Appendix F

Noise and Vibration

1.1 Wayside Noise Model Methods

Wayside noise collectively refers to noise generated by railcars and locomotives (i.e., without including horn noise). The joint lead agencies used noise measurements from past noise studies (Surface Transportation Board 1998a, 1998b) as a basis for the wayside noise level projections.

The basic equations used for the wayside noise model are:

- SELcars = Leqref + 10log(Tpassby) +30log(S/Sref)

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

- SELlocos = SELref + 10log(Nlocos) – 10log(S/Sref)

The total train sound exposure level is computed by logarithmically adding SELlocos and SELcars

- DNL100' = SEL + 10log(Nd +10*Nn) –49.4
- DNL = DNL100' + 15log(100/D)

The parameters that apply to these equations are:

- SELcars = Sound exposure level of rail cars
- Leqref = Level equivalent of rail car
- Tpassby = Train passby time, in seconds
- S = Train speed, in miles per hour
- Sref = Reference train speed
- SELlocos = Sound exposure level of locomotive
- SELref = Reference sound exposure level of locomotive
- Nlocos = Number of locomotives
- Nd = Number of trains during daytime
- Nn = Number of trains during nighttime
- D = Distance from tracks, in feet

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

Table C-1. Reference Wayside Noise Levels

Description	Average Level (dBA)
Locomotive SEL (40 mph at 100 feet)[a,b]	95
Rail car L_{eq}[c]	82

[a] To convert kilometers to miles, multiply by 1.6093.
[b] Surface Transportation Board 1998b
[c] Surface Transportation Board CNIC 1998
dBA=A-weighted decibels; L_{eq}=level equivalent; and SEL=sound exposure level

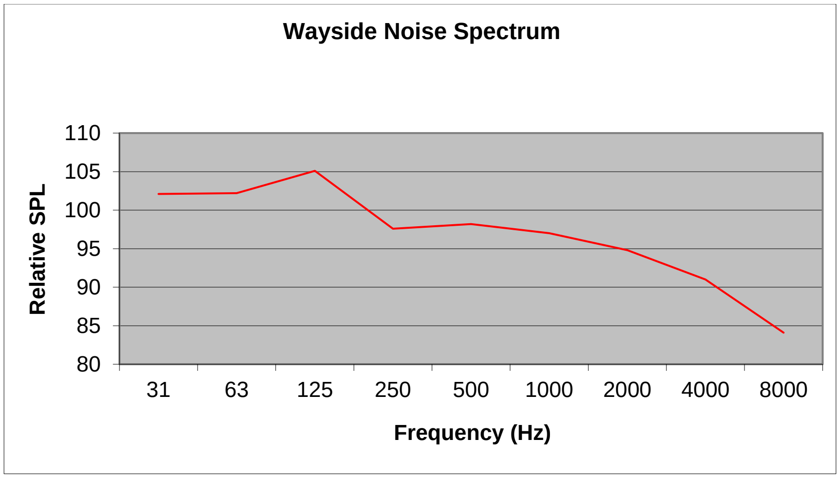


Figure C-1. Wayside Noise Spectrum

1.2 Horn Noise Model Methods

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 1999), hereafter 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 0.40 kilometer (0.25 mile) from the grade crossing to when it stops sounding at the grade crossing. In the first 0.201 kilometer (0.125 mile) segment, the energy average sound exposure level measured at a distance of 30 meters (100 feet) from the tracks was found to be 107 A-weighted decibels (dbA) and 110 dBA in the second 0.201 kilometer (0.125 mile) segment. A simplified geographic information system (GIS)-based buffer was used to perform the horn noise contour analysis.

Table C-2 shows the reference horn noise levels used in this study.

Table C-2. Reference Horn Noise Levels

Description	Average Level (dBA)
Horn SEL 1st 0.25 mile[a]	110
Horn SEL 2nd 0.25 mile[a]	107

Source: FRA 1999
[a] To convert kilometers to miles, multiply by 1.6093.
dBA=A-weighted decibels; Leq=level equivalent; and SEL=sound exposure level

1.3 Vibration Methods

1.3.1 Rail Operations

The joint lead agencies based the vibration methods on Federal Transit Administration (FTA) methods (Federal Transit Administration 2006). Vibration level due to train passbys is approximately proportional to

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

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.

Two ground-vibration impacts are 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. Two measurements correspond to human annoyance and building damage for evaluating ground vibration: peak particle velocity and root-mean square 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 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 x 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.

1.3.2 Rail Construction

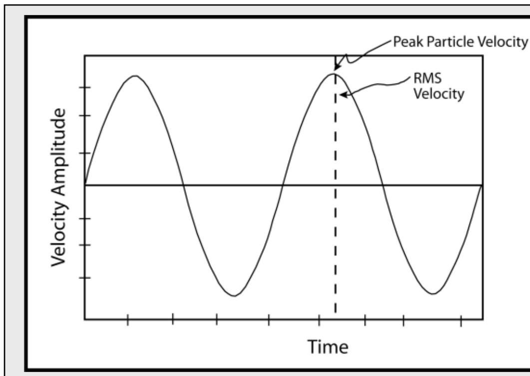
The joint lead agencies based the construction noise impact assessment on FTA methods (2006) General Assessment construction noise guidelines, shown in Table C-3.

Table C-3. FTA General Assessment Construction Noise Guidelines

	1-hour Leq (dBA)	
Land Use	**Day**	**Night**
Residential	90	80
Commercial	100	100
Industrial	100	100

dBA=A-weighted decibels; Leq=level equivalent;

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 which would exceed the noise guidelines in Table C-3.



Peak Particle Velocity (PPV) instantaneous positive or negative peak of a vibration signal, measured as a distance per time.

Root-mean-square velocity (VdB) is a measure of ground vibration in decibels used to compare vibration from various sources.

Construction vibration levels are estimated according to the following equation:

$$PPV_{equipment} = PPV_{ref} \times (25/D)^{1.5}$$

Where

- $PPV_{equipment}$ 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.

1.4 Glossary

Ambient noise	The sum of all noise (from human and naturally occurring sources) at a specific location over a specific time.
Day-night average sound level	The energy average of ***A-weighted decibel*** sound levels over 24 hours, which includes a 10 decibel adjustment factor for noise between 10 p.m. and 7 a.m. to account for the greater sensitivity of most people to noise during the night. The effect of nighttime adjustment is that one nighttime event, such as a train passing by between 10 p.m. and 7 a.m., is equivalent to 10 similar events during the daytime.
Decibel (dB)	A standard unit for measuring sound pressure levels based on a reference sound pressure of 0.0002 dyne per square centimeter. This is nominally the lowest sound pressure that people can hear.
Decibel, A-weighted (dBA)	A measure of noise level used to compare noise from various sources. A-weighting approximates the frequency response of the human ear.
Hertz (Hz)	A unit of frequency equal to one cycle per second.
Peak particle velocity (PPV)	The maximum instantaneous positive or negative peak of the vibration signal, measured as a distance per unit time (such as millimeters or inches per second). This measurement has been used historically to evaluate shock-wave type vibrations from actions like blasting and mining activities, and their relationship to building damage.
Root-mean-square vibration velocity (VdB)	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 inch per second and is not to be confused with noise ***decibels***.

1.5 References

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

Federal Transit Administration. 2006. *Transit Noise and Vibration Assessment.*

Surface Transportation Board. 1998a. *Final Environmental Impact Statement* No. 980194, Conrail Acquisition (Finance Docket No. 33388) by CSX Corporation and CSX Transportation Inc., and Norfolk

Surface Transportation Board. 1998b. *Draft Environmental Assessment for Canadian National and Illinois Central Acquisition.* Finance Docket No. 33556.