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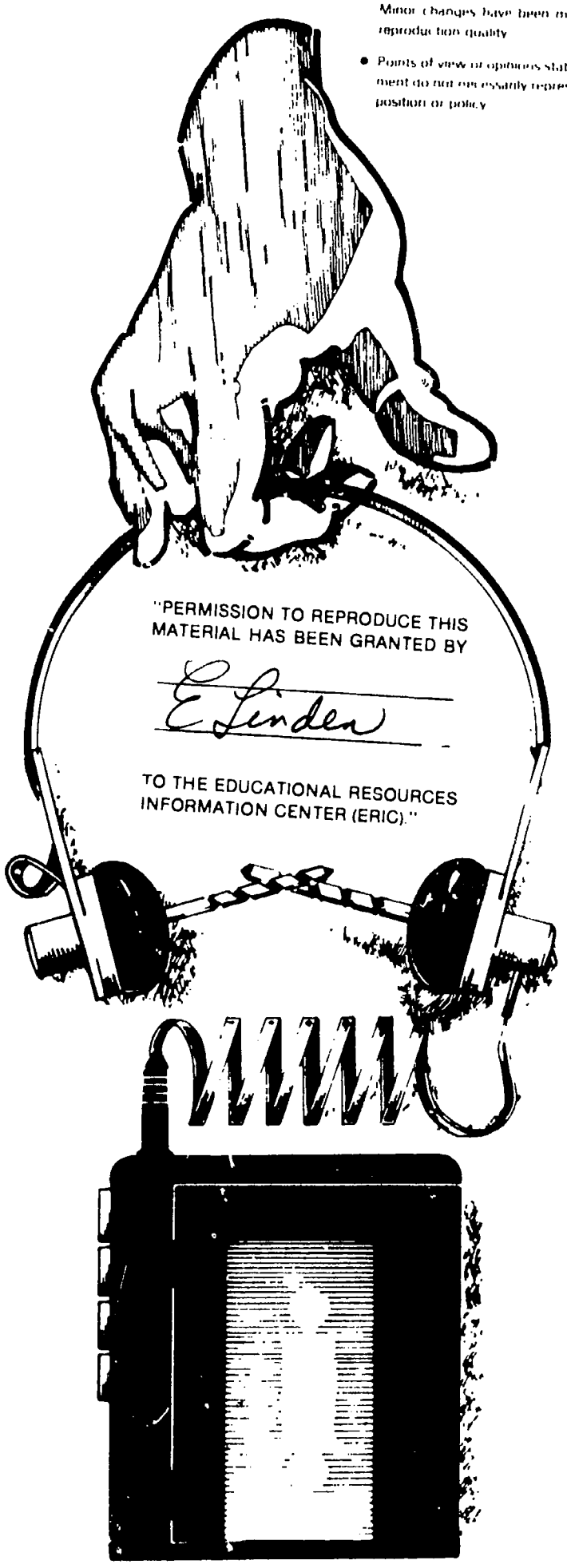
ABSTRACT

This guide is designed to assist industrial arts teachers in expanding their knowledge of hearing conservation and to enable them to answer some routine questions that their students may have concerning hearing protection and hearing loss. Addressed in the individual sections of the guide are the following topics: industrial arts, hearing protection, and the law; requirements for ear-protecting devices as set forth in the Iowa Code; legal limits for noise exposure; the structure and functioning of the ear; commonly asked questions about the ear; procedures for measuring hearing; noise and hearing loss; audio demonstration of simulated hearing loss; symptoms of hearing loss; procedures for establishing a hearing conservation program; kinds of hearing loss; the effects of noise on hair cells; and sources of help in implementing a hearing program. A bibliography and list of suggested references conclude the guide. (MN)



A Guide for Iowa Industrial Arts Teachers For the Prevention of Hearing Loss

Iowa Department
of
Public Instruction

October, 1984

State of Iowa
DEPARTMENT OF PUBLIC INSTRUCTION
Special Education Division
Grimes State Office Building
Des Moines, Iowa 50319

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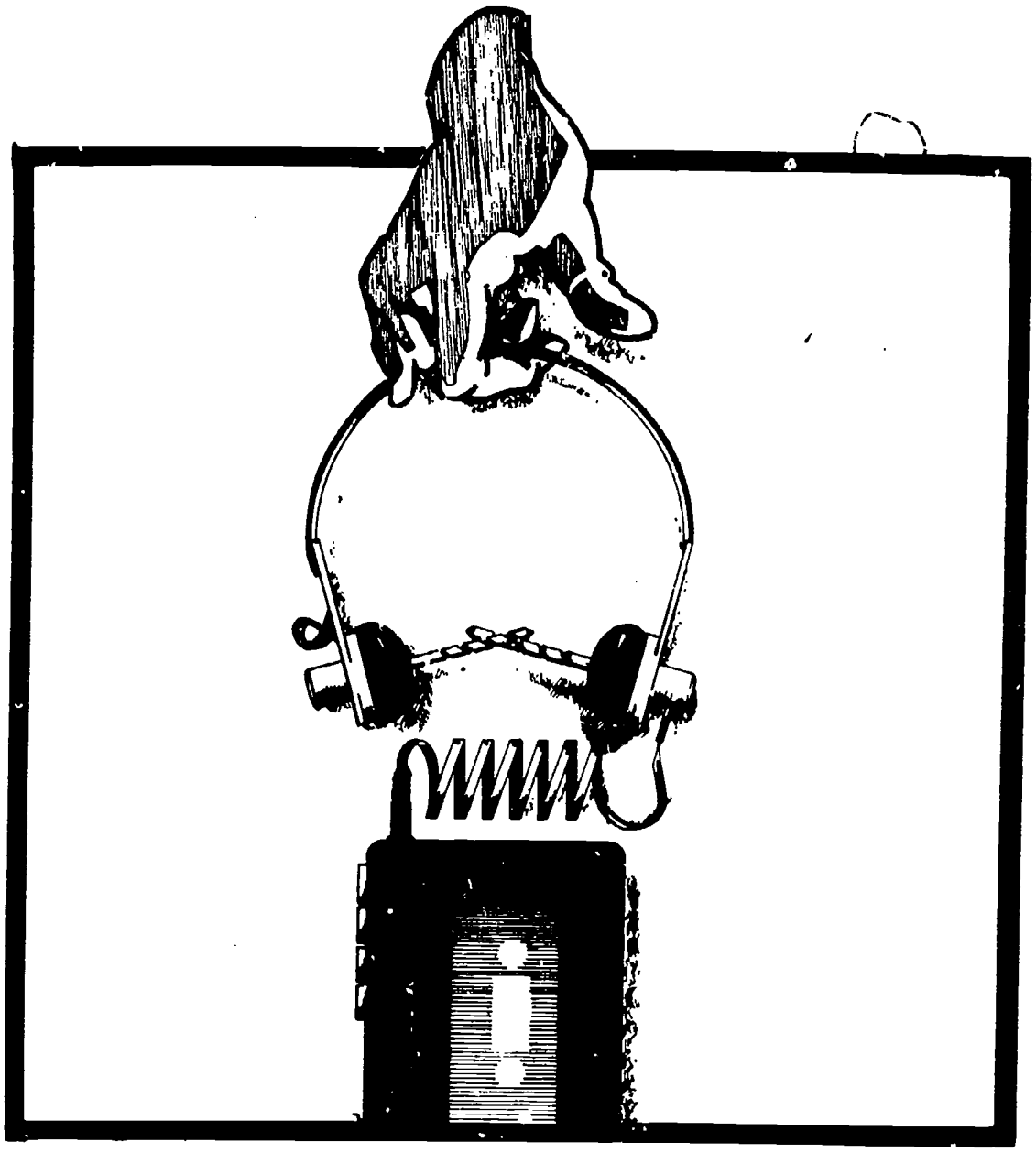


A Guide for Iowa Industral Arts Teachers

For the prevention of Hearing Loss

Recent studies have shown that there has been a significant increase in noise-induced hearing loss in junior/senior high school students. Some of this hearing loss has been attributed to noise exposure in school industrial arts laboratories.

A recent survey of Iowa industrial arts teachers showed:

Teachers were not aware of the hazards of noise exposure to their students and their obligation under the Iowa law requiring hearing protection.

Teachers were not aware of the hazards of noise-induced hearing loss to themselves and the high incidence of reported hearing loss in their profession.

Purpose of the Guide:

To assist teachers in expanding their knowledge on hearing conservation and to enable them to answer some routine questions that their students may have concerning hearing protection and hearing loss

To present this hearing conservation guide in two periods including the audio cassette tape simulation of hearing loss.

To raise the awareness of students regarding the hazards of excessive noise in both the laboratory or shop environment and everyday living experiences.

To show the industrial arts teachers how to begin a hearing conservation program in the school.

Industrial Arts, Hearing Protection and the Law.

Researchers have showed a growing percentage of secondary school students have high-frequency hearing losses. Significantly more males than females are showing noise-induced hearing loss.

Noise-induced hearing loss is caused by exposure to too great of a noise level (too loud), for too long of a time period. Noise-induced hearing loss is PERMANENT. Researchers are pointing to noise-induced loss in young men caused by gunfire, loud music, and high school shop classes. Not only should we be concerned about students, WHAT ABOUT THE TEACHERS WHO ARE EXPOSED TO NOISE ALL DAY, NOT JUST ONE PERIOD?

Note that a recent survey of industrial arts teachers in Iowa showed the following statistics:

54% of the industrial arts teachers surveyed indicated they may have acquired a hearing loss due to their occupation! HOWEVER, ONLY 2.7% ALWAYS wore hearing protection, 33% SOMETIMES wore hearing protection and 62% NEVER wore hearing protection!

DOES YOUR SHOP REQUIRE THE USE OF HEARING PROTECTION? IF NOT WHY NOT?

DID YOU KNOW THAT THE STATE OF IOWA REQUIRES HEARING PROTECTION TO THE SAME DEGREE AS EYE PROTECTION?

LETS EXAMINE THE IOWA CODE TO SEE WHAT IT SAYS.

280.11. Ear-protective devices

Every student and teacher in any public or nonpublic school shall wear industrial quality ear-protective devices while the student or teacher is participating in any phase or activity of a course which may subject the student or teacher to the risk or hazard of hearing loss from noise in processes or procedures used in any of the following courses:

1. Vocational or industrial arts shops or laboratories involving experiences with any of the following:
   a. Milling, sawing, turning, shaping, cutting, grinding or stamping of any solid materials.
   b. Kiln firing of any metal or other material.
   c. Electric arc welding.
   d. Repair or servicing of any vehicle while in shop.
   e. Static tests, maintenance or repair of internal combustion engines.
   f. Letter press, paper folders, monotype.

It shall be the duty of the teacher or other person supervising the students in said courses to see that the above requirements are complied with. Any student failing to comply with such requirements may be temporarily suspended from participation in the course and the registration of a student for the course may be canceled for willful, flagrant or repeated failure to observe the above requirements.

The board of directors of each local public school district and the authorities in charge of each nonpublic school shall provide the safety devices required herein. Such devices may be paid for from the general fund, but the board may require students and teachers to pay for the safety devices and shall make them available to students and teachers at no more than the actual cost to the district or school.

"Industrial quality ear-protective devices", as used in this section, means devices meeting the American National Standard for Measurement of the Real-Ear attenuation of Ear Protectors at threshold promulgated by the American National Standards Institute, Inc.

"Noise" as used in this section, means a noise level that meets or exceeds damage-risk criteria established by the present federal standard for occupational noise exposure, Occupational Safety and Health Standards.

Acts 1974 (65 G.A.) ch. 1168, 13.

Hearing conservation is not a frill, it is MANDATED BY STATE LAW!

The responsibility of providing the necessary funding for noise reduction and hearing protection rests with the school administration. Funds for providing said protection must come from the administration, not the budget of the shop teachers.

Teachers, for their part, must enforce the wearing of hearing protection.

HOW DO YOU KNOW IF YOU ARE EXCEEDING THE LEGAL LIMITS FOR NOISE EXPOSURE?

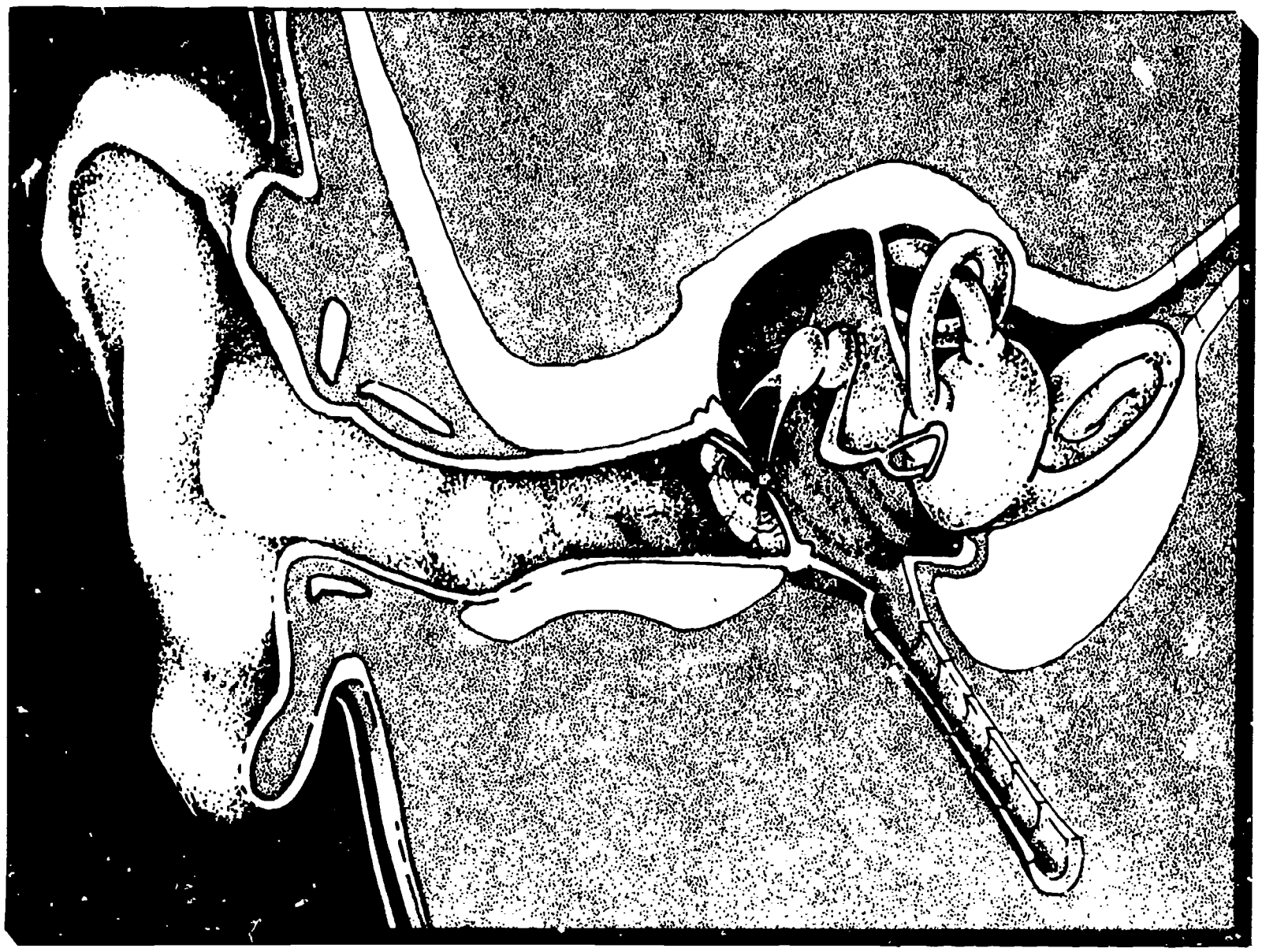
The Iowa Code refers to the current federal regulations for noise exposure. The damage-risk criteria established by the Occupational Safety and Health Administration, OSHA, gives the following time limits for various amounts of noise exposure. These are the per day limits:

Noise level	Time Allowed
85 dBA	16 hours
90 dBA	8 hours
95 dBA	4 hours
100 dBA	2 hours
105 dBA	1 hour
110 dBA	.5 hour
115 dBA	.25 hour

NO EXPOSURE OVER 115 dBA ALLOWED FOR ANY AMOUNT OF TIME!!!

For example, if you operated a machine with noise-levels of 106 dBA for more than 52 minutes a day, you would be exceeding the allowable legal levels and you would very likely develop noise-induced hearing loss over time.

Keep in mind, these noise-levels are for only one machine running at a time. Combinations of different machines and running different stock can vary noise-levels greatly.



HOW MUCH NOISE IS TOO MUCH?

A RULE OF THUMB — If you have to raise your voice almost to a shout and you are within 3 feet of the listener, that's an indication of too much noise and hearing protection is necessary.

The Ear and How It Works

In order to understand how the ear is damaged by excessive sound we need to understand some facts about the ear.

For discussion, the ear is divided into three parts, OUTER, MIDDLE and the INNER ear.

THE OUTER EAR

The outer ear includes the outer ear or pinna, and the ear canal. It functions to collect sound to a small degree but functions mostly to PROTECT the delicate middle and inner ear from temperature extremes, dirt, bugs, and water. Earwax, or cerumen, is only produced at the outer 1/3 of the ear canal and usually moves out the canal by drying up and falling out in flakes. Earwax is a natural insect repellent and it lubricates the tender ear canal and prevents it from drying, cracking and ITCHING.

THE MIDDLE EAR

The middle ear includes the eardrum, called the tympanic membrane, middle ear bones called ossicles, and the eustachian tube. The three bones, labeled from outer most to inner most, are mal'eus, incus and stapes. Their more common names are hammer, anvil and stirrup.

The middle ear serves to transfer and amplify the sound waves from the outer ear into the inner ear. The middle ear amplifies or increases the intensity of the sound from the outer ear by two ways. The bones function with a lever action, and the eardrum, which has a large collecting surface, tranfers the energy to the much smaller surface of the round window under the inner most bone, the stapes or footplate.

THE INNER EAR

The inner ear transforms the mechanical fluid waves sent into the cochlea, or inner ear into a nerve impulse, by a shearing action across tiny hair cells. When the hair cells are bent over they are stimulated to generate and send an electrical signal through the hearing nerve to the brain.

A FEW COMMONLY ASKED QUESTIONS AND ANSWERS ON THE EAR

Q: How much does the outer ear or, pinna, contribute to hearing? A: Very little, a person would hardly notice if it was gone, except to hold up their glasses!

The eardrum or tympanic membrane is very sensitive to pressure changes against it: Q: Why do I feel pressure in my ears when going up a large hill or riding in an elevator? A: The pressure is caused by the thinner air pressure on the outside of the eardrum and the thicker air on the middle ear side of the eardrum. The eardrum is being pushed out by the difference in pressure. The popping sound you often hear is the result of equalizing of the air pressure when air comes into the middle ear side of the eardrum through the eustachian tube. (The other end of eustachian tube opens directly behind the nose in the throat.)

Q: Why did the doctor take out my adenoids when I had ear infections?

A: Sometimes adenoids grow around the opening of the eustachian tube and prevent it from allowing air to go into the middle ear.

Q: How much does the eardrum move when sound waves strike it?

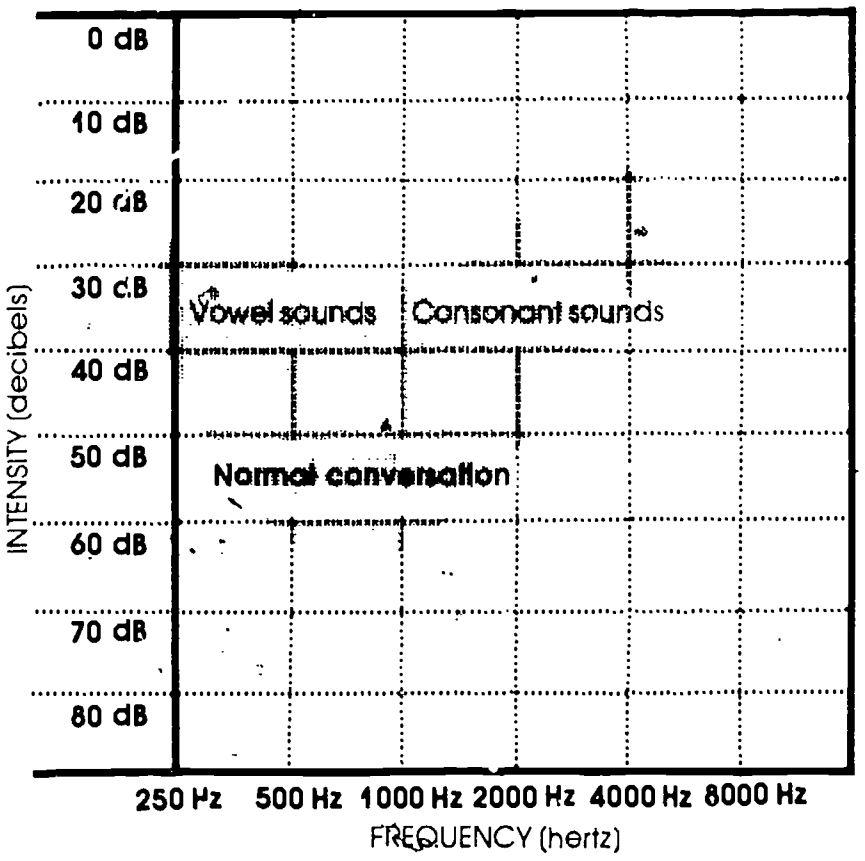
A: The movement of the eardrum can be very minute and still cause the sensation of hearing. The eardrum needs to move only a millionth of an inch for us to perceive a sound!!

Q: I had tubes put in my ears when I was little, did that hurt my eardrum and why didn't it cause a hearing loss?

A: The ventilation tubes are put into eardrums to replace the eustachian tube function of letting air into the middle ear. The tubes are put in to keep fluid from building up in the middle ear. They actually reduce hearing loss caused by the fluid. The tubes are very small, about as big around as the lead in a pencil.

Measuring Hearing

The chart used to record the results of hearing testing is called an audiogram. The chart records low pitches (low frequency) on the left side and high pitches (high frequency) on the right side. Somewhat like the piano key board, low tones on the left and high tones on the right.



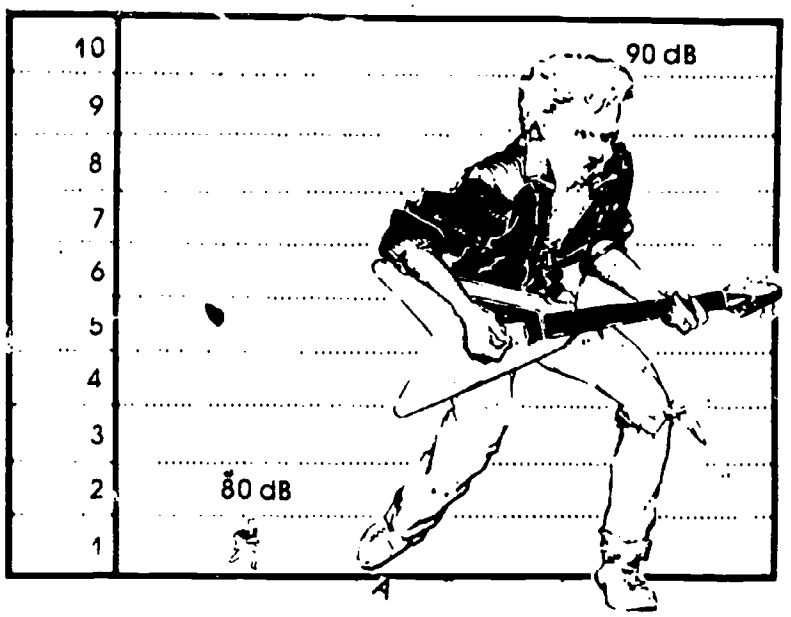
Loudness (intensity) is recorded in decibels or dB. The faint or quiet tones having a small number of decibels (dB) at the top of the graph and louder tones are recorded with a greater number of decibels (dB) nearer the bottom of the audiogram.

Normal hearing sensitivity would be anywhere from about 0 dB at the top down to 25 dB. (Sensitivity is measured by testing how quiet a person can hear the different pitch tones. The quietest level a person can hear is recorded as their threshold.) Marks made below 25 dB mean that the tones had to be made louder than for the average normal ear. The greater the hearing loss the farther down on the page the thresholds would be recorded.

Note on the audiogram that vowels are marked on the left or lower pitch side and the consonants of speech are more high pitch and not as loud. When persons get noise-induced hearing loss they have damage to their higher pitch hearing. This causes them to hear the vowel sounds of speech but not consonant sounds. When one cannot hear the consonant sounds one cannot understand. You can hear people talking but you cannot understand what they are saying. This problem is made much worse in noise because noisy listening situations tend to cover up more of the high pitch consonant sounds.

Decibels

Decibels are recorded on a logarithmic scale. 10 dB is 10 times greater than 0 dB. 20 dB is 100 times greater than 0 dB. 30 dB is 1000 times greater in intensity than 0 dB. A logarithmic scale is necessary to record hearing sensitivity because we humans can hear over a TREMENDOUS range of intensities. In fact, the faintest sound we can just detect is one trillion times softer than the loudest sound we can tolerate!! Logarithms are the short hand or scientific notation for recording large numbers. An increase of 10 dB at the higher intensities requires many millions of times greater increase in intensity than at the lower end of the dB scale.



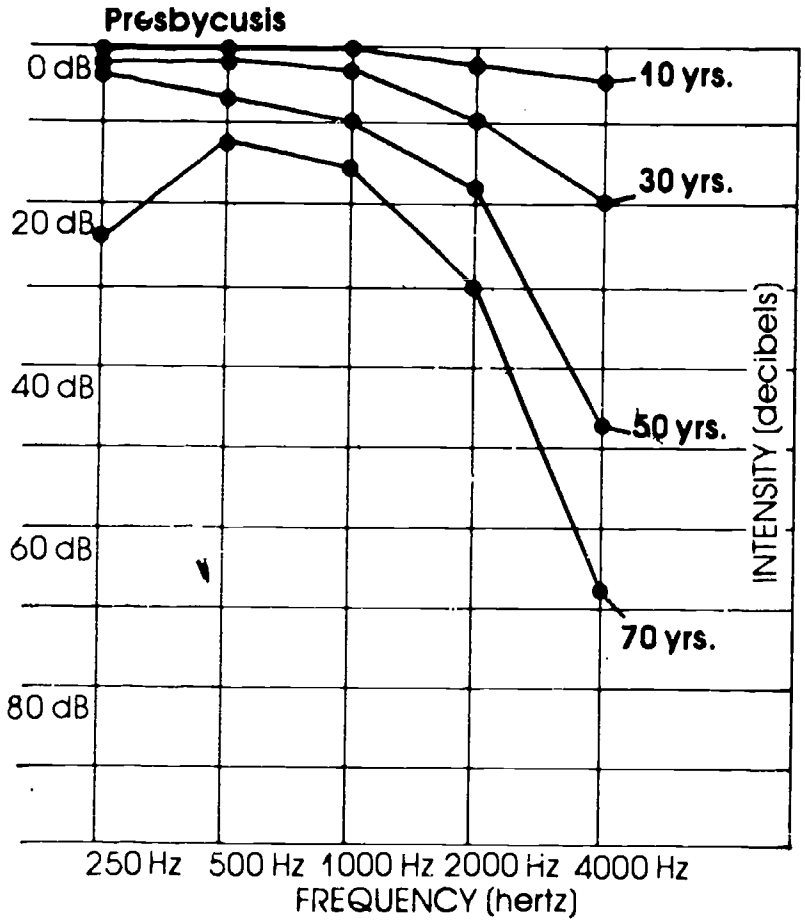
What does dBA mean?

The dBA scale means the sound level meter is measuring with an A weighting. The A weighting simulates listening with a real ear. The real ear, for example, is not equally sensitive to all the frequencies. In particular, the lowest and highest pitches take a lot more sound energy before the human ear can detect the presence of a sound. The A weighting takes this lack of sensitivity to low and high pitches into account.

A Stereo Example:

The ears' reduced sensitivity to low and high pitches at low volume settings explains why your stereo has a LOUDNESS switch. Near our thresholds especially, we are much less sensitive to low and high pitch sounds. So when you play your stereo at a lower volume, you use the LOUDNESS switch to boost the low and high frequencies to compensate for our poorer sensitivity to those frequencies. When we turn the volume up high enough above our thresholds, then our sensitivity becomes equal for all the pitches and we can hear the low, mid and high pitch tones equally and we don't need the loudness switch.

AUDIO DEMONSTRATION OF SIMULATED HEARING LOSS



The audio cassette tape (it can be played on a monaural or stereo cassette tape recorder), contains several samples of simulated hearing loss.

To begin, play the tape at a moderate volume setting, being careful not to set the volume too high to cause distortion.

The tape begins with a sample of music as it sounds to a normal hearing person. Then the music will be filtered to simulate what the same music sounds like to a 70 year old person. Listen carefully to the higher pitch sounds. Impress upon the students that they can easily acquire the hearing of a 70 year old person by subjecting their ears to excessive noise exposure!

Then speech is played as it sounds to a normal hearing person and one with high frequency hearing loss. Notice how you can hear the person talking but they cannot be easily understood.

NOISE AND HEARING LOSS

Noise can damage your hearing in two ways. The painless, gradual way that goes unnoticed until it is too late is called noise-induced hearing loss. This loss is acquired by exposure to noise over a relatively long period of time. The kind of loss we are trying to prevent by educating teachers and students to the hazards of loud noise. The other way noise can destroy hearing is by a one-time very loud exposure which is called noise trauma. Some examples might be an explosion, a firecracker going off near the ear, getting slapped across the ear with the open hand or a gun going off near the ear. Noise trauma can damage any part of the ear.

The Occupational Safety and Health Administration gives the time limits shown below for various amounts of noise exposure. These are the per day limits:

85 dBA	16 hours
90 dBA	8 hours
95 dBA	4 hours
100 dBA	2 hours
105 dBA	1 hours
110 dBA	.5 hours
115 dBA	.25 hours

NO EXPOSURE OVER 115 dBA ALLOWED FOR ANY AMOUNT OF TIME!

Notice that for every increase of 5 dB the amount of exposure is reduced by one-half. Excellent research has been done that shows that even these limits allow some persons to develop noise-induced hearing loss. There is a great deal of variation in the amount of noise people can tolerate without acquiring a permanent hearing loss. Unfortunately, some people require very little noise exposure before their hearing is damaged. There is no way to predict who is more susceptible. The OSHA guidelines are not adequate to protect every one from developing hearing loss. So these limits should be viewed conservatively. No research has been done to study the effects of noise on younger ears but unfortunately studies are showing young children are acquiring noise-induced hearing loss.

WHAT ARE SOME SYMPTOMS OF TOO MUCH NOISE EXPOSURE?

Ringing in the ears

Talking too loud after noise exposure

Hearing seems "dull" or muffled

Difficulty understanding conversation

Remember however, that you may never get any of these warning signs until it is too late and you have developed a hearing loss!!

ESTABLISHING A HEARING CONSERVATION PROGRAM

ALL SCHOOLS are required to have a hearing conservation program if any TEACHERS or STUDENTS are exposed to average noise levels of 85 dBA or greater over their 8 hour work day.

EXAMPLE: If someone works on a wood planer, having a noise level of 114 dBA for more than 15 minutes, they have been exposed to their entire daily noise dose. A Hearing Conservation Program is REQUIRED BY STATE LAW.

A school hearing conservation program in industrial arts would include:

1. Sampling of noise levels in the shop on an annual basis or when new machines or processes are installed.
2. Annual hearing evaluation of teachers.
3. Educating students to the harmful efffects of noise and what they can do to prevent hearing loss.
4. Reduction of noise levels by retrofitting, dampening and replacing noisy machines or processes with quieter ones.
5. Required wearing of hearing protection by all students and teachers.

Sound surveys provide the noise levels of the various machines. Typically the noise levels emitted by machines are relatively stable except when maintainance is neglected.

Hearing testing is the only way that the hearing sensitivity of teachers and students can be monitored for the harmful effects of noise. If significant shifts in hearing sensitivity are noted then specific steps must be taken to prevent further loss of hearing.

Hearing protection usually offers the most cost effective means of protecting teachers and students hearing. Hearing protection can be used immediately until other modifications can be made to reduce noise levels.

It is important to have several types of hearing protection available in the noise areas because some persons cannot wear a particular type of protection due to anatomical differences or physical changes due to surgery or injury. Two types of hearing protectors would be appropriate for use in school industrial arts shops, earplugs and earmuffs.

Disposable earplugs such as the E-A-R brand foam plug are a very good choice of protection. They offer a high amount of sound reduction, one-size-fits-all so the ears do not have to be measured individually for sizes and they are inexpensive to purchase, less than twenty cents a pair. These type of plugs can be washed and used repeatedly.

Earplugs must be kept clean at all times. Clean hands to insert them the first time, and as often as necessary when they work out from talking, chewing, etc. Washing with ordinary hand soap and water daily is recommended.

Earmuffs are recommended because they can be worn by different individuals without need for sanitation. They are appropriate where worn for shorter periods of time, or with repeated need to take them on and off frequently.

Earmuffs must be maintained to work effectively. Three major parts of earmuffs must be maintained in order to get adequate protection. The headband cannot be sprung to make them fit looser. The sound insulation inside the muff cup must be in good condition and the cushion around each muff must be free from cuts and tears. Muffs constructed entirely of plastic, including the headband, are recommended because they are diaelectric and the plastic bands cannot be sprung like metal banded muffs.

Take these action steps toward hearing conservation:

1. Borrow a sound-level-meter from your local area education agency or buy one.

2. Measure the sound levels of the machines in your shop. Here is a list of machines and the dBA levels measured in the Des Moines public schools in May 1972.

3. Make a poster listing the dBA levels and the machine. List the allowable exposure times from the OSHA table. Are your machines quieter than the one's listed here?

Shop Area	Tool/Machine	dBA Level
Auto	Pneumatic Metal Chipper	110-122
Wood	Planer-"working"	108-118
Metal	Electric Metal Grinder	102-106
Wood	Joiner	103-104
Wood	Plainer-"idling"	102-104
Auto-diesel	Diesel motor "revved up"	101
Metal	Arch Welder	88-100
Wood	Electric Belt Sander	98-99
Metal	Bandsaw	98
Wood	Table Saw	96-99
Wood	Air gun	95-98
Wood	Orbital sander	94-96
Metal	Kiln	94-96
Wood	Table Saw "idling"	94-96
Wood	Belt/disc sander	92-93
Print	"Monotype"	93
Auto-diesel	Diesel motor "idling"	92
Print	Paper folder	87
Print	Letter press	84

A study completed in 1983 showed the following levels for typical shop machines in a four state survey:

SHOP AREA	MACHINE/TOOL	dBA	SHOP AREA	MACHINE/TOOL	dBA
Welding	grinder	96		air blower	94
	sander	105		air compressor	74
	chipping	108			
			General Shop	band saw	92
				arm saw	109
Building	planer	114		table saw	102
Construction	table saw	104		planer	110
	hammering	94			
	circular saw	103			
	saber saw	98	Auto Shop	air chisel	102
			(Body)	sander	104
				grinder	92
Auto Shop	impact wrench	96		air blower	93
(mechanical)	air chisel	104		hammering	106

NOISE AND HEARING LOSS

It is not only the noise level that counts in how the ear is damaged but also how frequently we are exposed to noise. Hearing damage comes from the amount of noise exposure and the intensity of the noise We therefore measure noise dosages. REMEMBER, it is not just the noise that we are exposed to in the shop but the accumulative effect of all the noise we are exposed to during the day. (The sound level recorded in the band rooms for example in the above study were 90-110 dBA.)

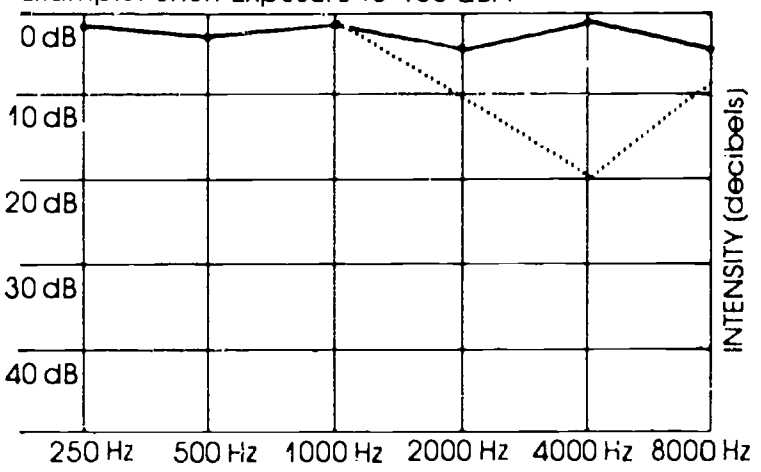
KINDS OF HEARING LOSS

Exposure to loud noise for a short time can actually cause your hearing to be reduced, that is you get a temporary hearing loss. Can you remember a time when you might have been exposed to loud sound for a while and then when you got out of the noise your hearing seemed to be "dull"? How about after a tractor pull or rock concert? If you were given a hearing test then your hearing would be reduced like that shown in the curve labeled TTS.

You may have also suffered temporary tinnitus or ringing of the ears. This is always a sign that you are getting too much noise. REMEMBER, you may think your ears are "tuff" and can take noise, and they can, but you will get PERMANENT HIGH FREQUENCY HEARING LOSS. The people who say noise used to bother them but they "got used to it", really don't understand their situation. Their used to it because they lost some of their hearing!

Repeated noise exposure that causes temporary threshold shift will lead to permanent threshold shift or PTS. PTS is the permanent sensorineural hearing loss that results from excessive noise exposure.

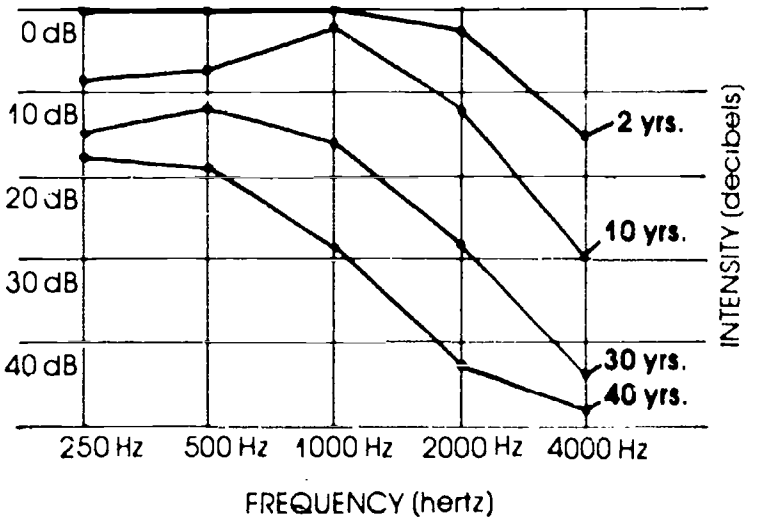
Temporary Threshold Shift (TTS)
Example: Short Exposure to 100 dBA



HOW ARE HAIR CELLS DAMAGED BY NOISE?

The hair cells do not have a direct blood supply because they are so sensitive they would respond to blood flowing around them. They receive food and oxygen from fluids and cells surroundi..g them. When we expose our hair cells to high noise they work hard and use up their oxygen and nutrients. They become "hungry" and need a "breather" from working hard and they develop for us temporary hearing loss. This temporary hearing loss is the TTS described above. If however we repeatedly expose our ears to excessive noise, they are literally "starved and strangled to death". Once the hair cells are damaged or destroyed they can never be repaired or grow back. NOISE-INDUCED HEARING LOSS IS PERMANENT!! The PTS described above.

Permanent Threshold Shift (PTS)
Example: Continuous Exposure to 100 dBA



WHERE TO LOOK FOR HELP IN IMPLEMENTING A HEARING CONSERVATION PROGRAM

Area Education Agency audiologists or audiologists affiliated with ear, nose and throat physicians can offer assistance in setting up hearing conservation programs. Also audiologists located at university communicative disorders departments and community speech and hearing centers.

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Reference Materials

An annotated listing of noise and hearing conservation films and videotapes is available from:

Mr Elliott H. Berger
Manager, Acoustical Engineering
E·A·R Division, Cabot Corporation
7911 Zionsville Road
Indianapolis, Indiana 46268

Hearing protection can be purchased from suppliers such as:

IESCO
P O Box 7151
1206 Grand Ave.
Des Moines, Ia 50309
Phone 515-243-6169

Mine Safety Appliances Company
600 Penn Center Boulevard
Pittsbourgh, Pennsylvania, 15235
Phone 412-273-5000

Bilsom International, Inc.
11800 Sunrise Valley Drive
Reston, VA 22170
Phone 703-620-3950