GE 302 - Industry and the Environment

Chapter V – NOISE POLLUTION

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5.1 Definition

Noise pollution (or environmental noise) is displeasing human-, animal- or machine-produced sound that disrupts the activity or balance of human or animal life.

The unwanted sound is called noise.

5.2 Sound Waves and Properties

Sound is produced by waves traveling in air, and just like waves in the ocean, they have height and, spacing. The height is a measure of the power of the sound, and is known as amplitude or volume. The spacing, peak to peak, is known as frequency or pitch. It is an indicator of how the sound will seem to our ears, from a low rumble to a high squeal.

Sounds are pressure waves reaching our hearing apparatus by the movement of surrounding air molecules.

5.3 Levels and the Decibel

Decibel, dB, it is the unit used to measure the loudness of sound. It is one tenth of a bel (named for A. G. Bell), but the larger unit is rarely used.

Decibel, dB, sound unit : a logarithmic unit of sound intensity; 10 times the logarithm of the ratio of the sound intensity to some reference intensity

given by $dB = 10 \log_{10} (I / I_R)$, where I is measured intensity and I_R is reference intensity.

The loudest sounds that can be tolerated by the human ear are about 120 dB. The level of normal conversation is about 50 to 60 dB. The decibel is also used to measure certain other quantities, such as power loss in telephone lines.

Noise intensity is measured in decibel units. The decibel scale is logarithmic; each 10-decibel increase represents a tenfold increase in noise intensity. Human perception of loudness also conforms to a logarithmic scale; a 10-decibel increase is perceived as roughly a doubling of loudness. Thus, 30 decibels is 10 times more intense than 20 decibels and sounds twice as loud; 40 decibels is 100 times more intense than 20 and sounds 4 times as loud; 80 decibels is 1 million times more intense than 20 and sounds 64 times as loud. Distance diminishes the effective decibel level reaching the ear. Thus, moderate auto traffic at a distance of 100 ft (30 m) rates about 50 decibels. To a driver with a car window open or a pedestrian on the sidewalk, the same traffic rates about 70 decibels; that is, it sounds 4 times louder. At a distance of 2,000 ft (600 m), the noise of a jet takeoff reaches about 110 decibels—approximately the same as an automobile horn only 3 ft (1 m) away.

Table 1. Sound intensity levels.

Decibel Level (dB)	Source
140	threshold of pain: gunshot, siren at 100 feet
135	jet take off, amplified music
120	chain saw, jack hammer, snowmobile
100	tractor, farm equipment, power saw
90	OSHA limit - hearing damage if excessive exposure to noise levels above 90 dB
85	inside acoustically insulated tractor cab
75	average radio, vacuum cleaner
60	normal conversation
45	rustling leaves, soft music
30	Whisper
15	threshold of hearing
0	acute threshold of hearing - weakest sound

Sound is measured by sound level meter.

The ear of the young, audiometrically healthy, adult male respond to sound waves in the frequency range of 20 to 16,000 Hz. Young children and women often have the capacity to respond to frequencies up 20,000 Hz. The speech zone lies in the range from 2000 to 5000 Hz.

5.4 Human health effects (Environmental effects)

Subjected to 45 decibels of noise, the average person cannot sleep. At 120 decibels the ear registers pain, but hearing damage begins at a much lower level, about 85 decibels. The duration of the exposure is also important. There is evidence that among young Americans hearing sensitivity is decreasing year by year because of exposure to noise, including excessively amplified music. Apart from hearing loss, such noise can cause lack of sleep, irritability, heartburn, indigestion, ulcers, high blood pressure, and possibly heart disease. One burst of noise, as from a passing truck, is known to alter endocrine, neurological, and cardiovascular functions in many individuals; prolonged or frequent exposure to such noise tends to make the physiological disturbances chronic. In addition, noise-induced stress causes severe tension in daily living and contributes to mental illness.

Noise health effects are both health and behavioral in nature. This unwanted sound can damage physiological and psychological health. The effects of noise can be broken into three areas:

- Physiological effects:
  - noise-induced hearing loss (Chronic exposure to noise may cause noise-induced hearing loss)

    - tinnitus
    - aural (hearing related) pain,
    - nausea
    - reduced muscular control.
    - Hypertension
    -
- Psychological effects:
    - noise can startle (frighten)
    - annoy (make angry)
    - sleep disturbances,
    - high stress levels
    - effects negatively the annoyance, sleep interface, performance and acustic privacy, agression
- Interference with communications.

Furthermore, stress and hypertension may cause further health problems. Moreover, tinnitus can lead to forgetfulness, severe depression and at times panic attacks.

Noise also makes species communicate louder, which is called Lombard vocal response.

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5.5 Noise Sources and Noise Control

5.5.1 SOURCES:

Noise pollution, human-made noise harmful to health or welfare. Transportation vehicles are the worst offenders, with aircraft, railroad stock, trucks, buses, automobiles, and motorcycles all producing excessive noise. Construction equipment, e.g., jackhammers and bulldozers, also produce substantial noise pollution.

The source of most outdoor noise worldwide is transportation systems, including motor vehicle noise, aircraft noise and rail noise. Poor urban planning may give rise to noise pollution, since side-by-side industrial and residential buildings can result in noise pollution in the residential area.

Other sources of indoor and outdoor noise pollution are car alarms, emergency service sirens, office equipment, factory machinery, construction work, grounds keeping equipment, barking dogs, appliances, power tools, lighting hum, audio entertainment systems, loudspeakers, and noisy people.

5.5.2 MITIGATION AND CONTROL OF NOISE:

Technology to mitigate or remove noise can be applied as follows:

There are a variety of strategies for mitigating roadway noise including: use of noise barriers, limitation of vehicle speeds, alteration of roadway surface texture, limitation of heavy vehicles, use of traffic controls that smooth vehicle flow to reduce braking and acceleration, and tire design. An important factor in applying these strategies is a computer model for roadway noise, that is capable of addressing local topography, meteorology, traffic operations and hypothetical mitigation. Costs of building-in mitigation can be modest, provided these solutions are sought in the planning stage of a roadway project.

The *sound tube* in Melbourne, Australia, designed to reduce roadway noise without detracting from the area's aesthetics.

Aircraft noise can be reduced to some extent by design of quieter jet engines, which was pursued vigorously in the 1970s and 1980s. This strategy has brought limited but noticeable reduction of urban sound levels. Reconsideration of operations, such as altering flight paths and time of day runway use, has demonstrated benefits for residential populations near airports. FAA sponsored residential retrofit (insulation) programs initiated in the 1970s has also enjoyed success in reducing interior residential noise in thousands of residences across the United States.

Exposure of workers to Industrial noise has been addressed since the 1930s. Changes include redesign of industrial equipment, shock mounting assemblies and physical barriers in the workplace.

There are four basic principles of noise control:

- Sound insulation: prevent the transmission of noise by the introduction of a mass barrier. Common materials have high-density properties such as brick, concrete, metal etc.

- Sound absorption: a porous material which acts as a 'noise sponge' by converting the sound energy into heat within the material. Common sound absorption materials include open cell foams and fiberglass

- Vibration damping: applicable for large vibrating surfaces. The damping mechanism works by extracting the vibration energy from the thin sheet and dissipating it as heat. A common material is sound deadened steel.

- Vibration isolation: prevents transmission of vibration energy from a source to a receiver by introducing a flexible element or a physical break. Common vibration isolators are springs, rubber mounts, cork etc.

5.6 Allowable Noise Levels

The two factors that determine how hazardous noise is are:

- Intensity (Loudness) measured in dBA

- Time of Exposure measured in Hours and Minutes

The louder the noise, the more hazardous it is. Also, the longer the exposure time, the more hazardous the noise is.

A "Noise Dose" combines both loudness and time and is a convenient way of describing the relative hazard of the noise.

Table 2. Permissible noise exposure scale*

Duration - hours per day	Sound level (dBA)
8	90
4	95
2	100
1	105
1/2	110
1/4 or less	115

* Based on OSHA Noise Standard.