The Acoustic Impact of Local Railways Lines

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Abstract: The aim of this study is to correlate the noise produced by trains along local lines with their speed and distance from the point of measurement and consequently to study the spectral components of noise.

THE MEASUREMENTS

The study has analyzed the noise produced by two trains of the Railways SATTI, between Turin and Ceres: the electric traction Ale 054 and the diesel traction Aln 668. Taking into consideration the direction of railway noise emission, the microphone was placed along the line connecting the standard measuring points, set at a distance of 7.5 and 25 m from the axis of the transit track, at a height of 1.2 m and 3.5 m, respectively from the tracks.

The positions (M_i) are indicated in table 1, together with the detected values of maximum noise level L_max.

<table>
<thead>
<tr>
<th>Position</th>
<th>M_1</th>
<th>M_2</th>
<th>M_3</th>
<th>M_4</th>
<th>M_5</th>
<th>M_6</th>
<th>M_7</th>
<th>M_8</th>
<th>M_9</th>
<th>M_10</th>
<th>M_11</th>
<th>M_12</th>
<th>M_13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance (m)</td>
<td>4.5</td>
<td>6.0</td>
<td>7.5</td>
<td>9.0</td>
<td>10.5</td>
<td>12.0</td>
<td>13.5</td>
<td>15.0</td>
<td>16.5</td>
<td>18.0</td>
<td>19.5</td>
<td>21.0</td>
<td>22.5</td>
</tr>
<tr>
<td>Height (m)</td>
<td>0.8</td>
<td>1.0</td>
<td>1.2</td>
<td>1.4</td>
<td>1.6</td>
<td>1.8</td>
<td>2.0</td>
<td>2.2</td>
<td>2.4</td>
<td>2.6</td>
<td>2.8</td>
<td>3.0</td>
<td>3.4</td>
</tr>
<tr>
<td>L_{max}(Ale054)</td>
<td>97.1</td>
<td>92.7</td>
<td>91.7</td>
<td>89.7</td>
<td>88.9</td>
<td>88.1</td>
<td>88.7</td>
<td>86.4</td>
<td>86.9</td>
<td>85.4</td>
<td>85.5</td>
<td>84.2</td>
<td>84.6</td>
</tr>
<tr>
<td>L_{max}(Aln668)</td>
<td>96.3</td>
<td>94.2</td>
<td>92.4</td>
<td>89.5</td>
<td>89.1</td>
<td>87.0</td>
<td>86.9</td>
<td>85.8</td>
<td>84.2</td>
<td>84.3</td>
<td>83.5</td>
<td>83.4</td>
<td>81.3</td>
</tr>
</tbody>
</table>

THE VARIATION OF MAXIMUM SOUND LEVEL WITH DISTANCE AND SPEED

The analysis of noise attenuation depending on distance was carried out while the train was traveling at the maximum allowed speed (90 km/h) with the microphone in points from M_1 to M_{15}.

For each point we registered the temporal evolution (time history) due to the transit of each train, the frequency spectra in thirds of octave bands and the relative statistical analyses.

By statistical elaboration of the maximum sound levels (dBA) in function of the distance, the following regression equation was obtained for the Ale 054 (1) and for the Aln 668 (2), respectively.

\[ \text{L}_{\text{max}} = 105.5166 - 15.5216 \cdot \log(d) \quad r = -0.9809. \quad (1) \]
\[ \text{L}_{\text{max}} = 108.4445 - 19.0056 \cdot \log(d) \quad r = -0.9880. \quad (2) \]

We later analyzed the variation of noise in function of train speed, getting the trains to transit at increasing speeds from 20 to 90 km/h. The regression analysis, for the Ale 054, in M_1 position, reveals the relationship between the L_{max} in dB(A) and the logarithm of the speed in km/h:

\[ \text{L}_{\text{max}} = 37.5414 + 27.0631 \cdot \log(v) \quad r = 0.9901. \quad (3) \]

The data agree with the numerous studies which establish the validity of the relationship:

\[ L = L_0 + 30 \cdot \log \left( \frac{v}{v_0} \right). \quad (4) \]
where $L_0$ is a reference level measured at 7.5 m from the track and at the reference speed $v_0$ of 60 km/h. Based on this relationship, each doubling of speed implies an increase of 10 dB(A) of the emitted noise. In our study $L_0$ is equal to 86.3 dBA. For the Aln 668, analogous results were obtained.

### SPECTRAL SURVEY

From the analysis of spectrograms in 1/3 of octave, of both carriage types, we can deduce that the prevalent components are within the 500-2000 Hz interval while low frequencies are less recurrent.

The multispectral analysis demonstrates that at speeds of 90 km/h, there is maximum correspondence to frequency at 1000 Hz (figure 1); at speeds of 40 km/h, on the contrary, the spectral components flatten out and the 1000 Hz peaks disappear; in any case there is a low sound contribution at low frequencies.

![Figure 1. Multispectrum analysis of transit of the Ale 054, at 90 km/h.](image)

As a final step, we elaborated the instantaneous spectra relevant to maximum sound level during the transit of both carriage types at 30, 60 and 90 km/h in M3 position.

For both the carriages the sound levels increase as frequency increases, up to 1000 Hz and then they decrease at higher frequencies. For the Ale 054 (figure 2), sound levels both at low and high frequencies are closer. Between 500 and 4000 Hz, they are distinct and increase as speed increases. For the Aln 668, on the contrary, sound levels are independent from the speed between 1000 and 4000 Hz. There is a prevailing contribution of the lower speeds, which produce higher sound levels up to 1000 Hz.

![Figure 2. Instantaneous spectrum relevant to the maximum sound level of the Ale 054 transit, with different speeds.](image)

### REFERENCES