



## Occupational Noise Measurement

Occupational hearing loss is damage to the inner ear from noise or vibrations due to certain types of jobs or entertainment. Occupational hearing loss is a form of **acoustic trauma** caused by exposure to vibration or sound. Sound is heard as the ear converts vibration from sound waves into impulses in the nerves of the ear.

Sounds above 90 decibels (dB, a measurement of the loudness or strength of sound vibration) may cause vibration intense enough to damage the inner ear, especially if the sound continues for a long time.

Did you know that occupational hearing loss was an ergonomic type injury? The reason being that it is a cumulative trauma which translates to exposures over time. In order to control and prevent occupational deafness you must be able to measure the exposures.

- 90 dB -- a large truck 5 yards away (motorcycles, snowmobiles, and similar engines range from 85 - 90 dB)
- 100 dB -- some rock concerts
- 120 dB -- a jackhammer about 3 feet away
- 130 dB -- a jet engine from 100 feet away

A general rule of thumb is that if you need to shout to be heard, the sound is in the range that can damage hearing.

Some jobs carry a high risk for **hearing loss**, such as:

- Airline ground maintenance
- Construction
- Farming
- Jobs involving loud music or machinery

- Oil rigs
- Refineries

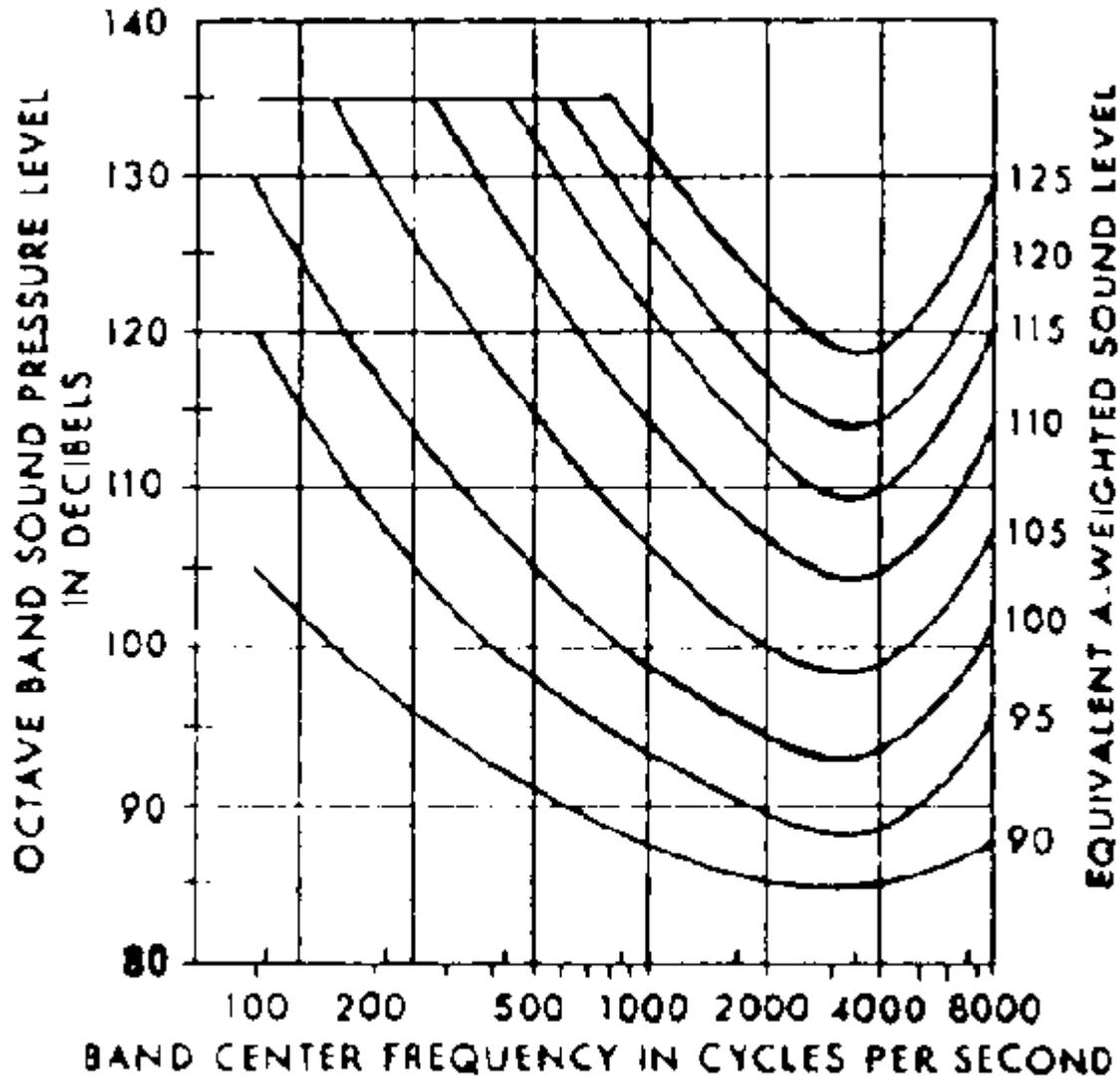
Measuring noise levels and workers' noise exposures is the most important part of a workplace hearing conservation and noise control program. It helps identify work locations where there are noise problems, employees who may be affected, and where additional noise measurements need to be made.

No single method or process exists for measuring occupational noise. Hearing safety and health professionals can use a variety of instruments to measure noise and can choose from a variety of instruments and software to analyze their measurements. The choice of a particular instrument and approach for measuring and analyzing occupational noise depends on many factors, not the least of which will be the purpose for the measurement and the environment in which the measurement will be made.

In general, measurement methods should conform to the *American National Standard Measurement of Occupational Noise Exposure*, ANSI S12.19-1997 [ANSI 1996a]. More detailed discussions about instrumentation and measurement protocols appear in reference sources such as NIOSH [1973], Earshen [1986], Johnson et al. [1991], and Harris [1991].

In the United States, the Occupational Safety and Health Administration (OSHA) developed a regulation for Occupational Noise Exposure, number 1910 which is part of the Occupational Safety and Health Standards, Occupational Health and Environmental Control 1910.95

Protection against the effects of noise exposure shall be provided when the sound levels exceed those shown in Table G-16 when measured on the A scale of a standard sound level meter at slow response. When noise levels are determined by octave band analysis, the equivalent A-weighted sound level may be determined as follows:



**FIGURE G-9**

Equivalent sound level contours. Octave band sound pressure levels may be converted to the equivalent A-weighted sound level by plotting them on this graph and noting the A-weighted sound level corresponding to the point of highest penetration into the sound level contours. This equivalent A-weighted sound level, which may differ from the actual A-weighted sound level of the noise, is used to determine exposure limits from Table 1.G-16.

[1910.95\(b\)\(1\)](#)

When employees are subjected to sound exceeding those listed in Table G-16, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels within the levels of Table G-16, personal protective equipment shall be provided and used to reduce sound levels within the levels of the table.

**1910.95(b)(2)**

If the variations in noise level involve maxima at intervals of 1 second or less, it is to be considered continuous.

TABLE G-16 - PERMISSIBLE NOISE EXPOSURES (1)

Duration per day, hours	Sound level dBA slow response
8.....	90
6.....	92
4.....	95
3.....	97
2.....	100
1 1/2 .....	102
1.....	105
1/2 .....	110
1/4 or less.....	115

Footnote(1) When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions:  $C(1)/T(1) + C(2)/T(2) + \dots + C(n)/T(n)$  exceeds unity, then, the mixed exposure should be considered to exceed the limit value.  $C_n$  indicates the total time of exposure at a specified noise level, and  $T_n$  indicates the total time of exposure permitted at that level. Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

For occupational hygiene purposes, the sound pressure level is measured to determine noise exposures. Various instruments and techniques may be used. The choice depends on the workplace noise and the information needed. However, the first step is to determine if there is a noise problem in the workplace.

The following outlines the steps involved in the noise measurement as recommended by the Canadian Standard CSA Z107.56 or the standard that applies in your jurisdiction.

The first step is to determine whether or not noise is a potential problem in your workplace. A walk-through survey helps in making this decision. The indicators of potentially hazardous noise level include:

- noise is louder than busy city traffic,
- people have to raise their voices to talk to someone at 3 feet (one metre) away,
- at the end of work shift, people have to increase the volume of their radio or TV to a level too loud for others
- after working for a few years in a workplace, employees find it difficult to communicate in a crowd or party situation where there are other sounds or many voices.

Noise measurement data from studies in similar situations are very helpful in assessing the potential noise problem. The [Noise Levels Data Base](#) produced by CCOHS provides a collection of measured noise levels for a wide range of industrial situations.

Before taking field measurements, it is important to determine the type of information required. The person making the measurement must understand:

- the purpose of measurement: compliance with noise regulations, hearing loss prevention, noise control, community annoyance etc.,
- the sources of noise, and times when the sources are operating,
- the temporal pattern of noise - continuous, variable, intermittent, impulse, and
- locations of exposed persons.

The initial measurements are noise surveys to determine if

- noise problem exists and
- further measurements are needed.

The second step is to determine personal noise exposure levels; that is, the amount of noise to which individual employees are exposed. If the workplace noise remains steady, noise survey data can be used to determine employee exposures. However, noise dosimetry is necessary if the workplace noise levels vary throughout the day or if the workers are fairly mobile.

The most common instruments used for measuring noise are the sound level meter (SLM), the integrating sound level meter (ISLM), and the noise dosimeter. It is important that you understand the calibration, operation and reading the instrument you use. The user's manual provided by the instrument manufacturer provides most of this information. Table 1 provides some instrument selection guidelines.

<b>Table 1 Guidelines for Instrument Selection</b>			
<b>Type of Measurement</b>	<b>Appropriate Instruments (in order of preference)</b>	<b>Result</b>	<b>Comments</b>
Personal noise exposure	1) Dosimeter	Dose or equivalent sound level	Most accurate for personal noise exposures
	2) ISLM*	Equivalent sound level	If the worker is mobile, it may be difficult to determine a personal

			exposure, unless work can be easily divided into defined activities.
	3) SLM**	dB(A)	If noise levels vary considerably, it is difficult to determine average exposure. Only useful when work can be easily divided into defined activities and noise levels are relatively stable all the time.
Noise levels generated by a particular source	1) SLM**	dB(A)	Measurement should be taken 1 to 3 metres from source (not directly at the source).
	2) ISLM**	Equivalent sound level dB(A)	Particularly useful if noise is highly variable; it can measure equivalent sound level over a short period of time (1 minute).
Noise survey	1) SLM	dB(A)	To produce noise map of an area; take measurements on a grid pattern.
	2) ISLM	Equivalent sound level dB(A)	For highly variable noise.
Impulse noise	1) Impulse SLM	Peak pressure dB(A)	To measure the peak of each impulse.
<p>* SLM stands for Sound Level Meter  ** ISLM stands for Integrating Sound Level Meter</p>			

The SLM consists of a microphone, electronic circuits and a readout display. The microphone detects the small air pressure variations associated with sound and changes them into electrical signals. These signals are then processed by the electronic circuitry of the instrument. The readout displays the sound level in decibels. The SLM takes the sound pressure level at one instant in a particular location.

To take measurements, the SLM is held at arm's length at the ear height for those exposed to the noise. With most SLMs it does not matter exactly how the microphone is pointed at the noise source. The instrument's instruction manual explains how to hold the microphone. The SLM must be calibrated before and after each use. The manual also gives the calibration procedure.

With most SLMs, the readings can be taken on either SLOW or FAST response. The response rate is the time period over which the instrument averages the sound level before displaying it on the readout. Workplace noise level measurements should be taken on SLOW response.

A Type 2 SLM is sufficiently accurate for industrial field evaluations. The more accurate and much more expensive Type 1 SLMs are primarily used in engineering, laboratory and research work. Any SLM that is less accurate than a Type 2 should not be used for workplace noise measurement.

An A-weighting filter is generally built into all SLMs and can be switched ON or OFF. Some Type 2 SLMs provide measurements only in dB(A), meaning that the A-weighting filter is ON permanently.

A standard SLM takes only instantaneous noise measurements. This is sufficient in workplaces with continuous noise levels. But in workplaces with impulse, intermittent or variable noise levels, the SLM makes it difficult to determine a person's average exposure to noise over a work shift. One solution in such workplaces is a noise dosimeter.

The integrating sound level meter (ISLM) is similar to the dosimeter. It determines equivalent sound levels over a measurement period. The major difference is that an ISLM does not provide personal exposures because it is hand-held like the SLM, and not worn.

The ISLM determines equivalent sound levels at a particular location. It yields a single reading of a given noise, even if the actual sound level of the noise changes continually. It uses a pre-programmed exchange rate, with a time constant that is equivalent to the SLOW setting on the SLM.

A noise dosimeter is a small, light device that clips to a person's belt with a small microphone that fastens to the person's collar, close to an ear. The dosimeter stores the noise level information and carries out an averaging process. It is useful in industry where noise usually varies in duration and intensity, and where the person changes locations.

A noise dosimeter requires the following settings:

(a) **Criterion Level:** exposure limit for 8 hours per day five days per week. Criterion level is 90 dB(A) for many jurisdictions, 85 dB(A) for some and 87 dB(A) for Canadian federal jurisdictions.

(b) **Exchange rate:** 3 dB or 5 dB as specified in the noise regulation.

(c) **Threshold:** noise level limit below which the dosimeter does not accumulate noise dose data.

Wearing the dosimeter over a complete work shift gives the average noise exposure or noise dose for that person. This is usually expressed as a percentage of the maximum permitted exposure. If a person has received a noise dose of 100% over a work shift, this means that the average noise exposure is at the maximum permitted. For example, with a criterion level of 90 dB(A) and an exchange rate of 3 dB(A), an eight-hour exposure to 90 dB(A) gives a 100% dose. A four-hour exposure to 93 dB(A) is also a 100% dose, whereas an eight-hour exposure to 93 dB(A) is a noise dose of 200%.

Usually the manufacturer electronically adjusts dosimeters to the criterion level and exchange rate in use. You may have to adjust them to suit the exposure guidelines/standards in force in your jurisdiction.

Dosimeters also give an equivalent sound or noise level. This is the average exposure level for noise over the time dosimeter was on. It has the same total sound energy as the actual, variable sound levels to which a person is exposed over the same time period. Scientific evidence suggests that hearing loss is

affected by the total noise energy exposure. If a person is exposed over an eight-hour work shift to varying noise levels, it is possible to calculate an equivalent sound level which would equal the same total sound energy exposure. This would have the same effect on the person's hearing as the variable exposure actually received (Figure 1).

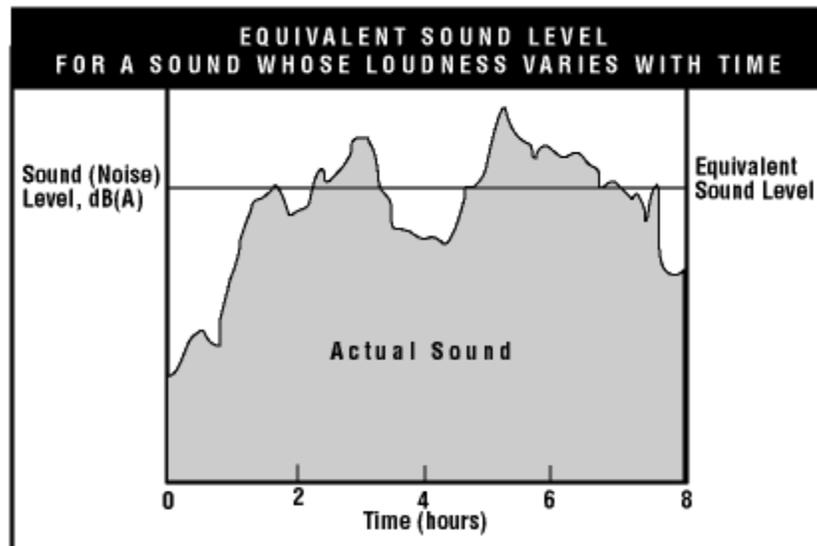


Figure 1

In Figure 1, the shaded area under the line that shows how the sound level changes over time (the "curve") represents the total sound exposure over eight hours.

When air blows by the microphone, the noise reading is altered. To avoid the effect of wind, one uses windscreens to cover the microphone in areas with considerable air movement. Windscreens are available from manufacturers of sound level meters.

Before taking any field measurements, it is important to determine the type of information required. Do the workplace noise levels vary throughout the day? Are the workers fairly mobile?

Noise levels may vary over the work shift. Instantaneous noise measurements, taken with an SLM (Type 2, SLOW RESPONSE, A-filter), at one person's work station, ranged from 63 dB(A) to 114 dB(A) over the day, although levels most

commonly ranged from 90 to 96 dB(A) and 104 to 107 dB(A). This information strongly suggested that there was a potential for excessive noise exposure.

The worker was asked to wear a noise dosimeter over a full eight-hour work shift. At the end of the shift, the noise dosimeter indicated a 270% dose. This was a substantial exposure. In addition, the dosimeter provided an equivalent noise level of 97 dB(A). In other words, a constant eight-hour exposure to a steady, continuous noise of 97 dB(A) would have resulted in the same exposure.

An ISLM could also have been used in this example, particularly if the worker spent most of the work shift in a defined location, or the first half of the shift in one area and the remainder in another area. The ISLM could have provided equivalent sound level measurements and a fairly accurate exposure assessment.

Measurements of impulse or impact noise depend on the guidelines and standards in force. Before you measure impact or impulse noise, you must ensure that the equipment has the capacity to measure this kind of noise. Normally measurements of either peak noise levels together with the actual number of peaks, or percentage dose or equivalent sound levels are required. Where there is little background noise, as for example on an outdoor rifle range, the measuring of peak pressures may be most appropriate.

In industrial settings, there is usually considerable background noise in addition to the impulse noise. In such cases, provided that a 3 dB(A) exchange rate is used, dosimeters or ISLMs which are sufficiently sensitive to respond well to peaks may be more appropriate. One can account for all of the noise, continuous and impulse, in the one measurement.

Frequency analysis is measuring noise level at each frequency or pitch. Frequency analysis is not required when the purpose of noise measurement is to assess compliance with regulatory exposure limits or to assess risk of hearing loss. For such purposes the A-weighted noise level in dB(A), percent noise dose or time-weighted average (TWA) equivalent sound level is sufficient. The frequency analysis is usually needed only for the selection of appropriate engineering control methods.

Sometimes it is necessary to determine the actual frequency distribution of the noise. A detailed frequency analysis is called narrow band analysis. In this method the entire audible frequency range is divided into frequency windows of fixed

width of a few hertz and noise level is measured in dB units at each of these frequency windows. Narrow band analysis is normally not needed for workplace noise. Such analysis is used for engineering measurements. For workplace noise we need octave band analysis.

Octave bands are identified by their centre frequency. The band width increases as the centre frequency increases. The audible sound frequency range (approximately 20 to 20,000 Hz) has been divided into 11 octave bands for this purpose. An octave band filter set can be attached to an SLM to measure the sound level in each octave band.

Sometimes it is necessary to determine whether or not the background noise is influencing the total noise level measured when the noise source is "on". In such cases, two readings of noise level are taken - one with the noise source "on" and the other with the noise source "off". The following table can be used to determine noise level due to the noise source. For example if the total noise level is 97 dB and the background noise is 90 dB, the noise due to source is 96 dB (97-1). If the difference is more than 10 dB, no correction is needed.

<b>Table 2</b> <b>Background Noise Level Correction</b>	
TOTAL NOISE LEVEL(dB) minus BACKGROUND NOISE LEVEL (dB) dB	SUBTRACTED FROM TOTAL NOISE LEVEL TO GET NOISE DUE TO THE SOURCE
8 - 10	0.5
6 - 8	1
4.5 - 6	1.5
4 - 4.5	2
3.5	2.5
3	3

A noise survey takes noise measurements throughout an entire plant or section to identify noisy areas similar to an audit. Noise surveys provide very useful information which enables us to identify:

- areas where employees are likely to be exposed to harmful levels of noise and personal dosimetry may be needed,
- machines and equipment which generate harmful levels of noise,
- employees who might be exposed to unacceptable noise levels, and
- noise control options to reduce noise exposure.

Noise survey is conducted in areas where noise exposure is likely to be hazardous. Noise level refers to the level of sound. A noise survey involves measuring noise level at selected locations throughout an entire plant or sections to identify noisy areas. This is usually done with a sound level meter ( SLM). A reasonably accurate sketch showing the locations of workers and noisy machines is drawn. Noise level measurements are taken at a suitable number of positions around the area and are marked on the sketch. The more measurements taken, the more accurate the survey. A noise map can be produced by drawing lines on the sketch between points of equal sound level. Noise survey maps, like that in Figure 2, provide very useful information by clearly identifying areas where there are noise hazards.

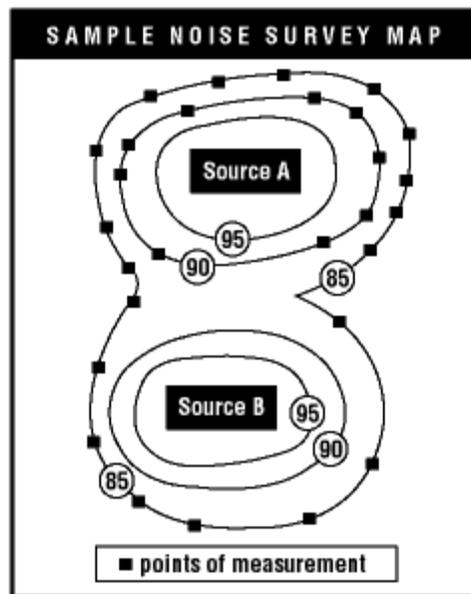


Figure 2

The SLM must be calibrated before and after each use. The manual gives the calibration procedure. To take measurements, the SLM is held at arm's length at the ear height for those exposed to the noise.

When the purpose of noise measurement is to assess the risk of hearing loss, the microphone position should be as close as possible to the location of the ears of the employee for whose benefit the noise exposure data are being taken.

Shielding by presence of employee and other objects between the noise source and microphone should be avoided. The employee need not be present during the measurement. For a stationary employee, the microphone should be positioned above the shoulder or as near as feasible. The microphone should be located within 0.5 metre of the employee's shoulder. If the employee works in a standing position, the microphone should be position of 1.5 metres above the floor is preferred. If the employee works in a sitting position, the microphone should be position of 1.1 metres above the floor is preferred.

A standard SLM takes only instantaneous noise measurements. This is sufficient in workplaces with continuous noise levels. But in workplaces with impulse, intermittent or variable noise levels, the SLM makes it difficult to determine a person's average exposure to noise over a work shift. One solution in such workplaces is a noise dosimeter.

Need for measuring employee noise exposure arises when noise survey indicates possibility that employees may exceed noise exposure limits set by noise regulations or the limits set by the company. Personal noise exposure of employees is done using a noise dosimeter.

The dosimeter is worn by the employee during entire or part of the shift unattended by the person responsible for taking the noise measurement. The reliability of the noise data will depend on the employee cooperation in the proper use of the dosimeter. The following are some helpful tips to ensure employee cooperation in noise dosimetry.

- Inform the employees about the purpose of measurement.
- Explain the importance of the accuracy of noise data in assessing the need for noise control.
- Emphasize the importance of wearing it all the time during the measurement period.
- Explain the consequences of tampering with the microphone - shouting in it, using it to knock doors, etc.

Usually, the manufacturer electronically adjusts dosimeters to the criterion level and exchange rate in use. You may have to adjust them to suit the exposure guidelines/standards in force in your jurisdiction. The calibration must be checked before giving out dosimeters and after the end of the measurement period. The start and stop times of the dosimeters must be noted.

The integrating sound level meter (ISLM) can be used to measure equivalent noise level averaged over the measurement period which could be several minutes, a few hours or an entire work shift. In this respect it is similar to a dosimeter used as area monitor. An ISLM does not provide personal exposure level because it is not worn on person. It gives equivalent sound levels at a particular location. The ISLM uses a pre-programmed exchange rate, with a time constant that is equivalent to the SLOW setting on the SLM.

A physical examination will not usually show any specific changes. Tests that may be performed include:

- Audiology/audiometry
- CT scan of the head
- Head x-ray

The hearing loss is usually permanent. The goal of treatment is to prevent further hearing loss, improve communication with any remaining hearing, and develop coping skills (such as lip reading).

Using a hearing aid may improve communication. Always protect the ear from further damage. For example, wear ear plugs or other hearing protection in noisy areas.

Hearing loss is often permanent in the affected ear. The loss may get worse if you don't take measures to prevent further damage.

Also, hearing loss may progress to total deafness.