



# NIOSH

# Hearing Loss Simulator

## *Instruction and Training Guide*



DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Centers for Disease Control and Prevention  
National Institute for Occupational Safety and Health

**NIOSH**

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# NIOSH Hearing Loss Simulator

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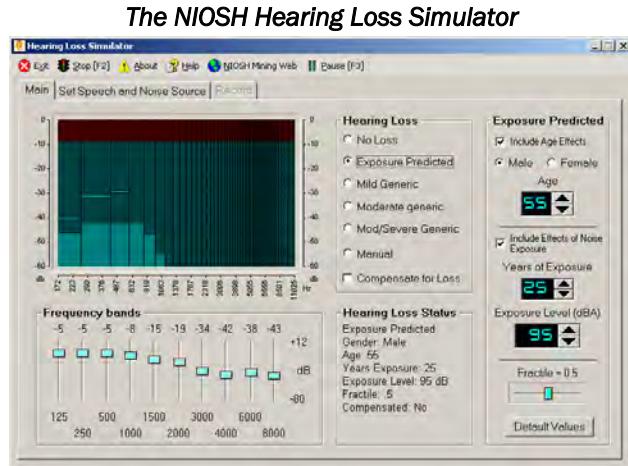
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NIOSH, Pittsburgh Research Laboratory

### Purpose

The NIOSH Hearing Loss Simulator is a software training and communication tool for promoting hearing loss prevention. It allows a user or trainer to demonstrate the effects of noise exposure on hearing without experiencing an actual noise-induced hearing loss.

Estimates of the effects of different levels of noise exposure are based on the *American National Standard Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment*, otherwise known as ANSI S3.44. This standard specifies the predicted hearing loss for noise-exposed populations of individuals based on risk factors that include gender, age, sound levels (in A-weighted decibels or dBA), and years of exposure. Algorithms specified in the standard were derived from empirical studies of populations that had no exposure to loud noise and other populations that had experienced various levels and durations of noise exposure.

This manual explains the major objectives that can be addressed with the simulator and training scenarios that can be applied to real-life, real-worker scenarios. The majority of this guide explains the simulator's functions in detail. Simulator users are encouraged to read this manual while learning how to run the software.



### Training Objectives

The main objective of the Hearing Loss Simulator is to increase motivation for taking effective hearing prevention action by demonstrating simulated noise-induced hearing losses.

The Simulator can also help teach the following facts about hearing loss.

- Ear Hearing loss is affected by noise levels.
- Ear Hearing loss worsens as the noise exposure duration increases.
- Ear Hearing loss can become permanent.
- Ear Hearing loss makes it harder to hear what others say.
- Ear Most hearing loss is not caused by age.
- Ear Speech is made up of both low and high pitch sounds.
- Ear Hearing loss due to noise makes it harder to hear high pitch sounds.
- Ear Hearing loss due to noise has less of an effect on hearing low pitch sounds.

# Required and Recommended Items

**Computer:** The Simulator runs on computers with Windows 98 or higher. The computer must have standard Windows sound support. As long as the computer can run current mainstream applications (word processing, web browser, etc.) and can play music, it should be more than adequate. Laptop and notebook computers usually work fine, but may need supplemental external speakers. On Windows Vista systems, the Simulator must be run as administrator in order to register its components. The Simulator does not run on Apple Macintosh computers, but users can access selected hearing loss simulations on the NIOSH Mining Web site.

**Speakers:** External speakers that can play at comfortable listening volumes are necessary to hear the different speech types, industrial sounds, and musical sounds generated by the simulator. For a classroom setting, you should have larger amplified speakers that can fill the room with sound.

**Projector (optional):** When training a group, a projector or large display will help the trainees see the information on the Simulator screen. The Simulator can be used even if the trainees can't see the display because the instructor can explain the settings that result in the different sounds they are hearing.

**Headphones (optional):** In conference halls and other settings with significant distracting background noise, headphones can be used to let trainees hear the Simulator while the background noise is blocked out. Full-size circumaural headphones that cover the ears completely are best at blocking background noise. An inexpensive headphone splitter/amplifier can be used to allow multiple trainees to listen through headphones at the same time.

**Microphone (optional):** A microphone can be used to record custom sounds (voices, machinery, etc.) with the Simulator to customize it for a specific



workplace. A good-quality external microphone that can connect to the computer's microphone jack works best. The simple microphones built into notebook computers tend to have low quality and pick up unwanted noise from the computer itself.

## Installation

**CD-ROM:** Insert the NIOSH Hearing Loss Simulator into your computer's CD or DVD drive. If the installer does not automatically start, browse to the drive letter containing the installation CD and run the setup.exe program.

**Web:** Download and run the simulator installation program from the NIOSH Web site:  
[www.cdc.gov/niosh/mining/products/product47.htm](http://www.cdc.gov/niosh/mining/products/product47.htm)  
Run the installer with administrator rights in Windows 2000, XP, or Vista.

For both versions, follow the on-screen prompts. When complete, the program can be run from an icon in your Start menu or (optionally) on the desktop.



In Windows Vista, the program must be run as Administrator.

# Guide to All Features

This section describes all of the Simulator's functions available through its screens and menus.

## Main Screen

When the program is first started, this main screen showing the basic functions is displayed. From here you can use tabs below the menu bar to select other screens to change or record sounds played by the program.

Adjust the volume on your computer so the spoken message is at a comfortable listening level that's audible to every listener.

Then select **Exposure Predicted** from the Hearing Loss list.

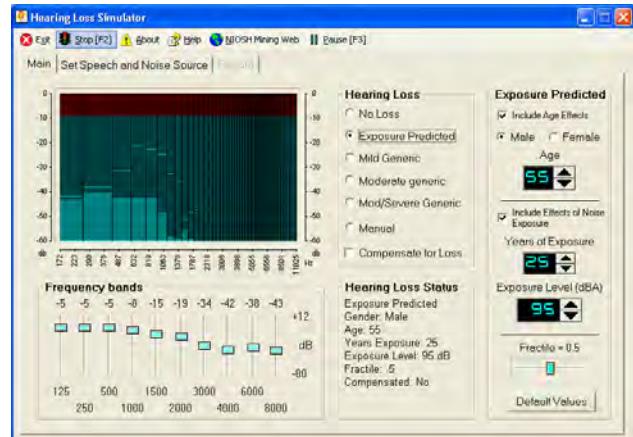


**Quick start tip:** Click **Start [F2]** on the top menu to start sounds playing.

## Main Screen with Exposure

Selecting the Exposure Predicted option changes the main screen by adding controls to adjust the amount of noise exposure being simulated.

In the sample screen shown here, the default exposure settings have been selected, and sound playback has started.



## Toolbar

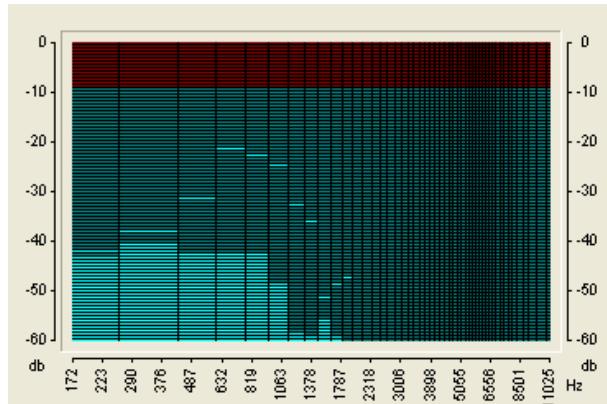
The toolbar appears at the top of all screens.

- 1** **Exit** - Exits the program.
- 2** **Start/Stop Toggle** - Controls the playback of the speech and noise sources. The F2 key also performs this function.
- 3** **About** - Information about the Hearing Loss Simulator (version number, technical support, etc.).
- 4** **Help** - Displays HLSim help, documentation, and sample scenarios.
- 5** **NIOSH Mining Web** - Opens the default browser to the NIOSH Mining Web site.
- 6** **Pause** - Pauses playback of the sound file. The F3 key also performs this function.

## Graphical Display

This graphical display shows current instantaneous levels of sound across the frequency spectrum. This is useful for showing the amounts of low- and high-frequency sound in the recording. For instance, for the female voice the high-frequency bars toward the right side of the graph will show higher peak levels than the male voice.

The display also demonstrates the loss of high-frequency information when a noise-induced hearing loss is simulated.



## Hearing Loss choices

This panel is used to select how the program simulates a hearing loss.

**No Loss** - Removes all hearing loss.

**Exposure Predicted** - High noise exposures cause much more hearing damage than lower exposures. This option applies the effect of different levels of noise exposure combined with age, gender, and other variables. When this option is selected, the main screen expands to show additional exposure controls.

**Mild Generic** - Applies a “mild” level of noise-induced hearing loss: 20 dB hearing level at 4000 Hz with surrounding frequencies impaired to a lesser extent.

**Moderate Generic** - Applies a “moderate” level of noise-induced hearing loss: 30 dB hearing level at 4000 Hz with surrounding frequencies impaired to a lesser extent.

**Mod/Severe Generic** - Applies a “moderate to severe” level of noise-induced hearing loss: 40 dB hearing level at 4000Hz with surrounding frequencies impaired to a lesser extent.

**Manual** - Activates the frequency band sliders so you can apply a hearing loss manually.

**Compensate for Loss** - Once a loss is simulated, it can be “compensated” for. This has the effect of

**Hearing Loss**

No Loss

Exposure Predicted

Mild Generic

Moderate generic

Mod/Severe Generic

Manual

Compensate for Loss

boosting the sound by an amount equivalent to the loss. To an imperfect extent, the boosted playback can compensate for a hearing loss to give trainees an idea of what it would be like to regain their normal hearing.

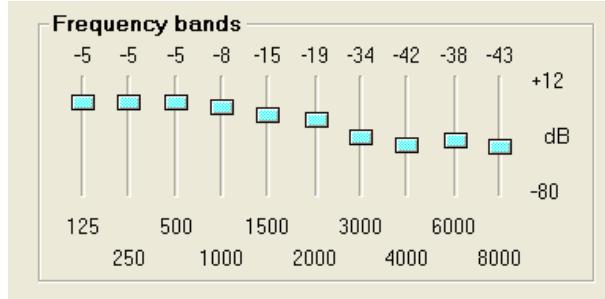
The limitations of any mechanical playback system and the complexity of the auditory system make it impossible to exactly reverse a hearing loss. Also, in cases of severe hearing loss, boosting the sound enough to compensate for a large deficiency and playing the resulting sounds through a high-power loudspeaker or headphone system **could potentially generate very loud and unpleasant sound levels**. In extreme cases, the levels could even become hazardous, so use this feature with caution — turn the volume down first and bring it up gradually.

## Frequency Band Sliders

These 10 sliders control different frequency bands. When the program is simulating a predicted hearing loss, these sliders are automatically adjusted to reflect a predicted hearing level as a result of noise exposure.

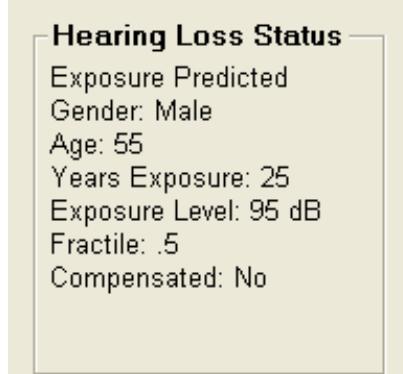
When you set the Hearing Loss to “Manual” you can manipulate the sliders directly. You might do this to enter the results of an actual audiogram. Then, others who have no hearing loss could, in effect, hear an approximation of the person’s hearing whose test results were entered. This is only an approximation. Individuals with sensori-neural hearing loss often have altered loudness perception and other subjective effects that are difficult to simulate accurately.

Also, since each slider can be manipulated independently, you can pinpoint the effects of hearing loss in each frequency band. For instance, a warning beeper may become much less audible as a result of a loss in a single frequency band.



## Hearing Loss Status

This portion of the screen contains information about status of the Simulator, including current hearing loss settings.



## Exposure Predicted Loss

### Parameters

**1** **Include Age Effects** - When checked, the effects of age are included in the hearing loss calculation. This provides a convenient way to demonstrate the effect that noise alone has on hearing loss, apart from aging.

**2** **Gender** - Males tend to have higher levels of hearing loss than females who have had the same noise exposure, so the program allows the user to specify the simulated worker's sex.

**3** **Age** - Some hearing loss occurs as people age, but deafness or even a severe hearing loss is not inevitable. One of the major lessons to be learned from the Simulator is that aging usually causes much less hearing loss than does noise exposure. The simulated individual's age in years can be entered to show how older people tend to have a gradual loss in the high frequencies, i.e., an older worker who has not been exposed to loud noise will typically have worse hearing at 8000 Hz than at any lower frequency. On the other hand, a worker exposed to large amounts of noise will typically have a "notch" in their hearing sensitivity around 4000 Hz or 6000 Hz, and will have better hearing at 8000 Hz.

**4** **Include Effects of Noise Exposure** - When checked, the effects of Years of Exposure, exposure level and fractile are included in the hearing loss calculation. This provides a convenient way to demonstrate the effect that age only has on hearing loss.

**5** **Years of Exposure** - Time is the second major ingredient of exposure. This is set in years to represent a noisy period in the simulated individual's life. It can cover just a noisy portion of a career (e.g., 10 years of working in a mill) or multiple noisy periods. The years represent working days, not continuous exposure. This value should be kept to the 0–40 year range for

The screenshot shows a software window titled 'Exposure Predicted'. It contains eight numbered input fields:

- 1**  Include Age Effects
- 2**  Male  Female
- 3** Age: 55 (with up/down arrows)
- 4**  Include Effects of Noise Exposure
- 5** Years of Exposure: 25 (with up/down arrows)
- 6** Exposure Level (dBA): 95 (with up/down arrows)
- 7** Fractile = 0.5 (a slider with a blue tick mark)
- 8** Default Values (a button)

predictions supported by the data behind the ANSI S3.44 standard.

**6** **Exposure Level (dBA)** - As expected, high-intensity sound levels cause much more hearing damage than lower levels. The effect of different levels of noise can be simulated by entering the desired A-weighted sound level in decibels. The A-weighting scale is used for all the key sound pressure level measurement standards in the Mine Safety and Health Administration (MSHA) and Occupational Safety and Health Administration (OSHA) regulations, so it should be familiar to both trainers and trainees. This value should be kept to the 75–100 dBA range for predictions supported by the data behind the ANSI S3.44 standard.

For simplicity, a single dBA number is set in the simulator, although employees may correctly point out that the sound levels they are exposed to vary considerably over time. Because of this, the dBA value should represent an estimate of the average

exposure over the simulated time period, commonly referred to as the “time-weighted average” (TWA).

**Fractile** (population distribution) - Noise does not affect everyone to the same extent. To account for variations within the population, the ANSI S3.44 standard specifies expected hearing loss for different population fractiles.

The program allows the user to specify the 0.1, 0.25, 0.5, 0.75, and 0.9 fractiles. For instance, a worker at the 0.1 fractile would have more hearing loss than 90% of the equally exposed population.

Those at the 0.75 fractile would have more hearing loss than just 25% of the population.

By changing this control to the low (0.1 or 0.25) settings, a trainer can show that lower exposure levels can still be dangerous for some workers, even if they are relatively “safe” for the average worker. Since most workers do not have a way of knowing their individual susceptibility, this allows them to err on the side of caution.

**Default Values** - Sets all the exposure predicted variables to their default values.

## Set Speech and Noise Source

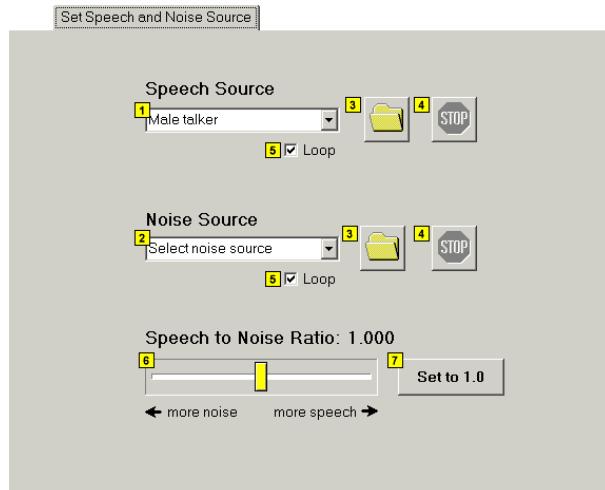
This screen is reached by selecting the tab for “Set Speech and Noise Source.” You can return to the main screen at any time by selecting the “Main” tab.

**Speech Source** (foreground sound) - Human speech is provided as both the most complex and important foreground sound most workers need to perceive. You can choose either a male or female voice recording from the dropdown list.

**Noise Source** (background sound) - Background sounds often severely tax a listener’s ability to hear and/or comprehend the intended message. The simulator allows the choice of several types of background sounds, including some recorded worksite sounds (continuous miner, haulage machine, drill) and some more generic standard background noises (male or female “speech babble,” white noise, etc.).

**Browse for a Sound File** - Select a Windows WAV file for playback in place of one of the sounds in the dropdown list.

**Stop Playback** - Stop the playback of the sound file.



**5 Loop** - Makes the sound repeat indefinitely.

**6 Speech to Noise Ratio** - The Speech to Noise Ratio control affects the loudness of the background noise source relative to the foreground sound. Use this to demonstrate how increasing background noise interferes more with understanding the foreground speech recording.

**7 Set to 1.0** - Resets the Speech to Noise Ratio to the default value of 1.0.

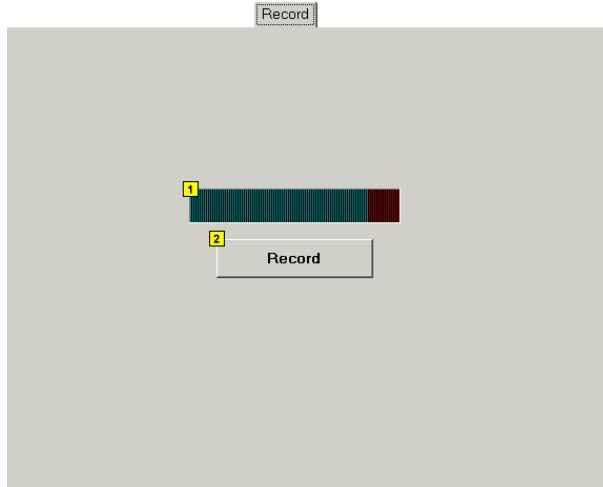
## Record Screen

This screen is reached by selecting the “Record” tab. You can return to the main screen at any time by selecting the “Main” tab.

**Recording Level** - Displays the input sound level while making a recording. Adjust the computer’s input controls so that the loudest peak levels stay below the red area to the right.

**Record** - Click this button to start recording a standard Windows WAV sound file for use as either foreground or background source. This can be used to record a different foreground voice message customized for trainees or to record a special machine or warning signal that’s common at the trainees’ worksite.

The program will ask for a file name before saving the recording. This feature requires a microphone or other sound source attached to the PC sound input.



## Training Scenarios

The Simulator can be used to show “real-worker, real-life” scenarios. A good training plan using the Simulator would work through a series of scenarios, using trainee input to tailor the lesson to the audience. Some of the many possible scenarios are listed.

### Older worker, noise-exposed

This scenario is one of the most important ones to include in a training session, especially with younger workers. A hypothetical male or female older worker, perhaps nearing retirement, would be described. He or she should be characterized as in the range of 55–65 years old with 35–45 years of exposure to 90–100 dBA. Users can select age and experience numbers that are typical of their workplace or industry. The trainer can then demonstrate the significant hearing loss this worker will have going into retirement.



### **Older worker, no exposure**

Immediately following a demonstration about a hypothetical noise-exposed older worker, the trainer can set the exposure years to zero and simulate an equivalent worker with no exposure. This will serve to counter any assumption that the first worker's hearing loss was a natural consequence of aging. Instead, trainees will see that a relatively small amount of high-frequency loss is expected in older workers, but that noise exposure is responsible for much more of the damage.

### **Midcareer worker**

Especially if there are a large number of midcareer trainees, a worker with 10–20 years of exposure may be simulated. Based on this worker, several progressions can be followed. For instance, additional exposure years can be added to show the accumulation of more hearing loss. It also allows comparison with an older non-noise-exposed worker, which then allows the trainer to make the point that, with enough exposure, a 30-year-old worker may have, in effect, 50-year-old ears.

### **Individualized**

The simulator can also be used as an individualized training and counseling tool. For instance, the trainer can show a worker how his/her hearing test results can be entered directly into the Simulator using the frequency band sliders in manual mode. The trainer can then drag the sliders down to show the additional loss that would occur after further noise exposure. A rough estimate of how much additional loss to add could be obtained through an exposure-predicted loss for 5–10 years of future exposure.



## **For More Information**

For more information on ANSI standard S3.44:

American National Standards Institute

[www.ansi.org](http://www.ansi.org).

Criteria for a Recommended Standard.

Occupational Noise Exposure. June 1998. Centers for Disease Control and Prevention. NIOSH.

[www.cdc.gov/niosh/docs/98-126](http://www.cdc.gov/niosh/docs/98-126).

Preventing Occupational Hearing Loss: A Practical Guide. June 1996. edited by John R. Franks, Mark R. Stephenson, Carol J. Merry. Centers for Disease Control and Prevention. NIOSH:

[www.cdc.gov/niosh/96-110.html](http://www.cdc.gov/niosh/96-110.html).

### **Downloading Information**

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