# Noise Pollution

# POLLUTION

"Pollution means any contamination of air, soil, water and environment. , Even loud noise and sound is also a part of pollution."

# NOISE

“The word noise comes from the Latin word noxia meaning "injury" or "hurt" .” Noise is an unwanted, unpleasant and annoying sound caused by vibration of the matter.

Vibrations impinge on the ear drum of a human or animal and setup a nervous disturbance, which we call sound. When the effects of sound are undesirable that it may be termed as “Noise”.

Physically there is no distinction between sound and noise. Sound is a sensory perception and the complex pattern of sound waves is labeled as noise, music, speech etc. Noise has become a very important "stress factor" in the environment of man.

# WHAT IS NOISE POLLUTION?

- Sound that is unwanted or disrupts one's quality of life is called as noise. When there is lot of noise in the environment, it is termed as noise pollution.

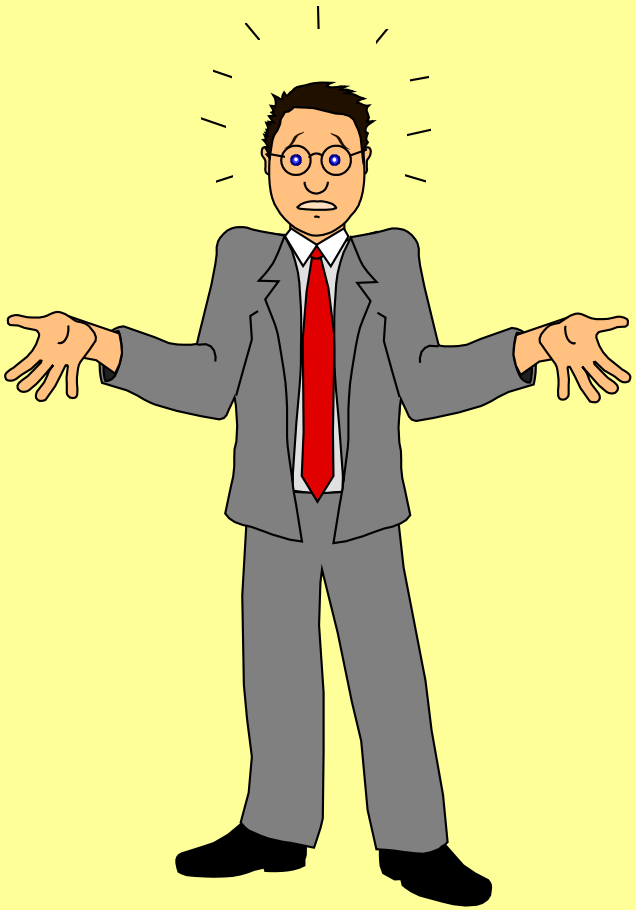
- Sound becomes undesirable when it disturbs the normal activities such as working, sleeping, and during conversations.

- It is an underrated environmental problem because of the fact that we can't see, smell, or taste it.

- World Health Organization stated that "Noise must be recognized as a major threat to human well-being"

# Sources of noise pollution

- Street traffic
- Rail roads
- Airplanes
- Constructions
- Consumer products



# NOISE
## MEASUREMENT & ABATEMENT

# MEASUREMENT OF NOISE

"A decibel is the standard for the measurement of noise"

- 20 db is whisper.
- 40 db the noise in a quiet office.
- 60 db is normal conversation.
- 80 db is the level at which sound

becomes physically painful. And can be termed as noise.

# Noise Pollution

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

" The term "noise pollution" has been recently used to signify the hazard of sounds which are consequence of modern day development, leading to health hazards of different type."

Noise pollution is a type of energy pollution in which distracting, irritating, or damaging sounds are freely audible. Noise pollution contaminants are not physical particles, but rather waves that interfere with naturally-occurring waves of a similar type in the same environment.

In the most narrow sense, sounds are considered noise pollution if they adversely affect wildlife, human activity, or are capable of damaging physical structures on a regular, repeating basis.

# Sources of Noise Pollution

- Road Traffic noise
- Air Craft
- Noise from railroads
- Construction Noise
- Noise in Industry
- Noise in building
- Noise from Consumer products
- Loud Speakers / Public Address Systems
- Firecrackers

# Classification of Noise Pollution

There are 2 kinds of noise pollution.

A.Community Noise/ Environmental Noise (*non industrial noise pollution).*

- Air craft noise
- Roadway noise pollution
- Under water noise pollution

B. Occupational Noise*( industrial noise pollution)*

# COMMUNITY NOISE

Community noise (also called environmental noise, residential noise or domestic noise) is defined as noise emitted from all sources, except at the industrial workplace. Main sources of community noise include road, rail and air traffic, construction and public work, and the neighborhood.

Typical neighborhood noise comes from live or recorded music; from sporting events including motor sports; from playgrounds and car parks; and from domestic animals such as barking dogs.

# Air craft Noise Pollution

Noise from planes flying over residential areas impairs people's ability to work, learn in school and sleep, and consequently also results in lowered property values in affected areas.

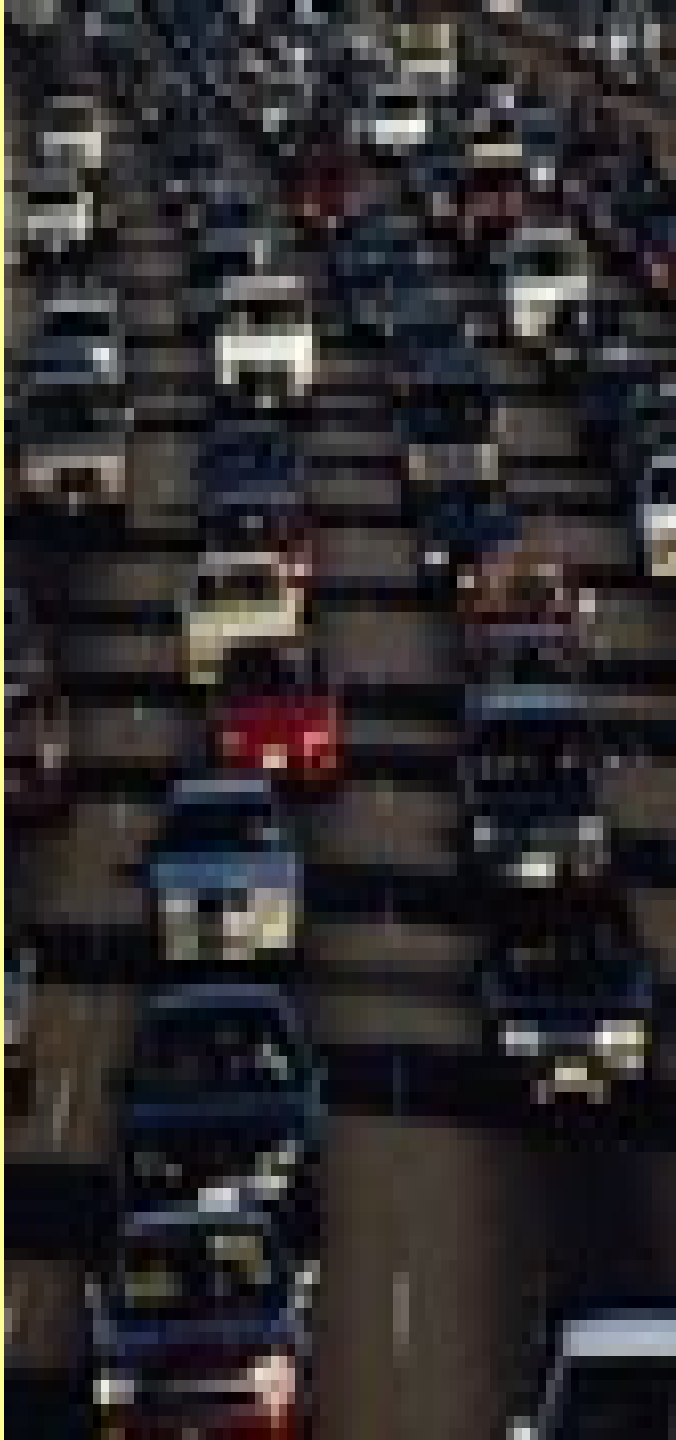
As passenger volume increases and new and larger airports are built, noise is becoming even more of a concern.

# Roadway noise pollution

Roadway noise is the collective sound energy emanating from motor vehicles.

In the USA it contributes more to environmental noise exposure than any other noise source, and is constituted chiefly of engine, tire, aerodynamic and braking elements.

In other Western countries as well as Lesser developed countries, roadway noise is expected to contribute a proportionately large share of the total societal noise pollution.



# Under water noise pollution

UNP is intense human-generated noise in the marine environment. It is caused by use of explosives, oceanographic experiments, geophysical research, underwater construction, ship traffic, intense active sonars and air guns used for seismic surveys for oil and related activities.

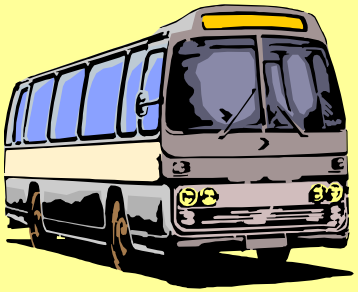
# OCCUPATIONAL NOISE

The many and varied sources of noise is industrial machinery and processes include: rotors, gears, turbulent fluid flow, impact processes, electrical machines, internal combustion engines, pneumatic equipment, drilling, crushing, blasting, pumps and compressors. Furthermore, the emitted sounds are reflected from floors, ceiling and equipment.

Occupational exposure limits specify the maximum sound pressure levels and exposure times to which nearly all workers may be repeatedly exposed without adverse effect on their ability to hear and understand normal speech. An occupational exposure limit of 85 dB for 8 hours should protect most people against a permanent hearing impairment induced by noise after 40 years of occupational exposure.

# ROAD TRAFFIC NOISE

In the city, the main sources of traffic noise are the motors and exhaust system of autos, smaller trucks, buses, and motorcycles.

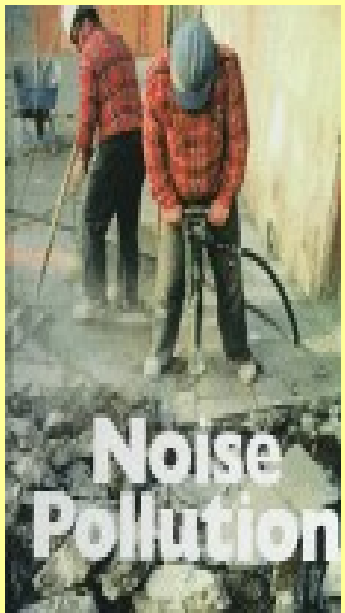


# Air Craft NOISE

Now-a-days , the problem of low flying military aircraft has added a new dimension to community annoyance, as the nation seeks to improve its nap-of the- earth aircraft operations over national parks, and other areas previously unaffected by aircraft noise has claimed national attention over recent years.

# Noise from railroads

rail car retarders can produce a high frequency, high level screech that can reach peak levels of 120 dB at a distance of 100 feet, which translates to levels as high as 138, or 140 dB at the railroad worker's ear.




# Construction Noise

The noise from the construction of highways, city streets, and buildings is a major contributor to the urban scene. Construction noise sources include pneumatic hammers, air compressors, bulldozers, loaders, dump trucks (and their back-up signals), and pavement breakers.

# Noise in building

Apartment dwellers are often annoyed by noise in their homes, especially when the building is not well designed and constructed. In this case, internal building noise from plumbing, boilers, generators, air conditioners, and fans, can be audible and annoying

# Noise from Consumer products

Certain household equipment, such as vacuum cleaners, mixers and some kitchen appliances are noisemakers of the house. Though they do not cause too much of problem, their effect cannot be neglected.

## Loud Speakers

Use of loud speakers / public address systems in functions, meetings, religious places in open areas is a source of serious nuisance.

## Fire crackers

Use of firecrackers with high noise level may harm the human hearing system. Especially sensitive are small children.

# NOISE POLLUTION PROBLEM AND SOLUTIONS

# Problems of Noise Pollution

Noise pollution makes men more irritable. The effect of noise pollution is multifaceted & inter related. The effects of Noise Pollution on Human Being, Animal and property are as follows:

- Hearing Impairment
- It Decreases the Efficiency of A Man
- Lack of concentration
- Abortion is caused
- Pupil Dilation
- Mental Illness
- It Causes Heart Attack
- Digestive problems
- Temporary or permanent Deafness
- Aggressive Behavior
- Effect on Vegetation Poor Quality of Crops
- Effect on Animal
- Effect on Property
- Sleep interference
- Speech interference

# HEARING IMPAIRMENT

Hearing is essential for well-being and safety. Hearing impairment is typically defined as an increase in the threshold of hearing as clinically assessed by audiometry. There is general agreement that exposure to sound levels less than 70 dB does not produce hearing damage, regardless of the duration of exposure. There is also general agreement that exposure for more than 8 hours to sound levels in excess of 85 dB is potentially hazardous; to place this in context, 85 dB is roughly equivalent to the noise of heavy truck traffic on a busy road

The WHO recommends that unprotected exposure to sound levels greater than 100 dB (for example, the sound of a jackhammer or a snowmobile) should be limited in duration (4 h) and frequency (four times/yr).The threshold for pain is usually given as 140 dB, a level readily achieved in today's boom-cars. Impulse noise exposure (gunfire and similar sources of intense noise of brief duration) should never exceed 140 dB in adults and 120 dB in children. Firecrackers, cap pistols, and other toys can generate sufficient sound levels to cause sudden and permanent hearing loss.

Levels greater than 165 dB, even for a few milliseconds, are likely to cause acute cochlear damage. It is important to remember to counsel patients that ears do not get used to loud noise. As the League for the Hard of Hearing notes-they get deaf.

# IT DECREASES THE EFFICIENCY OF A MAN

Regarding the impact of noise on human efficiency there are number of experiments which print out the fact that human efficiency increases with noise reduction. A study by *Sinha & Sinha* in India suggested that reducing industrial booths could improve the quality of their work. Thus human efficiency is related with noise. Noise can adversely affect performance, for example in reading, attentiveness, problem solving and memory.

# LACK OF CONCENTRATION

- For better quality of work there should be concentration, Noise causes lack of concentration. In big cities, mostly all the offices are on main road. The noise of traffic or the loud speakers of different types of horns divert the attention of the people working in offices. Deficits in concentration can lead to accidents.

# FATIGUE

Because of Noise Pollution, people cannot concentrate on their work. Thus they have to give their more time for completing the work and they feel tiring

# ABORTION

There should be cool and calm atmosphere during the pregnancy. Unpleasant sounds make a lady of irriative nature. Sudden Noise causes abortion in females.

# PUPIL DILATION

Noise Pollution causes dilation of the pupil of the eye

# IT CAUSES MENTAL ILLNESS

- Noise Pollution causes certain diseases in human. It attacks on the person's peace of mind. The noises are recognized as major contributing factors in accelerating the already existing tensions of modern living. These tensions result in certain disease like blood pressure or mental illness etc..

- Noise pollution may cause or contribute to the following adverse effects: anxiety, stress, nervousness, nausea, headache, emotional instability, argumentativeness, sexual impotence, changes in mood, increase in social conflicts, neurosis, hysteria, and psychosis.

# It Causes Heart Attack

Noise Pollution causes Increase in the rate of heart-beat, increased cholesterol level and Constriction of blood vessels which leads to blood pressure that resulted in heart attack.

Noise can trigger both endocrine and autonomic nervous system responses that affect the cardiovascular system and thus may be a risk factor for cardiovascular. high levels of stress hormones such as cortisol, adrenaline, and noradrenalin can lead to hypertension, stroke, heart failure, and immune problems.

Acute exposure to noise activates nervous and hormonal responses, leading to temporary increases in blood pressure, heart rate, and vasoconstriction.

# Digestive problems

Noise Pollution causes digestive spasms and stomach disorders

## Temporary or permanent Deafness

The effect of nose on audition is well recognized. Mechanics, locomotive drivers, telephone operators etc. All have their hearing Impairment as a result of noise at the place of work. Physicist, physicians & psychologists are of the view that continued exposure to noise level above. 80 to 100 db is unsafe, loud noise causes temporary or permanent deafness.

## Aggressive Behavior

Noise above 80 dB may increase aggressive behavior. Annoyance is defined as a feeling of displeasure associated with any agent or condition believed by an individual to adversely affect him or her.

# EFFECT ON VEGETATION,POOR QUALITY OF CROPS

Now is well known to all that plants are similar to human being. They are also as sensitive as man. There should be cool & peaceful environment for their better growth. Noise pollution causes poor quality of crops in a pleasant atmosphere.

# EFFECT ON ANIMAL

Noise pollution damages the nervous system of animal. Animal looses the control of its mind. They become dangerous

Noise can have a detrimental effect on animals by causing stress, increasing risk of mortality by changing the delicate balance in predator/prey detection and avoidance, and by interfering with their use of sounds in communication especially in relation to reproduction and in navigation.

Noise also makes species communicate louder, which is called Lombard vocal response. Scientists and researchers have conducted experiments that show whales' song length is longer when submarine-detectors are on.

# EFFECT ON BEACHED WHALE

One of the best known damage caused by noise pollution is the death of certain species of beached whales, brought on by the loud sound of military sonar.

# EUROPEAN ROBINS

- European **Robins** living in urban environments are more likely to sing at night in places with high levels of noise pollution during the day, suggesting that they sing at night because it is quieter, and their message can propagate through the environment more clearly.

# Effect on Property

Loud noise is very dangerous to buildings, bridges and monuments. It creates waves which struck the walls and put the building in danger condition.

# Sleep Interference

Very high levels of noise can wake people from their sleep with a jerk and keep them awake or disturb their sleep pattern. This could make them irritable and tired the next day. Arousal associated with night time noise exposure increased blood and saliva concentrations of these hormones such as cortisol, adrenaline, and noradrenalin even during sleep. It is known, for example, that continuous noise in excess of 30 dB disturbs sleep.

# Speech interference

- Noise more than 50dB can be very difficult to hear and interpret and cause problems such as partial deafness. Some effects may lead to increased accidents, disruption of communication in the classroom, and impaired academic performance.

# Noise Mitigation

"**Noise mitigation** is a set of strategies to reduce noise pollution."

- Construction of sound proof rooms for noisy machines in industries.
- Use of horns with jarring sounds to be banned. No motor vehicle should be fitted with multitioned horn giving a succession of different note or with any other sound producing device giving an unduly harsh, shrill , loud or alarming noise on other similar vehicles of such sound signals.
- Every motor vehicle shall be fitted with a device (silencer).
- Noise producing industries, aerodromes, and railway stations to be shifted away from the inhabited areas.
- Proper law should be enforced to check the misuse of loudspeakers and public announcements systems. Loud speakers are banned from 10pm to 6am.
- Growing green plants/trees along roadside to reduce noise pollution as they absorb sound.

- To avoid noise-induced hearing loss, pay attention to the noises around you and turn down the volume whenever possible.
- Avoid or limit time spent in noisy sports events.
- Wear adequate hearing protection, such as foam ear plugs or ear muffs, when you must be in a noisy environment or when using loud equipment.
- We must constantly check up on the appliances we use at home. Most of them have rubber insulations that act for soundproofing. But over time, this insulation may wear out, and that is when the noise pollution will begin. Keep track of which appliances need maintenance, and replace insulations if needed
- Noise is also made by the escape of exhaust gases from the engine, therefore every motor vehicle should be so constructed and maintained as not to cause undue noise when in motion.
- Before buying a home, see how far it is from the local airport.

# Level of tolerance

- Normal level of tolerance is 80dbA.
- Sound level below and above this is considered to be as noise pollution.

# Effects of noise pollution

- There are about 25000 hair cells in our ear which create wave in our ear, responding to different levels of frequencies.
- With increasing levels of sound the cells get destroyed decreasing our ability to hear the high frequency sound.

# Be cautious from today

- Irreversible hearing loss.
- Blood pressure rise of 5 to 10 mmHg on 8 hrs of exposure to even 70 db of sound level.
- Hearing loss begins at 80- 90 dbA. 140 dbA is painful and 180 dbA can even kill a person.
- Amplified rock music is 120 dbA.
- Most of the electronic vehicles and motors are above 80 dbA level.
- High noise levels may interfere with the natural cycles of animals, including feeding behavior, breeding rituals and migration paths.

# Symptoms of occupational hearing loss

- **Feeling of fullness in the ear.**
- **Sounds may seem muffled.**
- **Cannot hear high frequency sounds.**
- **Ringing in the ears while listening to the high frequency sounds.**
- **Loud noise for a long period of time, or sudden burst of sound can cause occupational hearing loss.**
- **Hearing that does not return after an acute noise injury is called a permanent threshold shift.**

# Actions taken and to be taken

- There are a variety of effective strategies for mitigating adverse sound levels
- use of noise barriers.
- limitation of vehicle speeds
- alteration of roadway surface texture.
- limitation of heavy duty vehicles
- use of traffic controls that smooth vehicle flow to reduce braking and acceleration, innovative tire design and other

# Legistation

- Noise Regulation Rules under the Environment (Protection) Act of 1986.
- Features
- Industrial- 75db
- Commercial- 65 db
- Residential zones- 55 db
- Zones of silence
- No public address system after 10:00 pm and before 06:00 am.

# Health Effects

- **According to the USEPA, there are direct links between noise and health. Also, noise pollution adversely affects the lives of millions of people.**
- **Noise pollution can damage physiological and psychological health.**
- **High blood pressure, stress related illness, sleep disruption, hearing loss, and productivity loss are the problems related to noise pollution.**
- **It can also cause memory loss, severe depression, and panic attacks.**

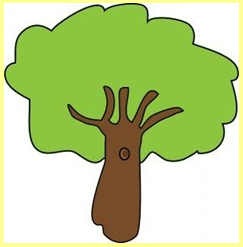
# Sources of Noise Pollution

- Transportation systems are the main source of noise pollution in urban areas.

- Construction of buildings, highways, and streets cause a lot of noise, due to the usage of air compressors, bulldozers, loaders, dump trucks, and pavement breakers.


- Industrial noise also adds to the already unfavorable state of noise pollution.

# Solutions for Noise Pollution



- **Planting bushes and trees in and around sound generating sources is an effective solution for noise pollution.**
- **Regular servicing and tuning of automobiles can effectively reduce the noise pollution.**
- **Buildings can be designed with suitable noise absorbing material for the walls, windows, and ceilings.**
- **Workers should be provided with equipments such as ear plugs and earmuffs for hearing protection.**

# Solutions for Noise Pollution

- Similar to automobiles, lubrication of the machinery and servicing should be done to minimize noise generation.
- Soundproof doors and windows can be installed to block unwanted noise from outside.
- Regulations should be imposed to restrict the usage of play loudspeakers in crowded areas and public places.
- Factories and industries should be located far from the residential areas.

# Solutions for Noise Pollution

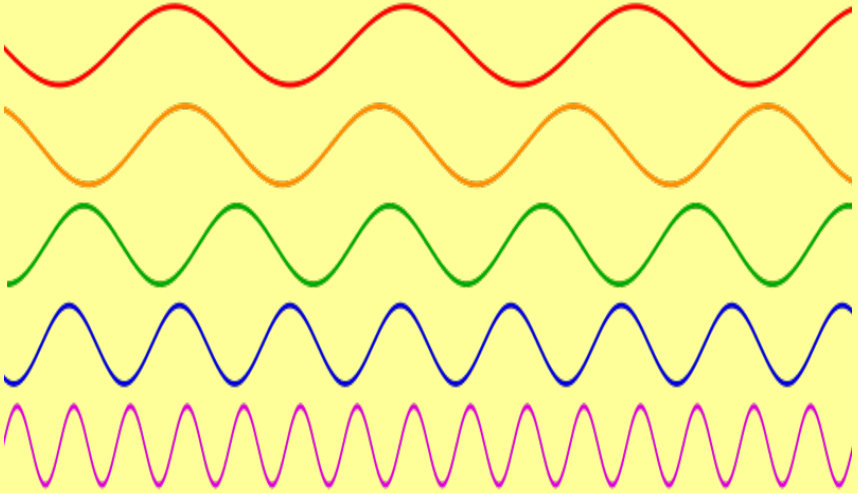
- Community development or urban management should be done with long-term planning, along with an aim to reduce noise pollution.

- Social awareness programs should be taken up to educate the public about the causes and effects of noise pollution.

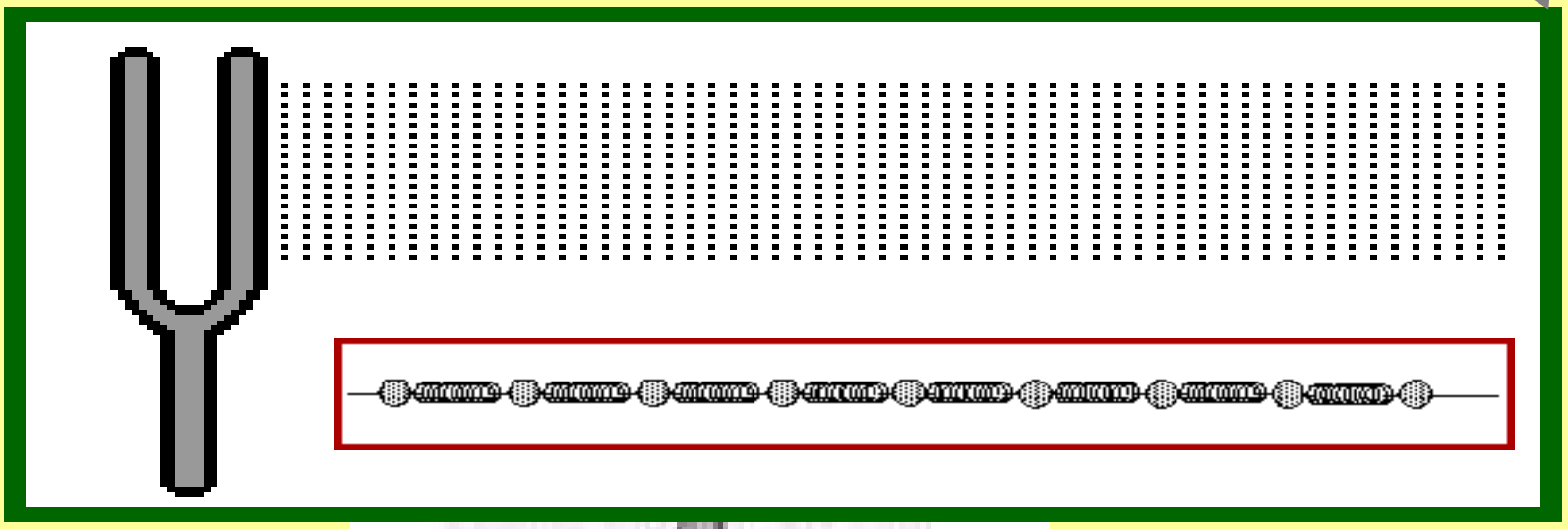
# The nature of sound

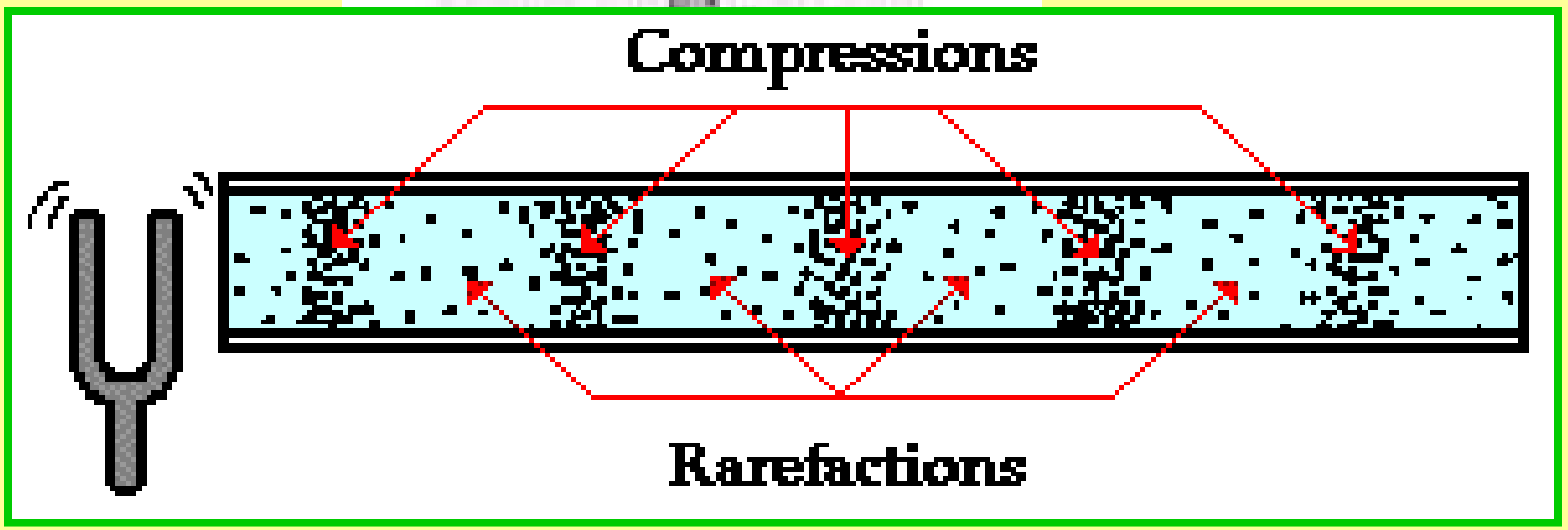
Sound, a manifestation of vibration, travels in wave patterns through solids, liquids and gases.
The waves, caused by vibration of the molecules, follow sine functions, typified by the amplitude and wavelength (or frequency)

Sound waves of equal amplitude with increasing frequency from top to bottom

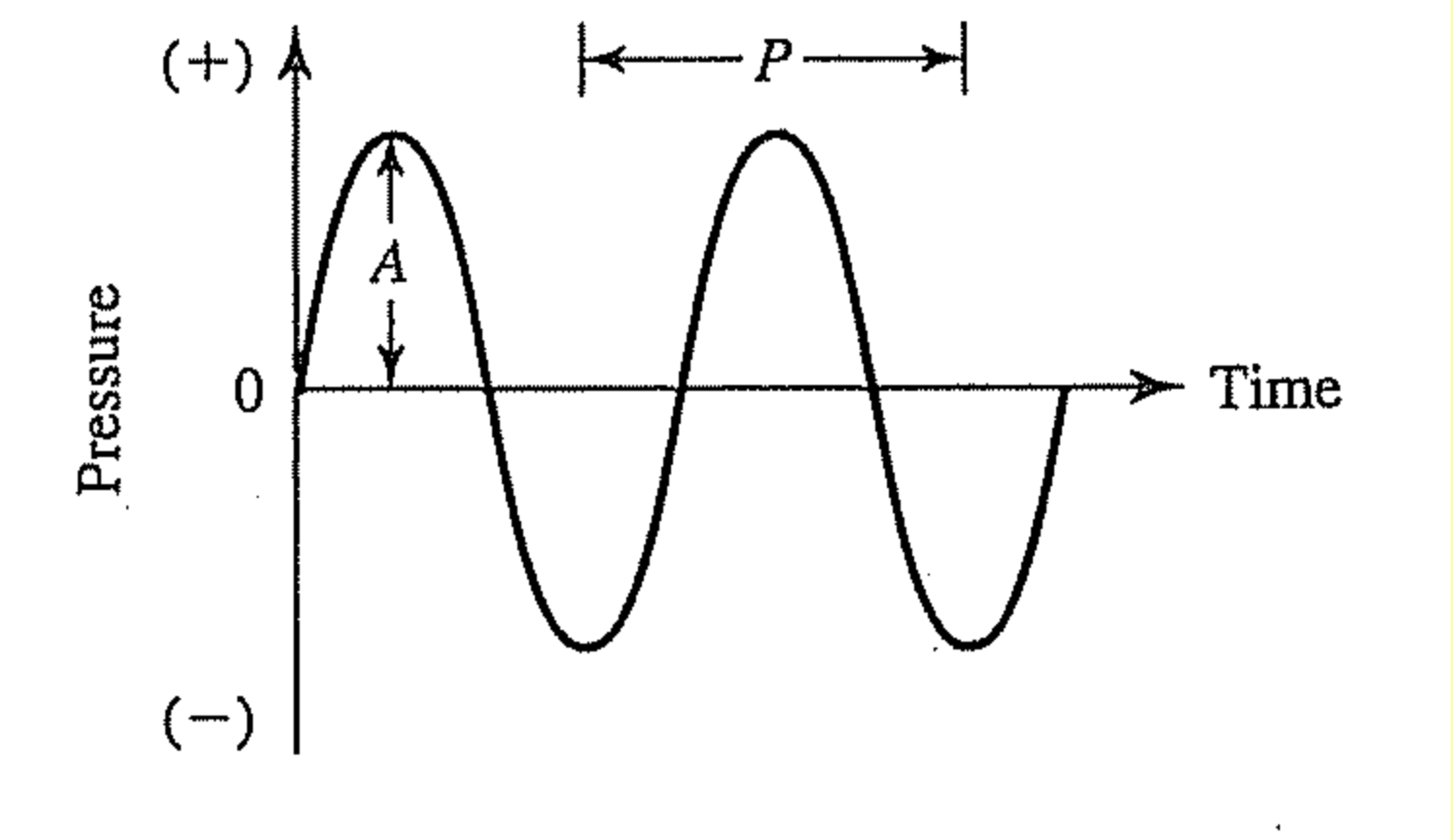


# Sound propagation





# Amplitude and wavelength (period)



# Bels and decibels

### *Levels and the Decibel*

The sound pressure of the faintest sound that a normal healthy individual can hear is about 0.00002 Pa. The sound pressure produced by a Saturn rocket at liftoff is greater than 200 Pa. Even in scientific notation this is an "astronomical" range of numbers.

To cope with this problem, a scale based on the logarithm of the ratios of the measured quantities is used. Measurements on this scale are called levels. The unit for these types of measurement scales is the **bel,** which was named after Alexander Graham Bell:

$$L' = \log \frac{Q}{Q_0} \qquad (15\text{–}7)$$

where $L'$ = level, bels
$Q$ = measured quantity
$Q_0$ = reference quantity
log = logarithm in base 10

A bel turns out to be a rather large unit, so for convenience it is divided into 10 subunits called **decibels** (dB). Levels in decibels are computed as follows:

$$L = 10 \log \frac{Q}{Q_0} \qquad (15\text{–}8)$$

The decibel does not represent any physical unit. It merely indicates that a logarithmic transformation has been performed.

# Sound power and intensity

**Sound Power Level.** If the reference quantity ($Q_0$) is specified, then the decibel takes on physical significance. For noise measurements, the reference power level has been established as $10^{-12}$ W. Thus, sound power level may be expressed as

$$L_w = 10 \log \frac{W}{10^{-12}} \qquad (15\text{–}9)$$

Sound power levels computed with Equation 15–9 are reported as decibels re: $10^{-12}$ W.

**Sound Intensity Level.** For noise measurements, the reference sound intensity (Equation 15–4) is $10^{-12}$ W · m$^{-2}$. Thus the sound intensity level is given as

$$L_I = 10 \log \frac{I}{10^{-12}} \qquad (15\text{–}10)$$

# Sound pressure level

**Sound Pressure Level.** Because sound-measuring instruments measure the $p_{rms}$, the sound pressure level is computed as follows:

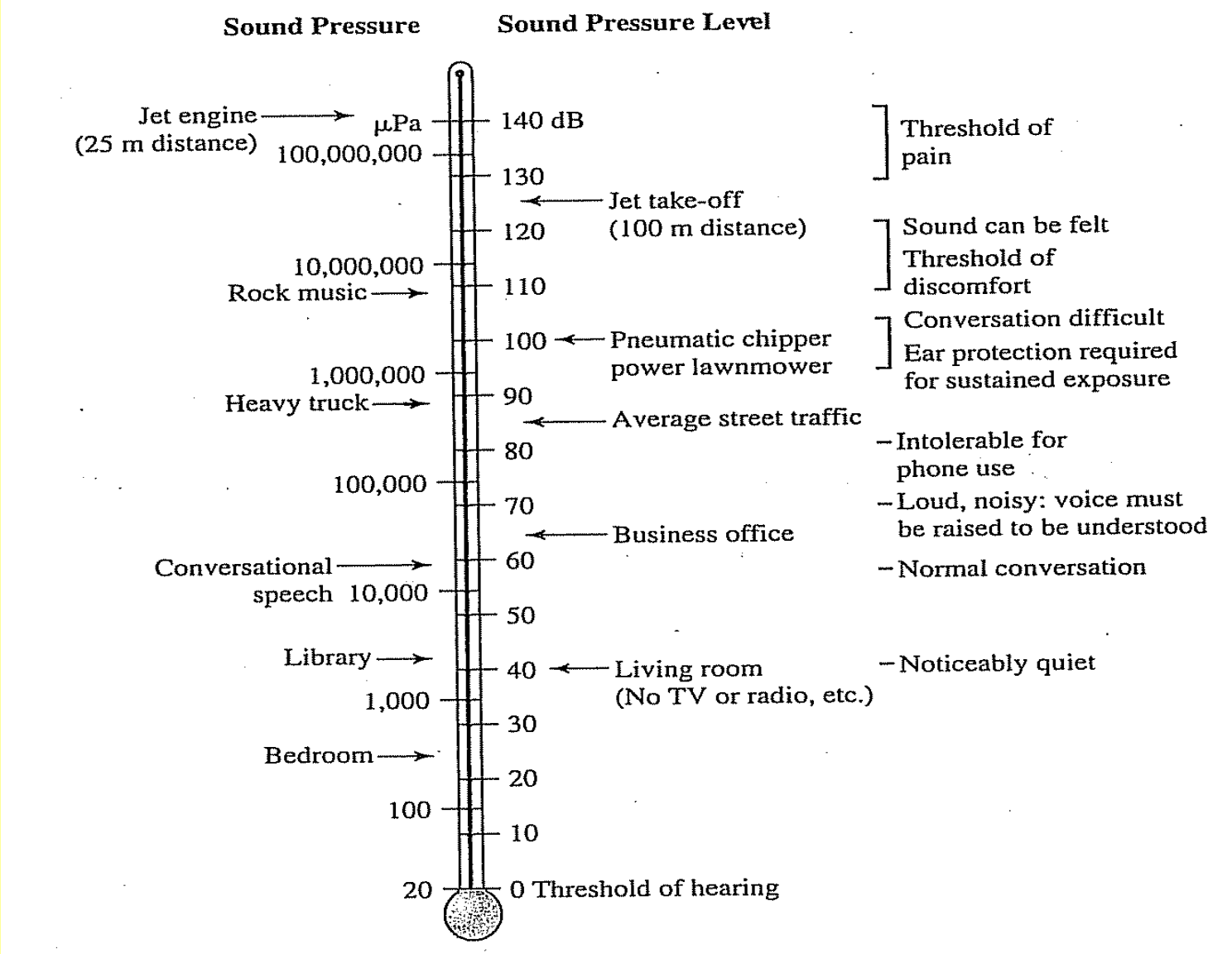
$$L_p = 10 \log \frac{(p_{rms})^2}{(p_{rms})_0^2} \qquad (15\text{–}11)$$

which, after extracting the squaring term, is given as

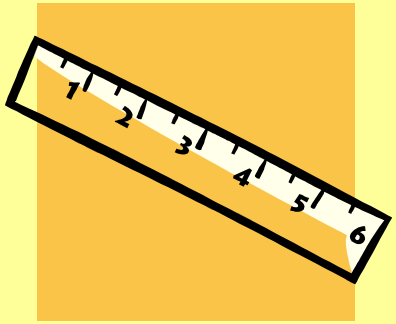
$$L_p = 20 \log \frac{(p_{rms})}{(p_{rms})_0} \qquad (15\text{–}12)$$

The reference pressure has been established as 20 μPa (micropascals). A scale showing some common sound pressure levels is shown in Figure 15–3.

# Sound pressure for known sounds



# How sound is measured




- **Pressure, P, usually Pascals**
- **Frequency, f, usually Hertz**
- **Intensity, I, usually W/m²**
- **Bels, L', derived from logarithmic ratio**
- **Decibels, L, derived from bels**

$P = 1/f$

$I = W/A$

$L' = \log (Q/Qo)$

$L = 10*\log (Q/Qo)$

E.g. Implications of the decibel scale: doubling sound level would mean that the sound will increase by 10*log2 = +3dB
Ten times the sound level = 10*log10 = +10dB

# Exposure to high sound levels

# Reflecting on noise

- “Noise" derived from "nausea," meaning seasickness
- Noise is among the most pervasive pollutants today
- Noise is unavoidable for many machines
- We experience noise in a number of ways

✓environmental
✓cause and victim
✓generated by others “second-hand”

- Noise negatively affects human health and well-being
- The air into which second-hand noise is emitted and on which it travels is a "commons“, a public good

# Noise regulation

Noise regulation includes statutes or guidelines relating to sound transmission established by national, state or provincial and municipal levels of government. After a watershed passage of the U.S. Noise Control Act of 1972[1], the program was abandoned at the federal level, under President Ronald Reagan, in 1981 and the issue was left to local and state governments. Although the UK and Japan enacted national laws in 1960 and 1967 respectively, these laws were not at all comprehensive or fully enforceable as to address (a) generally rising ambient noise (b) enforceable numerical source limits on aircraft and motor vehicles or (c) comprehensive directives to local government.

# Local noise regulation

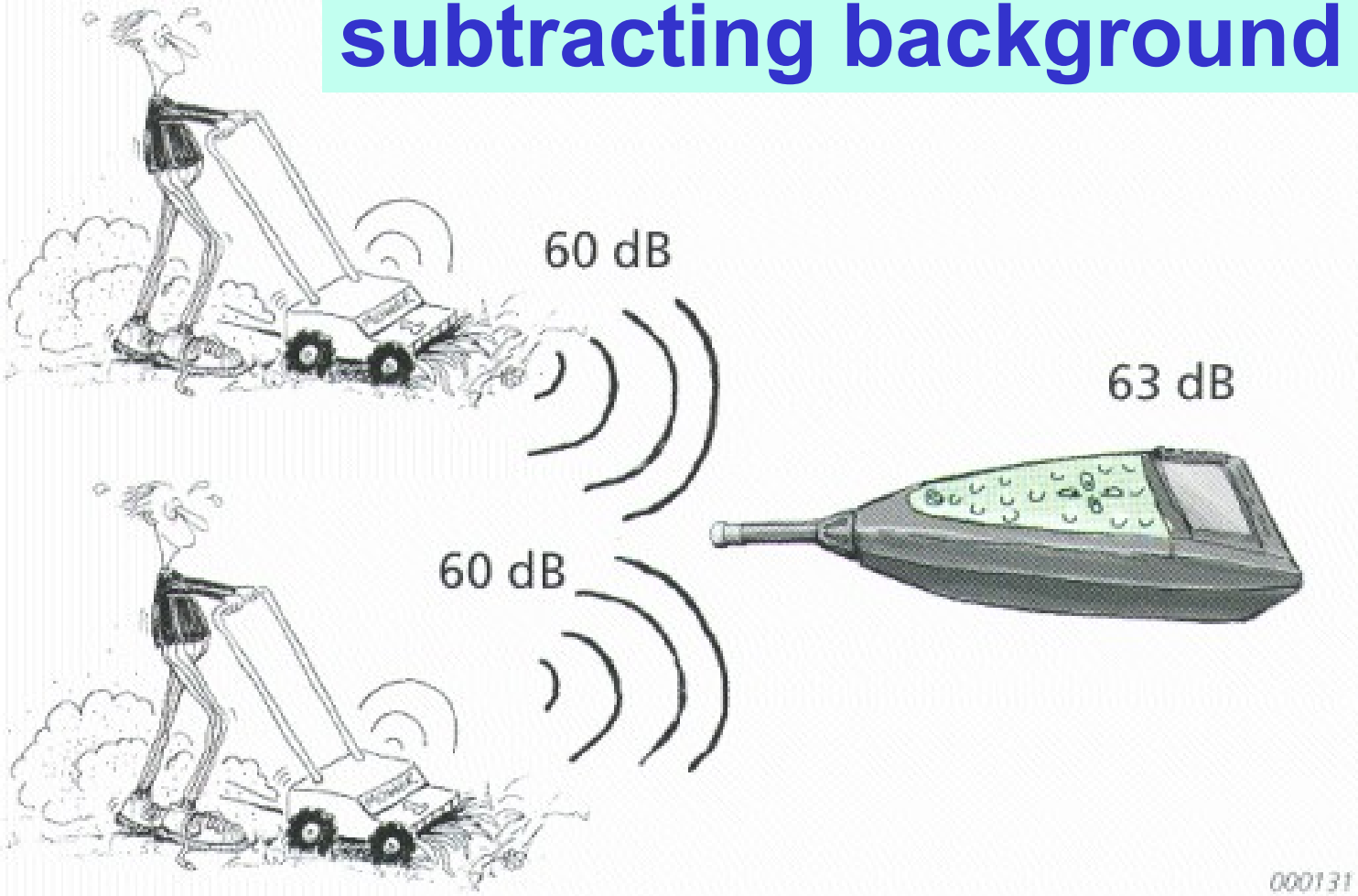
- Dr. Paul Herman wrote the first comprehensive noise codes in 1975 for Portland, Oregon with funding from the EPA (Environmental Protection Agency) and HUD (Housing and Urban Development). The Portland Noise Code became the basis for most other ordinances for major U.S. and Canadian metropolitan regions.[18]
- Most city ordinances prohibit sound above a threshold intensity from trespassing over property line at night, typically between 10 p.m. and 6 a.m., and during the day restricts it to a higher sound level; however, enforcement is uneven. Many municipalities do not follow up on complaints. Even where a municipality has an enforcement office, it may only be willing to issue warnings, since taking offenders to court is expensive.
- The notable exception to this rule is the City of Portland Oregon which has instituted an aggressive protection for its citizens with fines reaching as high at $5000 per infraction, with the ability to cite a responsible noise violator multiple times in a single day.
- Many conflicts over noise pollution are handled by negotiation between the emitter and the receiver. Escalation procedures vary by country, and may include action in conjunction with local authorities, in particular the police. Noise pollution often persists because only five to ten percent of people affected by noise will lodge a formal complaint. Many people are not aware of their legal right to quiet and do not know how to register a complaint

# Aircraft noise

FA-18 Hornet breaking sound barrier

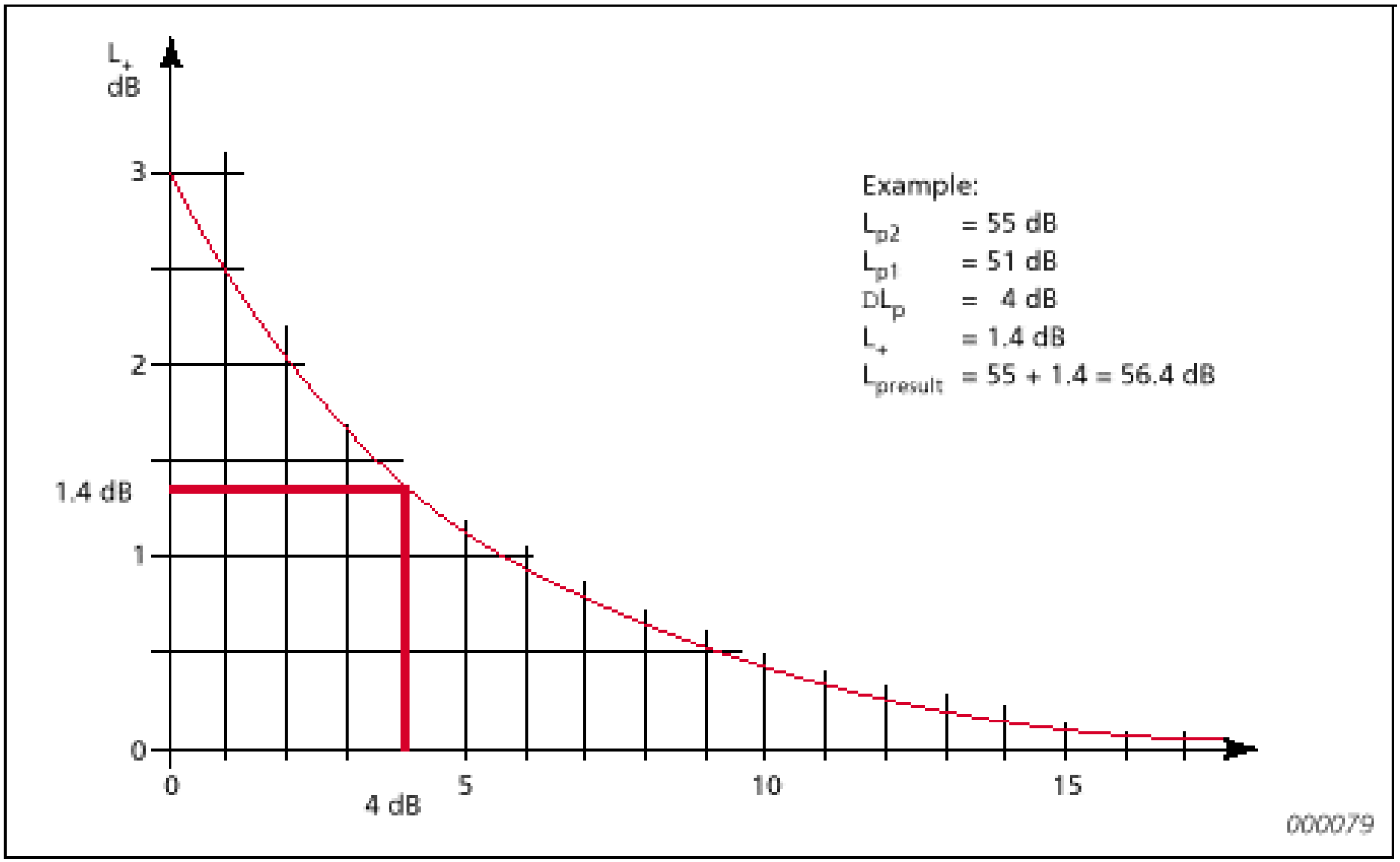
$$L_{presult} = 10 \cdot \log\left(10^{\frac{L_{p1}}{10}} + 10^{\frac{L_{p2}}{10}} + 10^{\frac{L_{p3}}{10}} + \ldots + 10^{\frac{L_{pn}}{10}}\right) \rightarrow L_{presult} = 10 \cdot \log\left(10^{\frac{L_{ptot}}{10}} - 10^{\frac{L_{pbackground}}{10}}\right)$$

# Adding noise sources and subtracting background noise

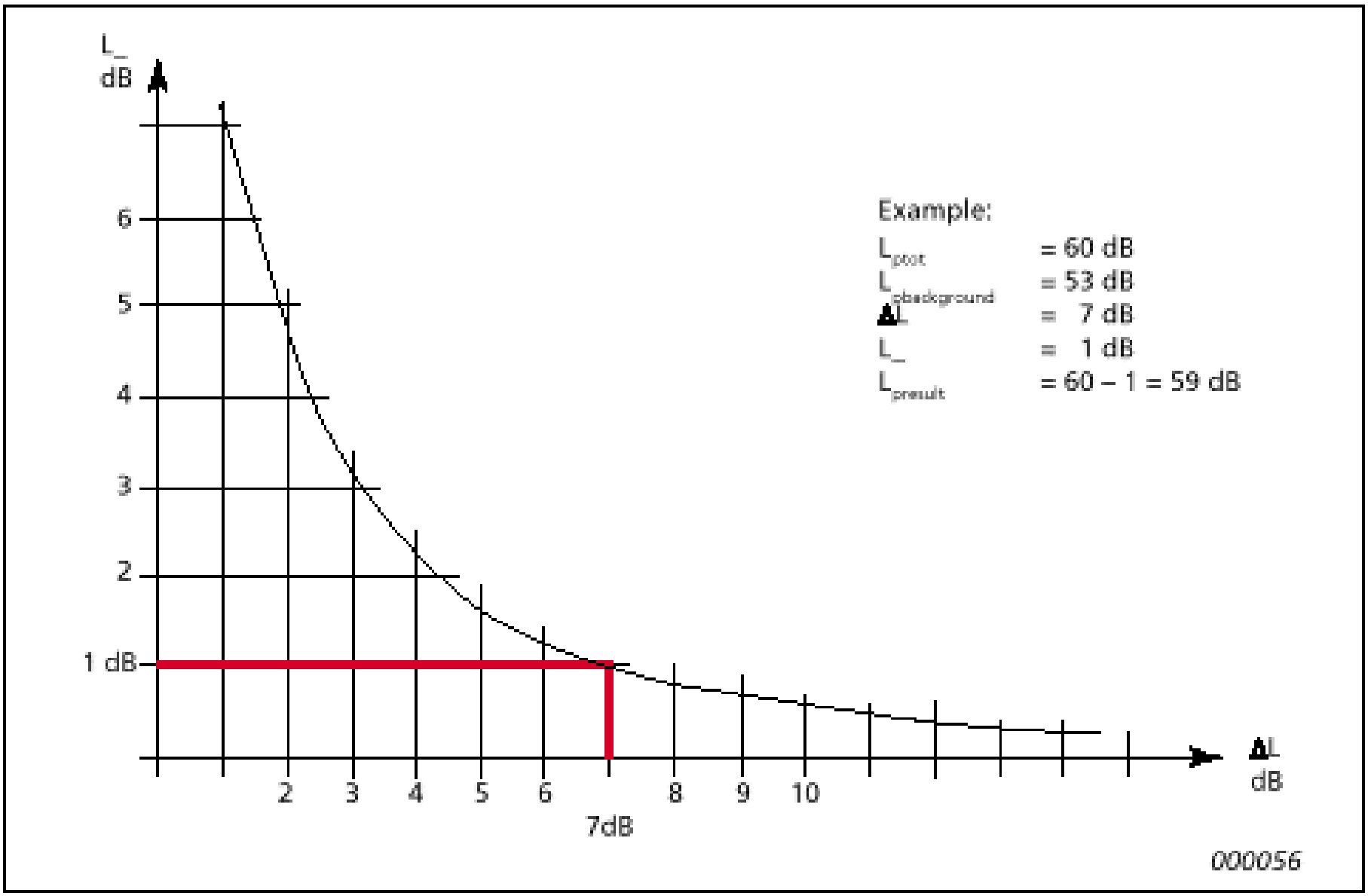



10 log 2
= 3 dB

# Chart method – adding decibels

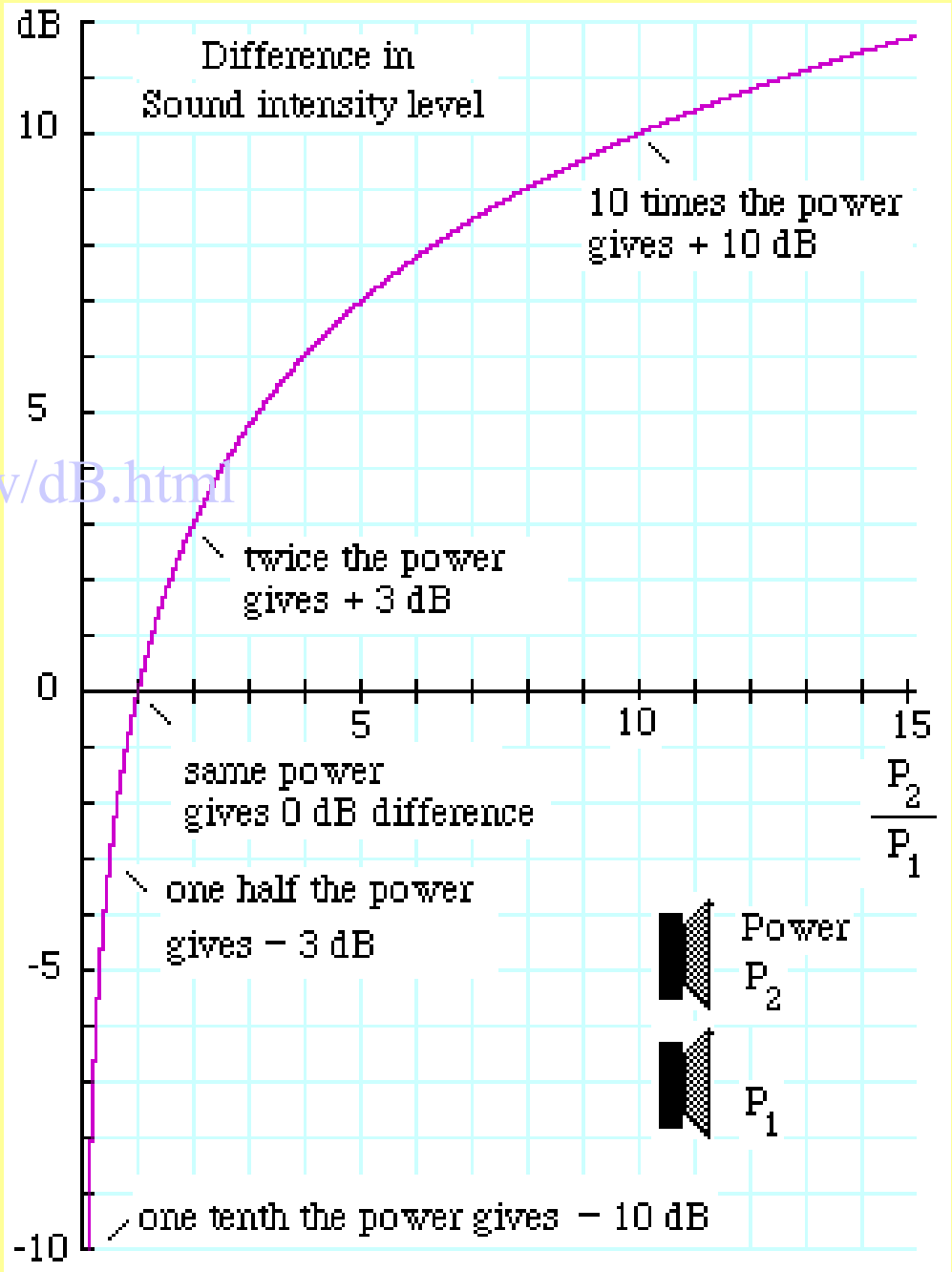


# Chart method – subtracting background noise

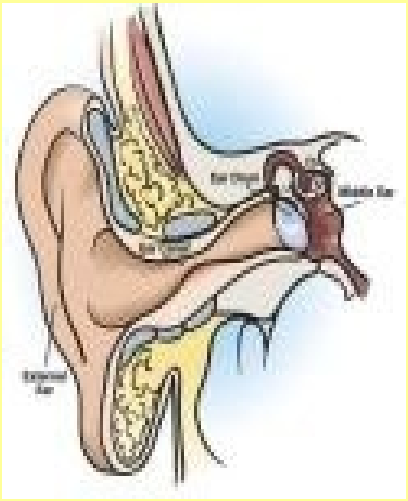


# Power ratio and dB

http://www.phys.unsw.edu.au/jw/dB.html



# Sound and human hearing



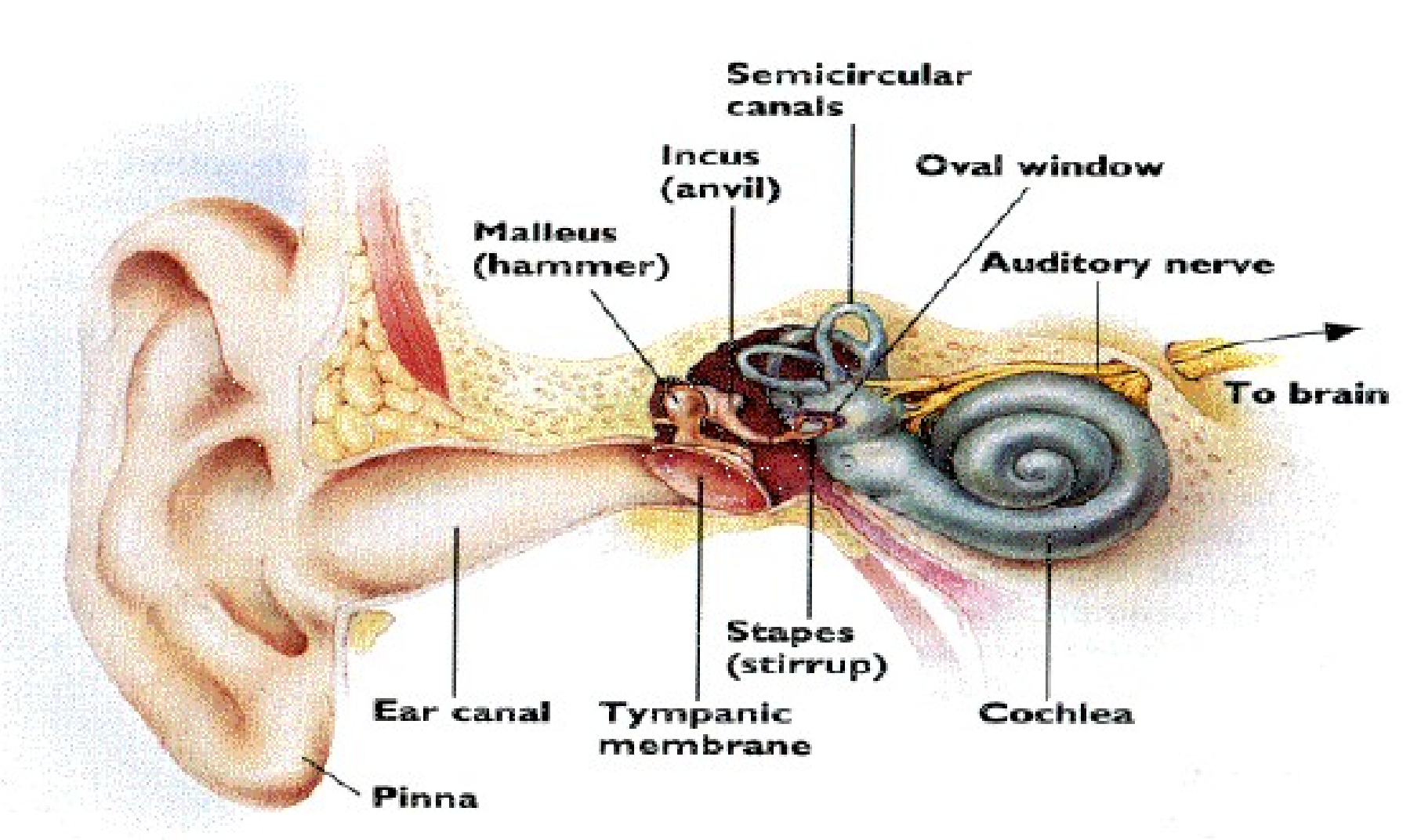
**People generally hear sounds between the "threshold of hearing" and the "threshold of pain"**

**In terms of pressure, this is 20 μPa – 100 Pa**

**The decibel scale was developed from this fact and makes numbers more manageable**

**The decibel scale generally ranges from approximately 0 to 130**

# How Sound is Heard



# Human hearing and Frequency

Inaudible

Subsonic

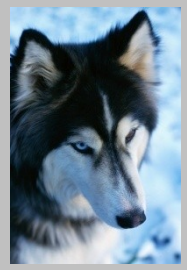
Range

Audible

Sonic

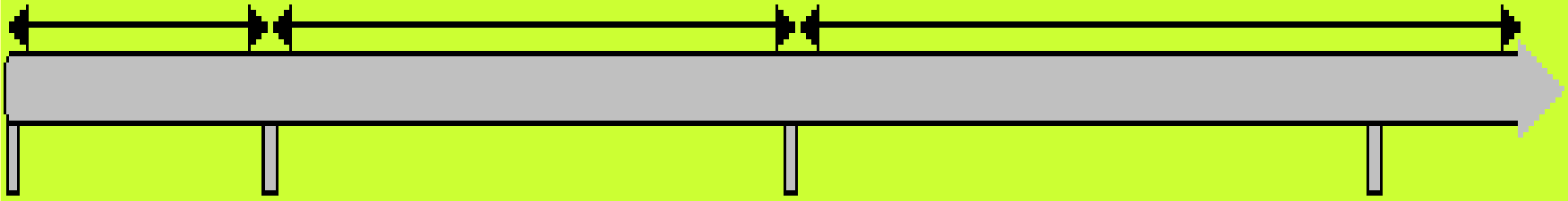
Range

Inaudible



Ultrasonic

Range



0 16 Hz 20 kHz 5 MHz

# Sound and human hearing – Frequency

**Humans are less sensitive to low frequency sound and more sensitive to high frequency sound. Therefore, sometimes the dB scale is adjusted to take this into account:**

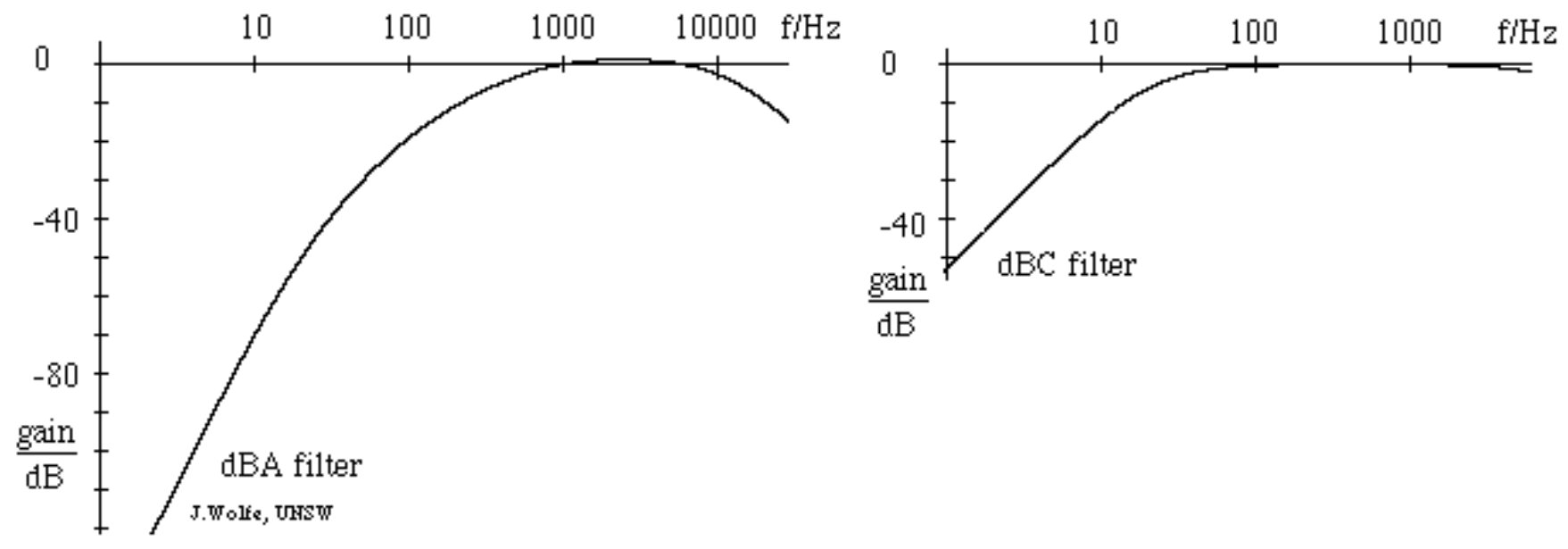
**A-weighting (db(A)): adjusts overall scale so it better matches what the human ear would hear**

**C-weighting (dB(C)): adjusts scale for loud or low frequency sounds**

**B-weighting (dB(B)): adjusts by factors that are "in between" the A-weighted factors and C-weighted factors (rarely used)**

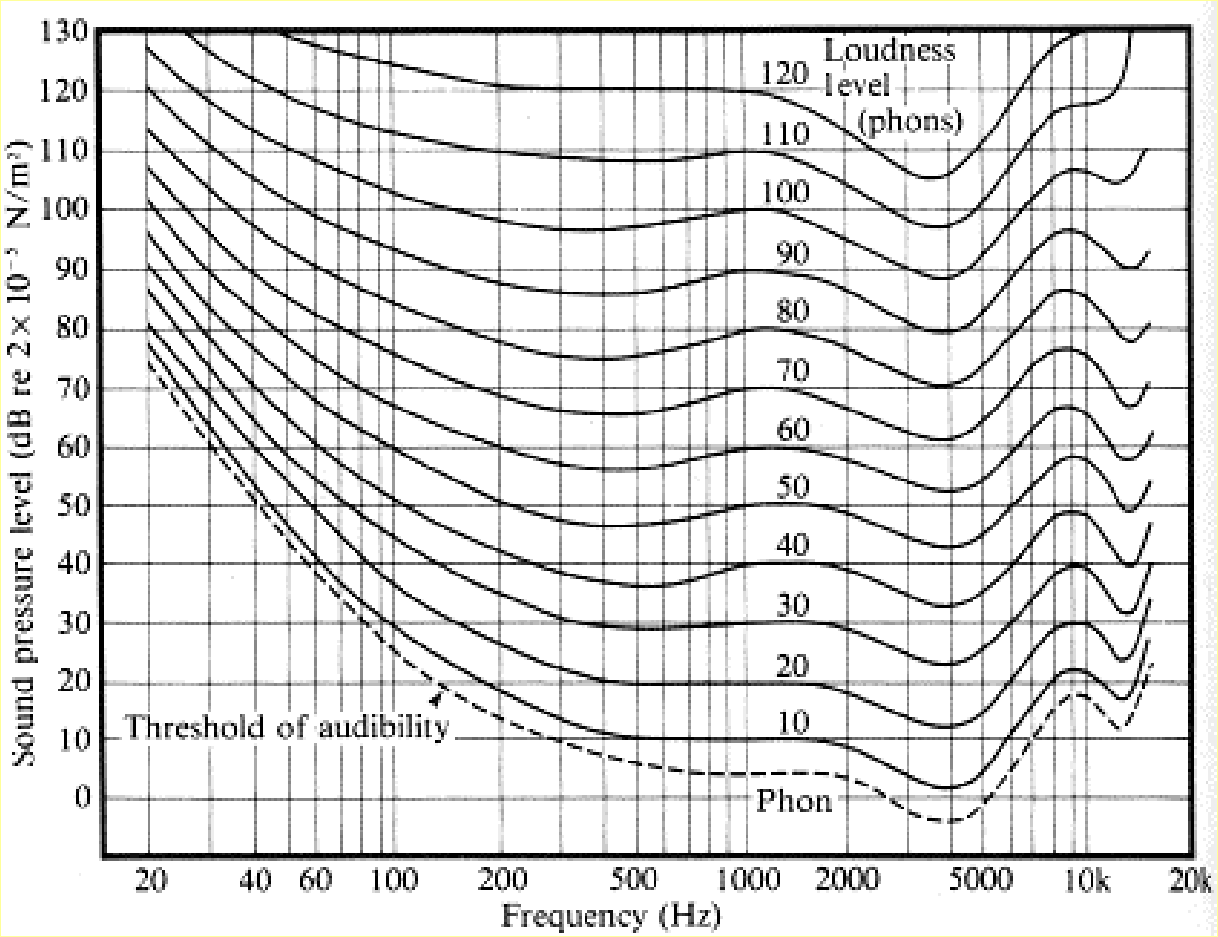
# The filters used for dBA and dBC

**The most widely used sound level filter is the A scale, which roughly corresponds to the inverse of the 40 dB (at 1 kHz) equal-loudness curve. The sound level meter is thus less sensitive to very high and very low frequencies. Measurements made on this scale are expressed as dBA. The C scale (in dBC) is practically linear over several octaves and is thus suitable for subjective measurements only for very high sound levels.**



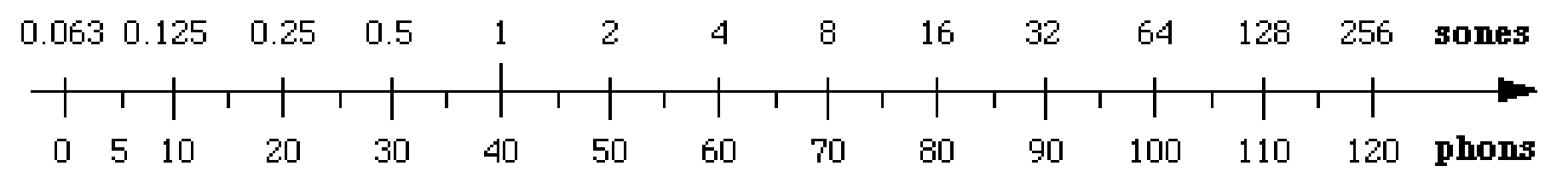
# Loudness in phons

**The phon is related to dB by the *psychophysically measured* frequency response. Phons = dB at 1 kHz. For other frequencies, the phon scale is determined by loudness experience by humans.**



# Loudness in sones

The **sone** is derived from psychophysical tests where humans judge sounds to be twice as loud. This relates perceived loudness to phons. A sone is 40 phons. A 10 dB increase in sound level corresponds to a perceived doubling of loudness. So that approximation is used in the definition of the phon: 0.5 sone = 30 phon, 1 sone = 40 phon, 2 sone = 50 phon, 4 sone = 60 phon, etc.



# Other descriptors of sound

**Equivalent sound level – the level of sound that has the same acoustical energy as does a time-varying sound over a stated time period.**

**Percentile sound level – the sound level exceeded “n” percent of the observation time interval.**

**Day-night average sound level – the equivalent sound level for a 24-h period that incorporates a decibel penalty during night hours.**

FIGURE I

## Loudness Ratio and A-Weighted Decibel Scale for Common Sounds

A – Loudness Level Ratio
B – A-Weighted Sound Pressure Level (dBA)

| A | B | |
|---|---|---|
| 128 | 130 | Threshold of pain |
| | | |
| 64 | 120 | Jet aircraft takeoff at 100 feet |
| | | |
| 32 | 110 | Riveting machine at operator's position |
| | | |
| 16 | 100 | Cutoff saw at operator's position |
| | | Automobile horn at 10 feet |
| 8 | 90 | Industrial boiler room |
| | | Bulldozer at 50 feet |
| 4 | 80 | Sports car interior at 60 m.p.h. |
| | | Diesel locomotive at 600 feet |
| 2 | 70 | Quiet air compressor at 50 feet |
| | | |
| 1 | 60 | Normal conversational speech at 5-10 feet |
| | | |
| 1/2 | 50 | Open office area background level |
| | | |
| 1/4 | 40 | Residential with soft radio music |
| | | Residential background level |
| 1/8 | 30 | Soft whisper at 2 feet |
| | | Recording studio |
| 1/16 | 20 | Concert hall |

# Typical suburban sound and their levels

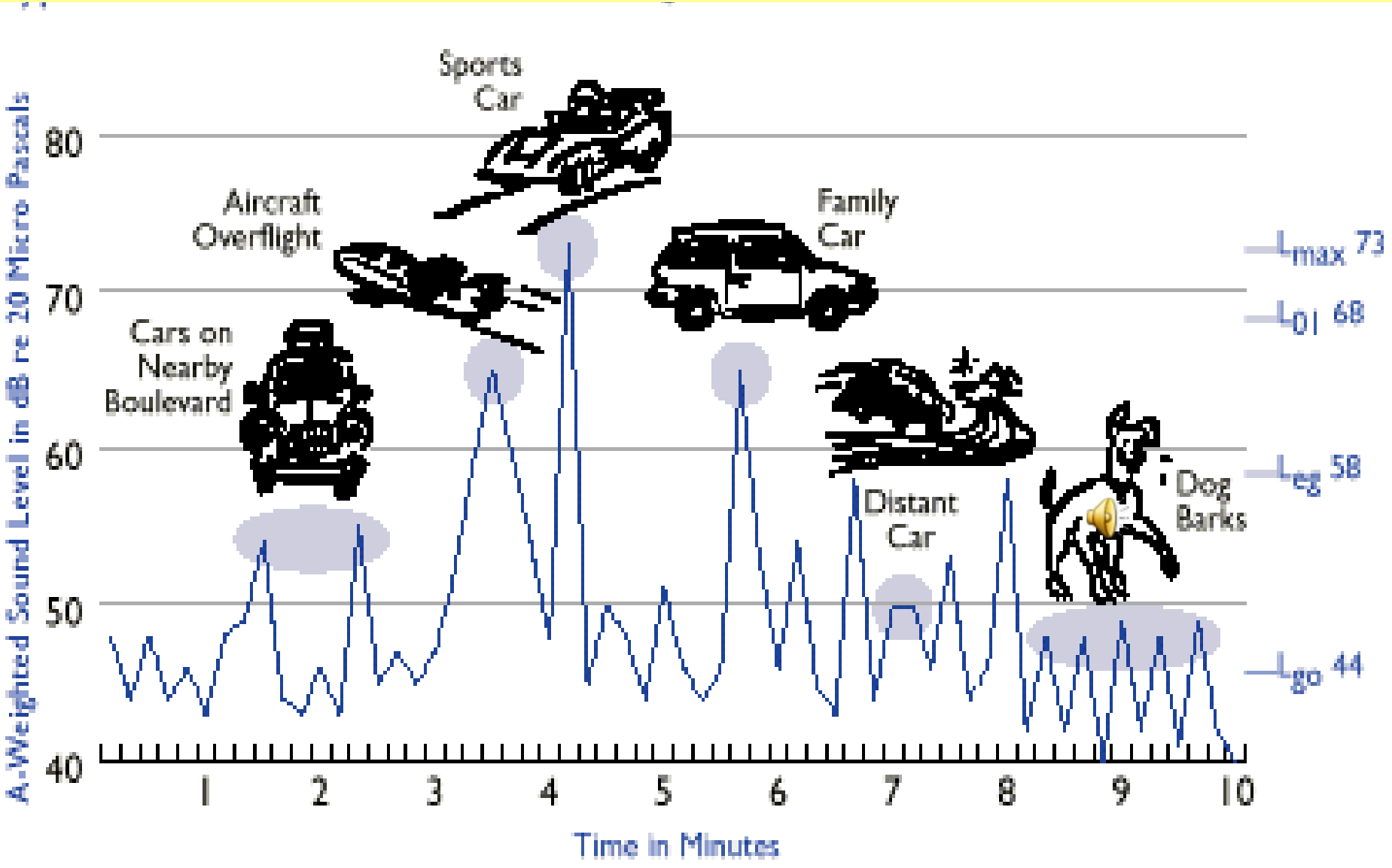
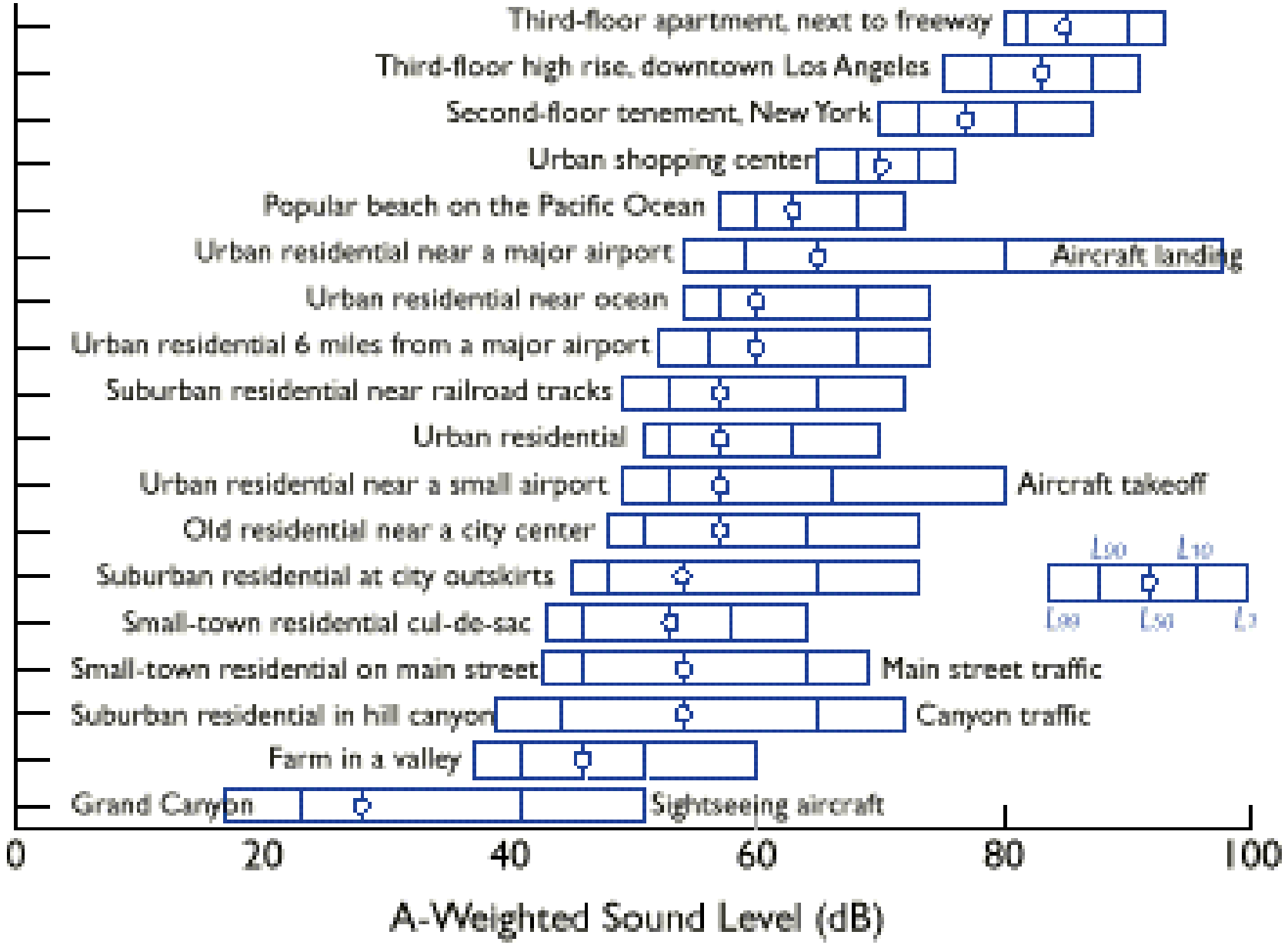
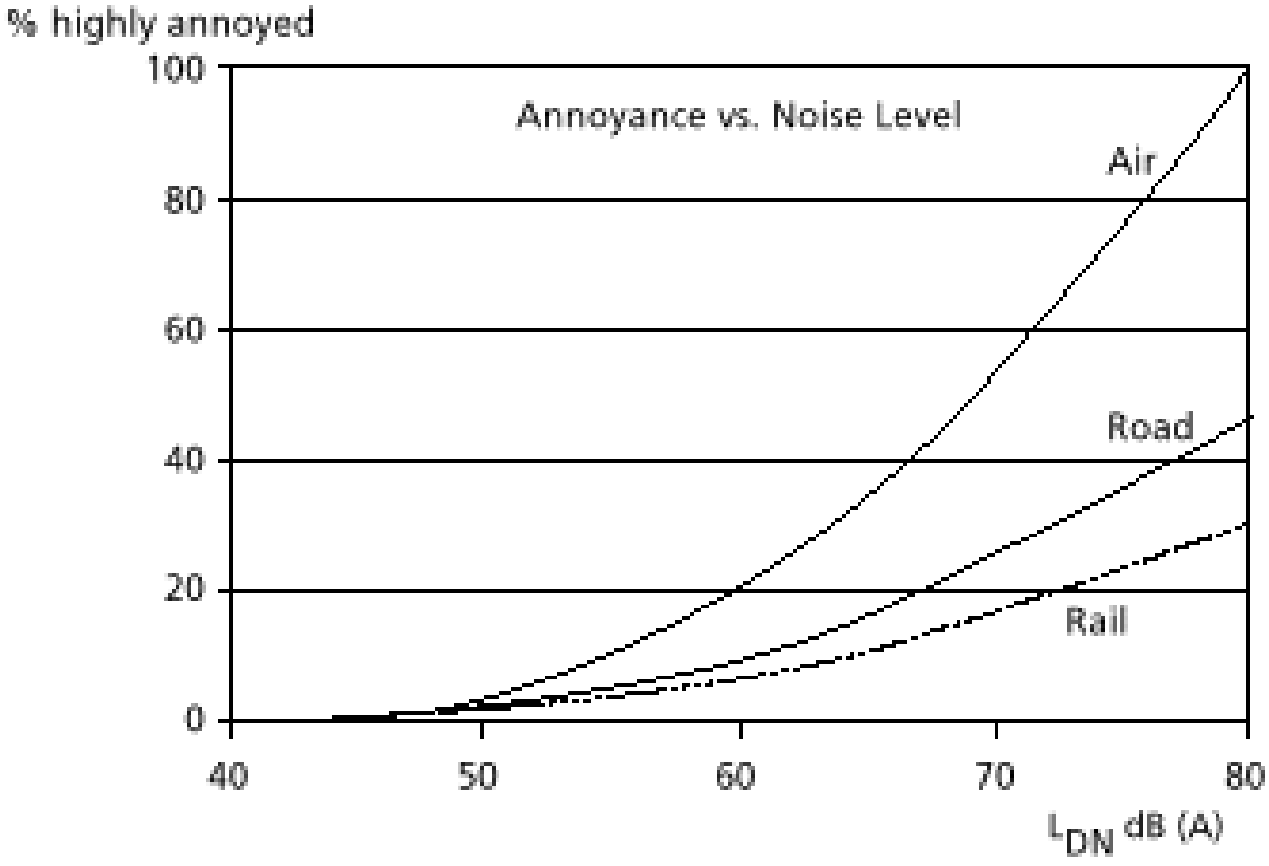


FIGURE 3

## A-Weighted Sound Levels Measured at 18 Locations in the United States



# Major transportation sources of noise pollution: rail, road, and air

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# Rail Noise: A Case Study

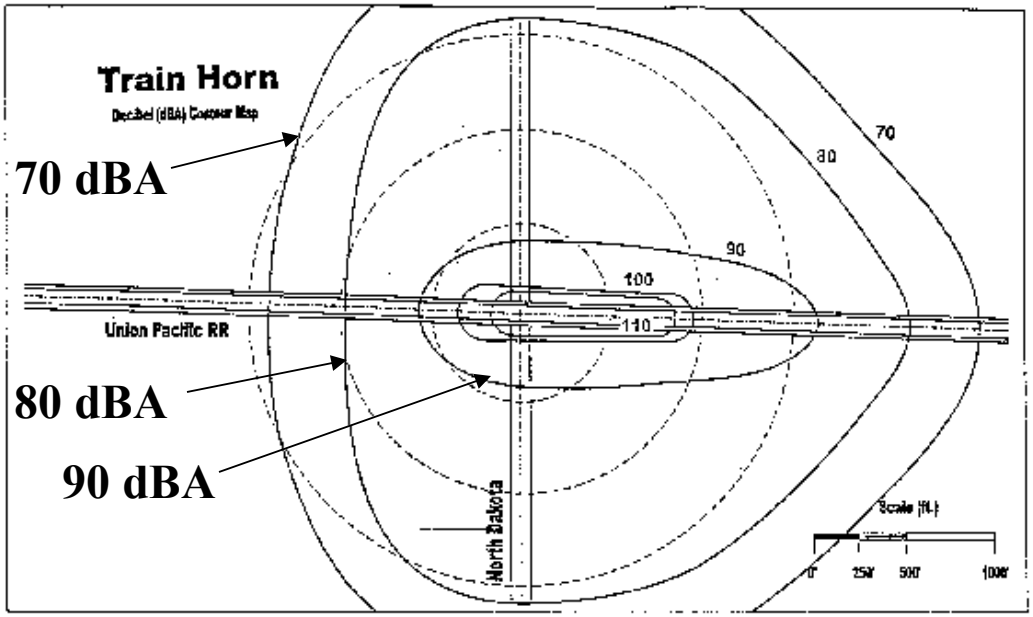
**The city of Ames, Iowa, began operation of three automated horn warning systems (AHS) in September of 1998. These systems were installed after nearby residents repeatedly expressed concerns over the disturbance created by the loud train horns.**

**The automated horn system provides a similar audible warning to motorists and pedestrians by using two stationary horns mounted at the crossing. Each horn directs its sound toward the approaching roadway. The horn system is activated using the same track signal circuitry as the gate arms and bells located at the crossing.**

# Train Horn Noise Reduction

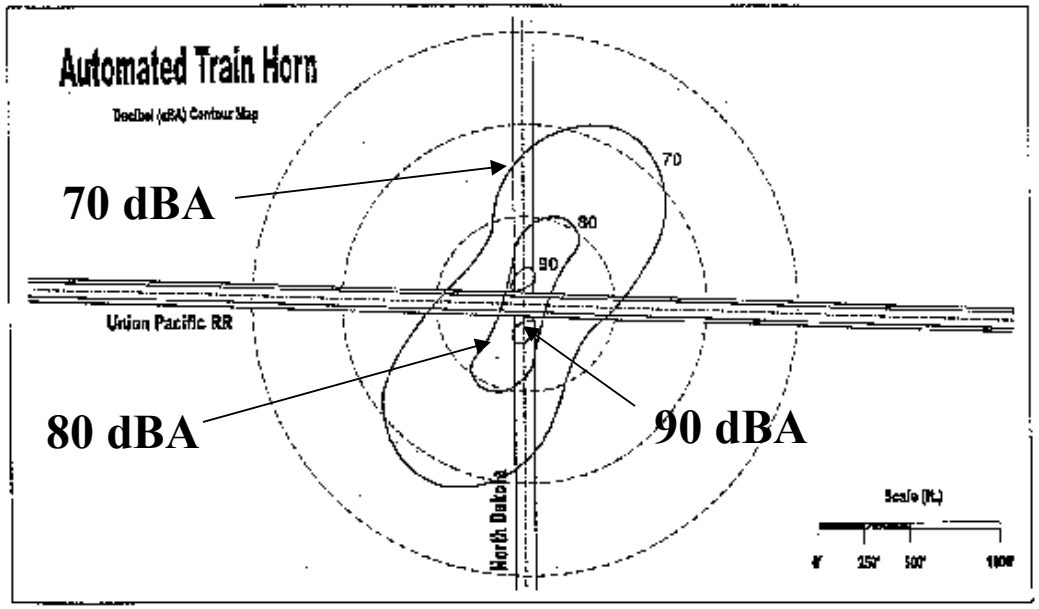
| Sound Level | Train Horn | AHS Horn | Reduction |
|---|---|---|---|
| (dBA) | Area (acres) | Area (acres) | |
| > 70 | 265 | 37 | 86% |
| > 80 | 171 | 5 | 97% |
| > 90 | 31 | < 1 | 98% |

# Intersection of railroad with North Dakota Avenue: A graphical depiction of the reduction




Before

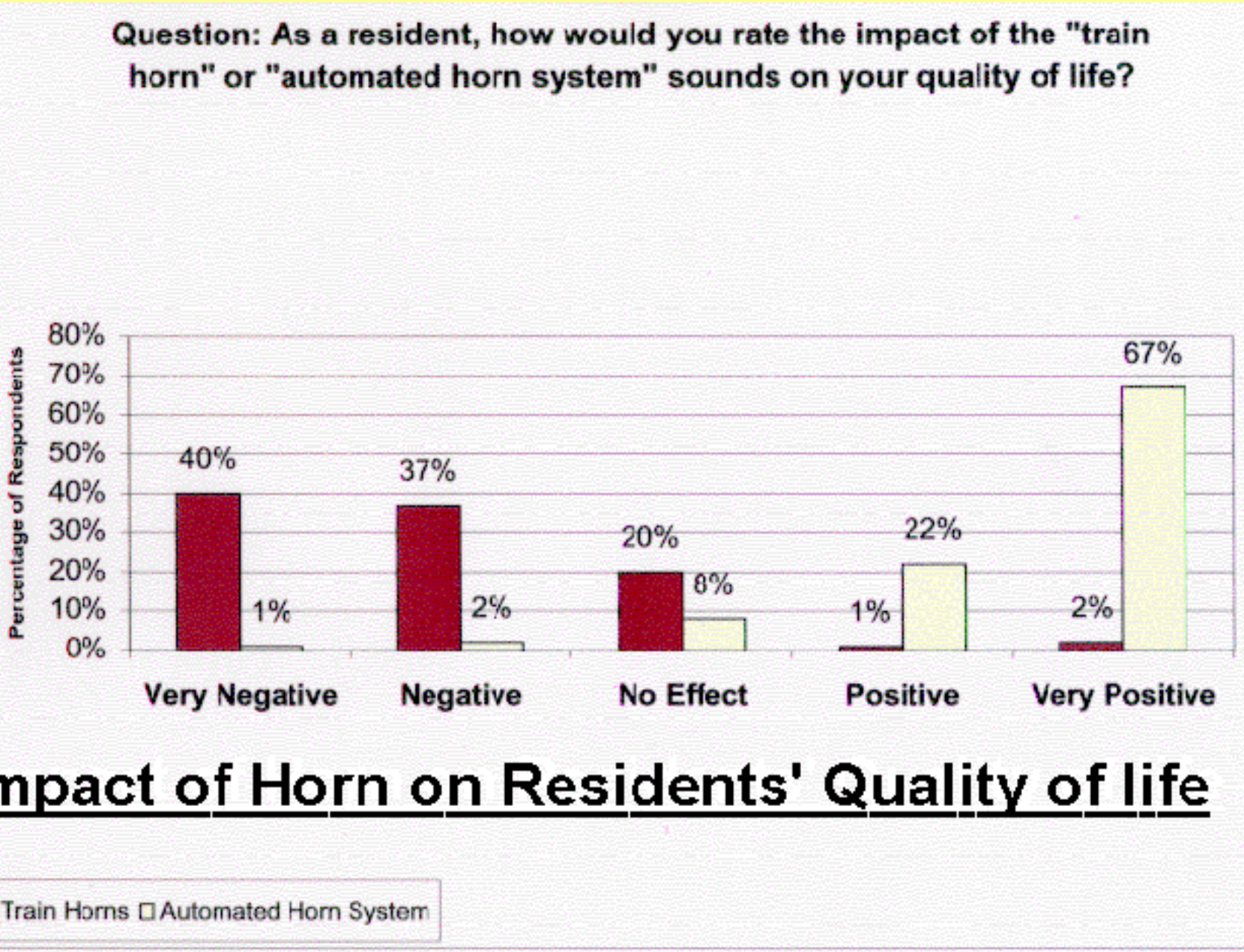
Figure 1




After

Figure 2

# Ames Train Horn Noise Survey



# Roadway Noise

- An example of a “line source” of noise pollution (as opposed to a “point source”)

- Level of noise is a function of volume, type of vehicle, and speed

# Roadway Noise - Solutions

- **Regulations limit the amount of noise some vehicles can produce**

- **Some regulations require vehicles to be properly operated and maintained**

- **Despite regulations, the noise levels are usually only reduced by 5 to 10 dBA**

# Roadway Noise - Solutions

## Barriers

- Buffer zones
- Earth berms/wooden fences/concrete walls
- Vegetation (if dense enough)

# Roadway Noise - Solutions

## Pavement type

**Certain asphalts, such as those containing rubber or stone, can be less noisy than other pavements.**

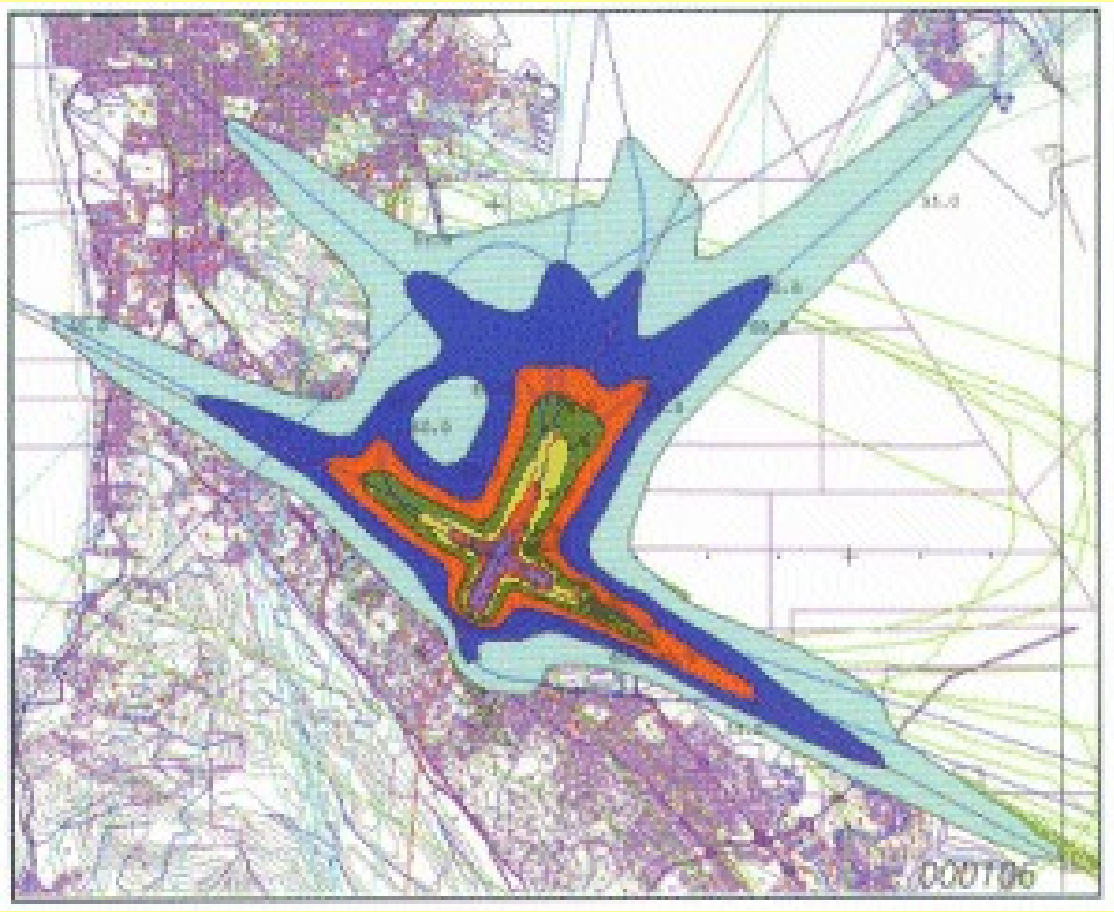
**However, some studies have shown the reduction in noise is only a few decibels, not enough to be significant.**

**More research is needed before pavement type can be an effective noise-reducing technique**

# Airport Noise

**Noise contours around an airport calculated using INM (Integrated Noise Modeling) based on previous noise measurements**

**55 - 60 dB = Light blue**
**60 - 70 dB = Dark blue**
**70 - 75 dB = Red**
**75 - 80 dB = Green**
**80 - 85 dB = Yellow**
**> 85 dB = Pink**



# Airport Noise

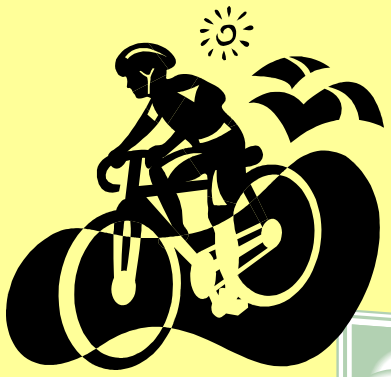
TABLE 3

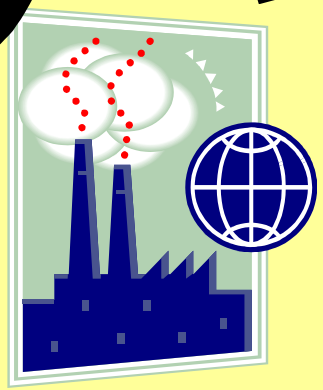
## Possible Airport Noise Abatement Actions

| Airport Feature and Activity | Possible Noise Abatement Actions |
|---|---|
| Flight tracks | Direct aircraft away from populated areas |
| Preferential runways | Foster use of runways with least impact |
| Restrict noisy aircraft | Minimize operations during day or night |
| Noise abatement flight procedures | Require use of noise abatement throttle and flap management procedures for takeoff and/or approach |
| Airport layout | Extend or build new runways and taxiways to make best use of compatible land and water |
| Shielding barriers | Shield people from noise of ground operations. |
| Building soundproofing | Soundproof schools, homes, and churches |
| Land use control | Ensure compatible land use through acquisition of property or other rights |
| Monitor and model | Monitor airport noise and flight tracks to provide data to the public and for evaluating proposed alternatives |
| Communications | Listen to complaints and suggestions; develop and institutionalize continuing effective dialogue and information transfer among all concerned parties |

# Other sources of noise pollution that need to be addressed

- Boat noise, especially jet skis
- Construction noise
- Snow mobiles
- Industry





# What are the sources of noise pollution?

The source of most outdoor noise worldwide is mainly construction and transportation systems, including motor vehicle noise.

# What are the effects of noise pollution?

In humans, noise pollution can cause:

- annoyance and aggression

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- hypertension (high blood pressure)

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- high stress levels
- tinnitus (ringing in the ears)

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- long-term hearing loss

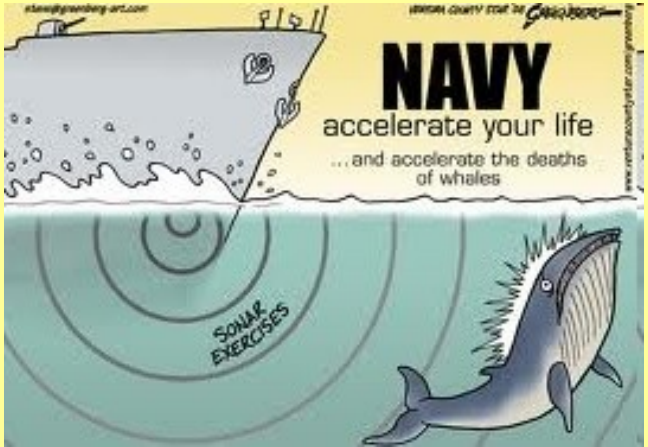
# What are the effects of noise pollution?

In humans, noise pollution can cause:

- annoyance and aggression
- hypertension (high blood pressure)
- high stress levels
- tinnitus (ringing in the ears)
- long-term hearing loss
- sleep disturbances

# What are the effects of noise pollution?

Noise can also harm animals, changing the delicate balance in predator or prey detection and avoidance, and interfering the use of the sounds in communication especially in relation to reproduction and in navigation.




# How can the effects of noise pollution be mitigated?

Mitigation: the act of reducing the severity, seriousness, or painfulness of something.

Tullamarine Freeway in Melbourne, Aus

# How can the effects of noise pollution be mitigated?

E.g. roadway noise can be mitigated by the:

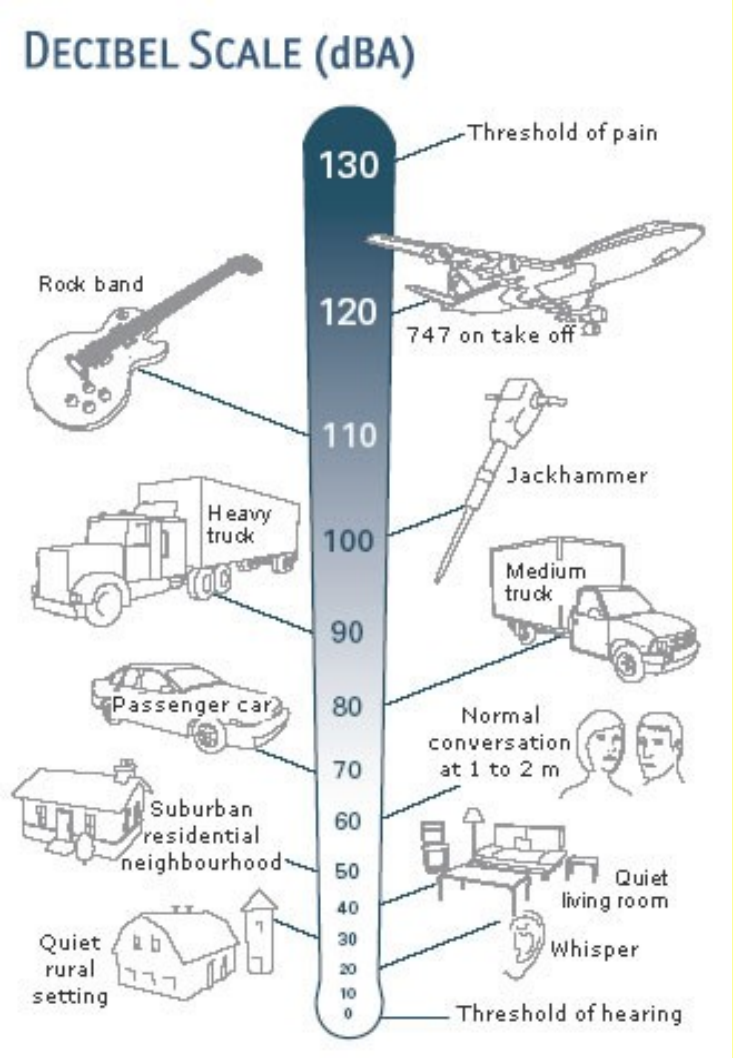
- use of noise barriers
- limitation of vehicle speeds
- alteration of roadway surface texture
- limitation of heavy vehicles
- use of traffic controls to reduce braking and acceleration
- tire design

# How is noise measured?

Noise is measured on the decibel scale:

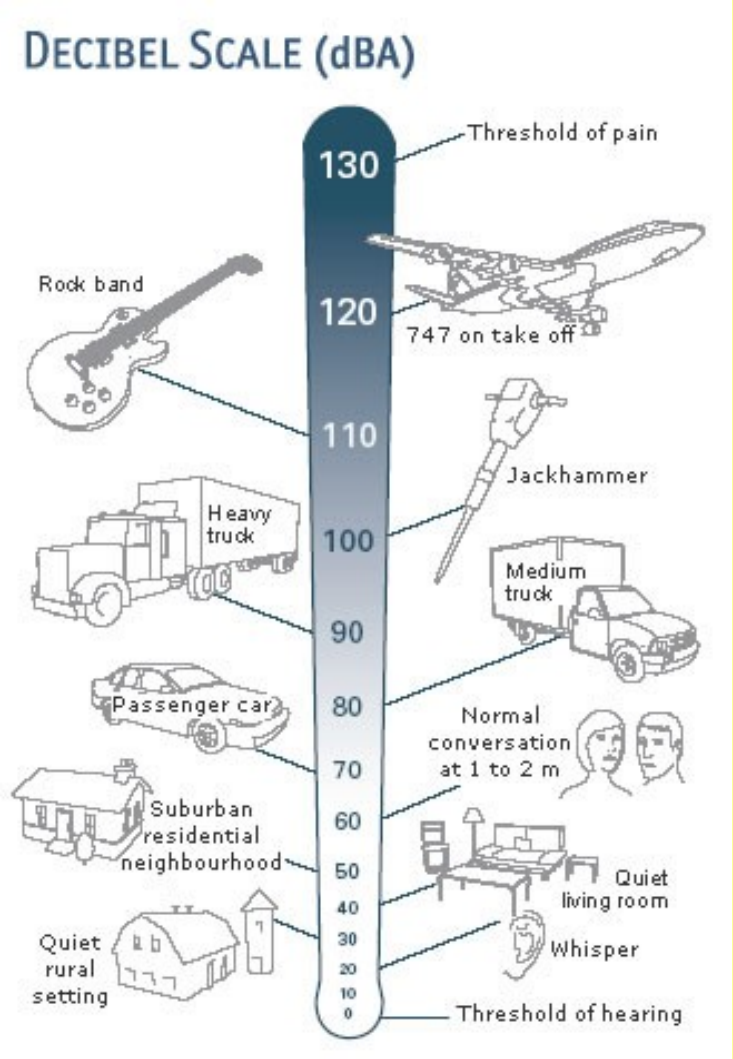
each +10 dB on the scale is 10 times louder

(60 dB is ten times louder than 50 dB)



# Noise PSA

- Regular exposure to 110 dB for more than a minute -- or to 100 dB for more than 15 minutes -- risks permanent hearing loss.
- Prolonged exposure to any noise above 85 dB can cause gradual hearing loss.
- Most MP3 players have a maximum volume setting equal to about 105 dB.



# Noise PSA

Earbud headphones can be the most destructive to hearing since

(a) they do not filter out external sounds, causing the listener to increase the volume, and

(b) they are positioned very close to the eardrum.

- **The following photos show two different kinds of decibel meters:**


# Sound level and human's perception

| perception | sound level (dB) | example |
| --- | --- | --- |
| | 100 | |
| | 80 | |
| | 60 | |
| | 30 | soft whisper (25 dB) |
| quiet<br>very quiet sound | 10 | breathing sound (10 dB) |
| | 0 | the lowest sound level that can be heard |

# Sound level and human's perception

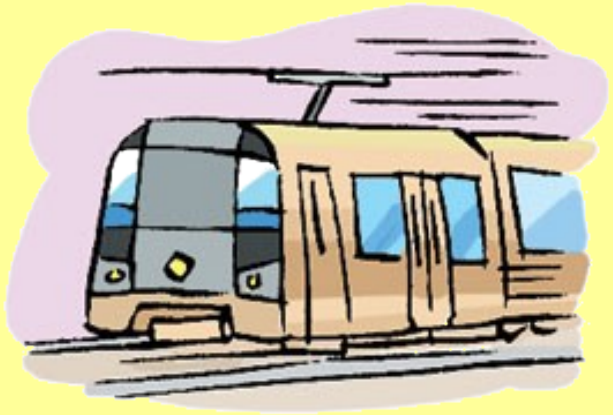
| perception | sound level (dB) | example |
| --- | --- | --- |
| | 100 | |
| | 80 | |
| | 60 | normal conversation (60 dB) |
| acceptable | | soft conversation in |
| | 30 | libraries (30 dB) |
| quiet | | |
| | 10 | |
| | 0 | |

# Sound level and human's perception

| perception | sound level (dB) | example |
| --- | --- | --- |
| annoying | 100 | |
| | 80 | alarm clock (80 dB) |
| noisy | | busy traffic (70 dB) |
| | 60 | |
| acceptable | | |
| | 30 | |
| quiet | | |
| | 10 | |
| | 0 | |

# Sound level and human's perception

| perception | sound level (dB) | example |
| --- | --- | --- |
| very noisy<br>damage our ears | 100 | crying baby (100 dB)<br>passing train (90 dB) |
| annoying | 80 | |
| noisy | 60 | |
| acceptable | 30 | |
| quiet | 10 | |
| | 0 | |



# Sound level and human's perception

| perception | sound level (dB) | example |
| --- | --- | --- |
| very noisy<br>damage our ears | 100 | road drilling (120 dB)<br>disco (110 dB) |
| annoying | 80 | |
| noisy | 60 | |
| acceptable | 30 | |
| quiet | 10 | |
| | 0 | |

# Sound level and human's perception

| perception | sound level (dB) | example |
|---|---|---|
| very noisy<br>damage our ears | 100 | rocket taking off (190 dB) |
| annoying | 80 | jet plane taking off (130 dB) |
| noisy | 60 | |
| acceptable | 30 | |
| quiet | 10 | |
| | 0 | |

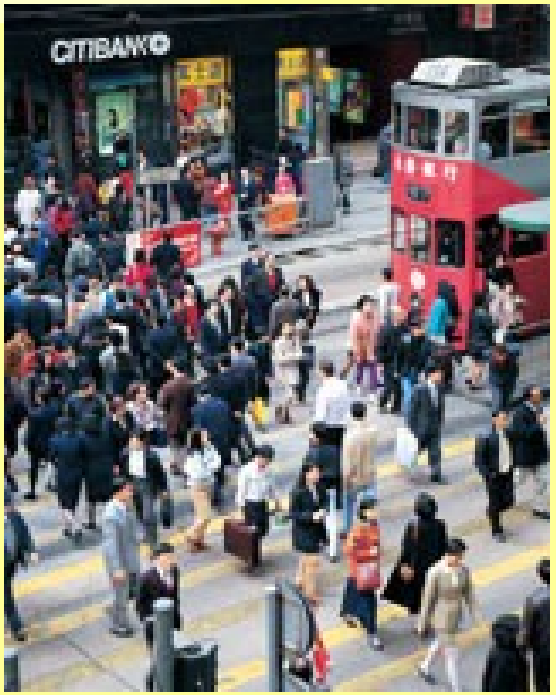
We can enjoy some sounds as music.
However, sound can also be
annoying noises.

# Noise ( 噪音 )



=> *annoying sound*

- Noise is a kind of pollution.
  It is a common problem in crowded cities.



There are many people but less space in Hong Kong. We live in a densely-populated city.
Noise pollution is serious.

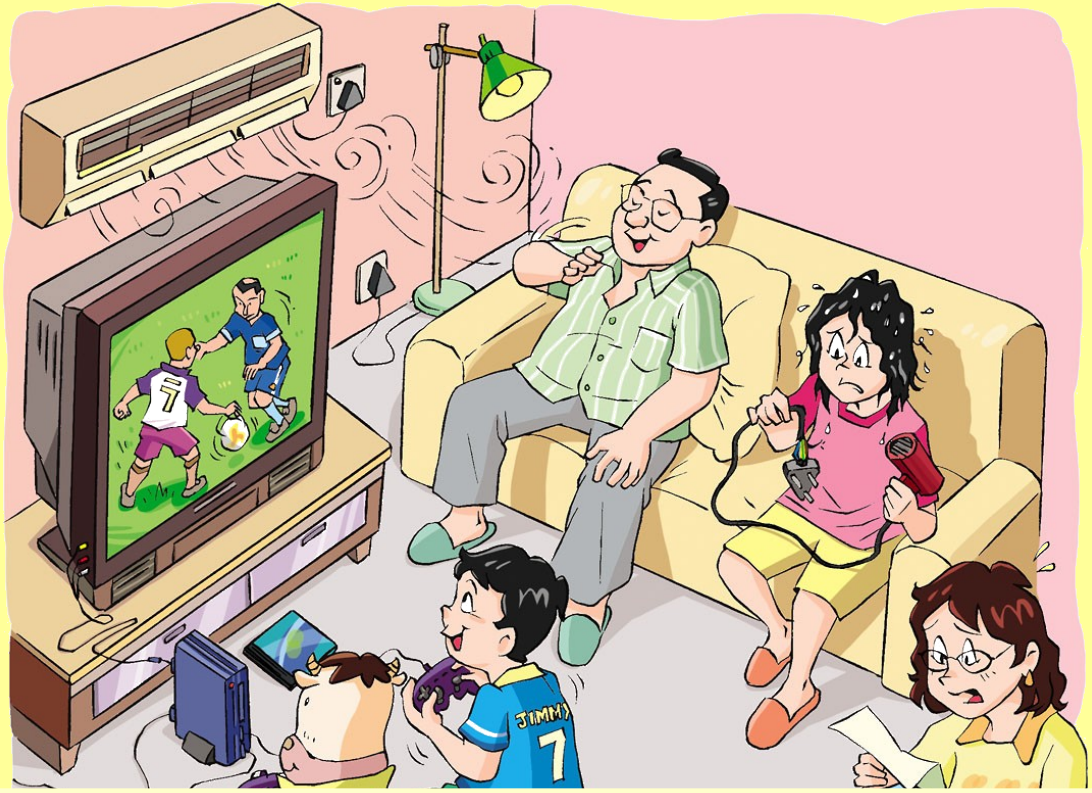
# Do you know ?

Can you give some examples of sources of noise in Hong Kong?

- construction site
- busy traffic
- road drill
- taking off and landing of plane

- repairing house
- playing mah-jong
- playing hi-fi
- burglar alarm

- There are many loud sounds in our surroundings, including some of the objects we often use.




What are these objects? How do they affect us? Try to do Activity Corner J to find out the answer.

# Effects of noise pollution



- causes mental stress
- increases the heartbeat rate and blood pressure
- disturbs our sleep
- makes us difficult to concentrate, so accidents happen more easily
- annoying, makes us become bad tempered more often

## e.g. in Chinese restaurants

- Hearing sound level at 80 dB for a long time,

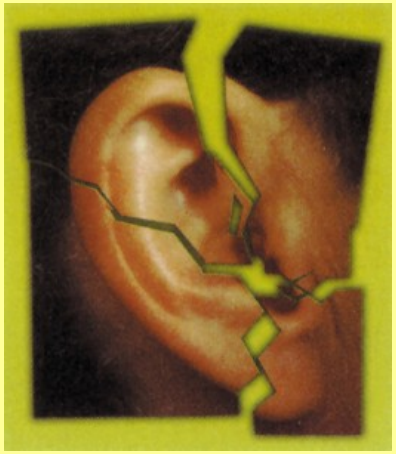
  => *may cause temporary or permanent damage to our ears.*

- Hearing sound level at 130 dB makes our ears feel pain,

  => *because the eardrum vibrates too vigorously.*

- When sound level reaches 150 dB,

  => *causes damage to the eardrum or ear bones, make us go deaf.*

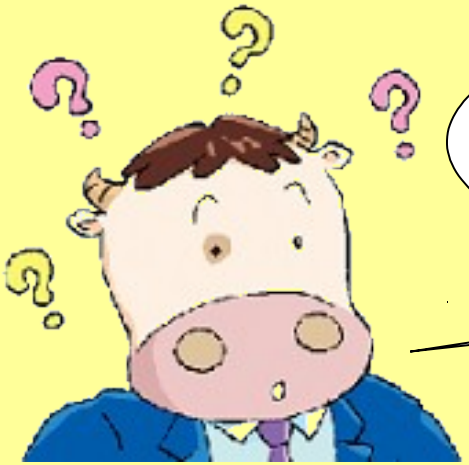


# Do you know ?

According to an investigation done by a group of Australian scientists in 1998:

Wear headphones to listen to music for more than 6 hours a week, the sense of hearing will decrease by 30 years.

# Do you know ?



How can noise pollution be controlled?

# Protecting our ears

p.103

1 Avoid listening to loud music for a long time.

2 Stay away from noisy places.

*e.g. disco, karaoke centre…*

3 Wear ear protectors when working at noisy places

We should wear an ear protector when working at a noisy place

- Prescribed by the laws in HK:

The employer cannot request employees to work in a place at sound level higher than 90 dB for more than 8 hours without break.

# Noise control

p.103

- HKSAR government has taken some measures to control noise:

- It is an offence to make loud noise between 11 p.m. and 6 a.m.


Pile drive

Road drill

public holidays

between 7 p.m. and 7 a.m. on weekdays

Noisy construction works (including pile drive and road drill) are not allowed without a permit.

- Schools in noisy environment are given special funding to install air-conditioners in their classrooms.

- Residential areas close to the highways are protected by noise barriers.

While the government has spent
a lot of money on noise control,

as responsible citizens, we
have the responsibility to
help reduce noise pollution.

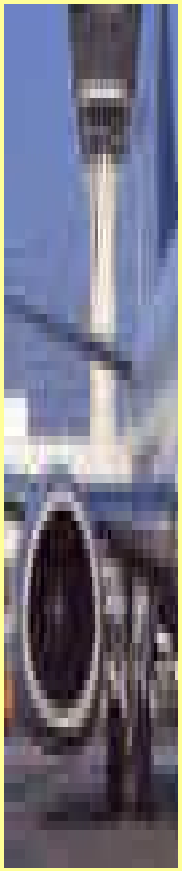
People with eye defects or ear defects are also part of the society.

They need our support and love.


# Noise Control

- General control measures include alteration of machines and equipment to gather up-dated machinery regarding noise prevention.

- Noise can be tackled through:



Reduction at source → Change to quieter methods → Prevention or reduction of propagation

# NOISE CONTROL

- It is often possible to reduce noise radiation from production equipment, material handling, and work in progress; for example by damping sound radiating panels, quietening power sources and transmissions, and reducing noise from compressed air exhausts.
- Sometimes machine alterations or enclosures do not give sufficiently good results, and if it is the work process itself which causes intense noise it can be difficult to predict the results of noise control measures.
- In such cases effort might be better aimed at changing the working methods and processes themselves.

## NOISE CONTROL

- **Changing the method of work is the only way to get to grips with noise generation; it requires that production equipment or part of it must be replaced and one must be aware of the availability of less noisy equipment for both production and material handling.**

- **Requires cooperation between the buyer, supplier, designer, and safety organization.**

- **Prevent propagation to avoid noise pollution can result economically more efficient than corrective measures.**
- **The noise in a workshop is often dominated by a relatively small number of intense noise sources.Try to enclose all noise sources points or keep them away from workers in the same room.**
- **By setting up sound absorbing ceiling and wall panels, noise levels within the room far from the noise sources can be reduced.**
- **Alteration and replacement of production equipment may mean that personnel monitoring this machinery do not need to be in its vicinity if monitoring can be carried out in a sound insulated control room.**

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## NOISE GUIDELINES

- For all noise control effor
- must be set.
- A highest level must be defined for each place of equipment or room

| Type of room | Highes sound level guideline (dB) |
|---|---|

Guideline noise levels

for specific locations

## NOISE CONTROL TIPS

- Machinery have to be adapted to new normative, relevant materials of the machines are key to ensure appropriate noise levels.
- Existing equipment must be attenuated without complicated operations.
- Handling material can be done by consider choosing conveyor belts and controlling the speed of conveyor belt transports.
- Enclosure of machines can reduce noise levels at its source very effectively.
- Attenuation by using absorbent materials is one of the key techniques to ensure that rooms and workshops do not communicate noise pollution to each other. To ensure so, best practices are providing sound isolated rooms.

## RESULTS for NOISE CONTROL

- **Mounting an absorbent roof or ceiling in a room will in general give a noise reduction of between 3 and 5 dB. Exceptionally, up to 10 dB can be obtained.**
- **Damping of vibration of small production machines by applying damping material can give between 3 and 10 dB attenuation.**
- **Factory-made screens can reduce noise from between 5 and 15 dB.**
- **Leakage where pipes pass through walls as well as acoustic leaks between walls, screens or enclosures, can produce large variations in the attenuation achieved. It is therefore important to seal air gaps carefully.**

# NOISE CONTROL at NEW PROJECTS

- **Noise control of new projects can be difficult to manage and implement, but very cost-effective at the long term.**
- **Implementing noise reduction measures at rooms, planning the building and purchase accurate machinery are necessary steps to execute a program for noise control.**
- **Noise abatement measures at the municipality level can reduce the background noise and establish an adequate framework to develop a detailed building code regarding noise reduction**

## NOISE SAMPLING

- To avoid noise pollution, it is very relevant to have an appropriate estimation of noise level at the place of work through modern and accurate techniques and measuring tools.
- Background noise can be very relevant at factories located around main highways, close to the airports.
- Sound-level meter is best used attached to the person exposed.
- Noise sampling has to take into account internal and external measures to the workplace

## NOISE GUIDELINES

- For all noise control efforts a target noise level must be set.
- A highest level must be defined for each place of equipment or room

Guideline noise levels for specific locations

| Type of room | Highes sound level guideline (dB) |
|---|---|
| Conference room | 35 |
| Office | 40 |
| Workshop office, rest room | 45 |
| Laboratory, measurement room | 50 |
| Canteen | 50 |
| Changing room | 55 |
| Repair shop | 60 |
| Production areas | 75 |
| Fan room, compressor room | 90 |