THE pebble PARTNERSHIP

Pre-Permitting Environmental / Socio-Economic Data Report Series

Report Series K-
Noise

Report K-4
Detailed Introduction to Acoustics
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The Pebble Partnership is providing environmental and socio-economic baseline data collected to inform the development of the Pebble Project to state and federal agencies, project stakeholders and the general public prior to project permitting as part of its commitment to full and open disclosure.

A comprehensive Environmental Baseline Document (EBD) will subsequently be prepared and appended to future project permit applications. The EBD will also be made publicly available when complete.

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Report K –

Detailed Introduction to Acoustics

Sound is defined as any pressure variation that the human ear can detect, from barely perceptible sounds to sound levels that can cause hearing damage. The magnitude of the variations of the air pressure from the static, or normal, air pressure is a measure of the sound level. The number of cyclic pressure variations per second is the frequency of sound. When sounds are unpleasant, unwanted, or disturbingly loud, they often are classified as noise.

Compared with the static air pressure, audible sound-pressure variations range from the threshold of hearing—a very small 20 microPascals (μPa; 20 x 10^{-6} Pascals)—to 100 Pascals (Pa), a level so loud it is referred to as the threshold of pain. Because the ratio between these numbers is more than a million to one, using Pascals to describe sound levels can be awkward. The decibel (dB) measurement is a logarithmic conversion of air-pressure level variations from Pascals to a unit of measure with a more convenient numbering system. This conversion not only allows for a more convenient scale, but is also a more accurate representation of how the human ear reacts to variations in air pressure.

The smallest noise-level change that can be detected by the human ear is approximately 3 dB. A doubling in the static air pressure amounts to a change of 6 dB, and an increase of 10 dB is roughly equivalent to a doubling in the perceived sound level. Under free-field conditions, where there are no reflections or additional attenuation, sound is known to decrease at a rate of 6 dB for each doubling of distance. This is commonly known as the inverse square law. For example, a sound level of 70 dB at a distance of 100 feet would decrease to 64 dB at 200 feet and to 58 dB at 400 feet. The mathematical definition of sound pressure level in dB is provided below:

> The sound pressure level (L_P) in dB is 20 times the log of the ratio of the measured pressure, P, to the static pressure, Po, where Po is 20 μPa:

$$L_P = 20\text{Log}_{10}\left(\frac{p}{p_0}\right) \; dB \quad re \; 20 \; \mu Pa$$

In acoustic measurements where the primary concern is the effect on humans, the sound readings are sometimes compensated by an A-weighted filter. The A-weighted filter accounts for people's limited hearing response in the upper and lower frequency bands. Sound-pressure level measurements made using the A-weighted filter are denoted as dBA. For low-frequency and impulsive noises, such as blasting and helicopters, a C-weighted filter is normally used. The C-weighted filter helps to account for the short time period and low-frequency energy of impulsive noises.

Following are the definitions of additional noise-measurement descriptors:

L_{dn} (day-night average sound level). A 24-hour equivalent continuous level in dBA where 10 dB is added to nighttime (10:00 p.m. to 7:00 a.m.) noise levels.

L_{eq} (equivalent continuous sound level). The constant sound level in dBA that, lasting for a time, T, would have produced the same energy in the same time period T as an actual A-weighted noise event.

$$L_{eq} = 10\mathrm{Log}_{10} \frac{1}{T} \int_0^T \left(\frac{p(t)}{p_o}\right)^2 dt$$

L_{max} (MaxL; maximum A-weighted root-mean square sound level). The greatest root-mean square (RMS) sound level, in dBA, measured during the preset measurement period.

L_{min} (MinL; minimum A-weighted RMS sound level). The lowest RMS sound level, in dBA, measured during the preset measurement period.

L_{PA} (A-weighted sound-pressure level). The sound pressure in dB is 20 times the log of the ratio of the measured A-weighted pressure, P_A, to the static pressure, P_O, where P_O is 20 μPa.

$$L_{PA} = 20\mathrm{Log}_{10} \left(\frac{p_A}{p_0}\right) dBA \quad re\ 20uPa$$

L_{peak} (MaxP; maximum A-weighted sound level). The greatest continuous sound level, in dBA, measured during the preset measurement period.

L_{xx} (statistical noise-level descriptor). The sound level that was equaled or exceeded during XX percent of the measurement period. For example: during a 1-hour measurement, an L_{10} of 65 dBA means the sound level was 65 dBA or more for 6 minutes (10 percent) of that hour.

SEL (sound exposure level). That constant level in dBA that, lasting for 1 second, has the same amount of acoustic energy as a given A-weighted noise event lasting for a period of time T. This measurement is most commonly used for airport noise.

Noise Source or Activity	Sound Level (dBA)	Subjective Impression	Relative Loudness (human judgment of different sound levels)
Jet aircraft takeoff from carrier (50 feet)	140	Threshold of pain	64 times as loud
50-horse power siren (100 feet)	130		32 times as loud
Loud rock concert near stage, Jet takeoff (200 feet)	120	Uncomfortably loud	16 times as loud
Float plane takeoff (100 feet)	110		8 times as loud
Jet takeoff (2,000 feet)	100	Very loud	4 times as loud
Heavy truck or motorcycle (25 feet)	90		2 times as loud
Garbage disposal (2 feet) Pneumatic drill (50 feet)	**80**	**Moderately loud**	**Reference loudness**
Vacuum cleaner (10 feet), Passenger car at 65 mph (25 feet)	70		1/2 as loud
Typical office environment	60		1/4 as loud
Light auto traffic (100 feet)	50	Quiet	1/8 as loud
Bedroom or quiet living room Bird calls	40		1/16 as loud
Quiet library, soft whisper (15 feet)	30	Very quiet	
High quality recording studio	20		
Acoustic Test Chamber	10	Just audible	
	0	Threshold of hearing	

Sources: Beranek (1988) and U.S. EPA (1971).

FIGURE K-6. Typical Noise Sources and Human Subjective Impression