

Appendix J – Noise and Vibration

J. NOISE AND VIBRATION

This appendix describes the methods used to model the potential noise and vibration effects of the proposed Northern Rail Extension (NRE). Discussion of effects can be found in Chapter 9.

J.1 Wayside Noise Model Methodology

Wayside noise collectively refers to noise generated by railcars and locomotives, but not including locomotive horn noise. The Surface Transportation Board Section of Environmental Analysis (SEA) used noise measurements from past noise studies including the Final Environmental Impact Statement for the Conrail Acquisition and the Draft Environmental Assessment for the Canadian National/Illinois Central Acquisition Environmental Assessment to provide the basis for the wayside noise level projections.

The basic equation used for the wayside noise model is:

- $SEL_{cars} = L_{eqref} + 10\log(T_{passby}) + 30\log(S/S_{ref})$

For locomotives, which can be modeled as moving monopole point sources, the corresponding equation is as follows:

- $SEL_{locos} = SEL_{ref} + 10\log(N_{locos}) - 10\log(S/S_{ref})$

The total train sound exposure level is computed by logarithmically adding SEL_{locos} and SEL_{cars}

- $DNL_{100'} = SEL + 10\log(N_d + 10*N_n) - 49.4$
- $DNL = DNL_{100'} + 15\log(100/D)$

The parameters that apply to the equations above are:

- SEL_{cars} = Sound Exposure Level of railcars
- L_{eqref} = Level Equivalent of railcar
- T_{passby} = Train passby time, in seconds
- S = Train speed, in miles per hour
- S_{ref} = Reference train speed
- SEL_{locos} = Sound Exposure Level of locomotive
- SEL_{ref} = Reference Sound Exposure Level of locomotive
- DNL = Day-night average noise level
- N_{locos} = Number of locomotives
- N_d = Number of trains during daytime
- N_n = Number of trains during nighttime
- D = Distance from tracks, in feet

Table J-1 shows the reference wayside noise levels used in this study and Figure J-1 shows the wayside noise frequency spectrum used in the calculations.

Description	Average Level (dBA)
Locomotive SEL (40 miles per hour at 100 feet) ^a	95
Railcar L_{eq} ^b	82

Notes: dBA = A-weighted decibels; L_{eq} = level equivalent; SEL = Sound Exposure Level.
^a STB, 1998a.
^b STB, 1998b.

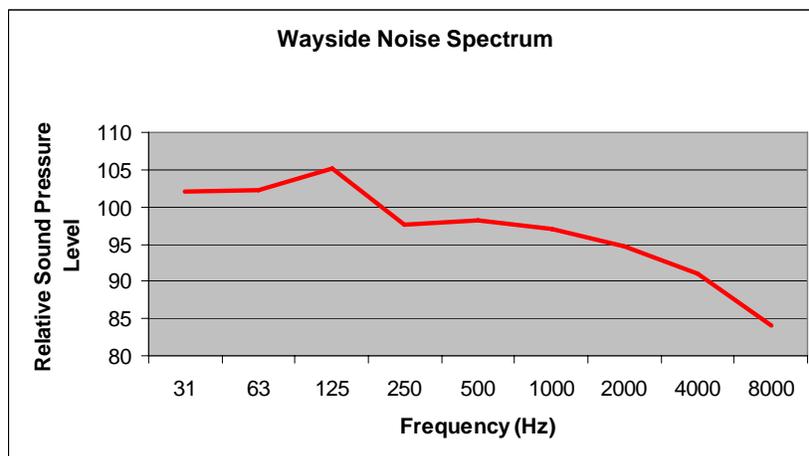


Figure J-1 – Wayside Noise Spectrum

J.2 Horn Noise Model Methodology

Freight train horn noise levels can vary for a variety of reasons, including the manner in which an engineer sounds the horn. Consequently, it is important to base horn noise reference levels on a large sample size. A substantial amount of horn noise data is available from the Draft Environmental Impact Statement, Proposed Rule for the Use of Locomotive Horns at Highway-Rail Grade Crossings (Federal Railroad Administration [FRA] 1999), hereinafter referred to as the 1999 FRA Draft EIS.

FRA data indicate that horn noise levels increase from the point at which the horn is sounded 0.25 mile (0.40 kilometer) from the grade crossing to when it stops sounding at the grade crossing. In the first 0.125-mile (0.201-kilometer) segment, the energy average sound exposure level measured at a distance of 100 feet (30 meters) from the tracks was found to be 107 dBA, and in the second 0.125-mile segment it was 110 dBA. The 1999 FRA Draft EIS simplified the horn noise contour shape as a five-sided polygon, when it is actually a teardrop shape. The Final Environmental Impact Statement, Construction and Operation of a Rail Line from the Bayport Loop in Harris County, Texas (STB, 2003) discusses this subject in detail. SEA used the more accurate teardrop horn noise contour shape for this analysis. The attenuation, or drop-off rate, of horn noise is assumed to be 4.5 dBA per doubling of distance away from the tracks (FRA, 1999).

Table J-2 shows the reference horn noise levels used in this study and Figure J-2 shows the horn noise spectrum used in the calculations.

**Table J-2
Reference Horn Noise Levels**

Description	Average Level (dBA)
Horn SEL 1st 0.25 mile ^{a,b}	110
Horn SEL 2nd 0.25 mile ^{a,b}	107

Notes: dBA = A-weighted decibels; SEL = Sound Exposure Level.
^a To convert kilometers to miles, multiply by 1.6093.
^b FRA, 1999.

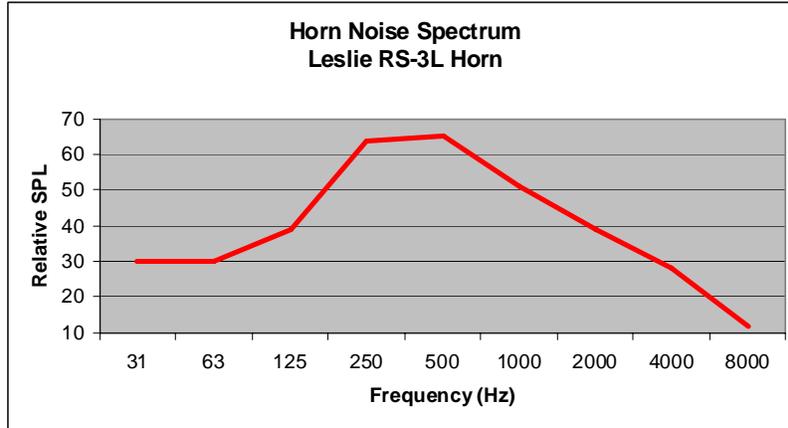


Figure J-2 – Horn Noise Spectrum

J.3 Construction Noise Methodology

SEA based the construction noise impact assessment on Federal Transit Administration (FTA) methods Transit Noise and Vibration Impact Assessment, General Assessment, construction noise guidelines (FTA, 2006), shown in Table J-3.

**Table J-3
FTA General Assessment Construction Noise Guidelines**

Land Use	1-hour L _{eq} (dBA)	
	Day	Night
Residential	90	80
Commercial	100	100
Industrial	100	100

Note: dBA = A-weighted decibels

The FTA General Assessment for construction noise is used when details of the construction schedule are not known. The method calls for estimating combined noise levels from the two noisiest pieces of construction equipment and determining locations that would exceed the noise guidelines in Table J-3.

J.4 Rail Operations Vibration Methodology

SEA based the vibration methodology on FTA methods (FTA, 2006). Vibration level due to train passbys is approximately proportional to

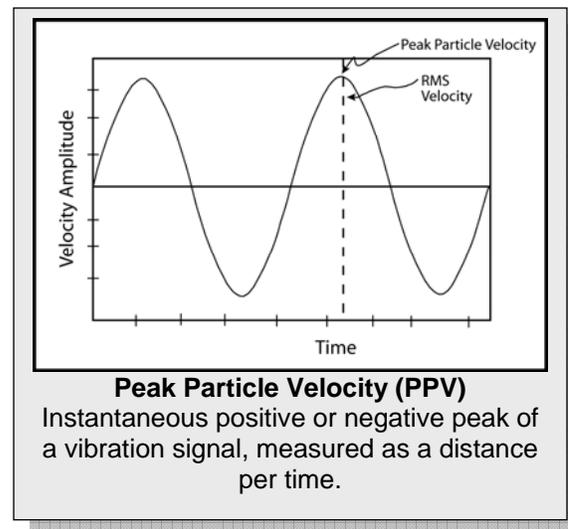
$$V = 20 \times \log (\text{speed}/\text{speed}_{\text{ref}})$$

Where

- V is the ground-borne vibration velocity.
- speed is the train speed.
- $\text{speed}_{\text{ref}}$ is the reference speed of the train relative to its corresponding vibration level.

Published FTA ground-borne vibration levels are adjusted for train speed by this equation and distance from the rail line to estimate vibration levels at receptor locations.

There are two ground-vibration impacts of general concern: annoyance to humans and damage to buildings. In special cases, activities that are highly sensitive to vibration, such as micro-electronics fabrication facilities, are evaluated separately. There are two measurements corresponding to human annoyance and building damage for evaluating ground vibration: peak particle velocity and root-mean-square (RMS) velocity. Peak particle velocity (PPV) is the maximum instantaneous positive or negative peak of the vibration signal, measured as a distance per time (such as millimeters or inches per second). This measurement has been used historically to evaluate shock-wave type vibrations from actions like blasting, pile driving, and mining activities, and their relationship to building damage. The root-mean-square velocity is an average or smoothed vibration amplitude, commonly measured over 1-second intervals. It is expressed on a log scale in decibels (VdB) referenced to 0.000001×10^{-6} inch per second and is not to be confused with noise decibels. It is more suitable for addressing human annoyance and characterizing background vibration conditions because it better represents the response time of humans to ground vibration signals.



J.5 Rail Construction Vibration Methodology

Construction vibration levels are estimated according to the following equation:

$$\text{PPV}_{\text{equipment}} = \text{PPV}_{\text{ref}} \times (25/D)^{1.5}$$

Where

- $\text{PPV}_{\text{equipment}}$ is the peak particle velocity in inches per second of the equipment, adjusted for distance.
- PPV_{ref} is the reference vibration level in inches per second at 25 feet.

- D is the distance from the equipment to the receptor.

Estimated construction vibration levels are then compared with building damage criterion.

References

Federal Rail Administration (FRA). 1999. Draft Environmental Impact Statement, Proposed Rule for the Use of Locomotive Horns at Highway-Rail Grade Crossings.

Federal Transit Administration (FTA). 2006. Transit Noise and Vibration Assessment. FTA-VA-90-1003-06 May 2006.

Surface Transportation Board (STB). 2003. Final Environmental Impact Statement, Construction and Operation of a Rail Line from the Bayport Loop in Harris County, Tx. May, 2003.

Surface Transportation Board (STB). 1998a. Final Environmental Impact Statement No. 980194, Conrail Acquisition (Finance Docket No. 33388) by CSX Corporation and CSX Transportation Inc., and Norfolk Southern Corporation and Norfolk Southern Railway Company (NS). July, 1998.

Surface Transportation Board (STB). 1998b. Draft Environmental Assessment Canadian National/Illinois Central Railroad Acquisition. December, 1998.