

Occupational Noise Exposure and Hearing Loss Prevention

*A technical report and guidebook for
Sheet Metal
Manufacturing Companies*

*Department of
Environmental and Occupational Health Sciences
University of Washington*



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Washington State Hearing Loss Prevention rule

This report includes the major requirements from the Washington State OSHA (WISHA) rule. The complete rule, WAC Chapter 296-817, is available online at:

<http://www.lni.wa.gov/wisha/Rules/noise/>

Or, you can obtain a free printed copy by contacting:

Department of Labor and Industries
WISHA Services Division
Standards and Information, PO Box 44620
Olympia, WA 98504-4620

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INTRODUCTION

What is this guidebook about?

Researchers at the University of Washington Department of Environmental and Occupational Health Sciences conducted a three-year study, evaluating noise levels and hearing loss prevention programs at companies in nine different industries in Washington State.

This guidebook contains the study results and recommendations for one of those industries, sheet metal manufacturing. The study included ten companies that make products such as electronic casings, ventilation ducts, and construction items. Field installers at three companies were also included.

This guidebook can guide sheet metal manufacturing companies as they improve the effectiveness of their hearing loss prevention programs. The report will be most useful for company owners and managers, hearing loss prevention program coordinators, safety personnel, and supervisors.

How this affects you

Our study concluded that most, if not all, sheet metal manufacturing companies are noisy enough to need a hearing loss prevention program under the Washington State OSHA (WISHA) Hearing Loss Prevention rule, also called the Noise rule.

The complete WISHA Hearing Loss Prevention rule is available online or as a free printed copy from the Washington Department of Labor and Industries. Contact information is on the inside front cover of this guidebook.

What is noise and how is it measured?

Noise is unwanted sound. Sound is measured in decibels (dB). The “A” weighting scale (dBA) gives extra weight to some frequencies and mimics how humans hear noise. This scale is required by WISHA for most noise measurements. Small differences in decibels are very important. If two noise levels differ by only five decibels, WISHA considers the louder level to be twice as high as the lower level: 85 dBA is twice as high as 80 dBA, 90 dBA is twice as high as 85 dBA, and so forth.



What is an unsafe level of noise?

A worker who is repeatedly exposed to noise at 85 dBA without hearing protection faces a significant risk of hearing loss. The risk is greater at louder noise levels, but noise levels are probably not safe unless they are under 80 dBA.

The WISHA Hearing Loss Prevention rule requires employers to maintain a hearing loss prevention program for any employee whose full-day average exposure might be 85 dBA or higher.

What is an “equivalent” noise exposure and what is the TWA_8 ?

Workplace noise can vary greatly during a work shift, and employees may move from one work area to another. This means that a worker’s noise exposure can be longer or shorter than eight hours, depending on how long the shift is and how long noisy operations last.

The TWA_8 is the equivalent eight-hour time-weighted average sound level. The WISHA rule uses the TWA_8 to calculate the average level of a worker’s noise exposure, allowing for different patterns and durations of exposure. Short periods of time spent in very high noise levels can be as harmful as longer periods of time at lower levels of noise. Figure 1 (page 9) illustrates exposures that are equivalent to a constant exposure at 85 dBA for eight hours, according to the WISHA rule.

Colors and signal words for noise levels

We use colors and specific “signal” words to show differences in noise levels among various jobs and noise sources (Figure 2, page 9). Companies can use these colors and signal words to:

- train employees
- help select the most appropriate hearing protection
- improve signs to make it easier for employees to know what to do in noisy areas.

Organization of this guidebook

The organization of this guidebook matches the major requirement areas of the WISHA Hearing Loss Prevention rule. Under this rule, an employer with a noisy workplace must provide:

- noise monitoring
- noise controls and warning signs
- employee training
- hearing protection
- audiometry (hearing tests)
- documentation and evaluation.

We will discuss each of these requirement areas in the following chapters.

NOISE MONITORING

What is an employer required to do?

- ☐ **Conduct employee noise exposure monitoring when there is reasonable information that any employee's exposure might be 85 dBA or higher, TWA_8 .**
- ☐ **Identify all employees whose exposure equals or exceeds:**
 - full-day exposure 85 dBA, TWA_8
 - full-day exposure 90 dBA, TWA_8
 - extreme noise level 115 dBA (more than 1 second in duration)
 - instantaneous exposure 140 dBC (less than 1 second in duration, using the "C" weighting scale).
- ☐ **Measure exposure levels for selection of hearing protection.**
- ☐ **Conduct additional noise monitoring whenever a change in production, process, equipment, or controls may reasonably be expected to result in:**
 - additional employees whose exposure is 85 dBA₈ or higher, TWA_8
 - employees exposed to a higher level of noise.
- ☐ **Provide employees and their representatives an opportunity to observe when employee noise exposures are measured.**
- ☐ **Notify each employee whose exposure is 85 dBA or higher, TWA_8 , within five days after receiving the results.**

What were companies doing?

We monitored 152 employees in ten sheet metal manufacturing companies, and found that 36% of them had full-day exposures (TWA_8) that were 85 dBA or higher. The percentage varied from 13% to 92% at the companies we evaluated, but we found at least two employees at each company with exposures this high.

We also found at least one employee with a full-day noise exposure at 90 dBA or higher at four of the ten companies. Employers are required to use noise controls, if feasible, when any employee is exposed to this much noise.

Many employees were exposed briefly to extreme noise, 115 dBA and higher. However, only one monitored employee was exposed continuously for one minute or longer.

All ten of the companies had conducted noise monitoring, but four had not kept any records. Most companies reported little use of those measurements.

Most employees were not well informed about their noise exposures. Only 17% recalled being told specific noise levels for their job or for other jobs or locations at their work site. Overall, 40% did not recall ever being told they might be overexposed to noise because of their job. Many of these workers were monitored for this study and had full-day noise exposures that were 85 dBA or higher.

What do we recommend?

- ☐ **Use the noise levels in this report as a starting point to identify specific jobs or employees with excessive noise exposure.**
- ☐ **Conduct enough monitoring to determine if work site noise levels are higher or lower than the levels in this report.**
- ☐ **If work shifts are longer than eight hours, convert average exposures during employee monitoring to the eight-hour equivalent TWA_8 value.**
- ☐ **Most, if not all, employees in production jobs should be included in the hearing loss prevention program.**

Figure 3 (page 10) shows the jobs where employees were more likely than others to have full-day exposures that reached 85 dBA or higher. Almost half (46%) of the monitored sander/grinders, welders, machine operators, and assembly workers had full-day exposures that were 85 dBA or higher.

- ☐ **Employees who work in production areas but have full-day exposures that are *under* 85 dBA should be included in most or all components of the hearing loss prevention program.**

Overall, about two thirds of monitored employees had full-day exposures that were *under* 85 dBA. None of the monitored material handlers or mechanical maintenance workers had full-day exposures that reached 85 dBA. However, *all* employees with a full-day exposure under 85 dBA spent part of their work shift in situations where noise levels were 85 dBA or higher.

All employees should wear hearing protection in noisy situations, even if their full-day exposure is under 85 dBA. Anyone who is expected to wear hearing protection should receive training and a hearing protector fitting. However, hearing tests are optional for employees whose full-day exposure is consistently under 85 dBA.

- ☐ **Supervisors should be included in the hearing loss prevention program.**

Supervisors usually have a key role in enforcing work-site regulations, including use of hearing protection. Employees commonly rely on supervisors as the first source of information for questions about noise or hearing protection. Supervisors should be prepared to provide this information and to serve as role models for promoting safe work practices. Supervisors themselves are at risk; one third of the supervisors in our study had full-day exposures that were 85 dBA or higher.
- ☐ **Field installers should be included in the hearing loss prevention program.**

Installers' tasks change daily and can produce full-day exposures over 85 dBA, as we found with two of 13 installers we monitored. Field installers work with some of the noisiest tools in this industry. Because many of these tools produce impact noise, they can damage hearing even if the full-day exposure is not very high.

NOISE CONTROLS AND WARNING SIGNS

What is an employer required to do?

- ❑ **Identify all employees whose full-day exposure is 90 dBA or higher, TWA_8 .**
- ❑ **Reduce employee noise exposure, using feasible controls, whenever exposure is 90 dBA or higher, TWA_8 .**
- ❑ **Post warning signs at the entrances or boundaries of all well-defined work areas where employees may be exposed to noise levels 115 dBA or higher.**

What were companies doing?

Employee full-day exposures at 90 dBA and higher were common enough that all sheet metal manufacturing companies should consider whether additional noise controls are needed. We found at least one employee with a full-day exposure this high at four of the ten companies we evaluated. At one company, five out of nine monitored employees had full-day exposures over 90 dBA. The jobs with exposures this high were:

- three of five sander/grinders (60%)
- two of 20 machine operators (10%)
- two of 21 welders (10%)
- fewer than 5% of assembly workers.

In general, welders' exposures were higher with parts handling than actual welding.

Signs commonly identified noisy areas. However, signs generally were not posted to indicate specific "extreme noise" areas, where noise levels could reach 115 dBA or higher. We identified noise levels this high near:

- some fixed-location saws
- activities using pneumatic hammers.

Half of the ten work sites had previously made changes or planned future changes to reduce noise levels. Our monitoring indicates that further noise control is needed.

What do we recommend?

- ❑ **Use Figure 3 (page 10) and Figure 4 (page 10) as a starting point to identify work areas, jobs, or tasks that may need noise controls or signs.**

We identified a number of machines, tools, and tasks with very high noise levels (Figure 4, page 10). We recommend giving priority to:

- fixed-location saws
- shear, press, punch, and winder machines
- pneumatic impact tools
- sanding/grinding operations
- welding areas.

- ❑ **Use a sound level meter to determine if any machines, tools, or activities produce noise levels 90 dBA or higher.**

Noise meters can be purchased for as little as \$50. Although an inexpensive meter will not satisfy WISHA technical specifications for sound level meters (WAC 296-817-30005), it can guide evaluation and planning.

- ❑ **Make a noise map—a floor plan showing noise levels in specific locations throughout the production area. Update the noise map whenever changes occur.**

Noise maps can be used to plan and prioritize noise controls, and to train or remind employees about the type of hearing protection that is needed in specific work areas.

- ❑ **Place signs in work areas and labels on machines or tools where noise levels may reach 85 dBA or higher. Use our color code and signal words for signs and labels, and in training, to make it easier for employees to know what to do when they work around noisy machines, tools, or areas.**

Figure 5 (page 11) shows our suggested noise labels and signs.

Guidelines for selecting feasible noise controls in the sheet metal industry

It is not practical to control or reduce all noise from machines, tools, and activities in this industry. However, even small reductions in noise can improve employees' ability to perform and communicate in noisy areas, and reduce employees' full-day noise exposures. Many situations can be treated with fairly simple solutions, needing little or no professional assistance. However, if a new noise control will be costly, it is probably worthwhile to hire a consultant, such as an acoustical engineer, to make sure money is invested in the best possible solution.

- ❑ **Maintain machines and tools**

Poor or delayed maintenance can cause tools or machines to become louder. Lubricating or replacing worn parts at cutting surfaces, drive chains, gears, and other moving machine components can reduce noise levels substantially.

- ❑ **Use alternative machine components**

Noise levels can be reduced for some machines and tools by using a different cutting or contact surface. For example, a saw might produce less noise using a blade with more teeth, different tooth patterns, different thickness, or perforations.

- ❑ **Isolate major noise sources**

Isolating loud machines or tools can protect nearby employees when it is not possible to make the noise source any quieter. One approach is to construct walls or barriers around loud equipment, and another is to locate work stations as far away as possible. Moveable barriers can be used while the noisy machine or tool is operated, and then moved out of the way when they are not needed.

Another approach is to use administrative (nonengineered) controls, such as relocating employees or limiting the use of unusually loud machines to slow work times, such as swing or night shifts.

- ❑ **Use sound absorption materials**

Unfortunately, isolating a noise source with a barrier can increase the noise exposure for the equipment operator. To protect operators, the noisy side of a barrier can be lined with a material that absorbs sound. The operator may need to wear hearing protection with a higher noise reduction rating. Sound absorption material can also be placed on walls or ceilings, to reduce the spread of noise.



Employers should obtain professional advice about materials before installing sound absorption. It may be necessary to consider the fire-resistance of sound absorption materials, especially near flames or sparks.

❑ **Use available resources**

Employees often know as much as management about how the production floor operates. Employers should ask employees for ideas about noise controls, and keep employees involved when designing and installing new controls.

Sheet metal manufacturing companies could work together to investigate noise control strategies and share information. The Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) and Sheet Metal Workers union could play important roles in these efforts.

The WISHA Web site provides useful information about noise controls, including:

- The "Helpful Tools" supplement to the WISHA rule:
<http://www.lni.wa.gov/wisha/Rules/noise/HT1EliminatingNoise.htm>
- The WISHA Noise Reduction Ideas Bank:
<http://www.lni.wa.gov/Safety/KeepSafe/ReduceHazards/NoiseBank/default.asp>

A very readable booklet produced by OSHA (*Noise Control, A Guide for Workers and Employers*, 1980) has a lot of information about noise controls:

<http://www.nonoise.org/hearing/noisecon/noisecon.htm>



Figure 1. Noise exposures equivalent to a constant exposure at 85 dBA for eight hours ($TWA_8 = 85$ dBA)

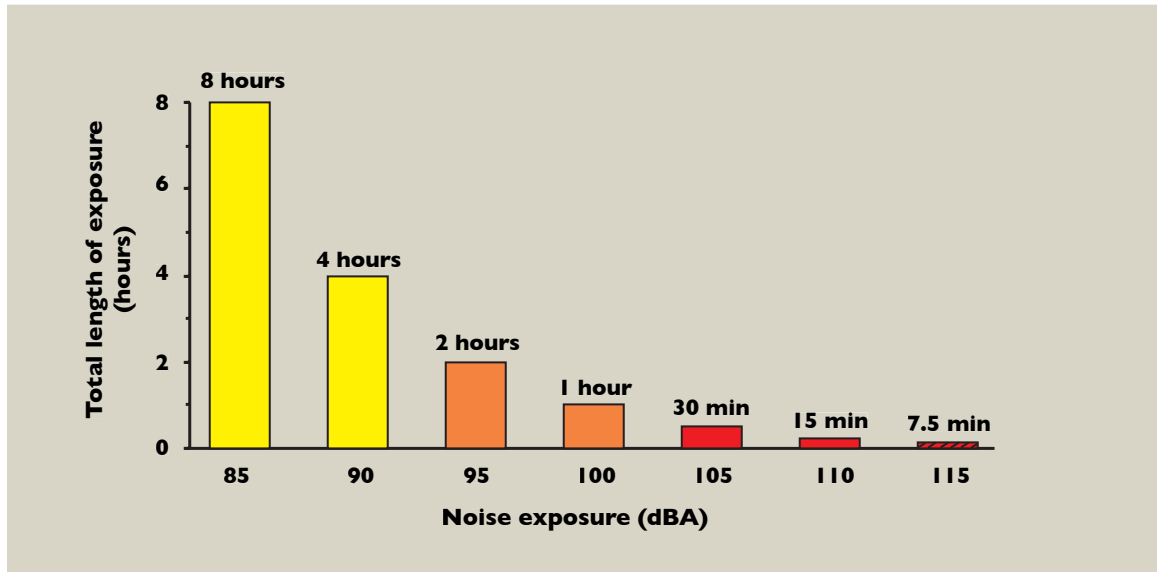
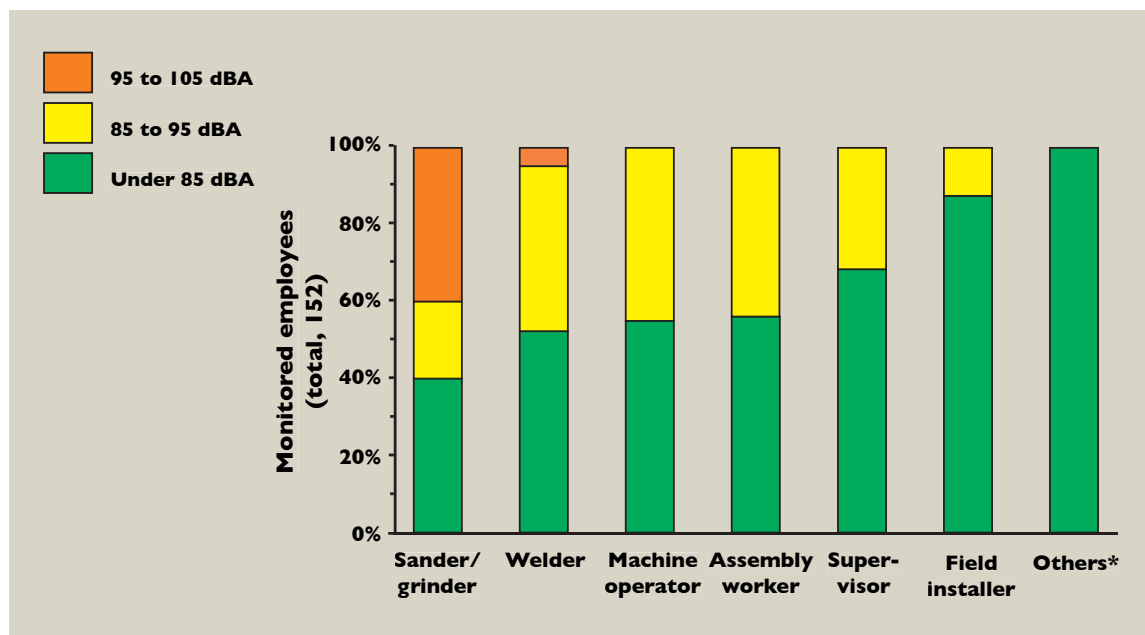


Figure 2. Colors and signal words used for different noise levels



Figure 3. Employee full-day noise exposures (TWA₈) compared between jobs



* The "Others" category includes mechanical maintenance workers and material handlers.

Figure 4. Area noise levels associated with selected machines, tools, and tasks

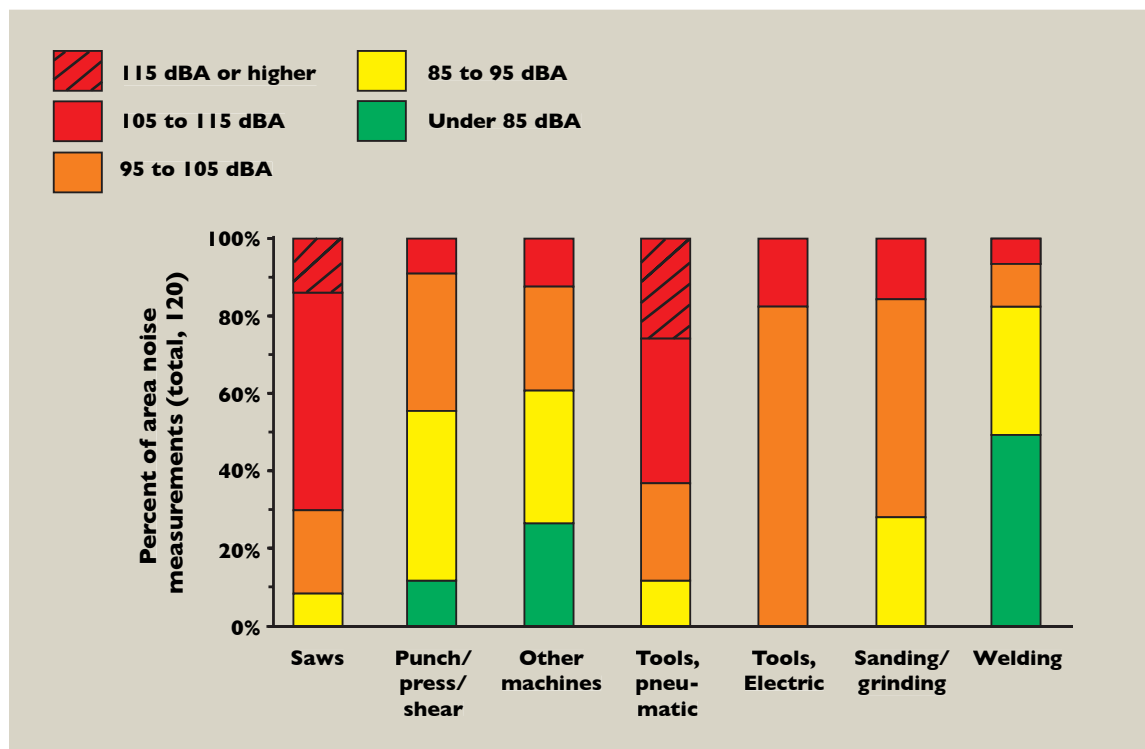


Figure 5. Noise safety signs and labels

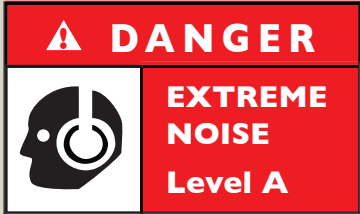
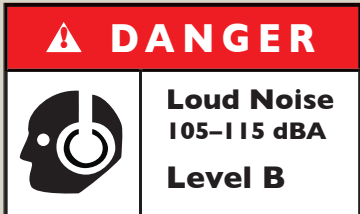
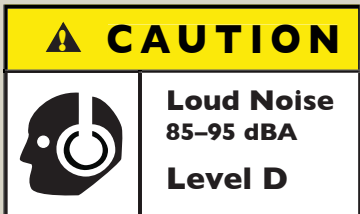
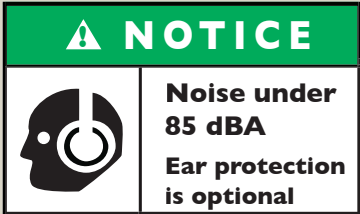
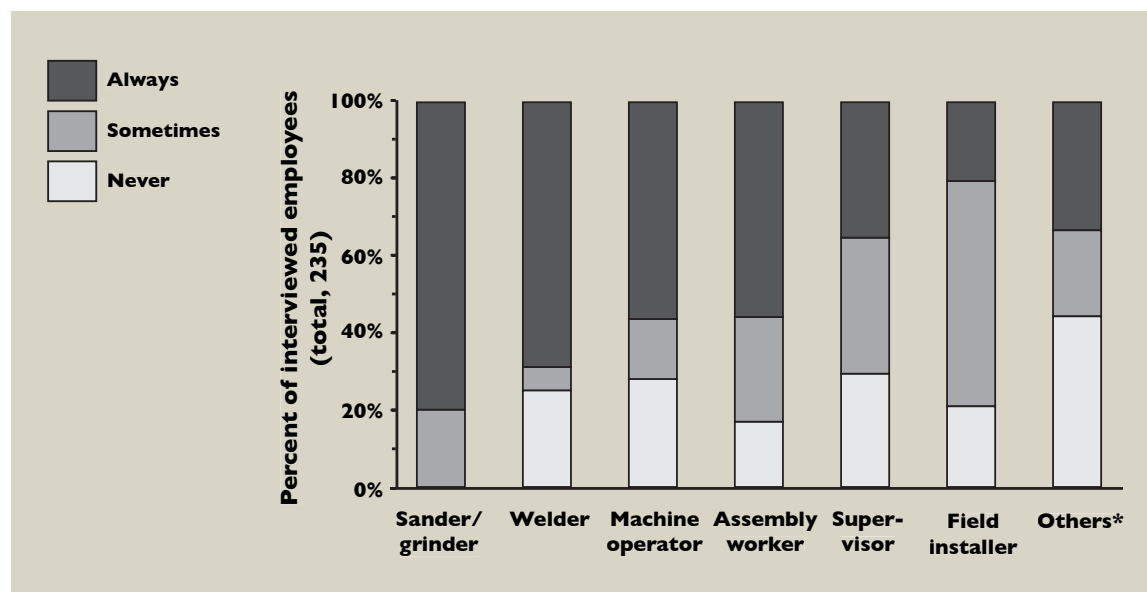
115 dBA or higher Extreme noise		
105 to 115 dBA		
95 to 105 dBA		
85 to 95 dBA		
under 85 dBA		
	Signs or labels can be any size, but must be large enough to be readable from an appropriate distance. See ANSI Z535.2 for text size specifications and ANSI Z535.1 for color specifications.	

Figure 6. Reported use of hearing protection, when exposed, compared between jobs



* The "Others" category includes mechanical maintenance workers and material handlers.

Figure 7. Major types of hearing protection

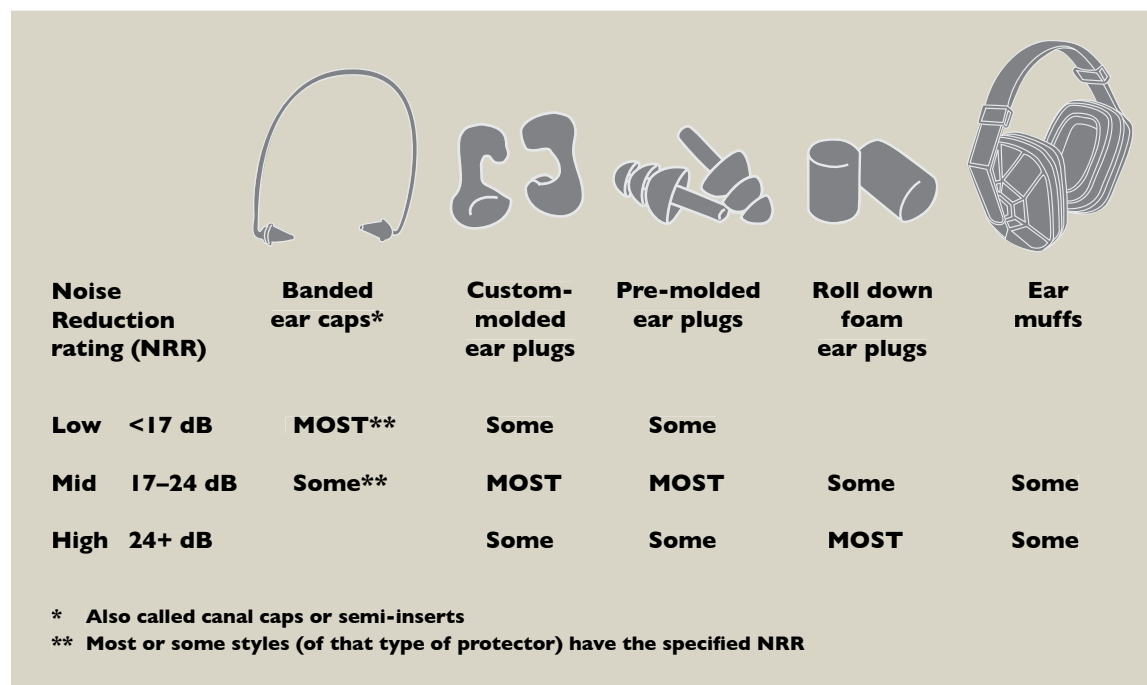


Figure 8. Guidelines for choosing hearing protection

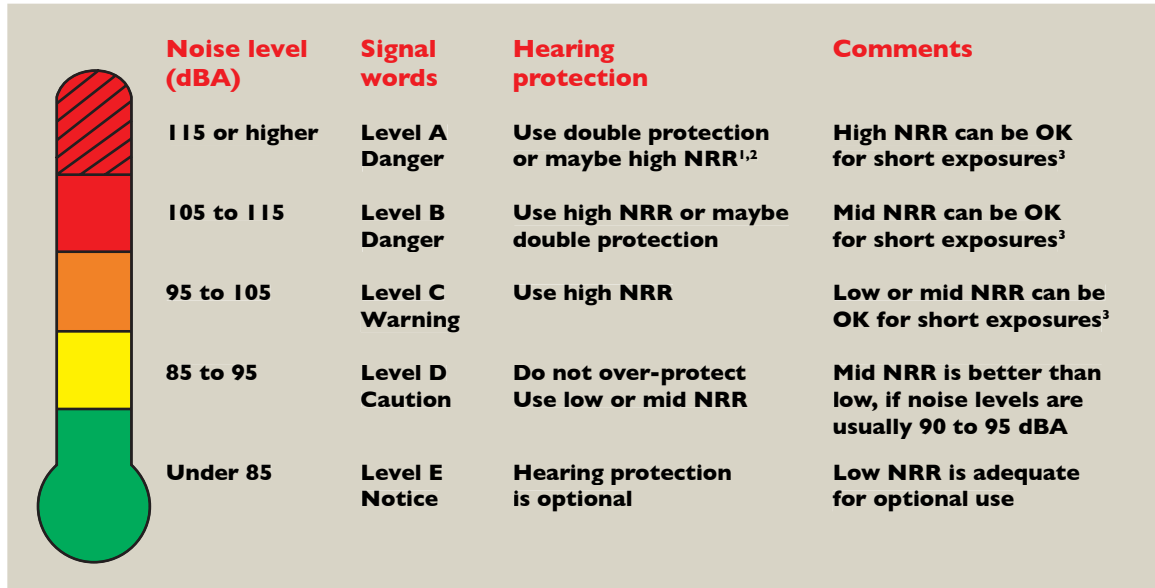
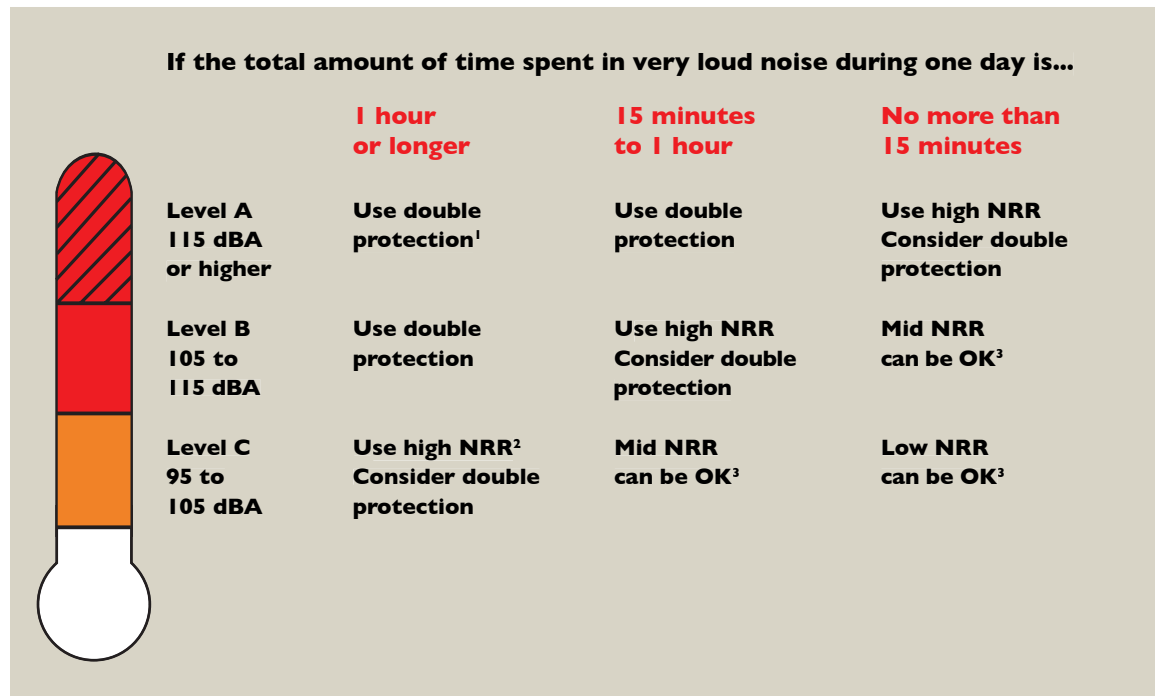


Figure 9. Guidelines for choosing hearing protection for very loud noise



¹ Double protection = ear muffs plus ear plugs, together

² Noise Reduction Rating (NRR): Low NRR < 17 dB; Mid NRR 17-24 dB; High NRR 24+ dB

³ It is OK to use the lower level of protection shown in the figure if...

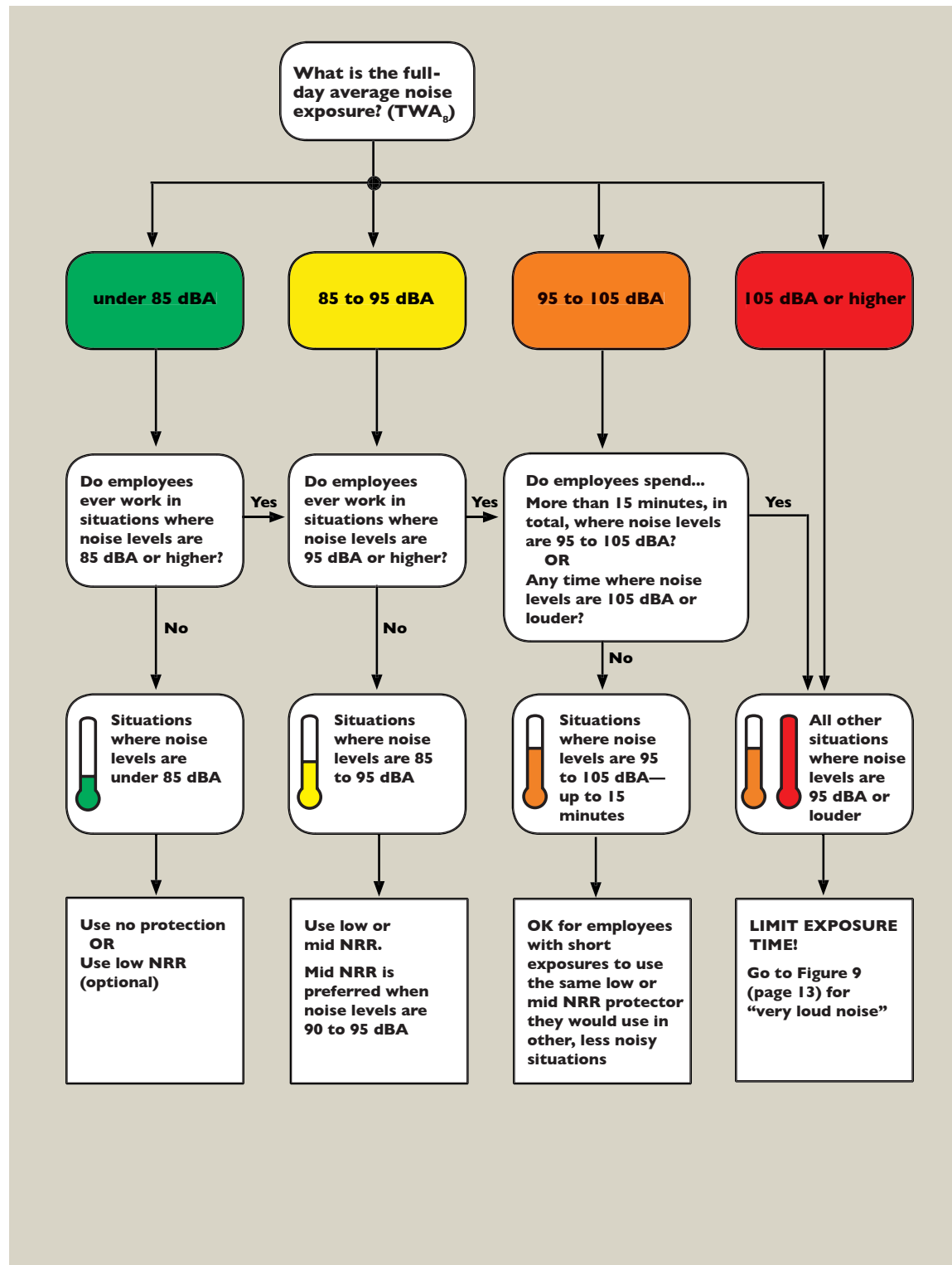
a The total amount of time and the typical noise levels are not both in the upper end of the range shown in Figure 9

b Exposure occurs as brief exposures spread out over the work shift and not continuously or within a short period of time

c The situation does not involve a lot of impact noise

d The employee will not be exposed to noise for a large part of the rest of the shift.

Figure 10. Step-by-step guidelines for selecting appropriate hearing protection



EMPLOYEE TRAINING

What is an employer required to do?

- ☐ **Train all employees whose full-day noise exposure is 85 dBA or higher, TWA_8 .**
- ☐ **Train an employee when he or she is first assigned to a position involving noise exposure of 85 dBA or higher, TWA_8 , and at least annually after that.**
- ☐ **Make sure the noise and hearing protection training includes:**
 - **the effects of occupational and nonoccupational noise on hearing**
 - **noise controls used in the workplace**
 - **the purpose of hearing protectors, including advantages, disadvantages, and levels of protection**
 - **instructions about selecting, fitting, using, and caring for hearing protection**
 - **purpose and procedures for program evaluation, including audiometric testing**
 - **the employees' right to review records kept by the employer.**
- ☐ **Update the training program to reflect changes in controls, hearing protectors, and work processes.**
- ☐ **Maintain a written program describing the initial training and refresher training.**

What were companies doing?

Of the ten companies we studied, all but one provided annual training. Half of the companies either had no written training plan or had shortcomings in their plan. All ten companies had a specific person who coordinated the hearing loss prevention program. Most employees could identify the program coordinator and relied on that person for information about noise or hearing loss prevention. However, many said they relied on a supervisor as their first source of information.

According to the program coordinators, training at nine companies covered how to select, use, fit, and care for hearing protectors. However, only 38% of employees said they were ever shown the right way to select or use a hearing protector. At most companies, fewer than 10% of employees said that someone had ever personally evaluated the fit of their protector.

Most employees were given annual training, but many could not recall it. Among employees who worked at their present company for at least one year, half said they never received training on noise or hearing protection. However, many of these employees had one or more annual hearing tests at this company and were probably shown a training video at that time. This suggests that the training was not memorable or seemed unimportant.

What do we recommend?

- ☐ **Assign one person to be coordinator of the work site hearing loss prevention program.**
- ☐ **Make sure at least one person in the company is able to conduct:**
 - **new employee training**
 - **refresher training**
 - **proper fitting of hearing protection.**
- ☐ **Ensure that supervisors know enough about noise levels and hearing protection to answer employee questions correctly.**
- ☐ **Train employees when they are first placed in a position involving noise exposure. Do not put off training for new employees until the next annual training.**
- ☐ **Provide brief refresher training throughout the year for all exposed employees. Training can be included in routine safety meetings. Emphasize selecting, fitting, using, and caring for hearing protection.**
- ☐ **Provide proper fitting of hearing protection for all new employees and for any employee who has difficulty using hearing protection:**
 - **make sure each employee knows how to select an appropriate protector for his or her job and ears**
 - **observe whether each employee is able to insert or place the protector correctly**
 - **reinstruct each employee as needed until the proper technique is mastered.**
- ☐ **If annual training is conducted by an audiology contractor, give the contractor information about noise levels for all jobs at the work site. Make sure the contractor trains employees to select and use hearing protectors that are appropriate for their specific job.**
- ☐ **Make sure that training is understandable by all employees, including those who are not fluent in English. Have a bilingual employee translate training information, questions, and answers.**
- ☐ **Use our color code and signal words in training to make it easier for employees to know what to do when they work around noisy machines, tools, or areas.**

HEARING PROTECTION

What is an employer required to do?

- ❑ **Make sure employees wear hearing protectors that provide sufficient protection when exposure equals or exceeds:**
 - **full-day exposure 85 dBA, TWA₈**
 - **extreme noise level 115 dBA**
 - **instantaneous exposure 140 dBC.**
- ❑ **Supervise employees to make sure that hearing protection is:**
 - **sufficient to reduce the employee's full-day exposure to 85 dBA or less, TWA₈**
 - **properly chosen for fit**
 - **used correctly**
 - **replaced as necessary.**
- ❑ **Provide an appropriate supply of hearing protectors:**
 - **at least two distinct types of protectors for each exposed employee**
 - **sufficient for all exposure levels, working conditions, and employee sizes**
 - **at no cost to employees.**
- ❑ **Hearing protector selection must consider employee requests regarding physical comfort, environmental conditions, and medical needs.**
- ❑ **Make sure that hearing protection has a Noise Reduction Rating (NRR) of at least 20 dB when exposures reach or exceed:**
 - **extreme noise level 115 dBA**
 - **instantaneous exposure 140 dBC.**

What is a noise reduction rating?

The noise reduction rating (NRR) for a hearing protector is the amount of noise reduction the manufacturer measured in a laboratory. The NRR is useful for comparing different hearing protectors. In general, the higher the NRR, the more the protector will reduce noise exposure.

Laboratory ratings usually show a higher level of protection than most users will get in the real world. It is necessary to make adjustments to the NRR to estimate how well a hearing protector will perform in the real world.

Noise reduction ratings, real-world adjustments, and hearing protector selection can be confusing. Fortunately, there are resources available that simplify the process of selecting appropriate hearing protectors—and the best NRR value—for noise-exposed workers.

The following pages provide guidelines for companies in the sheet metal manufacturing industry to choose hearing protectors with an appropriate NRR. The Hearing Protector Compendium at the National Institute for Occupational Safety and Health (NIOSH) Web site is also a useful resource: http://www2a.cdc.gov/hp-devices/hp_srchpg01.asp

Our guidelines and the NIOSH Web site have considered the necessary real-world adjustments.

What were companies doing?

All ten companies provided at least two types of hearing protection at no cost to employees. Almost all companies provided roll-down foam ear plugs, premolded ear plugs, and ear muffs. Most employees used roll-down foam ear plugs.

About half of employees said they always used hearing protection when they were exposed to loud noise. The others said they never or only sometimes used hearing protection. Use of hearing protection was much higher at some companies than others. The percentage of employees who said they always used hearing protection ranged from 15% to 96% at the companies we evaluated. In general, our observations confirmed what employees reported.

Four of the ten companies we evaluated had policies that required employees to wear hearing protectors in noisy areas. Hearing protector use was relatively high at two of those companies, where the policy was well known among employees. However, at the other two companies, most employees were not aware of such a policy and hearing protector use was similar to companies with no such policy.

Hearing protector use differed greatly between employees in different jobs (see Figure 6, page 12). In general, employees were more likely to use hearing protection if they worked in jobs where noise exposure was common or relatively constant, and less likely to use protection in jobs where exposures were lower or less frequent.

What do we recommend?

❑ Provide a wide variety of types, styles, and sizes of protectors.

We recommend having the following, at a minimum:

- **ear muffs—one or more styles**
- **roll-down foam ear plugs—one or more styles, and at least two sizes**
- **premolded ear plugs—one or more styles, and at least two sizes**
- **banded ear caps—one or more styles.**

The major types of protectors and their typical noise reduction ratings are shown in Figure 7 (page 12). Employees are most likely to wear a hearing protector if it is comfortable, easy to use, and not overprotective. Providing a variety of choices will allow employees to find a protector that meets their needs and personal preferences.

The most commonly used protectors—roll-down foam ear plugs—are excellent protectors but can be inconvenient for frequent use and removal. Other types of protectors—banded ear caps, pre-molded ear plugs, and ear muffs—might be more convenient for employees with brief or intermittent exposures, such as supervisors, material handlers, and field installers.

❑ Do not overprotect employees.

Hearing protection should reduce the full-day exposure inside the ear to less than 85 dBA, and ideally about 75-80 dBA. A hearing protector with an NRR that is too high will overprotect the employee. This can make it difficult to understand other people or hear production sounds or alarms. Sounds may seem muted and employees may feel isolated. Understandably, employees with these problems may resist using hearing protection.

Most employees in this industry only need a hearing protector with low NRR (<17 dB) or mid NRR (17-24 dB). High NRR protectors (24+ dB) provide too much protection for most employees in this industry.

- ❑ **Consider the long-term costs of each hearing protector and not just the cost per unit.**

Although most roll-down foam ear plugs are inexpensive per unit, they often cost the same or more in the long-term as other types of hearing protectors. Many other types can be reused longer than roll-down ear plugs.

- ❑ **Establish and enforce a company policy that clearly states when and where employees must wear hearing protection. It may be necessary to tailor training and enforcement to the different needs of some individual employees.**

A hearing protector policy will only be effective if it is known, understood, and enforced, and if hearing protectors are readily available. Enforcement of hearing protector use should be vigorous for employees in jobs with lower—but still hazardous—noise exposures.

No single enforcement strategy is likely to work for all employees, but behavioral scientists have found positive reinforcement to be effective when employees feel certain about their skills. Before considering disciplinary action, it is important to determine if the employee's hearing protector is incorrectly sized, uncomfortable, or overprotective, and if the employee knows how to use the protector correctly.



Guidelines for selecting appropriate hearing protectors in the sheet metal industry

❑ Make sure employees are satisfied with the available hearing protectors.

If employees feel that the available hearing protectors are uncomfortable or difficult to use, they may resist using them, even in very loud situations. It is important to have enough variety in hearing protectors to provide all employees one they are willing to wear. Remember, the best hearing protector is the one that's worn.

❑ Use our guidelines to select appropriate hearing protectors, depending on the levels and pattern of employee noise exposures. Be flexible when using these guidelines.

We give visual guidelines in Figures 7–10 (pages 12–14) to help employers and employees select appropriate hearing protectors. These guidelines should be easier to use than written descriptions and can be adapted for posting in the workplace.

Our guidelines should be used as a starting point. Depending on the pattern of noise exposure and employee preferences, it may be better for some employees to use a protector with higher or lower NRR than the guidelines indicate. In the remaining sections of this chapter, we describe how the guidelines apply, in general, for employees with the noise exposures we found in this industry.

❑ Employees with full-day exposures under 85 dBA (“Green”)

About two-thirds of employees we monitored had full-day exposures under 85 dBA. All of these employees spent some time in situations where noise levels were 85 to 95 dBA. About 65% of them spent time in very loud situations, with noise levels 95 dBA or louder. However, only 5% spent more than 15 minutes in such a setting and none spent more than 30 minutes.

Most of these employees should use a low or mid NRR hearing protector in noisy situations. Even in very loud situations, a low or mid NRR protector is adequate for almost all of these employees, because they spend so little time in those situations.

❑ Employees with full-day exposures between 85 and 95 dBA (“Yellow”)

About one third of the monitored employees had full-day exposures that were 85 to 95 dBA. All of them spent time in very loud situations, with noise levels 95 dBA or louder. About 75% spent more than 15 minutes, but only about 10% spent one hour or longer, up to four hours total.

Most of these employees should use a low or mid NRR protector in noisy situations. Even in very loud situations, most of them could continue using their usual mid NRR protector and possibly a low NRR protector. This can avoid the confusion and nuisance from having to use different hearing protectors in different situations.

The small number of employees who spend more than one hour in very loud situations should use a high NRR protector or double protection in those situations, especially if noise levels reach 105 dBA or louder. Double protection means using ear muffs plus ear plugs together. These employees could use a high NRR protector for *all* noisy situations, if they preferred. This may be simpler than using different hearing protectors in different situations.

❑ Employees with full-day exposures above 95 dBA (“Orange” and “Red”)

Only three monitored employees had full-day exposures this high. In general, they should wear high NRR or double protection when exposed. None of the monitored employees had full-day exposures above 105 dBA.

AUDIOMETRY (HEARING TESTS)

What is an employer required to do?

- ☐ **Conduct a baseline audiogram for each exposed employee, and conduct annual audiograms for employees as long as they are exposed to noise that is 85 dBA or higher, TWA_8 .**
- ☐ **Provide testing at no cost to employees.**
- ☐ **Make sure each employee's annual audiogram is compared to his or her baseline audiogram by a qualified individual.**
- ☐ **Take appropriate actions when any employee has measurable hearing loss indicated by a "standard threshold shift" (STS).**
 - evaluate noise exposures and noise controls in the work area
 - evaluate selection of hearing protection, and refit as necessary
 - conduct additional training as necessary
 - inform the employee in writing within 21 days after determining an STS occurred.
- ☐ **Obtain an opinion from the health care professional reviewing audiograms about whether an employee's audiogram indicates:**
 - possible occupational hearing loss
 - need for changes in hearing protection.
- ☐ **Make sure each employee is told the results of his or her test.**
- ☐ **See the WISHA Audiometric Testing rule (WAC 296-817-400) for other requirements:** <http://www.lni.wa.gov/WISHA/Rules/noise/HTML/296-817-400.htm>

What is a standard threshold shift?

The purpose of comparing annual and baseline audiograms is to determine whether any employees have lost hearing ability while working at the present company. WISHA defines a standard threshold shift (STS) as a 10 dB or greater worsening in hearing ability, on average, at the 2000, 3000, and 4000 Hz frequencies, in either ear. An STS does not necessarily mean that a significant hearing loss has occurred, or that it was caused by workplace noise. However, unless there is another explanation, an STS should trigger appropriate employer actions.



What were companies doing?

Eight of the ten companies provided annual audiometry, although many employees had not been tested as often as required. One company had never conducted audiometry, and another had not done so for years.

Hearing loss was common. We reviewed test records for 1,124 employees who were tested during 1999 to 2002. Overall, 13% had enough hearing loss to meet workers' compensation criteria for impairment (disability). Another 26% had significant high-frequency hearing loss. More than 40% of those who were 55 years or older had evidence of impairment. We did not judge whether hearing loss was caused by workplace noise exposure; however, we found more hearing loss than is expected in the general population.

About half of interviewed employees with significant hearing loss on their audiogram, and most employees with an STS did not recall ever being told about those findings.

What do we recommend?

- ☐ **Make sure each employee understands the results of his or her test.**
- ☐ **Make sure that each employee with hearing loss has a suitable hearing protector, and receives appropriate training and fit evaluation.**
Employees with hearing loss may need more training or different hearing protectors than other employees with similar noise exposures.
- ☐ **Conduct an audiogram when any employee is terminating employment.**
An employer can be liable for hearing loss that occurred after an employee left the work site, unless the employer can show what the employee's hearing ability was when employment ended.



EVALUATION AND DOCUMENTATION

What is an employer required to do?

- ☐ **Use audiometric testing to identify any hearing loss trend that may indicate program deficiencies.**
- ☐ **Take action when deficiencies are identified.**
- ☐ **Retain records, at a minimum, for this long:**
 - **exposure measurements, for at least 2 years and as long as you rely upon them**
 - **audiometric testing, for employee's duration of employment.**
- ☐ **Maintain a written training program.**

How can audiometry be used for program evaluation?

The percentage of employees who have a standard threshold shift (STS) each year can be a useful indicator of program effectiveness. In general, no more than 3% to 5% of employees will have an STS each year at a workplace with an effective hearing loss prevention program. A higher percentage may indicate program deficiencies.

What were companies doing?

We looked at the annual summary reports for five companies with established testing programs and found acceptable to somewhat unacceptable rates of employee hearing loss over time. From 1999 to 2002, the *average* annual STS percentage ranged from 3.5% to 8.2% at these five companies.

The STS percentage showed limited usefulness for evaluating program effectiveness on a year-to-year basis. The STS percentage differed up to 11% from year to year at individual companies. These large differences were caused by the workforce size and turnover at these companies. Testing at each company included only about 75 employees annually, on average, and about 30% of tests were baseline tests for new employees.

In this setting, it is difficult to decide if the STS percentage in any one year truly reflects the status of the hearing loss prevention program or occurred by chance. The STS percentage is probably not reliable in this industry unless it is averaged over several years or more.

What do we recommend?

- ☐ **Keep audiometry records permanently for possible use if a hearing loss claim is filed.**
- ☐ **Audit employee use of hearing protection, at least quarterly, to confirm:**
 - **employees wear a protector whenever they are exposed to noise 85 dBA or louder**
 - **the protector is appropriate for the conditions**
 - **the protector is worn properly**
 - **employees are satisfied with their protector.**

❑ **Periodically audit other major components of the hearing loss prevention program.**

Some of the companies we evaluated had much more complete hearing loss prevention programs than others. However, we found important shortcomings in training, use of hearing protection, or audiometric testing at most of the companies.

Even if changes were made immediately, it would take many years of audiometry to confirm whether the changes were successful. Therefore, employers should also rely on other, short-term measures to evaluate their hearing loss prevention program.

WISHA endorses, but does *not* require, hearing protector audits for program evaluation. We recommend that employers maintain such an audit program. Audits can help detect employees who may need additional training, fitting, or monitoring. They can also help determine if training should be improved or conducted more often, or if different hearing protectors may be needed. Audit records should be retained for at least two years and as long as you rely on them.

