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Noise—the Invisible Hazard

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Farm workers experience one of the highest rates of hearing loss caused in part by the many potential sources of loud noise on the farm: tractors, combines, grinders, choppers, shotguns, conveyors, grain dryers, chain saws, etc. Prolonged exposure to excessive noise can cause permanent hearing losses unless noise-control measures are taken.

This guide has information to help you protect this valuable gift that provides joy and happiness and helps you work efficiently with others.

How do we hear?

The human ear is composed of three major sections: the external, middle, and inner ear (see Figure 1). Each section has a specific function in the hearing process.

The middle ear consists of three tiny bones, or ossicles, that are suspended in an air-filled space. They connect the eardrum to the inner ear, which is embedded in the skull. The ossicles function as a mechanical lever system that delivers sound from the ear canal to the inner ear. Noise does not affect the middle ear unless there is an impact sound or pressure so great that it dislodges or fractures the ossicles.

The inner ear, or cochlea, is susceptible to damage from continued exposure to high-level noise. The cochlea (Latin term meaning snail shell) is a fluid-filled hydraulic system driven by the piston action of the last ossicle. The vibrating motion of the ossicle produces a wave motion in a membrane that runs the full length of the cochlea. If the vibrations are fast (high-frequency sound), the membrane has its greatest motion at the base of the cochlea near the vibrating ossicle; if the vibrations are slow (low-frequency sound), the maximum membrane motion occurs at the tip or apex of the cochlea.

Situated on top of the moving membrane are thousands of small hair-like structures with nerves connected to each hair cell. When a hair cell is bent because of membrane motion, the nerve fires and the message is transmitted to the brain. Hair cells near the base transmit information about high-frequency or high-pitch sound, while those at the apex provide information about low-pitch sound.

If the hair cells in a particular region of the cochlea are destroyed, the nerves will not fire, and the brain will not receive any information. If part of the hair cells are destroyed, the brain may receive a distorted message that it cannot interpret.

The whole cochlea is smaller than a dime and is embedded in the hardest bone in the body. When the microscopic structures are damaged, there is no way to repair them to restore reasonable hearing.

Typically, hair cells are damaged or destroyed when their supporting structures are overworked. With continued exposure to high-level noise, the membrane motion is great, and the cells that support the hair cells swell. Eventually, they rupture, and the hair is destroyed or damaged. Only a few hair cells may be lost at a time, but with repeated exposure over days, months, and years, the cumulative effect can be substantial.

Properties of sound or noise

Even though we cannot see sound, it is a force with real dimensions and three definite properties: intensity, frequency, and duration.

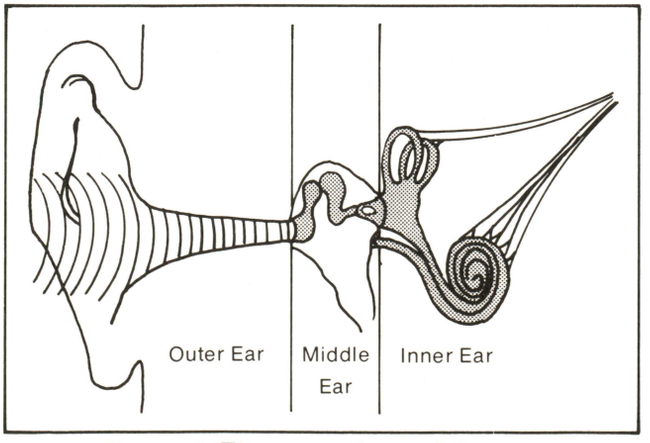

Figure 1. Three sections of the ear.

Intensity. Intensity is the loudness of a sound, or the pressure it exerts through the ear. It is measured in units called decibels (dB).

The ear is a remarkable organ, responding to sounds ranging from dripping water to amplified music (Figure 2). The normal range of hearing begins at approximately 0 decibels, a level at which a person with excellent hearing is able to detect a sound. Typically, a person begins to identify sounds when a level of 10 to 15 dBs is reached; this is the threshold of hearing.

The other end of the scale is known as the threshold of pain (140 dB), or the point at which the average person experiences pain.

Figure 2. 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

In assessing noise, a special measure called "dBA" indicates damage to hearing. The dBA rating is provided for many pieces of agricultural equipment; the higher the dBA number, the greater the risk of damage to hearing.

Frequency. Frequency is the number of sound waves (high and low pressure areas) produced by a noise source passing a given point per second. Frequency is measured in cycles per second (cps), also called hertz (Hz). The higher the number, the higher the frequency.

The human voice has a range of about 200 to 4000 Hz. A noise-induced hearing loss first causes the loss of the ability to hear sounds at 4000 Hz. Then hearing loss proceeds until the ear cannot hear frequencies between 500 and 3000 Hz, a range crucial to understanding conversation.

One of the first signs of loss is the inability to understand people (especially in a crowd) or other sources of voice communication, such as the television or radio. You become "hard of hearing," and sound seems muffled.

The most dangerous sounds are high in intensity (dB level) and have a high frequency. This is because a large number of sound waves are transmitted to the ears with a force greater than your ears can tolerate. Noise-induced hearing loss cannot be reversed, and a hearing aid does little good. Therefore, prevention is by far the best treatment.

Duration. The amount of time you are exposed to a sound level is duration. In figure 3, the right-hand column lists various high sound levels, and the left-hand column indicates the length of exposure that is safe for the corresponding noise level during a day. These figures have been determined after years of research on noise-induced hearing loss and are accepted as the standard for allowable noise level exposures.

Figure 3. Permissible noise exposure scale*

Duration hours per day	sound level (dBA)
8	90
4	95
2	100
1	105
½	110
¼ or less	115

*Based on OSHA Noise Standard.

The average person can be exposed to a sound source producing 90 dBA for a maximum of eight hours. If the sound level is at 100 dBA, then the maximum exposure is two hours. An unprotected ear can be exposed to 115 dBA for a maximum of only 15 minutes a day. Your ears should not be directly exposed for *any* length of time to sounds greater than 115 dBA.

For every 5 dB increase above 90 dBA, the permissible exposure time is reduced by half. For example, if you purchased a tractor with a 95 dBA rating, you would be risking a hearing loss after four hours of exposure. If the tractor had a 90 dBA rating, you could use the tractor for eight hours before reaching the same risk level.

Effects of noise

The effects of noise can be broken into three areas:

- physiological effects: noise-induced hearing loss or aural pain, nausea, and reduced muscular control.
- psychological effects: noise can startle, annoy, and disrupt concentration of sleep.
- interference with communications.

The ears provide two warning signs for overexposure to noise: temporary threshold shift (TTS) and ringing in the ears (tinnitus). After leaving a noisy area or piece of equipment, many people commonly experience both of these symptoms. The temporary hearing loss is difficult to detect unless a hearing test is performed.

This temporary hearing loss was taken into consideration in the exposure limits listed in Figure 3. For example, should you be exposed to a noise level of 100 dBA for two hours, the remaining 22 hours of that day's exposure should be at a noise level below 90 dBA. This

allows the ear to recover from the temporary hearing loss. This recovery period varies, depending upon the individual, the severity and length of exposure.

Hearing usually returns almost completely in 12 to 14 hours if there is no more noise exposure. Any amount of hearing that does not return becomes a permanent threshold shift (PTS) or permanent hearing loss. With repeated exposure, the effects are cumulative.

Tinnitus is a general symptom of the auditory system not functioning properly. If you have persistent tinnitus, consult a physician. If you experience tinnitus after exposure to noise, it is a sign of overexposure. Since some people are more susceptible to noise damage than others, one person may experience more tinnitus or damage than another with exposure to the same noise.

People who have damaged their ears permanently from overexposure to noise often have constant ringing in their ears. Some just learn to live with the ringing; others cannot stand it and seek professional help. For the most part, physicians and audiologists can do very little to alleviate tinnitus.

The permanent damage that occurs from overexposure to noise results in a hearing loss that is most annoying and deceptive. In general, most noises damage the hair cells near the base of the cochlea, where high-frequency information is processed. High-frequency hearing loss creates several problems:

- Under ideal listening conditions, speech may still sound mumbly (especially women's and children's voices). The listener is aware that someone is speaking but cannot understand the message. Unfortunately, normal-hearing people expect that, if speech can be detected, it can be understood. When this doesn't occur, they lose patience with the hearing-impaired listener.
- The ability to identify the source of sound is greatly reduced, and the listener seems inattentive.
- When there is background noise, the listener with a high-frequency hearing loss cannot separate one voice from another. Since all the voices are jumbled together, he or she understands no one, and since social functions and group meetings become a chore, the individual begins to avoid them.
- With noise-induced hearing loss, there is often a reduced tolerance for loud sounds. Thus, the level of a sound must be high before it is understood, but if it is slightly higher, it may be intolerably loud.
- With noise-induced hearing loss, hearing aids can help, but they do not totally restore the quality of hearing that was present before the loss.

The psychological effects of noise are more difficult to describe. Psychological effects such as depression and nervousness are a result of the ear's inability to adjust to sound. The eye has a very effective means of adjusting to light, but people never get "used" to noise. Instead, they usually adjust mental attitude, rather than hearing compensation. Subconscious frustrations can result when noise is endured, but the body system cannot adjust to it.

The effects of noise on communications are quite obvious. Did you ever try to communicate with someone while a tractor was running or around a grain dryer without yelling? This can be a major problem in an emergency situation.

Noise-induced hearing loss is a major problem because people are unaware of its warning signs and effects until it is too late. Since there is strong social pressure to have normal hearing, an individual rarely admits to having a hearing problem until the effects are very substantial. Early awareness and corrective action are essential to eliminating noise as a hearing hazard.

Reducing exposure to agricultural noise

Engineering controls. When practical and economically feasible, engineering controls are the most effective ways to reduce noise exposure because they reduce sound level at the source. Some examples are:

- replacing worn, loose, or unbalanced machine parts to cut down on the amount of vibration generated.
- making sure that machine parts are well-lubricated to cut down on noise exposure created by friction.
- installing a good, high-quality muffler on all engine-powered equipment to reduce vibration produced by airflow.
- isolating yourself from the noise source with an acoustically-designed cab. In recent years, farm machinery manufacturers have designed cabs that reduce noise level exposure to safe limits. Many of the new tractor cabs may reduce an operator's noise exposure by at least 10 to 15 dBs.

Before purchasing a new tractor, consider the use of an acoustical rollover protective cab. Just as tractors are different, so are cabs in their ability to reduce noise levels. Sound data is available on most new tractors as part of the Nebraska Tractor Test Report.

To get information on the sound levels of various tractor models, write to: Nebraska Tractor Test Data, Department of Agricultural Engineering, University of Nebraska-Lincoln, College of Agriculture, Nebraska 68583. Ask for publication MP37. Tractor dealers should also have this information for any tractor tested at Nebraska.

Reduction of noise exposure on new tractors is only a part of the total noise problem in agriculture. Additional noise engineering must be done on grain dryers, combines, pickers, elevators, chain saws, shellers, grinders, mixers, pulverizers, snow blowers, conveyors, grain roller mills, to name just a few. Noise not eliminated by engineering must be controlled by altered work schedules.

Altered work schedules

A second alternative to preventing noise-related problems is to reduce the amount of exposure to high sound levels on farms. Arrange work schedules, when practical, so that farm workers do not exceed the allowable exposure limit to a high noise source.

For example, for a tractor that produces a noise level of 95 dBA, the safe exposure is four hours per day per person. Try to arrange work schedules to let farm workers exchange work activities so that no one person is exposed to the noise for more than four hours a day.

Personal protection equipment

The final alternative is to wear some type of hearing protection that reduces noise exposure. The two basic types of hearing protection are ear muffs and ear plugs.

Ear muffs (see figure 4) are the most effective. The attenuation (noise reduction) provided by ear muffs varies widely due to differences in size, shape, seal material, shell mass, and type of suspension. Some *may* attenuate sound by as much as 40 dBs.

To get good quality muffs, deal with a reputable firm. Examine them for comfort, construction, seal, and attenuation. Manufacturers supply attenuation data for their product, so you can evaluate their effectiveness.

Ear plugs (see figure 5) are available as pre-formed inserts made of rubber, plastic, or foam and hand-formed inserts of disposable materials such as wax or Swedish Wool. For agricultural use, wax or Swedish Wool has little value from a sanitation standpoint (must be changed daily and must be shaped by hand before inserting) and because of their lower attenuation level.

Pre-formed ear plugs may be cheaper, but due to the difference in the shape of a person's ear canal, trained personnel should fit each individual for plugs. The wearer must also know how to properly insert the ear plug. When purchasing ear plugs, follow the directions closely so that a snug, tight fit is obtained in the ear canal when the plug is inserted.

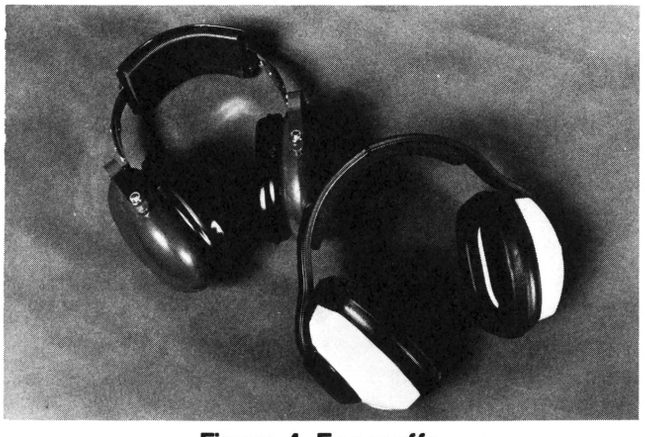

Figure 4. Ear muffs.

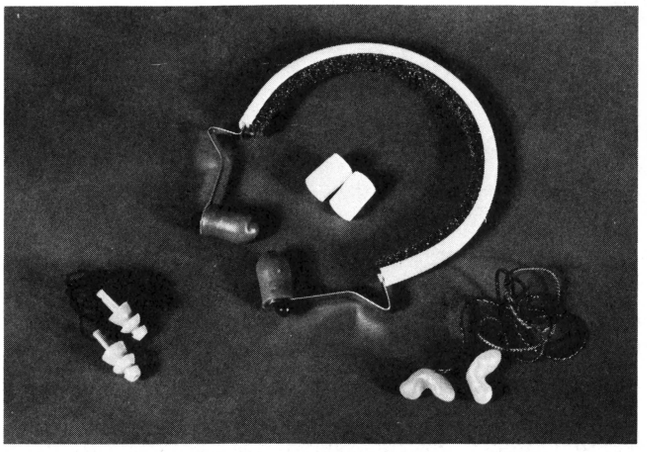

Figure 5. Ear plugs.

WARNING: *Cotton should never be used for the purpose of reducing noise exposure.* Cotton cannot block out high frequency sound and will provide no protection from high sound levels.

Ear protective devices will not block out all sounds. They will block out only those sounds that are dangerous to hearing. Machinery sounds differently when you are wearing ear protection, but with continuous use, you can learn the new sounds and still be able to determine whether the machinery is operating properly.

Operators who have suffered previous hearing losses may find that when using ear protection, they are unable to detect certain sounds necessary to assure proper machine operation. In these cases, it may be necessary for the operator to remove the ear protection to check for these sounds. *But remember to properly replace the ear protection to protect against further hearing loss.*

Have your hearing tested

If you are continually exposed to high sound levels, you should have a hearing test periodically. This test, called an audiogram, will reveal signs of hearing loss as a result of high sound level exposure. If a hearing loss is noted, take necessary steps to reduce exposure, and thus eliminate further damage to your hearing.

It's up to you

If you allow your ears to be exposed to the invisible dangers of agricultural noise or other high sound level sources, the result could be a permanent loss of hearing. You can make the difference between a life with all the joys of sound or a life of silence by following the safe work procedures outlined in this guide.

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