

7.2 FUNDAMENTAL CONCEPTS OF ENVIRONMENTAL NOISE

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This section provides background information to aid in understanding the technical aspects of this report.

Three dimensions of environmental noise are important in determining subjective response. These are:

- a) The intensity or level of the sound;
- b) The frequency spectrum of the sound;
- c) The time-varying character of the sound.

Airborne sound is a rapid fluctuation of air pressure above and below atmospheric pressure. Sound levels are usually measured and expressed in decibels (dB), with 0 dB corresponding roughly to the threshold of hearing.

The "frequency" of a sound refers to the number of complete pressure fluctuations per second in the sound. The unit of measurement is the cycle per second (cps) or hertz (Hz). Most of the sounds which we hear in the environment do not consist of a single frequency, but of a broad band of frequencies, differing in level. The name of the frequency and level content of a sound is its sound spectrum. A sound spectrum for engineering purposes is typically described in terms of octave bands which separate the audible frequency range (for human beings, from about 20 to 20,000 Hz) into ten segments.

Many rating methods have been devised to permit comparisons of sounds having quite different spectra. Surprisingly, the simplest method correlates with human response practically as well as the more complex methods. This method consists of evaluating all of the frequencies of a sound in accordance with a weighting that progressively de-emphasizes the importance of frequency components below 1000 Hz and above 5000 Hz. This frequency weighting reflects the fact that human hearing is less sensitive at low frequencies and at extreme high frequencies relative to the mid-range.

The weighting system described above is called "A"-weighting, and the level so measured is called the "A-weighted sound level" or "A-weighted noise level." The unit of A-weighted sound level is sometimes abbreviated "dBA." In practice, the sound level is conveniently measured using a sound level meter that includes an electrical filter corresponding to the A-weighting characteristic. All U.S. and international standard sound level meters include such a filter. Typical sound levels found in the environment and in industry are shown in Figure A-1.

Although a single sound level value may adequately describe environmental noise at any instant in time, community noise levels vary continuously. Most environmental noise is a conglomeration of distant noise sources which results in a relatively steady background noise having no identifiable source. These distant sources may include traffic, wind in trees, industrial activities, etc. and are relatively constant from moment to moment. As natural forces change or as human activity follows its daily cycle, the sound level may vary slowly from hour to hour. Superimposed on this slowly varying background is a succession of identifiable noisy events of brief duration. These may include nearby activities such as single vehicle passbys, aircraft flyovers, etc. which cause the environmental noise level to vary from instant to instant.

To describe the time-varying character of environmental noise, statistical noise descriptors were developed. "L₁₀" is the A-weighted sound level equaled or exceeded during 10 percent of a stated time period. The L₁₀ is considered a good measure of the maximum sound levels caused by discrete noise events. "L₅₀" is the A-weighted sound level that is equaled or exceeded 50 percent of a stated time period; it represents the median sound level. The "L₉₀" is the A-weighted sound level equaled or exceeded during 90 percent of a stated time period and is used to describe the background noise.

As it is often cumbersome to quantify the noise environment with a set of statistical descriptors, a single number called the average sound level or "L_{eq}" is now widely used. The term "L_{eq}" originated from the concept of a so-called equivalent sound level which contains the same acoustical energy as a varying sound level during the same time period. In simple but accurate technical language, the L_{eq} is the average A-weighted sound level in a stated time period. The L_{eq} is particularly useful in describing the subjective change in an environment where the source of noise remains the same but there is change in the level of activity. Widening roads and/or increasing traffic are examples of this kind of situation.

In determining the daily measure of environmental noise, it is important to account for the different response of people to daytime and nighttime noise. During the nighttime, exterior background noise levels are generally lower than in the daytime; however, most household noise also decreases at night, thus exterior noise intrusions again become noticeable. Further, most people trying to sleep at night are more sensitive to noise.

To account for human sensitivity to nighttime noise levels, a special descriptor was developed. The descriptor is called the CNEL (Community Noise Equivalent Level) which represents the 24-hour average sound level with a penalty for noise occurring at night.

The CNEL computation divides the 24-hour day into three periods: daytime (7:00 am to 7:00 pm); evening (7:00 pm to 10:00 pm); and nighttime (10:00 pm to 7:00 am). The evening sound levels are assigned a 5 dB penalty and the nighttime sound levels are assigned a 10 dB penalty prior to averaging with daytime hourly sound levels.

For highway noise environments, the average noise level during the peak hour traffic volume is approximately equal to the CNEL.

The effects of noise on people can be listed in three general categories:

- a) Subjective effects of annoyance, nuisance, dissatisfaction;
- b) Interference with activities such as speech, sleep, and learning;
- c) Physiological effects such as startle, hearing loss.

The sound levels associated with environmental noise usually produce effects only in the first two categories. Unfortunately, there has never been a completely predictable measure for the subjective effects of noise nor of the corresponding reactions of annoyance and dissatisfaction. This is primarily because of the wide variation in individual thresholds of annoyance and habituation to noise over time.

Thus, an important factor in assessing a person's subjective reaction is to compare the new noise environment to the existing noise environment. In general, the more a new noise exceeds the existing, the less acceptable the new noise will be judged.

With regard to increases in noise level, knowledge of the following relationships will be helpful in understanding the quantitative sections of this report:

- a) Except in carefully controlled laboratory experiments, a change of only 1 dB in sound level cannot be perceived.
- b) Outside of the laboratory, a 3 dB change is considered a just-noticeable difference.
- c) A change in level of at least 5 dB is required before any noticeable change in community response would be expected.
- d) A 10 dB change is subjectively heard as approximately a doubling in loudness, and would almost certainly cause an adverse community response.

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A-WEIGHTED
SOUND PRESSURE LEVEL,
IN DECIBELS

	140	} THRESHOLD OF PAIN
	130	
CIVIL DEFENSE SIREN (100') JET TAKEOFF (200')	120	
RIVETING MACHINE	110	
DIESEL BUS (15')	100	ROCK MUSIC BAND PILEDRIVER (50') AMBULANCE SIREN (100')
BAY AREA RAPID TRANSIT TRAIN PASSBY (10')	90	BOILER ROOM
PNEUMATIC DRILL (50')	80	PRINTING PRESS PLANT
SF MUNI LIGHT-RAIL VEHICLE (35')	70	GARBAGE DISPOSAL IN THE HOME
FREIGHT CARS (100')		INSIDE SPORTS CAR, 50 MPH
VACUUM CLEANER (10')	60	
SPEECH (1')		DATA PROCESSING CENTER
AUTO TRAFFIC NEAR FREEWAY	50	DEPARTMENT STORE
LARGE TRANSFORMER (200')		PRIVATE BUSINESS OFFICE
AVERAGE RESIDENCE	40	LIGHT TRAFFIC (100')
		TYPICAL MINIMUM NIGHTTIME LEVELS--RESIDENTIAL AREAS
SOFT WHISPER (5')	30	
		RECORDING STUDIO
RUSTLING LEAVES	20	
		MOSQUITO (3')
THRESHOLD OF HEARING	10	
	0	

(100') = DISTANCE IN FEET
BETWEEN SOURCE
AND LISTENER

TYPICAL SOUND LEVELS
MEASURED IN THE ENVIRONMENT
AND INDUSTRY

FIGURE A3

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