td>
<td>84</td>
</tr>
<tr>
<td>Constant Speed Test</td>
<td>60</td>
<td>81</td>
<td>86</td>
</tr>
<tr>
<td>Acceleration Test</td>
<td>0-30</td>
<td>80</td>
<td>87</td>
</tr>
<tr>
<td>Deceleration Test</td>
<td>30-0</td>
<td>76</td>
<td>84</td>
</tr>
<tr>
<td>Low Idle (Vehicle #111)</td>
<td>0</td>
<td>65</td>
<td>--</td>
</tr>
<tr>
<td>High Idle (Vehicle #111)</td>
<td>0</td>
<td>71</td>
<td>--</td>
</tr>
<tr>
<td>Background Noise Test</td>
<td>--</td>
<td>47</td>
<td>--</td>
</tr>
</tbody>
</table>

\(^1\) Values for moving trains correspond to the maximum one-second Leq
DMU Noise Level Frequency Spectra
(at 50 feet from the test track center line)
Noise Measurement Observations

- Constant speed tests indicate that one-third octave band noise levels typically increase with increasing speed above 63 Hz
- Spectra at lower speeds include peak at 50 Hz generated by the diesel engines
- Stationary low-idle condition includes peak at 40 Hz
- Peak shifts to 63 Hz for high-idle condition
- Potential for annoyance from noise-induced vibration if DMU vehicles idle in close proximity to residences
DMU Noise Prediction Model

- The FTA guidance manual has a method for predicting noise from DMU vehicles (although measurements are preferred).
- The FTA method is based on older DMU technology which may not be applicable to the newer Stadler vehicles used by DCTA.
- A primary objective of the DMU test program was to develop a model to predict noise from the Stadler vehicles for impact assessments on other projects.
- The noise prediction model is based on the Sound Exposure Level (SEL) for a single-vehicle pass-by.
DMU Noise Prediction Model: SEL

- **FTA Prediction Models:**
  - SEL for DMU is independent of speed
  - SEL for rail cars varies in proportion to $20 \times \log(\text{Speed})$

- **Stadler DMU:**
  - SEL < FTA DMU model below 60 mph
  - SEL > FTA rail car model below 45 mph
  - SEL (at 50 ft.) = $10.63 \times \log(\text{mph}) + 63.74$
  - Adjustments made for added noise from operation at higher throttle settings and from regenerative braking
Vibration Test Procedures

- **DMU Ground Vibration Measurements:**
  - Runs of the DMU test train were made in each direction at constant speeds of 15, 30, 45 and 60 mph.
  - Vertical ground vibration was measured at 6 positions, with accelerometers at distances ranging between 15 and 125 feet from the test track center line.

- **Ground Vibration Propagation Tests:**
  - Impact forces were generated at 11 points spaced 15 feet apart along a line parallel to and 15 feet from the track.
  - Vibration response was measured at 5 positions on the ground ranging from 10 to 110 feet from the impact line.
  - The relationship between the impact force and ground surface vibration determines the line source transfer mobility (LSTM).
Ground-Borne Vibration Test Locations
Average DMU Ground Vibration Level Spectra vs. Speed (at 50 feet from the track center line)
Line Source Transfer Mobilities (LSTM) at Test Site

![Graph showing Line Source Transfer Mobilities (LSTM) at Test Site](https://www.hmmh.com)
DMU Vibration Prediction Model: Force Density Level

- FTA detailed vibration analysis prediction method is based on the Force Density Level (FDL)

- FDL spectra are calculated for specific DMU speeds

- FDL = Lv – LSTM
  - Lv = rms ground vibration velocity level
  - LSTM = line source transfer mobility
DMU Force Density Levels vs. Speed

[Graph showing the relationship between one-third octave band center frequency (Hz) and force density level (dB re: 1 lb/(ft)^2) for different speeds: 15 mph, 30 mph, 45 mph, and 60 mph.]
Comparison of DCTA Stadler DMU Force Density Levels with FTA Averages (at 45 mph)
Comparison of Force Density Levels for Different DMU Vehicles (at 45 mph)

- Stadler DMU (DCTA)
- Colorado Railcar DMU (TTCI)
- Bombardier DMU (Ottawa)
Summary of DMU Force Density Level Comparisons

- DCTA Stadler DMU FDL values fall in between the FTA average values for commuter and light rail vehicles in the 10 Hz to 80 Hz frequency range.

- DCTA Stadler DMU FDL values are similar to Colorado Railcar DMU values between 12.5 Hz and 125 Hz.

- DCTA Stadler DMU FDL values are generally higher than those for the Bombardier Ottawa DMU.
ACKNOWLEDGMENTS

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Thank You!

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