Appendix F

Vibration Analysis

Vibration Analysis - SDMP

PPV (in/sec) = PPV {ref} * (25/D)^1.5
Where PPV = Peak Particle Velocity
{ref} = PPV at the reference distance of 25 feet
D = distance to the receptor

Equipment =	**Bulldozer - Small**		
PPV{ref} =	0.003	in/sec	
D =	50	feet	
PPV at receptor =	***0.001***	***in/sec***	
PPV is 1.7x to 6x larger than RMS velocity			
Assume typical conversion factor of		4	PPV:RMS
Therefore estimated RMS velocity =		***0.000***	***in/sec***
Receptor Lv =		***48***	***VdB***

Source: Section 5 Transit Vibration
Section 6 Vibration Impact Analysis
Section 7 Noise and Vibration during Construction
Transit Noise and Vibration Assessment, September 2018
John A. Volpe National Transportation Systems Center
Prepared For: USDOT Federal Transit Administration

* RMS Velocity in decibels VdB with Vref of 1E-6 in/sec and PPV:RMS of ~4

Criterion

Building Damage	
Type	VdB
Extremely susceptible to vibration damage	90
Non-engineered timber and masonry buildings	94
Engineered concrete and masonry buildings	98
Typical buildings	100
Reinforced concrete, steel, or timber buildings	102

Canmet, Bauer, and Calder, 1977		
Equipment	PPV Threshold, in/sec	Type of Damage
Rigid Mercury Switches	0.5	Trip Out
House	2	Cracked Plaster
Concrete Block	8	Crack in Block
Cased Drill Holes	15	Horizontol Offset
Pumps, Compressors	40	Shaft Misalignment

Human Response Criteria

Level, Lv in VdB	Equivalent Noise Level, dBA		Human Response
	Low Freq (30 Hz)	Mid Freq (60 Hz	
65	25	40	Approximate threshold of perception, low-freq inaudible, but mid-freq excessive for sleeping
75	35	50	Approx. dividing line between barely perceptible and distinctly perceptible. Annoying vibration for most people. Low-freq acceptable for sleeping areas. Mid-freq excessive in most quiet occupied space.
85	45	60	Vibration tolerable only if infrequent number of events/day. Low-freq excessive for sleeping areas; mid-freq excessive even for infrequent events for some activities.

Impact Criteria

Land Use	Lv in VdB		
	Frequent Events (70+/day)	Occasional Events (30-70/day)	Infrequent (<30 events/day)
Category 1: Vibration	65	65	65
Concert Halls	65	65	65
TV Studios	65	65	65
Recording Studios	65	65	65
Category 2: Residences, hotels, sleeping areas	72	75	80
Auditoriums	72	80	80
Theaters	72	80	80
Category 3: Institutional with primarily daytime use only (i.e. schools and churches)	75	78	83

Vibration Source Levels For Construction Equipment

Equipment	PPV at 25 ft (in/sec)	Approximate Lv at 25 feet *
Impact Pile Driver - Upper Range	1.518	112
Impact Pile Driver - Typical	0.644	104
Sonic Pile Driver - Upper Range	0.734	105
Sonic Pile Driver - Typical	0.17	93
Clam Shovel Drop (slurry wall construction)	0.202	94
Hydromill (slurry wall construction) - in Soil	0.008	66
Hydromill (slurry wall construction) - in Rock	0.017	75
Vibratory Roller	0.21	94
Hoe Ram	0.089	87
Bulldozer - Large	0.089	87
Bulldozer - Small	0.003	58
Caisson Drilling	0.089	87
Loaded Trucks	0.076	86
Jackhammer	0.035	79