



Politecnico di Milano
M.Sc. in Mechanical Engineering

VEHICLE ACOUSTICS

Lab. 03: interior noise of rail vehicles

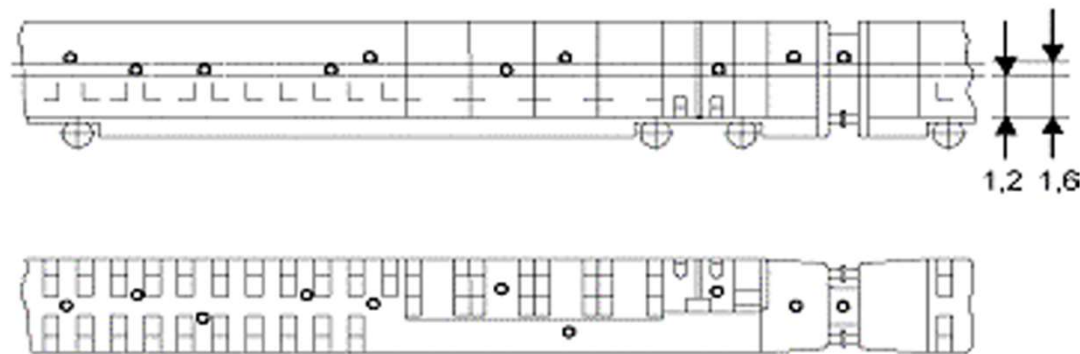
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Interior noise – experimental tests

The **measurement procedure for internal noise** in rail vehicles is outlined in the EN ISO 3381:2005 standard. This document prescribes five to seven different measurement positions, which are divided into:

- Seated positions, where the microphone is placed at a height of 1.2 m.
- Standing positions, where the microphone is placed at a height of 1.6 m.
- Working positions, located in the center of the compartment at a height of 1.6 m above the floor or at ear level, i.e., at a distance of 0.1 m from the ear most exposed to the noise, whether from the driver or any other person normally occupying the driver's cab.
- Lying positions for sleeping cars, where one microphone is placed 0.2 m above the pillow.

The vehicle must operate under typical conditions and should be unloaded (without passengers, with the exception of the train crew).

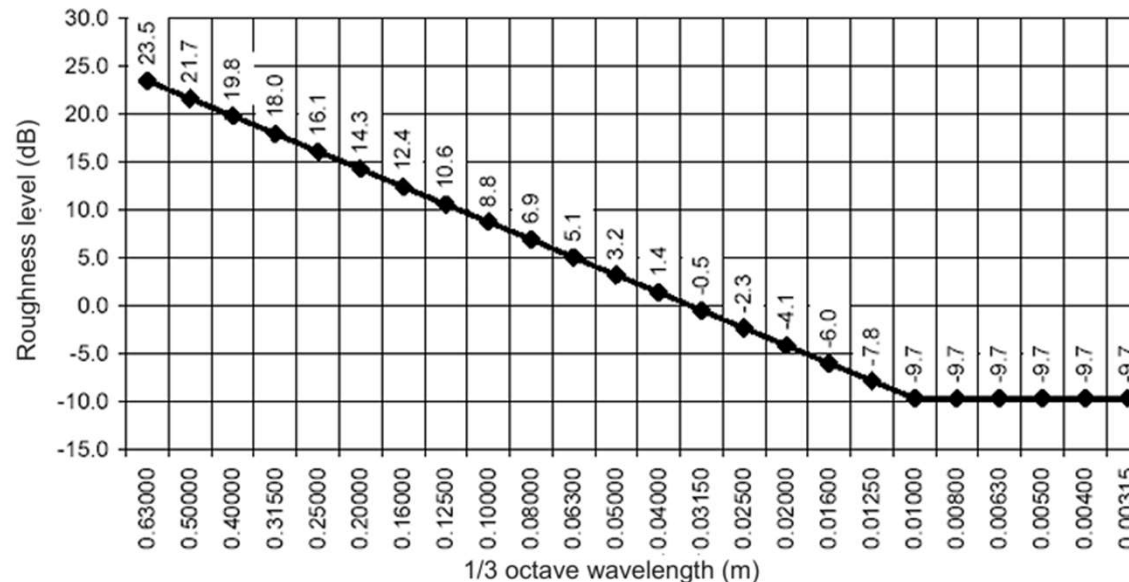


Examples of microphone positioning according to EN ISO 3381:2005.

Interior noise – experimental tests

Internal noise measurement shall only be performed if the **rail's roughness condition** is below a specific limit. The roughness condition of the rail at the test site is assessed through the following steps:

- Direct measurement of roughness at three sites, considering a 1/3 octave band wavelength range of [0.008, 0.5 m].
- Calculation of the 1/3 octave roughness wavelength spectrum for each site, followed by an averaging procedure.
- Comparison of the averaged spectrum with a reference curve.



Threshold indicated in EN ISO 3381:2005 for the rail roughness of the test site.

Interior noise – experimental tests

The EN ISO 3381:2005 standard specifies the following:

- For each microphone, the A-weighted equivalent continuous sound pressure level $L_{pAeq,T}$ must be calculated:

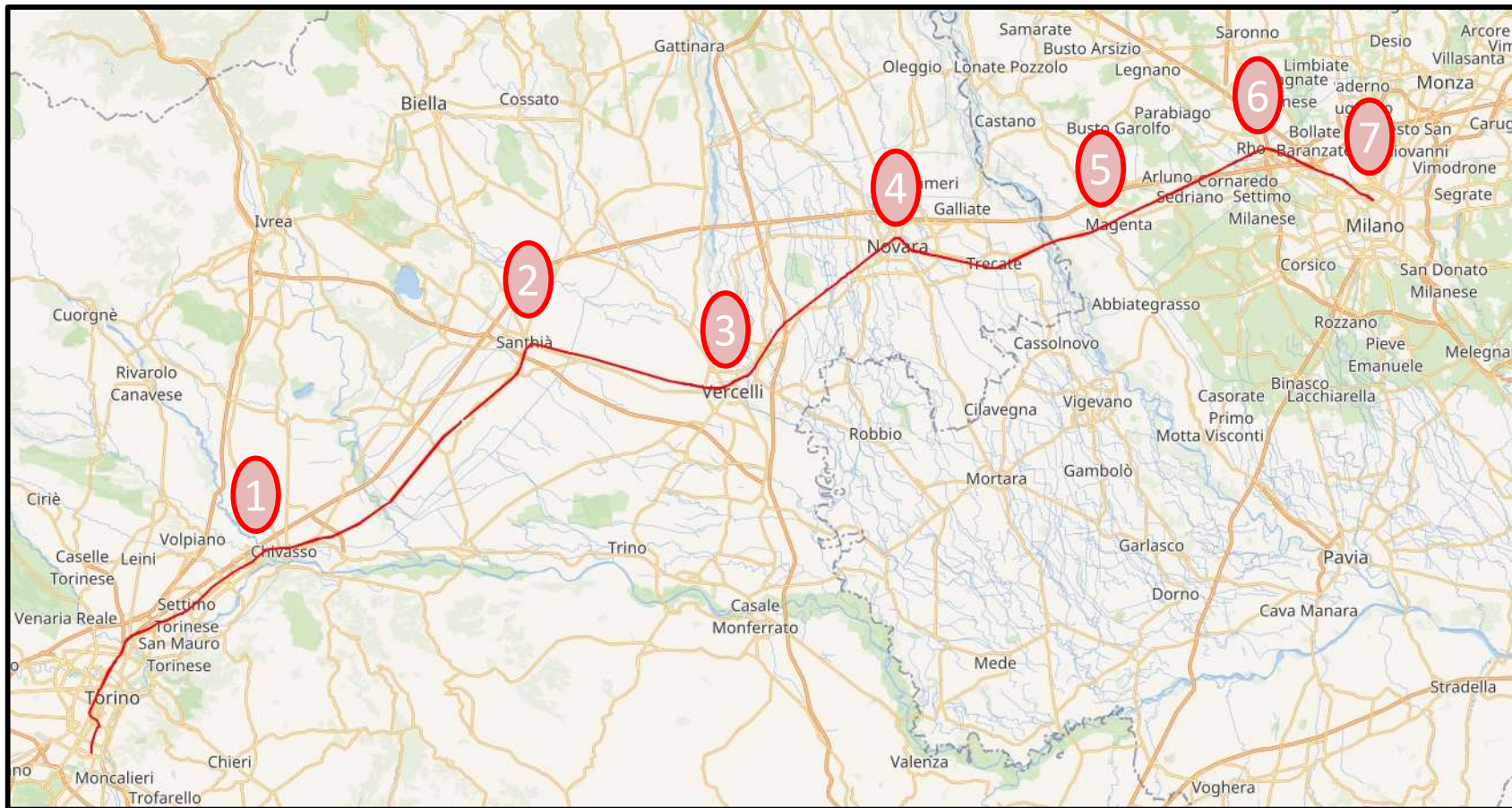
$$L_{pAeq,T} = 10 \log_{10} \left(\frac{1}{T} \int_0^T \frac{p_A^2(t)}{p_0^2} dt \right) dB$$

- The internal noise measurement must be repeated at least three times. The arithmetic mean of each set of measurements shall be taken as the test result and rounded to the nearest integer in decibels. If the variation between readings exceeds 3 dB, a new series of measurements must be conducted.
- Measurements should be taken at each microphone position and for each measuring condition, with a measurement time interval of $T = 20$ s.
- The preferred vehicle speeds are: 20 km/h, 40 km/h, 60 km/h, 80 km/h, 100 km/h, 120 km/h, 140 km/h, 160 km/h, 200 km/h, 250 km/h, 300 km/h, 320 km/h, and 350 km/h.

Experimental measurements

In this laboratory assessment, interior noise measurements are acquired on a “Regionale Veloce” suburban train running from Torino to Milano.

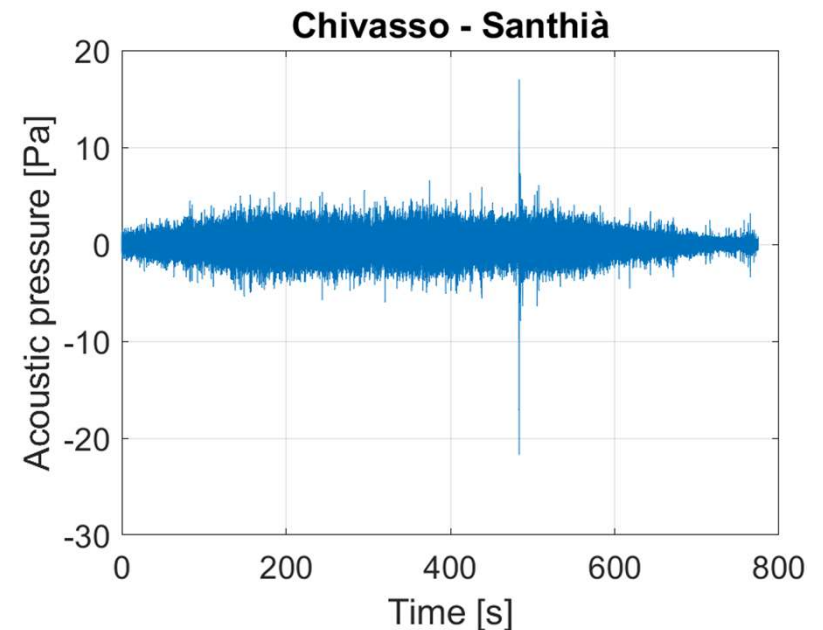
① Chivasso ② Santhià ③ Vercelli ④ Novara ⑤ Magenta ⑥ Rho ⑦ Milano Centrale



Experimental measurements

The acoustic pressure inside the wagon is measured by means of a ½ inch microphone. Different measurements are provided:

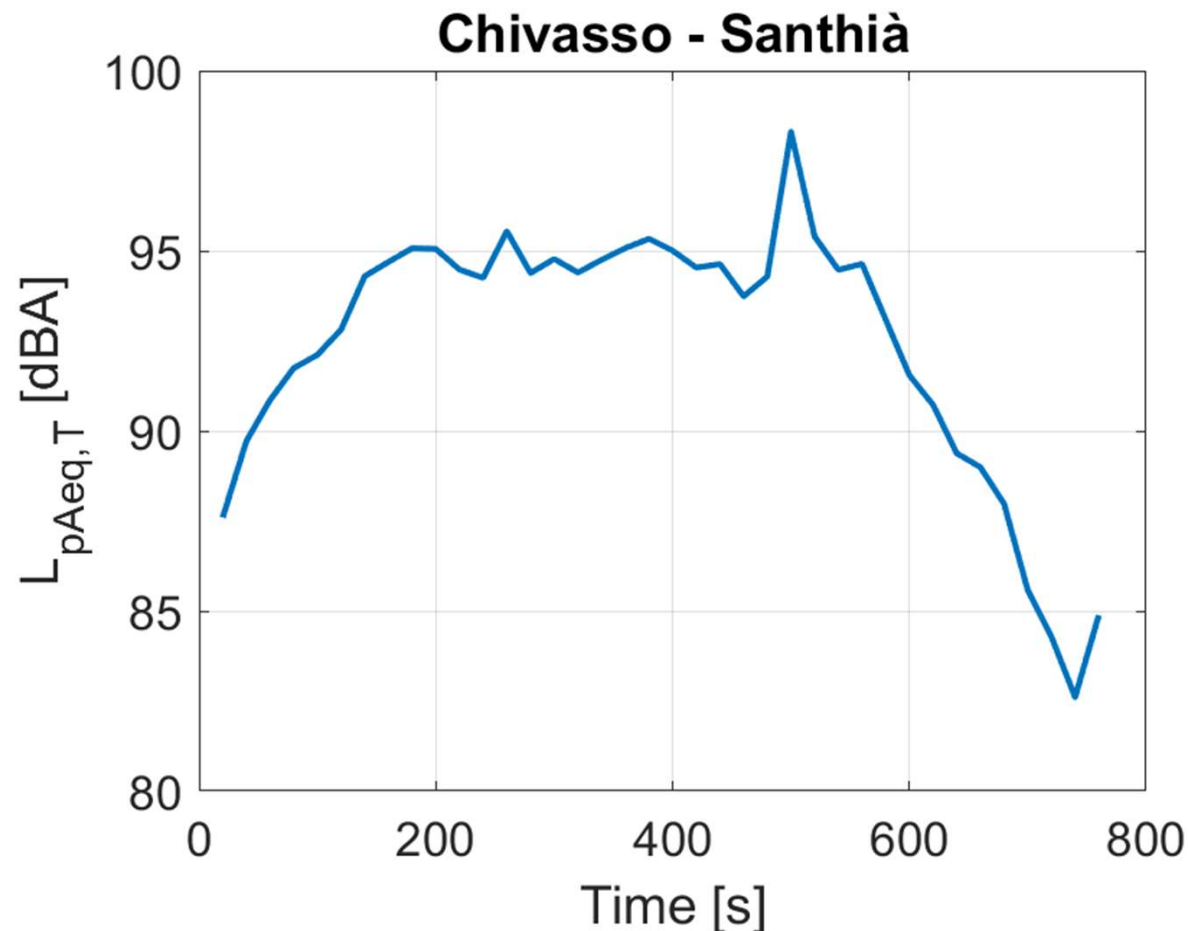
File	Initial station	Final station
Test 1	Chivasso	Santhià
Test 2	Santhià	Vercelli
Test 3	Vercelli	Novara
Test 4	Novara	Magenta
Test 5	Magenta	Rho
Test 6	Rho	Milano Centrale



A sampling frequency of **25600 Hz** was used during the data acquisition. The raw data are provided in **Pa**.

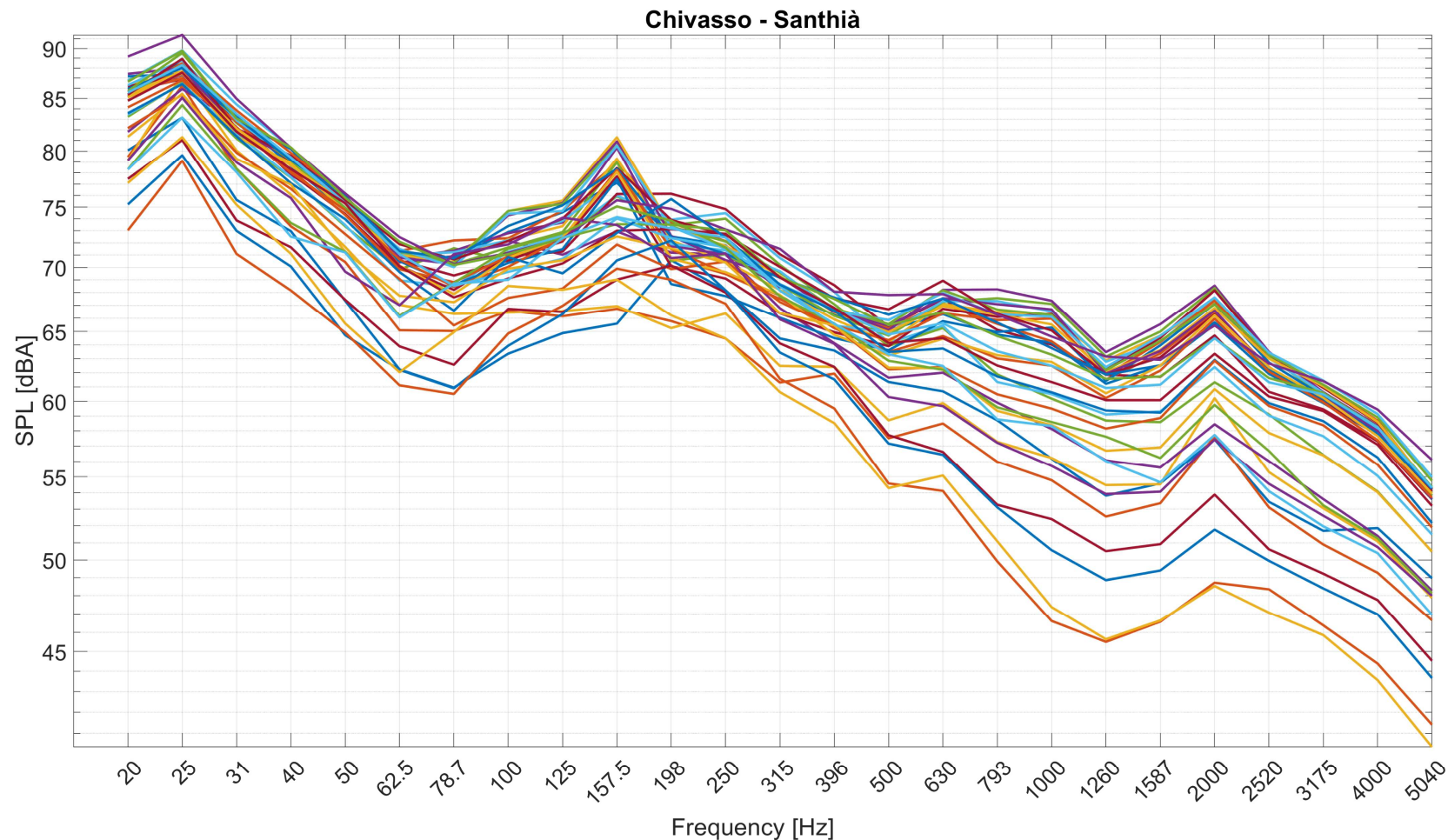
Post-process, equivalent continuous sound pressure level

The measurements can be processed taking inspiration from BS EN 3381:2005 standard. The A-weighted equivalent continuous sound pressure level $L_{pAeq,T}$ can be calculated over time windows of 20 s.



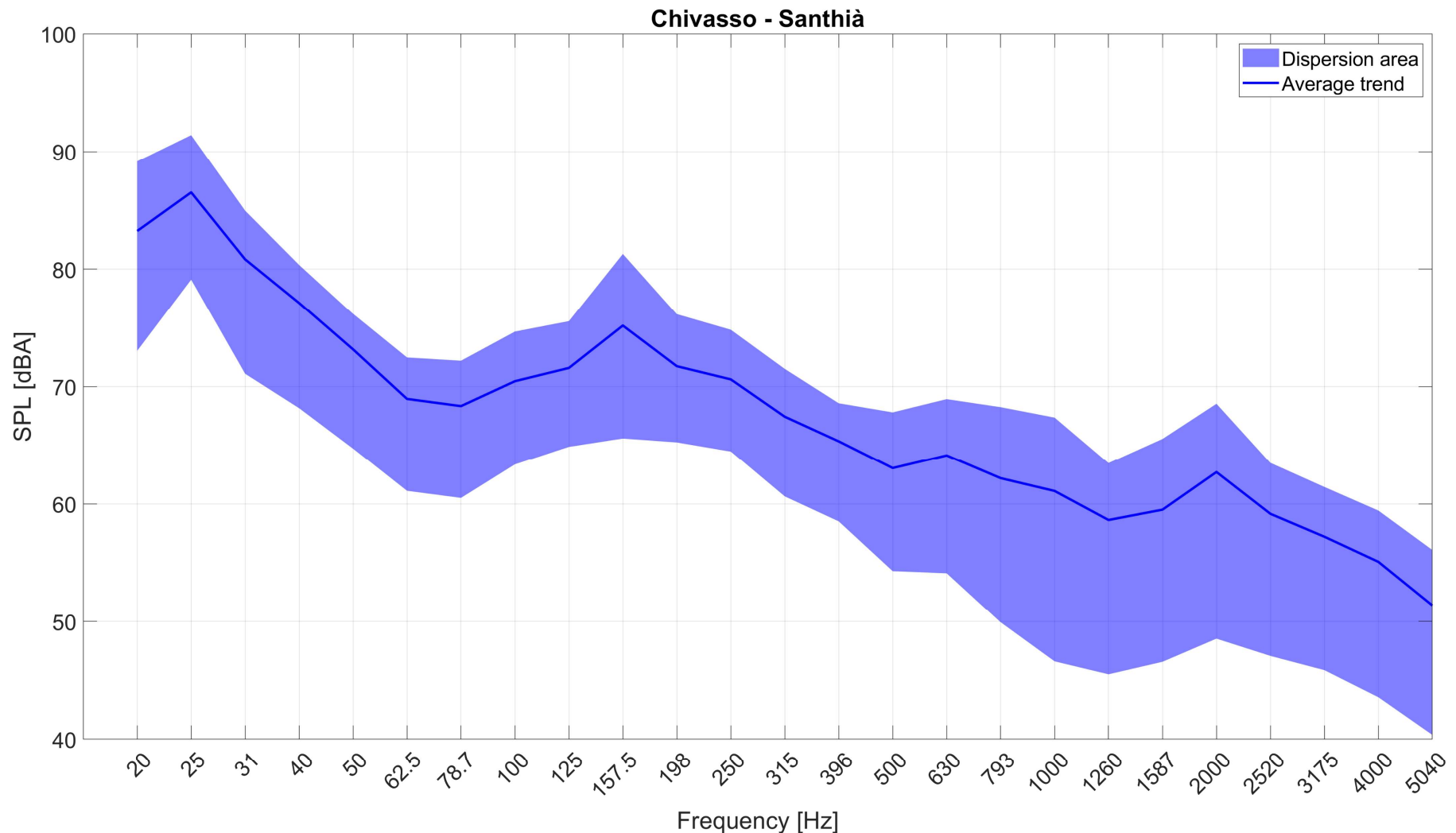
Post-process, equivalent continuous sound pressure level

The distribution of the A-averaged SPL of the different time windows isolated from the main recording can be compared in one-third octave bands.



Post-process, equivalent continuous sound pressure level

Finally, an average A-weighted SPL distribution can be plotted in one-third octave bands together with a distribution area.



Assignment

- Provide graphical representation of the $L_{pAeq,T}$ trends along the different sections of the railroad. Support graphical representations with a table reporting maximum and mean values of the interior noise index for different sections.
- Provide graphical representations of the one-third octave band A-weighted SPL for the different time windows within the same sections.