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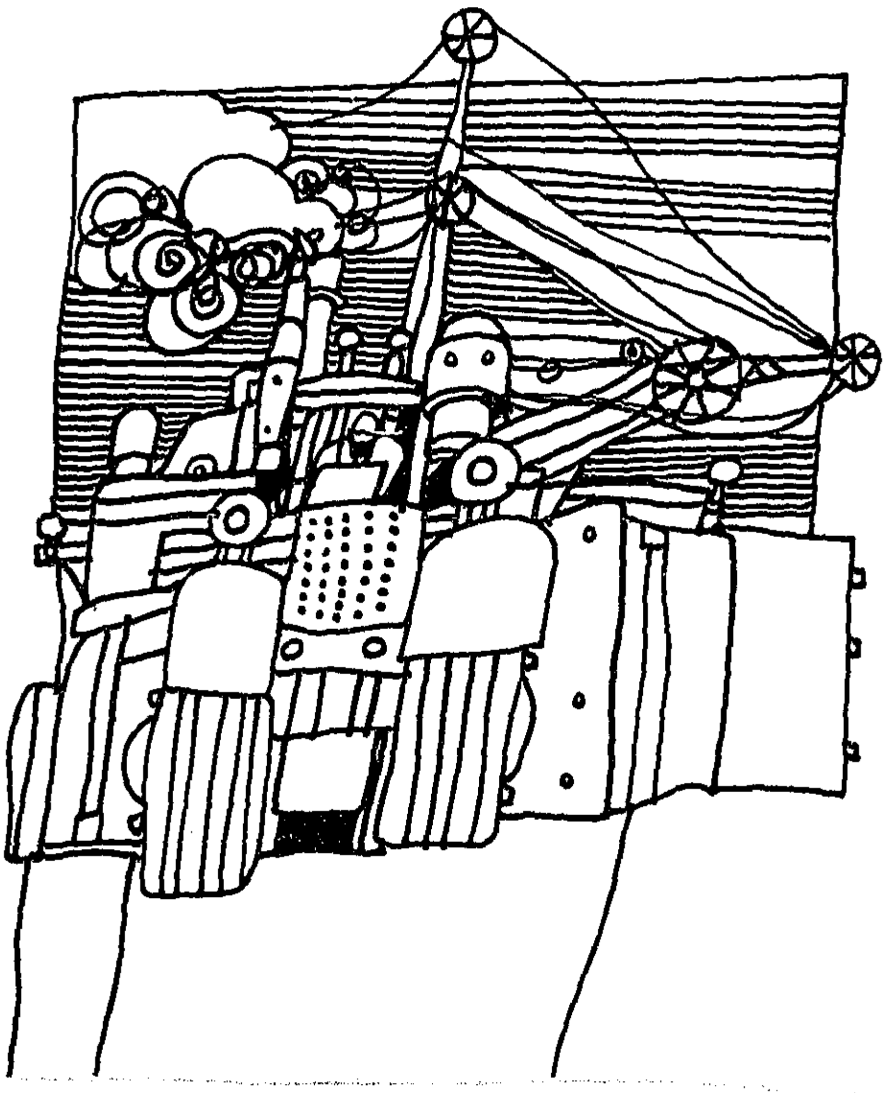
Understanding Noise and Noise Control

Instructional Units for Operating Engineers in Apprenticeship Programs



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UNDERSTANDING NOISE AND NOISE CONTROL

Instructional Units for Operating Engineers in Apprenticeship Programs

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Noise Abatement and Control

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INTRODUCTION — TO THE INSTRUCTOR

DESIGN AND PURPOSE

This document is designed to serve as the basis for a self-contained program of instruction addressing noise in the total environment of the operating engineer. It is designed to be used as an independent program of instruction for operating engineer apprentices, or to be integrated with other components of a complete apprenticeship training program.

Units of Instruction

The instructional content of this document is divided into two major units.

- Unit I: Understanding Noise and Its Harmful Effects
- Unit II: Understanding Noise Control

Unit I is intended to increase apprentices' awareness of the fact that noise may pose a hazard to their hearing and may create, or contribute to, other problems affecting their lives. Unit I also addresses the ways in which noise may affect apprentices' co-workers, families, and friends.

Unit II describes the variety of sources of noise present on the work site and in the home, and describes the basic approaches to reducing noise in both environments.

In general, Unit I focuses on the questions of what noise is and why apprentices should be concerned with it; Unit II focuses on the question of what can be done about noise.

Both units are designed to serve as a text for apprentices and/or a script for instructors. Both units are divided into lettered parts which contain major concepts or categories of information. Key words describing the ideas and information items within each part are presented in the margin to the left of the text.

Questions and Activities

Discussion questions and/or activities follow most of the parts of the two units. These are designed to serve as a check on apprentices' understanding of the concepts and information presented in the text, and to provide an opportunity for apprentices to apply the concepts and information to their own personal situations, both on and off the job.

How these discussion questions and activities are used, and whether they are used, is at the option of the instructor. Instructors may wish to assign questions or activities to individual apprentices or to groups of apprentices. Instructors may request structured responses and reports, or simply rely upon unstructured discussion to reinforce the instructional content of the text.

Unit Tests

Appendix A to this document contains one test that may be administered at the conclusion of Unit I, and one test that may be administered following Unit II. These unit tests are keyed to the specific concepts addressed in the text, and contain a combination of question and exercise designs. Answer keys follow these tests in Appendix A. Here again, the use of these tests, as well as criteria for satisfactory performance on the tests, is at the option of the instructor.

It should be noted that the answer keys for the unit tests and this introductory section for instructors are the only parts of this document not intended for distribution to apprentices participating in this instructional program.

Information Sheets

Appendix B contains six information sheets designed to be distributed to apprentices at points during the instructional program (to be discussed below). These information sheets summarize key concepts and information items contained in the text, and are intended to serve as convenient information references for apprentices.

PRESENTATION OF UNITS

In preparing to present the two instructional units to apprentices, instructors may wish to consider the following points.

Unit I

- Part A is designed to establish the fact that noise can cause hearing damage — either deafness or hearing impairment. The discussion questions following this part are intended to help apprentices personalize the experience of hearing loss.

  Deafness and hearing impairment are abstract concepts for persons with normal hearing ability. It is difficult for most persons to project the feelings of anger, frustration, annoyance, fear, or isolation that may accompany hearing loss. Instructors may wish to discuss this with apprentices, and encourage them to explore their feelings about hearing loss.

A long-playing record produced by the Zenith Radio Corporation should be considered as a potentially valuable instructional aid. This record, entitled "Getting Through", helps to demonstrate the problems associated with hearing loss, and is especially effective in illustrating the difficulties that arise in everyday conversation for persons who have suffered some hearing impairment. Included on the record is a variation of a hearing test which may be taken by listeners. (Test forms are included with the record.) This hearing test is an interesting and informative exercise for listeners, and should be given serious consideration by instructors.

The record is available (free of charge for first copy) from the Zenith Radio Corporation, 6501 West Grand Avenue, Chicago, Illinois 60635. Copies may be readily available from individual local Zenith hearing aid dealers.

- Part B describes the process of hearing and describes sound in terms of its basic characteristics: pitch and intensity. Part B contains illustrations of sound waves and the structure of the ear.

  The information sheet entitled "Examples of Sound Levels Found in Work, Community, and Home Environments" is keyed to this part, and may be distributed to apprentices at the conclusion of the part.

- Part C defines noise as "unwanted sound". In this part, apprentices are helped to become aware of their neighbors (including co-workers) and themselves as noisemakers. The discussion questions following Part C encourage apprentices to think about the noise sources around them. The suggested activity — keeping a day-long log of noise exposure — may serve as an effective device to increase apprentices' awareness of noise.

- Part D describes the way in which noise can damage hearing on a temporary or permanent basis, and includes a discussion of "warning signals" given by the ears. The discussion questions which follow encourage apprentices to think about the warning signals they may have experienced in the past. The fact that many apprentices may have experienced these warning signals may be used by instructors to stimulate discussion of susceptibility to noise-induced hearing damage.

  At the conclusion of this part, instructors may wish to distribute the information sheet entitled "As Threshold of Hearing is Raised, Ability to Understand Speech Becomes More Difficult". The information contained on this sheet should be useful in stimulating discussion of hearing loss, warning signals, and hearing conservation.

- Part E describes the variables affecting noise-induced hearing damage. The key variables are noise level (measured in decibels), duration of exposure to noise, and individual differences in sensitivity to noise. In this part, the noise safety standards of the Occupational Safety and Health Administration (OSHA) are introduced, along with the noise safety goals of the Environmental Protection Agency (EPA). Instructors should take care to ensure that apprentices understand the concept of interrelatedness of noise level and time exposure to noise, as embodied in the OSHA standards and EPA goals.

  The information sheet entitled "Exposure to Noise: The Higher the Intensity, the Shorter the Time Required for Hearing Damage to Occur" summarizes the OSHA standards and EPA goals for noise safety, and may be distributed to apprentices at the conclusion of this part.

  For this program of instruction in general, and for this part in particular, a sound level meter would serve as a valuable instructional aid. These meters, which measure the sound (in decibels) produced by any sound source, may be used by apprentices to establish, for themselves, the levels at which hazards to hearing are posed. The meters may be used in classroom settings or in the home to measure the levels of familiar sounds, or may be used on work sites to measure the noise levels of equipment or tools.

  Instructors should consider the purchase of relatively inexpensive sound level meters as instructional tools. If purchase is not possible, it may be possible to obtain a meter, on loan, from an EPA Regional Noise Representative. Instructors are encouraged to contact the representative in their region for information on sound level meters and other instructional resources that may be available. A list of EPA Regional Noise Representatives appears in Appendix C.

- Part F describes problems, in addition to hearing loss, that can be created by noise. It is important that apprentices understand that noise does not have to damage their hearing in order to have some very negative effects on their lives.

  The discussion questions which follow this part require apprentices to think about noise sources both on and off the job, and to think about how they, personally, have been affected by noise. To reinforce the concepts in this part, instructors may wish to probe apprentices' thinking about the "little noises" which, when accumulated, cause nervousness and irritability. Instructors may also wish to encourage discussions of "chain reactions" which occur when one person's noise-induced irritability is passed on to other persons through anger, shortness of temper, etc.

- Upon completion of Unit I, instructors may wish to stimulate discussions or create activities which help apprentices "pull together" or integrate all of the major concepts to which they have just been exposed. For example, instructors may wish to consider forming three small groups of apprentices: the first to present the potential hazards of noise, the second to serve as "devil's advocates" and challenge the noise dangers presented, and the third to evaluate the positions taken by the two groups.

  As another example, instructors may wish to consider asking apprentices, as a group, to reach a concensus on three noises, either on or off the job, that they would want to eliminate from their lives. Individual apprentices would be required to nominate the three most dangerous and/or irritating noises they came into contact with, and decide, as a group, on just three. In this example, it is the exercise, not necessarily the outcome, that is important.

<u>Unit II</u>

- Part A is designed to establish the fact that operating engineers must protect themselves and others from potential hearing damage. Part A introduces the two key topics covered in Unit II: Recognition of sources of potentially dangerous noise, and options available to reduce noise or avoid it.

- Part B describes the major sources of noise present on a work site, and presents apprentices with an activity in which they can identify, for themselves, the various types of noise-producing equipment they are likely to be working with or working near. By indicating (estimating) the number of hours that may be spent working with or near certain equipment, apprentices may assemble a composite picture of personal noise exposure during a typical day on a work site. For this activity, the definition of "working near" the equipment (in terms of feet or yards between worker and equipment) is at the discretion of the instructor.

  Instructors may wish to offer examples of various work situations in order to stimulate apprentices' thinking about their exposure to noise-producing equipment.

  The discussion questions which follow in Part B are designed to build upon the activity. Apprentices must use the results of the activity to respond to these questions. As a group, the discussion questions are intended to help apprentices evaluate the implications of noise exposure for themselves and their co-workers.

Prior to the discussion questions, instructors may wish to distribute the information sheet entitled "Construction Equipment Noise Ranges". The information on this sheet may be useful to apprentices in their estimates of personal noise exposure on the job.

- Part C describes the basic approaches to control of work site noise. The three basic approaches — source, path, and point of hearing — are described in some detail, with specific examples of noise control methods included. In treating the subject of control of noise at point of hearing, instructors may wish to assemble examples of personal hearing protection devices for apprentices to examine. Instructors may also wish to consider classroom activities in which these devices are worn by apprentices, and in which the effectiveness of the devices is demonstrated to the wearer.

  The discussion questions at the end of this part require that apprentices apply their understanding of noise control methods to the work site.

  The information sheet entitled "Basic Approaches to Noise Control" contains a summary of the noise control methods described in Part C, and may be distributed to apprentices at any time during the treatment of this part.

- Part D illustrates the fact that the basic approaches to the control of noise are as applicable in the home environment as they are in the work environment. Part D contains a review of source control, path control, and control at point of hearing — all in the context of application in the home. The discussion questions which follow this part require that apprentices apply their understanding of noise control methods to their specific home situations.

  Following the discussion questions, instructors may wish to distribute the information sheet entitled "Some Simple Approaches to Control of Noise in the Home". This sheet summarizes noise control methods for selected appliances in the home.

  The brief text which concludes Part D offers instructors an opportunity to discuss the concept of individual responsibility for protecting the hearing and the general well-being of self and others.

Appropriate Level of Apprentice Experience

Throughout this instructional program, apprentices are asked to relate information on noise hazards and noise control to their roles as operating engineers. This program assumes, therefore, that the apprentices are generally familiar with the equipment and tools used by operating engineers, and with the work sites on which the equipment and tools are found. With this in mind, instructors should exercise judgment concerning the scheduling of this instructional program as part of an overall apprenticeship program. It is unlikely that Unit II, in particular, would be as effective during the early stages of an apprenticeship program as it would during the latter stages.

Additional Resources

The two instructional units contained in this document do not require the use of any additional instructional resources. These units represent a self-contained program of instruction. This does not mean, of course, that supplementary aids should not be considered by instructors who wish to enhance or expand upon the text, discussions, activities, and information sheets.

Many publishers, film producers, government agencies and other organizations have produced print and audio-visual materials which address the topics of hearing protection and noise control. Resource persons with experience and expertise in hearing protection and noise control may also be identified in most areas of the country. Guidance in the selection of both materials and resource persons may be obtained from the EPA Regional Noise Representative and from the Director of Training Materials Development, the International Union of Operating Engineers.

References

Information used in the preparation of the two instructional units was drawn from the references listed in Appendix D. These references also represent sources of additional information on hearing and noise that interested instructors and apprentices may wish to obtain.

INTRODUCTION — TO THE APPRENTICE

This program of instruction is intended to help operating engineers in apprenticeship programs acquire an understanding of the hazard to hearing posed by high noise levels, both on and off the job. It is intended to present a way of looking at the scope of the problem, and a way of looking at the approaches that may be taken to correct the problem.

The program is designed to move apprentices, in a steady progression, from the question of "why" be concerned about noise through the question of "how" to eliminate the hazard it can pose.

The focus of this program is on increasing awareness of high noise levels as an occupational hazard and as a threat to general health and well-being in the non-work environment. The package also focuses on methods to be used in both analyzing and correcting the noise problem.

ORGANIZATION OF PROGRAM

The information in this program is presented in two major units:

- Unit I: Understanding Noise and Its Harmful Effects
- Unit II: Understanding Noise Control

Each of these units is divided into lettered parts which contain major concepts and/or categories of information. The key points in each part are noted in the margins to the left of the text.

Questions and Activities

Included in most parts of this text are suggestions for questions to be discussed and/or activities to be conducted. The questions and activities are intended to serve as a check on the understanding of the concepts and information that have been presented in the parts, and as reinforcement for understanding of the concepts and information.

In some cases, the questions and activities address specific concepts and information contained in the parts. In some cases, the questions and activities require apprentices to project their thinking beyond the specifics covered in the part.

UNIT I: UNDERSTANDING NOISE AND ITS HARMFUL EFFECTS

Unit I is designed to

A. establish the fact that noise can cause hearing damage – deafness or hearing impairment,

B. describe the process of hearing and define sound in terms of its characteristics: pitch and intensity,

C. define noise in terms of "unwanted sound",

D. describe the way in which noise can damage hearing on a temporary or permanent basis,

E. describe the variables affecting noise-induced hearing damage, including the level of noise, time exposure to noise (using OSHA safety standards and EPA safety goals), and individual differences in sensitivity to noise,

F. describe problems, in addition to hearing loss, that can be created by noise.

In the text of this unit, these objectives are addressed in the sequence in which they are listed here. The objectives, A through F, correspond to the sections, A through F, which constitute the text.

A. NOISE CAN DAMAGE HEARING

Noise and Deafness

Let's think about the meaning of the word "deafening".

We are all familiar with the meaning of deafness, and we understand it in terms of the lack of ability to hear.

But do we understand how one loses the ability to hear?

Many persons are deaf from birth; they lack the ability to hear due to birth defects or complications which occur during their mother's pregnancy.

Many others become deaf due to diseases or illnesses contracted at some point during their lives, or due to accidents.

Still others become deaf because of exposure to noise — noise that is capable of causing irreversible damage to their hearing.

For many of us, a handicap is seen as tragic if we believe that something could have been done to prevent it.

Certainly, a preventable birth defect or illness or accident that causes deafness is tragic.

But perhaps the greatest tragedy of all occurs when deafness is caused by noise.

1. We know that deafness <u>can</u> be caused by noise.
2. We know how to identify potentially harmful noise, or to recognize it when we hear it.
3. We know how to avoid it, or to protect ourselves from it.

The tragedy is that, knowing these things, so many of us continue to incur hearing losses caused by noise.

Noise and Hearing Impairment

Noise can be deafening, <u>literally</u> deafening.

But noise does not have to produce total deafness in order for it to change our lives in some very dramatic ways.

Noise can cause hearing impairment.

When our hearing is impaired, we are not totally deaf to all sound, but we may not be able to hear a full range of sound. We may not be able to hear all of the sounds present in conversation or in music or on the street or on the job. And the sounds we do hear may be difficult to understand.

<u>Any</u> hearing loss can change our lives, because hearing plays such an important role in our lives.

- o Communication – We get along with other people at home and at work primarily through speaking and listening.
- o Learning – Much of what we learn is based on what we hear.
- o Safety – We depend on our hearing for warnings of danger.
- o Pleasure – Many of the activities we enjoy – music, sports, hobbies – depend on our ability to hear.

When we lose any ability to hear, we do not necessarily lose the ability to communicate, learn, protect ourselves from danger, or pursue our personal interests.

We may continue to do these things, but with greater effort. We must learn to adjust for our hearing loss.

Have you ever tried to imagine how your life, or the lives of your family or friends or co-workers, would be affected if you were to incur even a moderate hearing loss?

Try to imagine.

For discussion: Consider the following questions:

1. If you were to lose some or all of your hearing, what activities in your personal life do you believe would be the least affected?

2. If you were to lose some or all of your hearing, what activities in your personal life would be most affected?

3. If you were to lose some or all of your hearing, in what ways might you feel annoyed or angered, frustrated or isolated?

B. PROCESS OF HEARING AND CHARACTERISTICS OF SOUND

Under-standing Hearing Damage

The fact is that all of us, at one time or another, are exposed to noises on the job and off the job that have the potential to damage our hearing.

Noises that we have become accustomed to hearing — for example, those produced by compressors, furnaces, home shop tools, lawnmowers, food blenders, motorcycles, rock bands — can cause hearing damage if we are exposed to them for a sufficiently long period of time.

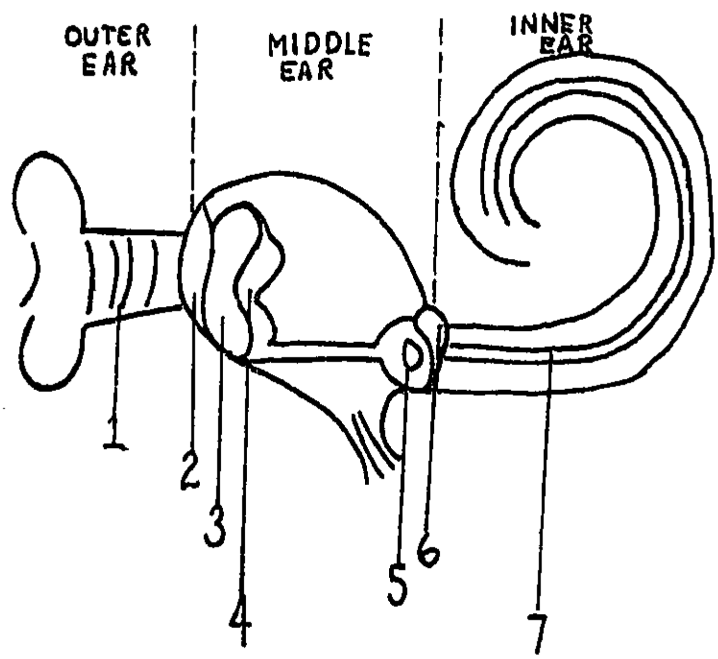
However, in the case of noises at high levels of intensity, we do not have to be exposed for very long periods of time before hearing damage can occur.

Before we can understand how hearing can be damaged by noise, we must understand something about both the characteristics of noise and the process of hearing.

Sound and the Ear

Sound travels through the air in the form of a series of moving pressure disturbances or waves. These pressure waves, which are caused by minute back-and-forth movements of the air molecules, are formed by the vibration or motion of the sound source. (A rough analogy to the motion of sound waves in the air is the motion of water waves on the surface of a pool of water when a rock is thrown into it.)

Now, examine the following illustration and trace the path of a sound from its source outside the body, through the ear, to the brain.



- Sound waves enter the outer ear canal (1) and are directed to the eardrum (2), causing it to vibrate.

- The eardrum passes the vibrations on to the three small bones located within the middle ear -- the hammer (3), the anvil (4), and the stirrup (5).

- These three small bones pass the vibration along to the oval window (6) which is connected to the inner ear (7). The inner ear, or cochlea, is a small snail-shaped bony structure filled with fluid and lined with tiny hair cells. The oval window passes the vibrations along to the fluid in the cochlea, which in turn stimulates the hair cells in the cochlea.

- The hair cells change the vibrations to electrical signals which are carried to the brain and identified by the brain as sound. (A sound is not a sound until we <u>recognize</u> it as a sound.)

Sound may be understood in terms of its two basic characteristics: pitch and intensity.

Pitch

We are already aware that sound travels through the air in the form of pressure disturbances or waves. The frequency with which the waves strike our ears determines for us the pitch of the sound: the higher the frequency of the waves, the higher the pitch of the sound.

Within a sound wave, each pressure disturbance or back-and-forth movement of the air molecules is referred to as a <u>cycle</u> of the wave. The frequency of sound waves, therefore, can be measured in terms of the number of <u>cycles per second</u> (CPS) that are generated by a sound source. Most often, the unit used to describe frequency is the hertz (Hz). One hertz is equivalent to one cycle per second.

A sound source vibrating rapidly — for example, 10,000 times per second — will produce a sound that strikes our ears at a frequency of 10,000 cycles per second (or 10,000 Hz). This is a sound of relatively high pitch, very near the upper limit of human hearing. A sound source vibrating slowly — say, 200 times per second — will produce a sound of 200 cycles per second (or 200 Hz), which is a sound of relatively low pitch.

Intensity

The second characteristic of sound, <u>intensity</u>, is what we commonly understand to be the loudness of sound.

While the pitch of a sound is determined by the frequency of the waves, the intensity of a sound is determined by the size of the air pressure disturbance. A larger pressure disturbance results in a sound of higher intensity; a smaller pressure disturbance results in a sound of lower intensity.

Decibels

Air pressure disturbance of sound waves is measured in units called decibels (dB). The higher the number of decibels, the greater the pressure disturbance, and the more intense the sound. Most of us would consider the sound produced by a gasoline-powered lawnmower, at about 90 decibels, to be of high intensity, and the sound of leaves rustling, at about 30 decibels, to be of very low intensity.

C. NOISE AS "UNWANTED SOUND"

Sound and Noise

Pitch and intensity are primary characteristics of sound. What are the corresponding characteristics of noise?

The answer to this question is quite simple: The corresponding characteristics are the same.

But if they are the same characteristics, what is the difference between sound and noise?

The answer to this question is also quite simple: The difference is in the ear of the listener. It is subjective.

This means that what is perceived as sound by one person may be perceived as noise by another.

What one hears and perceives as either sound or noise depends upon one's values, attitudes, and circumstances at the time.

Our Neighbors As Noise-makers

At one time or another, most of us have probably felt that "noise is what our neighbor makes."

Our neighbor's stereo may be producing beautiful sounds for her, but distracting noise for us — if we are not wanting to listen to it, or if it is interfering with something that we are trying to do at the time.

Our "neighbor" may also be our co-worker, whose equipment or machinery produces sounds that we do not wish to hear, or sounds of such intensity that we are distracted from the work that we are trying to perform.

Noise, therefore, may be defined simply as unwanted sound — unwanted because it interferes with our conversation, our work, our study, our leisure, or our rest, and because it may produce in us some unwanted physical and emotional stress.

Ourselves as Noise-makers

The examples of noise generated by our "neighbors" should not suggest to us that the only noise — the only unwanted sound — in our lives is generated by other people. We are all capable of generating a lot of noise for ourselves — and for others — both on the job and in the home.

Even though we may be doing what we are called upon to do on the job, or what we want to do in the home, we may be using equipment, machinery, tools or appliances that produce high levels of noise.

For discussion: Consider the following questions:

1. What are the primary sources of noise (equipment, tools, etc.) that you are aware of on the job?

2. What are the primary sources of noise that you are aware of off the job?

   a. At home
   b. In transit between home and worksite
   c. In recreation/leisure activities

3. What are some examples of high intensity sounds that are not "noise" in the strict sense of that word, but rather serve some valuable purpose in terms of our job or our safety both on and off the job?

Consider the following activity:

For one entire day, morning to night, maintain a log or diary of all sounds that you hear and that you consider to be noisy. Include all noise that you are aware of in your home, in transit, on the job, and during your leisure hours.

For each noise noted, indicate (approximate) the length of time you were exposed to it or aware of it.

For each noise noted, indicate whether the noise was produced by someone other than yourself, or by you.

When you have completed this activity for an entire day, review your log to determine (1) for what portion of your day you are exposed to some form of noise, (2) what role you play in producing the noise, and (3) whether listening for noises made you aware of certain noises that you had not noticed before.

D. HOW NOISE DAMAGES HEARING

Threshold of Hearing

Thus far, we have examined the process of hearing, we have examined the characteristics of sound, and we have examined the difference between sound and noise.

We are now prepared to examine the fact that certain noises may be more than simply unwanted — they may be dangerous.

We are now prepared to examine how certain noises may be harmful to our hearing.

Everyone has what is known as a threshold of hearing. Your threshold of hearing is the sound level below which you do not hear any sound. For most young people with normal hearing sensitivity, this threshold of hearing occurs near zero decibels. (This is not coincidental since the decibel scale was developed so that its zero point would coincide approximately with the threshold of hearing.)

Noise at high levels of intensity can raise this threshold of hearing. When the threshold is raised, we are unable to hear sounds at lower decibel levels — sounds that we normally can hear.

Intense noise can raise the threshold on a temporary basis, or on a permanent one.

Temporary Threshold Shift

A Temporary Threshold Shift (TTS) is a condition in which we temporarily lose the ability to hear sounds at lower decibel levels.

The TTS occurs during our exposure to potentially damaging noise. The TTS is noticed after the noise has subsided, or after we have removed ourselves from the noise. It is at this point that we may become aware that certain lower decibel sounds that are normally easy to hear are now more difficult to hear — or perhaps cannot be heard at all.

Nature of Damage to the Ear

This threshold shift is the result of damage to the tiny hair cells within the cochlea. These are the cells that ultimately transmit sound to the brain in the form of electrical impulses. When these cells are damaged, the brain does not receive sound signals; the sounds are simply not heard.

Intense noise damages the hair cells by overstimulating or overloading them, thus weakening their ability to transmit signals to the brain. Given an opportunity to recover (being removed from the source of the damaging noise), the hair cells will generally do so. Following a recovery period — usually a few hours — the threshold of hearing will return again to its normal level.

But this return to a normal threshold level does not always occur.

When it does not, we experience a Permanent Threshold Shift (PTS).

Permanent Threshold Shift

A PTS is a condition in which we permanently lose the ability to hear sounds at lower decibel levels. One of the most harmful effects of such a hearing loss is that we lose some of our ability to understand the speech of other persons.

A PTS can result from a single damaging exposure to very high intensity noise, but most often results from exposure to intense noise over an extended period of time.

A permanent shift can be the result of a series of temporary threshold shifts, each of which weakens the hair cells in the cochlea. The cumulative effect of the temporary shifts can be that the hair cells are actually destroyed. At this point, recovery is not possible; neither is hearing the lower decibel sounds ever again.

A permanent hearing loss can occur over time without our even being aware of it. If exposed to sufficiently high levels of noise over time, our ability to hear may be diminished little by little — not enough at any one time for the loss of hearing to be immediately noticeable. Unfortunately, hearing loss is often noticed only after the permanent damage has been done.

It is also important to understand that after the first permanent hearing loss has been detected, further hearing losses can occur so long as there continues to be exposure to damaging noise at higher levels.

Warning Signals

None of us can predict when a Temporary Threshold Shift will become, for us, a Permanent Threshold Shift. Our ears can warn us, however, when the danger of permanent hearing damage from relatively short exposure to intense noise is imminent.

Warning signals, such as a ringing in the ears (this is called "tinnitus"), a threshold shift which lasts more than just a few hours, or a tickling sensation in the ears (which is actually a mild form of pain), tell us that we should remove ourselves from exposure to high intensity noises — or suffer the consequences.

These warning signals also tell us that, before returning to the proximity of high intensity noises, we should take steps to protect our hearing.

Unfortunately, permanent hearing loss can often result from long-term exposure to noise levels which are below the range where we perceive warning signals.

It takes longer for hearing to be damaged by noise at these lower levels, but the result for us is just the same.

Regardless of whether we have been receiving warning signals of hearing damage, hearing tests should be part of our routine physical examinations. A hearing test can detect the early signs of a hearing loss, and can alert us to a problem before more serious damage occurs.

For discussion: Consider the following questions:

1. Can you recall ever experiencing a ringing sensation or a tickling sensation in your ears?

   Can you recall the source of the noise that caused the sensation?

2. Can you recall ever experiencing a hearing threshold shift?

   Can you recall the source of the noise that caused the shift?

E. VARIABLES AFFECTING HEARING DAMAGE

Three Major Variables

How intense must noise be before it has the potential to damage our hearing, on either a temporary or permanent basis?

There is no simple definitive answer to this question. There are too many variables involved.

Chief among these variables are three:

1. the level of the noise, as measured in decibels,
2. the length of time to which we are exposed to the noise, and
3. our personal sensitivity to, or tolerance for, noise.

The danger that noise poses to our hearing is a function of the interaction of these three variables.

Noise Level

Let's examine the first variable: the level of the noise.

- We are already aware that, for most persons, the threshold of hearing occurs near 0 decibels — usually between 0 and 10 decibels.
- Noises below approximately 40 decibels are considered low intensity noises. Examples include the rustling of leaves, a whisper, and a watch ticking.
- Noises between 40 and 70 decibels are considered moderate in intensity, and include such things as conversational speech, a typewriter, and the singing of birds.
- Noises between 70 and 90 decibels are considered loud, and include such things as a television, a dishwasher, and a table saw.
- Noises between 90 and 110 decibels are considered intense, and include such things as a gasoline-powered lawnmower, a rock band, and an emergency siren.
- Noises between 110 and 130 decibels may induce pain in the ears. Examples include nearby thunder, sonic booms, and jet plane takeoffs.

It is at the higher decibel levels (80-90 and above) that the likelihood of noise-induced hearing damage begins to increase — given that an individual is exposed to noise at or above these levels for a sufficiently long period of time.

Time Exposure This brings us to the second variable affecting potential hearing damage: the time variable.

The essential thing to understand about time exposure to noise is that the higher the intensity of the noise, the shorter the time required for hearing damage to occur.

OSHA Standards The Occupational Safety and Health Administration (OSHA) within the U.S. Department of Labor has established standards for occupational noise exposure.

These standards describe the lengths of time beyond which a worker should not be exposed to noise at various levels of intensity during a normal 8-hour working day.

The following table describes the permissible noise exposures established by OSHA.

Hours Per Day of Exposure	A-Weighted Sound Level, dB
8	90
6	92
4	95
3	97
2	100
$1\frac{1}{2}$	102
1	105
$\frac{1}{2}$	110
$\frac{1}{4}$ or less	115

(Note that in this table sound level is designated "A-weighted". A-weighting is a sound measurement technique which filters out the low frequency sounds which the human ear does not hear well, thus roughly simulating the sensitivity of the human ear to sound frequency.)

The table indicates that workers should not be exposed to a noise level which exceeds 90 dB, on the average, for an 8-hour day.

If a worker is exposed to a noise level that averages greater than 90 dB during the work day, steps must be taken to protect the worker's hearing.

The table also indicates that workers should not be exposed to a noise level which exceeds 115 dB, on the average, for even 15 minutes of a work day. Clearly, workers should never be exposed to steady sound levels above 115 dB.

It should be noted that the OSHA standards presented in this table apply only to working environments. It is important to understand that our hearing is affected by the totality of the noise that we are exposed to in our daily lives. If we do work in noisy environments in which it is possible to experience threshold shifts, we must avoid extended contact with noisy environments outside of our work. Using power shop tools or lawnmowers or attending rock concerts will not allow our hearing to recover from the effects of day-long noise exposure on the job.

EPA Recommendation and Goals

Another government agency concerned with the protection of all citizens from the damaging effects of noise has recommended lower levels of safe noise exposure. The Environmental Protection Agency (EPA) recommends that for an 8-hour work day, workers should not be exposed to A-weighted noise levels averaging greater than 85 dB.

In terms of goals for the hearing protection of citizens, the EPA believes that even lower levels of noise exposure are appropriate. In the EPA's judgment, an A-weighted noise level averaging greater than 75 dB should not be experienced by workers during an 8-hour work day. Further, the EPA believes that over an entire 24-hour day, individuals should not be exposed to A-weighted noise levels averaging greater than 70 dB. This means that if a worker is exposed to an average 75 dB while at work, the noise exposure for the 16-hour balance of the day should be low enough to bring the overall 24-hour average noise exposure down to the 70 dB level.

The lower noise exposure goals of the EPA are designed to protect public health and welfare under a wide range of situations, and contain what the EPA believes is an adequate margin of safety for hearing.

It is difficult to state precisely what an adequate margin of safety should be for all persons in all types of jobs.

Individual Differences

And this brings us to the third variable affecting potential hearing damage: individual differences.

Needless to say, all of us differ, one from another, in a variety of ways. This includes hearing.

A safe level of noise exposure for one person may not be safe for another. The fact that co-workers may not report any hearing difficulty resulting from work in a noisy environment does not mean that we will not suffer hearing damage in the same environment.

F. OTHER NOISE-INDUCED PROBLEMS

Beyond Hearing Damage

Loss of hearing is certainly the most dramatic effect of overexposure to noise of high intensity.

It is probably fair to say that loss of hearing is the effect that we think about, and fear, the most. Because of this, there is a tendency to overlook some of the other negative effects that noise can have on our lives.

We are already aware of the value of our hearing in communication, learning, safety, and pleasure.

Let's now examine the detrimental effects of noise on all facets of our lives — both on the job and off.

Short of causing hearing damage, or in addition to causing hearing damage, noise can create a state of annoyance and tension that can interfere with everything we try to do.

Noise and Conversation

When we hold a conversation in a noisy environment, we are forced to raise our voice and/or talk at very close range and/or repeat ourselves quite often.

We may also be required to concentrate very closely on what the other persons are saying, and ask them to repeat themselves as necessary.

The extra effort that this requires can, over a period of time, increase our tension or cause us to feel uncomfortable.

When we spend a lot of time conversing in a noisy environment, we may think that "we get used to it." In reality, we tend to adjust to it by talking less and relying more on non-verbal forms of communication such as gestures and expressions. The general effect of this is a reduction in the effectiveness of our communication with others, or a reduction in our efforts to communicate at all.

Noise and Sleep

When we sleep in a noisy environment, we may be deprived of much of the physical and psychological benefit we normally obtain from sleep.

When we are awakened from sleep or when our sleep is disturbed, for any reason, our bodies may not fully rebuild the physical energy reserves that we require when we are awake, and we may not attain all of the important stages of sleep which contribute to our psychological well-being.

Noise and Relaxation

When we try to relax in a noisy environment, we may not fully escape the pressures and tensions that surround us. When we do not relax, the anxieties and stress that build up can affect us in a number of ways.

Constant exposure to intense noise can cause headaches and nausea and can cause us to be argumentative, moody, and nervous. Noise exposure can raise our blood pressure, increase our heart rate, and affect many other body functions. It can blur our thought processes and cause us to be irrational and unstable.

Noise and Work

When we work in a noisy environment, our job performance may suffer. Noise can distract us from the task on which we are concentrating. It is especially detrimental to complicated tasks or tasks in which several subtasks must be performed.

Noise can induce muscle tension which interferes with the fine physical movement required for many tasks. (A prolonged state of muscle tension can actually bruise a muscle!)

Noise can also startle us, causing errors or even accidents. It can cause us to operate our machinery with our tempers rather than our minds.

Noise can interfere with our ability to hear sounds that are important to the proper operation of our machinery, and warning signals that are important to our safety. It can lengthen our reaction time which is also imporant to our safety.

In Summary: Noise and Our Total Lives

It is not difficult to see that the negative effects of noise are interrelated, and that they can build on one another.

The noise in our lives off the job can contribute to problems on the job, and vice-versa.

- If noise affects our sleep or relaxation, our job performance may suffer.
- If noise on the job increases our tension or anxiety, our personal relationships may suffer.

If we are exposed to high noise levels both on and off the job, our total lives may be affected. By creating "over-work" reactions in our bodies, noise can even reduce our resiliency and contribute to the aging process.

For discussion: Consider the following questions:

1. Given the on-the-job noise sources that you have already identified (in a previous discussion question), which of these noise sources do you believe could be dangerous to your hearing if you were exposed to them for a full 8-hour day?

2. Given the off-the-job noise sources that you have already identified (also in a previous discussion question), which of these noise sources do you believe would contribute most to your average daily level of noise exposure?

3. Has noise ever interfered directly with something you were trying to do, either on the job or off? Do you recall how you were affected by the noise or how you reacted to it?

UNIT II: UNDERSTANDING NOISE CONTROL

Unit II is designed to

A. establish the fact that operating engineers must protect themselves and others from potential hearing damage,

B. describe the major sources of noise present on a work site,

C. describe the basic approaches to the control of work site noise at its source, along its path, and at the point of hearing,

D. illustrate the fact that the basic approaches to the control of noise are as applicable in the home environment as they are in the work environment.

In the text of this unit, these objectives are addressed in the sequence in which they are listed here. The objectives, A through D, correspond to the sections, A through D, which constitute the text.

A. NEED FOR PROTECTION

Operating Engineers and Noise Danger

The Environmental Protection Agency estimates that approximately 14.7 million American workers are exposed to an average A-weighted noise level of 75 dB during their normal 8-hour work days.

You will recall from Unit I that this is the level which the EPA proposes should not be exceeded if workers are to be protected from the adverse effects of noise.

How likely is it that operating engineers are numbered among this very large group of workers whose average work day noise exposure is at the 75 dB level?

The answer, obviously, is that it is quite likely.

In fact, when we think for a minute about the tools and equipment normally present on a construction site, it appears that the 75 dB level is easily exceeded for many operating engineers.

And when we think about it for another minute, it appears likely that the higher noise safety limit set by the Occupational Safety and Health Administration — 90 dB for 8 hours — may also often be exceeded for operating engineers.

A Key Question

Given that we are going to be working in an environment in which high noise levels are usually present, how are we to avoid being included in that growing number of workers whose Workmen's Compensation claims are based on noise-induced hearing loss?

Each of us will have to find an answer to this question. Indeed, when we consider what is at stake — our own hearing and the hearing of others on the work site and in the surrounding community — each of us shares in the responsibility for answering this question.

In answering this question, we will be aided by two things:

1. the ability to recognize the sources of potentially dangerous noise in our environment, and

2. the knowledge of the options available to us to reduce the noise or to avoid it.

B. SOURCES OF NOISE ON THE WORK SITE

Three Basic Noise Sources

As operating engineers, we are exposed to high noise levels from three basic sources.

1. The equipment we operate
2. The equipment we work near
3. The work site as a whole

While there are many different pieces of equipment present on most work sites, we can group all of them into three broad categories for purposes of noise analysis.

1. Equipment powered by internal combustion engines
2. Impact equipment and tools
3. General equipment

Internal Combustion Engines

Most of the steady noise level of the work site is generated by internal combustion engines — usually diesel. These engines drive the mobile earthmoving equipment, the partly mobile handling equipment, and the stationary equipment — obviously, the majority of all equipment that operating engineers work with or near.

The A-weighted levels of noise generated by diesel engines fall in a range between approximately 73 and 96 dB (heard at 50 feet).

Impact Equipment

Impact equipment is usually powered by steam or by diesel.

In impact equipment, noise comes from two sources: the power supply and the impact of the hammer on the work surface.

We have already examined the noise-generating capability of diesel power. Steam power can easily match the diesel's noise.

With diesel drivers, noise is also generated by the combustion explosion that actuates the hammer.

With steam drivers, noise is also produced by the release of steam at the head.

With both types of drivers, the chief source of noise is the impact of the hammer when it is dropped onto the work surface.

And with both types of drivers, the combination of the power supply exhaust and the tool-work interaction (the impact) will produce A-weighted noise levels ranging from 95 to 105 dB at 50 feet.

Impact Tools Most impact tools, like jackhammers, are pneumatically powered. Others use hydraulic and electric power. In the pneumatic tools, noise is generated by the high-pressure exhaust and by the impact of the tool against the work surface.

The noise generated by these tools can range between 80 and 97 dB at 50 feet.

General Equipment General equipment, such as small pumps and generators, is used less frequently than the other equipment, and when it is used, it is for relatively short periods of time. General equipment is usually powered by diesel or electricity.

The noise generated by this smaller, lighter equipment is usually not as intense as that generated by the other equipment. Still, this noise must be taken into account when assessing the noise level of the work site as a whole.

Work Site Noise The following table shows the average A-weighted sound levels in decibels that have been measured on construction sites at points at least 50 feet from the noisiest equipment. Column A reports the level when all pertinent equipment is present on a site; Column B reports the level when the minimum required equipment is present. The table shows typical noise levels on construction sites located in areas in which a sound level of 50 dBA is normally present in the background (not generated by construction activities on the sites themselves).

	Domestic Housing		Office Building, Hotel, Hospital, School, Public Works		Industrial Parking Garage, Religious, Amusement & Recreations, Store, Service Station		Public Works, Roads & Highways, Sewers, and Trenches	
	A	B	A	B	A	B	A	B
Ground Clearing	83	83	84	84	84	83	84	84
Excavation	88	75	89	79	89	71	88	78
Foundations	81	81	78	78	77	77	88	88
Erection	81	65	87	75	84	72	79	78
Finishing	88	72	89	75	89	74	84	84

Consider the following activity.

The chart on the following pages lists major types of equipment familiar to most operating engineers.

The chart also identifies the four major occupational categories for operating engineers.

For one or more (and preferably all) of the four occupational categories, imagine that you are present on a work site for a typical eight-hour day.

For each piece of equipment listed — plus other pieces of equipment you may wish to add to the list — estimate the number of hours that you may spend working directly with the equipment, or working near the equipment. Use the two columns marked "with" and "near" to record your estimates of daily time exposure to the equipment.

Upon completion, this chart will serve to illustrate the number and variety of noise sources to which you may be exposed as an operating engineer. You may now use the general information on equipment noise ranges contained in the text, combined with your own experience with the equipment, to estimate for yourself the length of time that you may be exposed (on a daily or at least frequent basis) to numerous sources of high noise levels on the job.

Note: The decibel levels for all equipment and tools listed in the text were measured at a distance of 50 feet. In estimating your potential on-the-job noise exposure, bear in mind that you will actually be working within only a few feet of certain pieces of equipment and tools.

For discussion: Consider the following questions:

1. For the occupational categories you chose to complete, is most of the noise you may be exposed to generated by the equipment you work with, or is it generated by the equipment you work near?

2. Given your estimates of noise exposure, are operating engineers in certain occupational categories likely to be exposed to higher noise levels than operating engineers in other categories?

3. For the occupational categories you chose to complete, do your estimates of noise exposure for any pieces of equipment indicate that the OSHA noise safety standards may be exceeded?

4. Do your answers to questions 1 through 3 suggest that steps to protect your hearing, as well as the hearing of others on or around the work site, may be necessary?

	GRADING/ PAVING EQUIPMENT OPERATOR		PLANT EQUIPMENT OPERATOR		HEAVY DUTY REPAIRMAN		UNIVERSAL EQUIPMENT OPERATOR	
EQUIPMENT	Work With	Work Near	Work With	Work Near	Work With	Work Near	Work With	Work Near
Tractor								
Crawler								
Wheel								
Bulldozer								
Loader								
Crawler								
Wheel								
Scraper								
Tractor								
Drag								
Dump Truck								
Light								
Heavy								
Off-Road								
Heavy Grader								
Roller								
Tamper								
Vibrator								
Drop Hammer								
Pile Hammer								
Steam								
Diesel								
Compressor								
Hand Breaker								
Rock Drill								
Crawler Drill								
Diamond Drill								
Vacuum Collector								
Tunneling Machine								
Revolving Shovel								
Diesel								
Electric								

	GRADING/ PAVING EQUIPMENT OPERATOR		PLANT EQUIPMENT OPERATOR		HEAVY DUTY REPAIRMAN		UNIVERSAL EQUIPMENT OPERATOR	
EQUIPMENT	Work With	Work Near	Work With	Work Near	Work With	Work Near	Work With	Work Near
Drag Line								
Hydraulic Excavator/ Backhoe								
Ditcher Wheel Ladder								
Drag Trencher								
Hydraulic Dredge								
Hydraulic Crane								
Portable Conveyor Belt								
Portable Belt Loader								
Pump Centrifugal Diaphragm								
Shaking Screen								
Rock Crusher								
Mobile Asphalt Plant								
Asphalt Distributor								
Paving/Finishing Machine								
Other:								

C. APPROACHES TO NOISE CONTROL

Recognizing sources of potentially dangerous noise is the first step in preventing damage to our hearing and to the hearing of others.

Knowing what can be done to reduce or avoid the noise is the next step.

Three Approaches to Control

In general, there are three basic ways to control noise.

- The first is to control it at its source.
- The second is to control it along its path.
- The third is to control it at the point of hearing.

Which approach to controlling noise is best?

When you think about it, control of noise at its source is probably the best approach.

The reason, quite simply, is that if a piece of equipment or a tool is operating, or is made to operate, at a safe noise level, there is no hearing danger posed and no need to use additional approaches to noise control.

If, however, a piece of equipment or a tool does not operate at a safe noise level, and cannot be made to do so, controlling the noise it generates along the noise path is usually the next best approach.

Controlling noise along its path is the next best approach because it limits the numbers of workers on-site, <u>and</u> the numbers of persons off-site, that are exposed to the noise.

Path control is not as desirable as source control because it does not always eliminate the noise problem for all persons affected — especially those working directly with, or very near, the noise source — and because it often requires that new noise control steps be taken whenever equipment is moved or work sites are changed.

But if circumstances dictate that neither source control nor path control are possible or effective, personal hearing protection must be used as a "last ditch stand" against the possibility of hearing damage.

Personal hearing protection — the use of ear protection equipment — is not as desirable as either source control or path control because it affords protection <u>only</u> to those on or near the work site who are wearing the equipment, and because workers <u>must be willing</u> to wear hearing protectors whenever they are exposed to potentially dangerous noise. Further, certain conditions and activities can reduce the effectiveness of the hearing protectors themselves.

Let's now examine how noise can be controlled at its source, along its path, and at the point of hearing.

1. Source Control

Need for Analysis

Source control begins with a careful analysis of the noise-producing equipment, to isolate the major sources of noise within the equipment, and to determine how the noise is being transmitted from these sources. The major noise source may be an engine or a motor, but the noise itself may be transmitted as vibration to other parts of the equipment which, in turn, radiate the noise heard outside the equipment.

In source control, both the major noise source and the secondary noise radiators must be examined and quieted to the extent possible.

Approaches to Source Control

Points to consider in source control of noise include the following.

1. Reducing impact noise produced when parts of equipment strike one another. This may be accomplished by

   a. reducing the size or weight of the impacting mass,

   b. reducing the travel of the impacting mass,

   c. using small impact force over a longer period, rather than large impact force over a shorter period,

   d. cushioning the impact with shock-absorbing material,

   e. avoiding the use of metallic material on both impact surfaces,

   f. applying smooth acceleration to impact mass.

2. Reducing speed of moving parts and rotating parts. This may be accomplished by

   a. operating motors, turbines, fans, etc., at lowest blade-tip speeds that meet job requirements,

   b. using the largest diameter, lowest speed fans that meet job requirements,

   c. using centrifugal or squirrel cage fans which are less noisy than propeller or vaneaxial fans.

3. Reducing pressure and flow velocities in air, gas, or liquid circulation systems. Reducing velocities lessens turbulance which, in turn, reduces noise radiation.

4. Balancing rotating parts. When shafts, flywheels, pulleys, etc., are not in balance, they cause structural vibration which transmits noise.

5. Reducing friction in rotating, sliding, or moving parts. When friction is reduced, the smoother operation of parts translates into lower noise levels. Friction is reduced by

   a. lubricating moving parts,

   b. properly aligning moving parts,

   c. properly polishing smooth surfaces on moving parts,

   d. properly balancing rotating parts,

   e. replacing eccentric or out-of-round rotating parts, or any worn parts.

6. Reducing flow resistance in air, gas, and liquid circulation systems. By using large-diameter, low-velocity pipes and ducts, and by ensuring that the inside surfaces of the pipes and ducts are smooth and free of obstructions and sharp corners, the resulting streamlining of flow will result in lower noise levels.

7. Isolating vibration within equipment. Steps to follow to prevent a vibrating component from transmitting all of its noise-producing vibration to other parts and surfaces of equipment include

   a. installing the vibrating components (motors, pumps, fans, etc.) on the most massive part of the equipment,

   b. installing the components on vibration-absorbing, resilient mounts,

   c. using belt- or roller-drive systems rather than gear trains,

   d. using flexible, not rigid, hoses and wiring.

8. Reducing the size of the surface radiating the noise. As a rule, the larger the vibrating surface, the greater the noise that is radiated. When vibrating surfaces are reduced in size — for example, by removing excess material, cutting out portions of the surface, or using wire mesh in place of sheet metal — the noise output is reduced.

9. Applying vibration-damping materials to vibrating parts and surfaces. The concept of vibration damping is, quite simply, that reducing the vibration reduces the noise. Materials that can be applied to vibrating surfaces include liquid mastics (such as automobile undercoating), pads (such as rubber, felt, adhesive tape, fibrous blankets), and sheet metal laminates or composites. The liquid mastics may be sprayed, the pads may be glued, and the sheet metal laminates may be bonded directly to the vibrating surfaces.

10. Reducing the leakage of noise from within equipment. Sealing noise within a piece of equipment is another simple noise control concept. This may involve

    a. sealing or covering all unnecessary holes and cracks,

    b. using gaskets around all electrical and plumbing penetrations,

    c. installing lids or shields with gaskets over functional or required openings,

    d. using mufflers, silencers, or acoustically lined ducts for intake, exhaust, cooling, or ventilation openings,

    e. directing openings away from the equipment operator, and to the extent possible, away from other workers,

    f. using sound-absorbent linings on inner surfaces of equipment,

    g. using vibration-damping materials on vibrating inner surfaces of equipment.

As can be seen, approaches to control of noise at its source are simple and logical. Approaches such as these should constitute our first line of defense against noise produced by equipment and tools.

2. Path Control

Four Basic Approaches

In situations where approaches to source control will not work, or where source control methods will not lower the noise level to a safe point, control of noise along its path to our ears must be considered.

In path control, we attempt to block or reduce noise before it reaches our ears.

In general terms, we do this by

- o containing or enclosing the noise,
- o absorbing the noise along the path,
- o deflecting the noise away from our ears,
- o separating the noise from the hearer.

The approach that we choose depends on the type of equipment or tool that we are concerned with, and on the environment in which we are working.

Enclosing Noise

We are already aware that reducing the leakage of noise from within equipment is one of the basic approaches to source control of noise.

This same concept also applies to path control of noise.

Enclosing a noisy piece of equipment in a box or a room or covering a noisy pipe with a heavy sound-absorbing material can be an effective approach to quieting.

Obviously, this may not be practical for highly mobile equipment. But for noisy equipment that is stationary, or at least not frequently moved, it should be considered.

Absorbing Noise

The concept of absorbing noise that we examined for source control of noise is also applicable to path control of noise.

Efforts to enclose equipment noise in a box or a room can be aided by the use of sound-absorbing materials or acoustic lining in the box or room.

Noise transmitted from its source through ducts, pipes, or electrical channels can be reduced through the use of sound-absorbing materials. The inside surfaces of these noise passageways can be lined with glass fiberboard, and the ducts, pipes, or channels can be wrapped with a glass fiber blanket. Baffles constructed of glass fiber board can also be installed inside the noise passageways.

Deflecting Noise

Screens or barriers can be used to deflect the noise that is generated by equipment and tools. Much noise can literally be "walled in" by barriers which surround the noise source. This can be aided by lining the barriers — which may be wood or metal panels — with sound-absorbing material.

But barriers do not have to surround the noise source to be effective in reducing noise transmission. A free-standing wall between the noise source and a hearer can, if it is sufficiently large, reflect much of the noise and create a noise "shadow" to protect the hearer.

Isolating an equipment operator in a cab or booth is an approach to deflecting noise with which most of us are familiar. Many pieces of equipment are now being built with cabs which offer protection to the operator.

Separating Noise and Hearer

Putting distance between the noise source and the persons exposed to the noise is a simple and effective approach to path control. The farther away from the noise source we work, the lower the noise level we receive.

Operating engineers on a work site may be limited in their ability to separate themselves from the equipment and tools that generate high noise levels. But this concept of separation can often be applied to the protection of those persons living and working in proximity to the work site. By locating equipment and tools as far away from work site boundaries as possible, the hearing of persons off the site can be protected.

3. Personal Hearing Protection

Three Basic Types

The need for personal hearing protection arises when source control and/or path control are not present, or when source and/or path control do not lower noises to safe levels, or when a worker cannot avoid direct exposure to noisy equipment and tools.

There are three basic types of personal hearing protection devices.

- Disposable acoustic material, such as fine glass wool, mineral fibers, and wax-impregnated cotton, may be inserted in the ear, and must be fresh each day.

- Ear plugs may be inserted in the ear, and must be individually fitted to the wearer.

- Cup-type protectors — like ear muffs — may be worn with the band over the head or around the back of the neck, or may be incorporated into safety helmets.

Noise Reduction

The amount of noise protection afforded by these devices varies from one device to another at different sound frequencies. Although it is difficult to generalize for all of the devices available commercially, the wearer of a hearing protection device may expect noise reduction ranging from 10 dB to over 40 dB at certain frequencies. (The EPA has proposed that, in the future, all hearing protection devices be labeled to indicate their effectiveness in reducing the noise exposure of wearers.)

In general, hearing protection devices may be most effective in reducing noise in the 2000-6000 Hz range; that is, the devices may effect the greatest noise level reductions in this frequency range.

Selection of Device

To a great extent, selection of a protective device is governed by individual preference. Factors to consider are effectiveness, comfort (which is often a problem), and cost.

Many feel that cup-type protectors are most effective over a wide frequency range, providing that glasses temples or long hair do not break the seal of the cup over the ear.

Cup-type protectors represent a higher one-time cost than other devices. It must be noted, however, that this is a one-time cost; over a period of time, the cost of acoustical material to insert in the ear will exceed the cost of the cup-type protector.

Ear plugs offer economical hearing protection, but talking or chewing or yawning can sometimes loosen them in the ears, thereby reducing their effectiveness.

Under hot working conditions, acoustical material or ear plugs may be more comfortable than cup-type devices. However, under dusty or dirty working conditions, cup-type protectors may be more desirable, and more hygienic, than devices inserted in the ear.

Factors such as effectiveness, comfort, and cost present us with options to be considered in the selection of a hearing protection device.

The option of not selecting any hearing protection device, however, should never be considered by anyone exposed to potentially dangerous noise levels.

We should be as willing to wear protectors for our ears as we are to wear safety glasses or goggles for our eyes or safety shoes for our feet.

4. Management of Noise Control

A Fourth Factor

While source control, path control, and control at point of hearing are generally accepted as the three basic approaches to noise control, there is a fourth factor which directly affects the need for these three approaches, and directly affects the noise exposure of workers on a site, as well as other persons near a site.

This fourth factor may be termed the management of noise control.

The management of noise control refers to the administrative decisions that are made to purchase certain types of equipment and tools, to use certain procedures on the work site, and to schedule work during certain hours of the day.

Purchasing

It is obvious that the purchase of equipment can affect the noise level on a work site: If relatively quiet equipment is purchased for use, the noise exposure of workers and others will be lower; if relatively noisy equipment is purchased, the noise exposure will be higher, and the need for source, path, and point-of-hearing control will be greater.

Opportunities for decisions which have positive effects on noise control present themselves whenever a piece of equipment or a tool becomes damaged, worn out, or obsolete and must be replaced.

Decisions to replace equipment and tools with the quietest models available should, over time, result in much quieter and safer work sites. An example would be the replacement of pneumatic drills with electric or hydraulic models.

Procedures

Decisions to choose certain work procedures over others can also affect noise levels in some obvious ways.

For example, if material can be either welded or riveted, the choice of welding would result in less noise generation. If concrete can be mixed off the site as well as on, the decision to mix off the site would result, obviously, in less noise on the site.

Scheduling

When noise is generated may be as important a consideration as how much noise is generated. Decisions may be made to alter work schedules in order to minimize numbers of workers and other persons exposed to high noise levels. To protect individual workers, decisions may be made to "break up" especially noisy tasks among a number of workers, so that the noise exposure of any single worker is minimized.

If work sites are located away from residential areas, noisy procedures may be performed after normal working hours when the fewest workers would be present on the site.

Decisions may also be made to schedule noisy procedures for several short periods of time during a day, or over a number of days, rather than one long, continuous period.

For discussion: Consider the following questions:

1. What source control methods do you believe would be appropriate and effective in quieting the noisiest pieces of equipment with which you work? (Refer back to the previous discussion questions for your examples of noisy equipment.)

2. What is the first path control method that you would consider using to quiet

   a. a piece of equipment that is stationary,

   b. a piece of equipment that is mobile?

3. If you were a safety director on a work site, with what pieces of equipment, and under what conditions, would you recommend the use of personal hearing protectors for workers, regardless of the source control and path control methods that may already be in use?

4. What one of your noise-producing tasks do you believe would most easily lend itself to scheduling for a time at which the fewest workers and other persons would be exposed to the noise

   a. if you were a grading and paving equipment operator,

   b. if you were a plant equipment operator,

   c. if you were a heavy-duty repairman,

   d. if you were a universal equipment operator?

D. NOISE CONTROL IN THE HOME ENVIRONMENT

Total Noise Control

In Unit I, we examined the concept of the total noise environment.

Under this concept, we understand that our hearing, as well as many other facets of our lives, is affected by the noises we are exposed to both on the job and off.

Under this concept, again, it should follow that our efforts to protect ourselves and others from the potential dangers of noise must be pursued both on the job and off. Again, when a worker experiences regular loud noises during the work day, it is especially important to avoid regular loud noise outside of work in order to allow the hearing threshold to return to normal.

Control of noise in the home environment requires an understanding of the ways in which noise is both generated and transmitted.

In general, we are concerned with two basic ways in which noise travels: airborne and structureborne.

Airborne Noise

Airborne noise is noise that is generated directly into the air; it may be generated inside or outside the home.

Familiar examples of airborne noise sources outside the home include jet aircraft, automobile horns, emergency sirens, motorcycles, power lawnmowers, etc.

Familiar examples of sources inside the home include televisions, radios, vacuum cleaners, power shop tools, etc.

Obviously, it is difficult to avoid many airborne noises outside the home. It is not so obvious — but still true — that it is difficult to avoid airborne noises inside the home as well.

There are many reasons for this, including

- the open space layout of homes, with doorless passageways and few partitions to block the transmission of noise,
- the presence of so many noise-generating devices, such as appliances,
- the lack of adequate insulation in the exterior walls, and the lack of well-sealed openings (doors, windows) to prevent exterior noise from entering the home,
- the lack of adequate noise insulation in the interior walls, doors, and floors.

Airborne noise is generally most annoying to the persons closest to the actual noise source.

This is not necessarily the case with structureborne noise.

Structure-borne Noise

Structureborne noise is noise that is generated when the walls, floors, or other parts of a building are made to vibrate by other noise sources, such as mechanical equipment or appliances.

In a home, noise energy is passed from one room to another by the vibration in floors and walls having large vibrating surface areas. In apartment buildings, noise energy is passed from one apartment to another by this vibration.

In many cases, large surface areas like floors and walls serve as "soundingboards" to amplify or increase the noise level produced by the actual noise source. For example, a small vibrating source (such as a small water pipe) may generate little airborne noise by itself, but when it comes into direct contact with a floor or wall and the vibration is passed onto the floor or wall, the noise intensity may be greatly increased.

Interplay of Noise

In most homes and buildings, there is a lot of interplay between airborne and structureborne noises; there are a lot of "chain reactions" as noises move from air to structure and back to air again.

For example, a stereo at high volume may produce airborne noise in a room. This airborne noise energy creates vibration in the walls of the room. The vibrating walls then create airborne noise in the adjoining rooms.

Many noise sources produce airborne and structureborne noise at the same time.

For example, a window air conditioner which is rigidly mounted on a window sill will produce airborne noise through its compressor and fan, and structureborne noise through the wall on which the window is located.

Same Three Approaches to Control

Controlling noise in the home environment is not unlike controlling noise on the work site. The same basic approaches to control — source control, path control, and control at point of hearing — are applicable.

And as on the work site, source control should be the first line of defense against noise, path control the second, and personal hearing protection the third.

Source Control

A brief review of the source control methods we have already examined may help put their home applicability in perspective.

- Reducing impact noise

- Reducing speed of moving parts and rotating parts
- Reducing pressure and flow velocities in circulation systems
- Balancing rotating parts
- Reducing friction in rotating, sliding, and moving parts
- Reducing flow resistance in circulation systems
- Isolating vibration within equipment
- Reducing the size of the surface radiating the noise
- Applying vibration-damping materials to vibrating parts and surfaces
- Reducing the leakage of noise from within equipment

It is not difficult to see how source control methods such as these can be used to quiet both airborne and structureborne noises generated by furnaces, air conditioners, clothes washers, clothes dryers, dishwashers, food blenders, etc.

Path Control

Now let's review the four basic approaches to control of noise along its path.

- Containing or enclosing the noise
- Absorbing the noise along the path
- Deflecting the noise away from our ears
- Separating the noise from the hearer

The applicability of each of these approaches in the home should be obvious.

For example, a furnace or a clothes washer or dryer may be quieted by enclosing it in a room; all noises generated in a room may be absorbed to some extent by carpeting, draperies, and acoustical tile; walls, screens, and partitions may serve to deflect noise; locating noisy activities or noisy appliances away from living areas may serve to keep noise away from most persons in the home.

Personal Hearing Protection

In the home environment, personal hearing protection — the use of hearing protection devices — should be considered in the context of the total noise environment in which we live.

Persons working every day in a quiet environment may not perceive a need for personal hearing protection in and around the home. But persons working every day in a noisy environment may very well have a need for protection from continued high noise levels generated by chainsaws, power lawnmowers, or other power tools used in and around the home.

Management of Noise Control

The fourth factor which we examined under noise control — management — is also relevant in the home environment.

The "noise-sensitive" decisions we make in the home may result in our purchase of quiet appliances and tools, our avoidance of noisy activities, and our scheduling of necessary noise-generating activities for times that will be least disturbing to family and neighbors.

For discussion: Consider the following questions:

1. What source control methods do you believe would be appropriate and effective in quieting the noisiest appliances in your home?

2. Assume you have the resources (time and/or money) to make three modifications or improvements in your home or apartment. Given the airborne and structureborne noises present, what three modifications or improvements would you make in order to effect the greatest reduction in noise level?

In Conclusion: Doing our Share

Noise control in our society is a shared responsibility.

- On the job, we share the responsibility with our co-workers and our employers.

- In the home, we share the responsibility with our family, friends, and neighbors.

To share responsibilities with others is one thing; to do our share in meeting those responsibilities is another.

When we share responsibilities with others, we often assume that those others will take the initiative.

Too often they do not, and too often, nothing is accomplished.

Now that we have examined noise, and now that we understand its causes and its effects, each of us is capable of taking the initiative; each of us is capable of controlling noise for ourselves and for others.

APPENDIX A

Test Questions — Unit I

1. Arrange the parts of the ear in proper order (from a. to g.) to illustrate the path of sound vibrations from outside the body to the brain.

   a. ____________________ Stirrup

   b. ____________________ Cochlea

   c. ____________________ Ear drum

   d. ____________________ Anvil

   e. ____________________ Ear canal

   f. ____________________ Oval window

   g. ____________________ Hammer

2. Hertz (Hz) are used to measure and describe sound in terms of its

   a. Intensity
   b. Duration
   c. Pitch
   d. Loudness

3. Decibels (dB) are units used to measure and describe sound in terms of its

   a. Intensity
   b. Duration
   c. Pitch
   d. Tone

4. Explain in one or two sentences why noise may be defined simply as "unwanted sound".

5. Noise-induced hearing loss usually results from damage within the

   a. Eardrum
   b. Oval window
   c. Cochlea
   d. Ear canal

6. Define, in one sentence, a Temporary Threshold Shift (TTS).

7. Define, in one sentence, a Permanent Threshold Shift (PTS).

8. Describe two warning signals in the ears that tell us that we should remove ourselves from the proximity of high intensity noise.

9. Listed below are ranges of decibel levels. Also listed below are examples of sound or noise sources. List each of the sound or noise sources under the decibel range appropriate to it.

<u>dB Range</u>

15-40

____

____

____

40-70

____

____

____

70-90

____

____

____

90-110

____

____

____

110-130

____

____

____

<u>Sound/Noise Sources</u>

Television
Nearby Sonic Boom
Conversational Speech
Rock Band
Dishwasher
Whisper
Nearby Jet Plane Takeoff
Rustling of Leaves
Singing of Birds
Emergency Siren
Watch Ticking
Table Saw
Electric Hair Dryer
Power Lawnmower
Nearby Thunder

10. Using the Occupational Safety and Health Administration (OSHA) standards for noise exposure, what is the maximum length of time a worker may be exposed to noise

a. at 90 decibels? ____________

b. at 100 decibels? ____________

c. at 110 decibels? ____________

d. at 120 decibels? ____________

11. Using the Environmental Protection Agency (EPA) goals for safe noise exposure, what average noise level (in decibels) should not be exceeded

a. during an 8-hour work day? ____________

b. during a 24-hour period? ____________

12. Without causing hearing damage, noise can have negative effects on our lives in general. List four important activities that can be adversely affected by noise:

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

ANSWER KEY
TEST QUESTIONS — UNIT I

1. a. Ear canal
   b. Ear drum
   c. Hammer
   d. Anvil
   e. Stirrup
   f. Oval window
   g. Cochlea

2. c

3. a

4. Acceptable response at instructor's discretion — Response should contain some of the following elements.

   a. What is perceived as sound or as noise depends upon one's values, attitudes, and circumstances at the time.

   b. Noise interferes with our conversation, work, study, leisure, rest.

   c. Noise may produce some unwanted physical and emotional stress.

5. c

6. Acceptable response at instructor's discretion — Response should approximate the following.

   A TTS is a condition in which one temporarily loses the ability to hear sounds at lower decibel levels that are normally heard.

7. Acceptable response at instructor's discretion — Response should approximate the following.

   A PTS is a condition in which one permanently loses the ability to hear sounds at lower decibel levels.

8. Description should include an approximation of any two of the following.

   a. Tickling sensation in the ears.

   b. Threshold shift that lasts more than just a few minutes.

   c. Ringing in the ears.

9. 15-40 dB (in any order):
   - Rustling of leaves
   - Whisper
   - Watch ticking

   40-70 dB (in any order):
   - Conversational speech
   - Electric hair dryer
   - Singing of birds

   70-90 dB (in any order):
   - Television
   - Dishwasher
   - Table saw

   90-110 dB (in any order):
   - Power lawnmower
   - Rock band
   - Emergency siren

   110-130 dB (in any order):
   - Thunder
   - Sonic boom
   - Jet plane takeoff

10. a. 8 hours
    b. 2 hours
    c. ½ hour
    d. never

11. a. 75 dB
    b. 70 dB

12. Acceptable response at instructor's discretion — Response may include any four of the following (from the text).

    a. Communication
    b. Learning
    c. Safety
    d. Pleasure
    e. Sleep
    f. Relaxation
    g. Job performance

Test Questions — Unit II

1. List three basic sources of high noise levels to which operating engineers are normally exposed.

   a. ____________________

   b. ____________________

   c. ____________________

2. List three broad categories of noise-producing equipment to which operating engineers are normally exposed.

   a. ____________________

   b. ____________________

   c. ____________________

3. Listed below are three examples of noise-producing equipment. Also listed below are three decibel ranges of noise. Match the types of equipment with the decibel ranges (at 50 feet) in which they fall.

Equipment		dB Ranges
a. Diesel Engines	____________	95-105
b. Diesel/Steam Drivers	____________	80-97
c. Pneumatic Impact Tools	____________	73-96

4. The text presented average A-weighted noise levels (dB) measured on various construction sites located in areas in which a sound level of 50 dB is normally present. What was the approximate range (±5 dB) of noise levels on these construction sites? ____________

5. List three basic approaches to control of noise.

   a. ______________________________

   b. ______________________________

   c. ______________________________

6. In most cases, which is the best noise control approach to take? Why?

____

____

____

7. In analyzing a piece of noise-producing equipment, what two basic things do you look for?

a. ____________________

b. ____________________

8. List five methods that may be used to reduce equipment noise at its source.

a. ____

b. ____

c. ____

d. ____

e. ____

9. List four general methods of controlling noise along its path.

a. ____

b. ____

c. ____

d. ____

10. List the three basic types of personal hearing protection devices.

a. ____________________

b. ____________________

c. ____________________

11. In general, what is the range of noise reduction (in decibels) that the wearer of a personal hearing protection device may expect? ____________________

12. List three basic factors that should be taken into consideration when selecting a personal hearing protection device.

a. ______________________________

b. ______________________________

c. ______________________________

13. List three ways in which work site noise can be reduced through proper management of noise control.

a. ____

b. ____

c. ____

14. What are the two basic ways in which noise travels?

a. ____________________

b. ____________________

15. Give two examples of home appliances that may generate, or start chain reactions of, <u>both</u> airborne and structureborne noise.

a. ____________________

b. ____________________

16. List the three basic approaches to control of noise in the home.

a. ______________________________

b. ______________________________

c. ______________________________

17. Give three examples of home appliances for which both source control and path control methods may be effective in reducing noise.

a. ____________________

b. ____________________

c. ____________________

18. What kind of person has the greatest need to wear personal hearing protection devices when using noise-producing tools in and around the home?

____

19. List three ways in which noise in the home environment can be reduced through proper management of noise control.

a. ____

b. ____

c. ____

ANSWER KEY
TEST QUESTIONS — UNIT II

1. Answer should include an approximation of the following — in any order.

   a. The equipment being operated
   b. The equipment one works near
   c. The work site as a whole

2. Answer should include an approximation of the following — in any order.

   a. Equipment powered by internal combustion engines
   b. Impact equipment and tools
   c. General equipment

3. a. 73-96
   b. 95-105
   c. 80-97

4. 65 dB (±5 dB) - 89 dB (±5 dB)

5. Answer should include an approximation of the following — in any order.

   a. Source control
   b. Path control
   c. Control at the point of hearing

6. Acceptable response at instructor's discretion — Response should identify source control as being best approach to take for one or both of the following reasons.

   a. Equipment or tools operating at safe noise levels do not pose a danger to hearing.

   b. The need for additional approaches to noise control is eliminated where source control is effective.

7. Answer should include the following — in any order.

   a. Major or primary noise source
   b. Secondary noise radiators

8. Answer should include an approximation of any five of the following — in any order.

   a. Reducing impact noise
   b. Reducing speed of moving parts and rotating parts
   c. Reducing pressure and flow velocities in circulation systems
   d. Balancing rotating parts
   e. Reducing friction in rotating, sliding, and moving parts
   f. Reducing flow resistance in circulation systems
   g. Isolating vibration within equipment
   h. Reducing size of surface radiating the noise
   i. Applying vibration-damping materials to vibrating parts and surfaces
   j. Reducing the leakage of noise from within equipment

9. Answer should include an approximation of the following — in any order.

   a. Containing or enclosing the noise
   b. Absorbing the noise along the path
   c. Deflecting the noise away from our ears
   d. Separating the noise from the hearer

10. Answer should include the following — in any order.

   a. Disposable acoustical material
   b. Ear plugs
   c. Cup-type protectors (ear muffs)

11. 10 dB to over 40 dB at certain frequency levels.

12. Answer should include an approximation of the following — in any order.

   a. Effectiveness
   b. Comfort
   c. Cost

13. Answer should include an approximation of the following — in any order.

   a. Purchase of quiet equipment
   b. Implementation of quietest work procedures
   c. Scheduling work to minimize number of workers and others exposed, and assigning noisy tasks to several workers to minimize exposure for any one worker.

14. Answer should include the following — in any order.

    a. Airbome
    b. Structureborne

15. Acceptable response at instructor's discretion — Two examples from the text are

    a. Stereos
    b. Window air conditioners

16. Answer should include an approximation of the following — in any order.

    a. Source control
    b. Path control
    c. Control at the point of hearing

17. Acceptable response at instructor's discretion — Three examples from the text are

    a. Fumaces
    b. Clothes washers
    c. Clothes dryers

18. Answer should include an approximation of the following statement: A person working every day in a noisy environment.

19. Answer should include an approximation of the following — in any order.

    a. Purchase of quiet appliances and tools
    b. Avoidance of noisy activities
    c. Scheduling noise-generating activities for times that will be least disturbing to others

APPENDIX B

EXAMPLES OF SOUND LEVELS FOUND IN
WORK, COMMUNITY, AND HOME ENVIRONMENTS

A-Weighted Sound Level dB	Work Environment	Community Environment	Home Environment
120*	Oxygen Torch (121)		
	Scraper-Loader (117) Compactor (116)		
110	Riveting Machine (110)		
		Jet Flyover at 1,000 ft. (103)	
100	Tractor, Farm (98)	Power Mower (96)	
	Compressor at 20 ft. (94) Rock Drill at 100 ft. (92)		
90		Motorcycle at 25 ft. (90) Propeller Aircraft Fly-over at 1,000 ft. (88)	Food Blender (88)
	Diesel Truck, 40 mph at 50 ft. (84)	Diesel Train, 40–45 mph at 100 ft. (83)	
80			Garbage Disposal (80) Clothes Washer (78) Dishwasher (75)
70			Vacuum (70)
		Nearby Freeway Auto Traffic (64)	
60		Air Conditioning Unit at 20 ft. (60)	Conversation (60)
50		Light Traffic at 100 ft. (50)	

* Threshold of Pain.

Note: Unless otherwise specified, sound levels are measured at typical operator-listener distances from source.

As Threshold of Hearing is Raised,
Ability to Understand Speech Becomes More Difficult

DEGREE OF HANDICAP	AVERAGE HEARING THRESHOLD LEVEL FOR 500, 1000, and 2000 Hz IN THE BETTER EAR		ABILITY TO UNDERSTAND SPEECH
	More Than	Not More Than	
Not Significant		25 dB	No significant difficulty with faint speech
Slight Handicap	25 dB	40 dB	Difficulty only with faint speech
Mild Handicap	40 dB	55 dB	Frequent difficulty with normal speech
Marked Handicap	55 dB	70 dB	Frequent difficulty with loud speech
Severe Handicap	70 dB	90 dB	Can understand only shouted or amplified speech
Extreme Handicap	90 dB		Usually cannot understand even amplified speech

To protect your hearing, avoid situations where

1. You have to raise your voice to converse with anyone.
2. Ordinary melodic music sounds discordant.
3. You cannot manage to talk over the telephone.
4. Sharp noises are repeatedly making your ears ring.
5. Everything seems too bright and too loud.
6. The racket makes it difficult to "think straight".
7. You begin to feel detached and a little dizzy.
8. In a short while you begin to feel tired and dazed.
9. The noise makes you seasick.

Your hearing may have begun to deteriorate when it seems that

1. You have trouble recognizing what is said from the stage or pulpit.
2. You have to ask people to repeat what they say.
3. People ask you to repeat what you say.
4. You lose the thread of conversation at the dinner table.
5. The birds seem to have stopped singing.
6. You miss the telephone bell or the doorbell.
7. Your family repeatedly asks you to turn down the TV or radio.
8. People seem to have begun to mumble.

Exposure to Noise:

The Higher the Intensity, the Shorter the Time Required for Hearing Damage to Occur

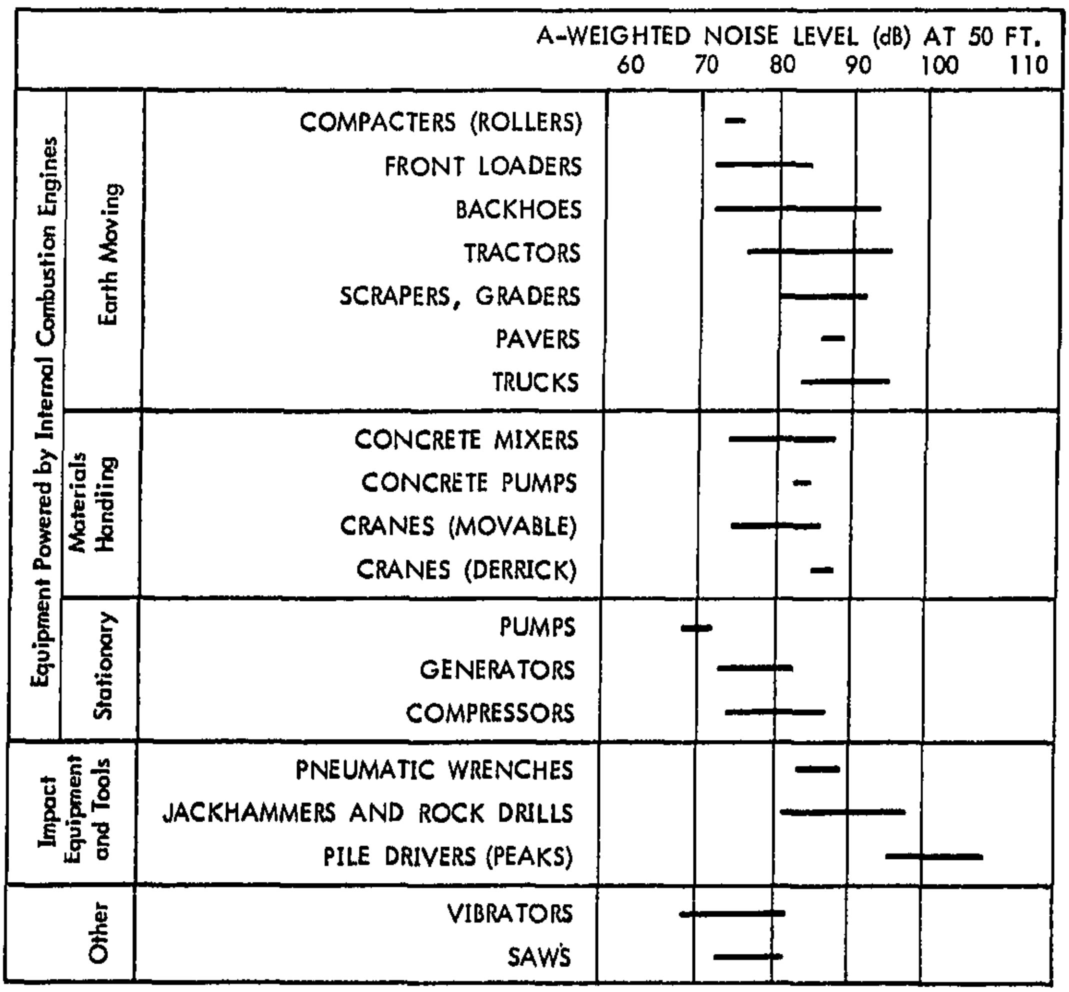
Noise Exposure Standards for Worker Safety
Established by the
Occupational Safety and Health Administration (OSHA)

Hours Per Day of Exposure	A-Weighted Sound Level, dB
8	90
6	92
4	95
3	97
2	100
1 ½	102
1	105
½	110
¼ or less	115

Average Sound Level Exposure Limit
Identified by the
Environmental Protection Agency
as Requisite to Protect the Public Health and Welfare
With an Adequate Margin of Safety

Hours Per Day of Exposure	A-Weighted Sound Level, dB
24	70
8 (Work)	75

CONSTRUCTION EQUIPMENT NOISE RANGES
(Based on Limited Available Data Samples)



BASIC APPROACHES TO NOISE CONTROL

METHODS OF SOURCE CONTROL

- Reduce Impact Noise of Equipment Parts Striking One Another
- Reduce Speed of Moving and Rotating Parts
- Reduce Pressure and Flow Velocities in Air, Gas, or Liquid Circulation Systems
- Balance Rotating Parts
- Reduce Friction in Rotating, Sliding, and Moving Parts
- Reduce Flow Resistance in Air, Gas, and Liquid Circulation Systems
- Isolate Vibration Within Equipment
- Reduce Size of Surface Radiating Noise
- Apply Vibration-Damping Materials to Vibrating Parts and Surfaces
- Reduce Leakage of Noise From Within Equipment

METHODS OF PATH CONTROL

- Contain or Enclose the Noise
- Absorb the Noise Along the Path
- Deflect the Noise Away From the Hearer
- Separate the Noise From the Hearer

METHODS OF PERSONAL HEARING PROTECTION

- Use Disposable Acoustical Material
- Use Ear Plugs
- Use Cup-Type Ear Muffs

MANAGEMENT OF NOISE CONTROL

- Purchase Quietest Equipment Available
- Use Quietest Work Procedures Possible
- Schedule Noisy Work For Minimum Exposure to Smallest Number of Workers and Others

SOME SIMPLE APPROACHES TO CONTROL OF NOISE IN THE HOME

o AIR CONDITIONERS	- Select units with low noise rating - Select slow-speed, large-diameter fans - Mount central air compressors and motors on resilient pads - Mount window units on resilient pads - Surround window units with soft rubber gaskets
o FOOD BLENDERS	- Select units with low noise rating - Select glass rather than plastic containers - Select heavy metal rather than light plastic bases - Mount on resilient pads
o ALARM CLOCKS	- Select models that chime or turn on radios - Place clocks on soft padded surfaces - Place clocks away from walls that adjoin other sleeping rooms or apartments
o CLOTHES WASHERS AND DRYERS	- Select units with low noise rating - Install units on resilient pads or mounts - Use flexible connectors in water and electric supply lines - Apply sound-absorbing and vibration-damping materials on inside surfaces - Vent dryer where noise is least disturbing - Isolate units from living areas
o FURNACES	- Have fuel nozzles adjusted for minimum noise - Use flexible connectors and sound-absorbing lining in air ducts - Select slow-speed, large-diameter fans (wide blade or squirrel cage designs) - Use belt drive rather than direct motor drive to fans - Isolate units from living areas
o DISHWASHERS	- Select units with low noise rating - Select built-in models (because of limited surfaces for radiating sound) - Mount units on resilient pads - Surround built-in models with soft rubber gaskets - Use flexible connectors in water intake and drain lines - Load dishes so that they are not free to move during washing
o TELEVISION/ STEREO SETS	- Place cabinets or speakers away from walls that adjoin other apartments - Mount cabinets or speakers on resilient pads - Keep units properly adjusted - Set volume controls at comfortable listening levels

APPENDIX C

EPA REGIONAL NOISE REPRESENTATIVES

Region I

Mr. Al Hicks
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(617) 223-5708
FTS 223-5708

Region II

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Mr. Tom O'Hare
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APPENDIX D

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