Listen While You Work

Hearing Conservation for the Arts

for performers and other workers in arts and entertainment

SHAPE
SAFETY & HEALTH IN ARTS PRODUCTION & ENTERTAINMENT

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About SHAPE

SHAPE (Safety and Health in Arts Production and Entertainment) is an industry association dedicated to promoting health and safety in film and television production, theatre, music, and other performing arts industries in British Columbia. SHAPE provides information, education, and other services that help make arts production and entertainment workplaces healthier and safer.

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Introduction: Lend me your ears

Got ears? If you do, then listen up. Your ears are much more than a convenient place to stick piercings. Think of your ears as workers — after all, they're on the job collecting sound information and sending it to your brain, 24 hours a day. If you don't treat them right, those little aural workers might just go on strike — permanently. So what can you do about it?

Reduce your exposure to sound. If you can't avoid loud environments, use hearing protection.

Some people consider hearing protection an annoying hindrance. Earplugs and earmuffs are often considered unprofessional-looking or even unnecessary. But consider this: Sound-induced hearing loss is irreversible. That means permanent, possibly career-ending. The question of whether or not hearing protection looks unprofessional won't matter much if you're no longer able to work.

This manual will tell you a lot about the risks you face — on the job and off — and what you can do to conserve your hearing. Whether or not you like what you hear, this manual will help ensure that you will hear, and continue to hear in the years to come.

CHOOSE YOUR WORD CAREFULLY

He who wants to persuade should put his trust not in the right argument, but in the right word. The power of sound has always been greater than the power of sense.

—*Joseph Conrad,* A Personal Record *(1912)*

ALL IN THE EAR OF THE BEHOLDER

For twenty-five centuries, Western knowledge has tried to look upon the world. It has failed to understand that the world is not for the beholding. It is for hearing. It is not legible, but audible. Our science has always desired to monitor, measure, abstract, and castrate meaning, forgetting that life is full of noise and that death alone is silent: work noise, noise of man, and noise of beast. Noise bought, sold, or prohibited. Nothing essential happens in the absence of noise.

—*Jacques Attali,* Noise: The Political Economy of Music *(1977)*

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Who should read this manual

This manual is for performers and other workers who work part-time or full-time in British Columbia's arts production and entertainment industries.

Much of the information in this manual applies to performers, audio engineers, and other workers who are exposed to significant amounts of sound in their jobs and whose work relies directly on their ability not only to hear, but to hear well.

This manual also provides information for performers and other workers whose work is not directly sound-related, but who encounter sound-exposure hazards in their jobs all the same. Good hearing may or may not be essential in your job, but it's a luxury few of us are willing to do without.

If you want to be able to keep working and enjoying simple pleasures — going to the movies, listening to music, or even just talking with family and friends — you need to conserve your hearing now.

GOOD VIBRATIONS

The sound of laughter is like the vaulted dome of a temple of happiness.

—*Milan Kundera,* The Book of Laughter and Forgetting *(1978)*

WHAT'S THAT YOU SAY?
Have you ever:

- Heard ringing or buzzing in your ears?
- Noticed that your hearing seems muted or music sounds distorted?
- Had to ask others to repeat themselves frequently?
- Had difficulty distinguishing between similar-sounding words in conversation?
- Been told you were speaking too loudly when you thought you were speaking normally?
- Had others tell you to pull some of the treble out of the mix or turn the volume down?

If you answered yes to any of these questions, you may have a hearing loss. Whether you've lost a little or a lot of your hearing, it's never too late to do something about it. A hearing test will let you know what's up with your hearing and what you can do to protect yourself.

Who may be at risk

Only the most common jobs in the arts production and entertainment industries are included here. Other performers and workers whose titles or positions are not mentioned here may also be at risk.

Music industry — performers

- Musicians and conductors in symphony orchestras and other classical-music ensembles
- Pit-orchestra musicians and conductors as well as other musical-theatre performers
- Opera singers and other vocalists
- Popular musicians (such as pop, rock, jazz, and country groups and soloists), both onstage and in the studio

Music industry — other workers

Studio

- Audio engineers and assistants
- Producers

Live venues (such as clubs and concert halls)

- Audio engineers and assistants
- Lighting technicians (including follow-spot operators)
- Crew (roadies)
- Staff (such as managers, bouncers, and servers)

Other

- Music instructors (such as school band teachers and private teachers)
- Dance and aerobics instructors
- DJs and VJs
- Composers
- Piano technicians

Theatre, stage, and other live performance

- Performers (such as actors and dancers)
- Technical directors
- Artistic directors
- Choreographers
- Stage managers
- Sound designers
- Lighting and set designers
- Special effects designers
- Other stage workers (such as carpenters, props builders, electricians, and welders)
- Producers
- Front-of-house staff
- Projectionists

What's inside

This manual is divided into six parts.

Part 1, In the Beginning: Sound Basics, describes how we hear, the characteristics of sound, and the short- and long-term effects of sound exposure on hearing. Part 1 will help you recognize the warning signs and symptoms of hearing damage.

Part 2, Sound Sources: Identifying Music-Related Sound Hazards, focusses on sound sources that performers and other workers may encounter at work, including acoustic and electric instruments, and amplified sound.

Part 3, Sound Sources: Identifying Non-Musical Sound Hazards, focusses on non-musical sound sources that performers and others may be exposed to at work and during off-hours.

Part 4, Prevention: Reducing or Eliminating Exposure to Sound Sources, explains how you can conserve your hearing by reducing or eliminating your exposure to the sound hazards identified in Part 2 and 3.

Part 5, Protection: Working Safely Around Sound Sources, describes the types of hearing protection you can use to protect against the sound hazards identified in Part 2 and 3.

Part 6, Get with the Program: Hearing Conservation Programs, describes the basic components of an effective hearing conservation program and provides some information on hearing tests.

A **Resources** section includes information on hearing conservation organizations, product suppliers, and publications.

Note This manual does not replace the Workers' Compensation Board of British Columbia's Occupational Health and Safety Regulation or the *Workers Compensation Act*. Employers and workers should always refer to the Regulation for specific requirements that apply to their work activities.

Terms

This section defines a few of the terms used in this manual.

background sound
Background sound is the sound in a given environment that comes from several non-distinctive sources. Examples of background sound include traffic noise, crowd noise, and natural sounds made by wildlife or weather conditions. In arts production and entertainment environments, background sound is typically any sound other than the music, dialogue, or sound effects central to the situation.

continuous sound
Continuous sound is sound that remains at a relatively stable, constant level, such as the sound produced by a generator. Continuous sounds can be hazardous even at relatively quiet levels if a worker is exposed to them for a long time without recovery periods between exposures.

decibel (dB)
The *decibel (dB)* is a unit used to measure a sound's intensity. For more information on dB and dBA, see "1.3 Intensity (Loudness)."

impulse sound
Impulse sound is an instantaneous burst of intense sound that lasts less than one second and is followed by an interval of at least one second before the next burst. Impulse sounds such as gunshots and explosions can be hazardous. Impulse sounds produced when two objects strike one other (for example, a drumstick hitting a snare drum) are also referred to as *impact sounds*.

intensity
Intensity is the term used to describe how loud a sound is. We perceive a sound's intensity as *loudness*. Intensity is measured using the *decibel (dB)*.

loudness
Loudness is our perception of a sound's *intensity*. Sounds we perceive as louder have more intensity than sounds we perceive as quieter.

occlusion effect
The *occlusion effect* occurs when you insert an object into your ear. Blocking the ear canal improves the jawbone's ability to conduct lower-frequency sound and makes the sound of swallowing, chewing gum, or your own voice seem loud or hollow.

performers
Performers includes musicians, vocalists, actors, and dancers.

permanent threshold shift
A *permanent threshold shift* is a permanent hearing loss. Damage to the ear results in a shift of the hearing threshold, which is the minimum level at which one begins to hear sound. For example, a person with a low hearing threshold will be able to hear relatively quiet sounds. A person who has a higher threshold will not be able to hear those same quiet sounds.

practice
Practice refers to time used by performers to maintain and develop their skills and abilities as performers.

rehearsal
Rehearsal refers to time used by performers and other workers to prepare for a performance.

sound
Sound is any sort of audible vibration in the air, including music, industrial noise, background sound, and anything else that can be heard. The WCB and other agencies and experts concerned with occupational issues often use the term *noise* (as in *industrial noise* or *noise measurement*). Generally, "noise" has negative connotations, while "sound" has more positive connotations and is used to refer to pleasing vibrations such as music or speech. To simplify things, this manual will use the term *sound* whenever possible.

sound-induced hearing loss
Sound-induced hearing loss is hearing damage that occurs as a result of overexposure to sound. Sound-induced hearing loss can result in a temporary or permanent threshold shift. Permanent hearing loss may be the result of either a single, intense exposure to a very loud sound, or long-term exposure to sounds of varying loudness, or a combination of individual and long-term exposures. The effects of long-term sound exposure are cumulative and include every sound a person is exposed to, including work and off-hours exposures.

temporary threshold shift
A *temporary threshold shift* is a temporary hearing loss that usually occurs after exposure to intense sound levels. Symptoms include muted or muffled hearing, a ringing or buzzing in the head, or a punchy, dazed feeling. These effects generally subside as time passes, provided that sound-exposure levels are reduced and the ears are given a chance to recover.

Part 1
In the Beginning: Sound Basics

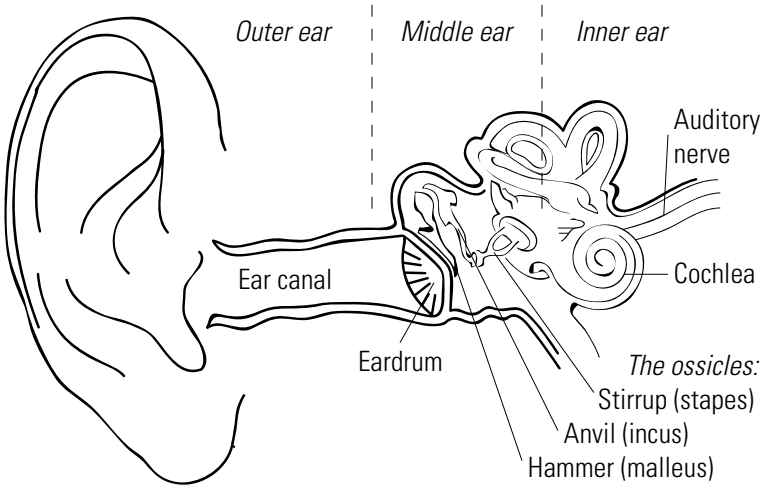
Overview

Part 1 explains basic concepts about sound, including how we hear and what happens when we are exposed to sound levels that exceed safe limits. The background knowledge provided here will help you understand the concepts and tips presented later in this manual.

This part includes the following sections:

1.1 How we hear

Sound waves travel through the air (or other substances such as water or walls), the ears detect the waves, convert the waves to neural signals, and then send the signals to the brain. That's the simplified version of a fairly complicated process. Let's look a little closer:



The human ear consists of three sections: the outer ear, the middle ear, and the inner ear.

The outer ear includes the external part that you can see and the ear canal leading to the eardrum.

The middle ear consists of the eardrum and three tiny bones behind the eardrum.

The inner ear consists of a neurosensory receptor called the cochlea.

Outer ear

The collector. The outer ear collects sound waves and funnels them down the ear canal to the eardrum. The outer ear also amplifies higher-pitched sounds, and it's a great place to hang things.

Middle ear

The amplifier and transmitter. Sounds vibrate the eardrum, which is connected to the middle ear bones (the ossicles, the smallest bones in the body). Working together, these wee bones — the hammer (malleus), the anvil (incus), and the stirrup (stapes) — amplify sound and transmit it to their neighbour, the cochlea.

Inner ear (cochlea)

The translator. The cochlea is a coiled tapering tube that looks like a snail shell. It's filled with fluid and lined with long rows of tiny hair cells. Sound vibrations from the ossicles cause these tiny hair cells to flex and bend, generating neural signals that pass along the auditory nerve to the brain. Think of the cochlea as a translator that converts audio information into data that your brain can understand.

1.2 How we don't hear: Sound-induced hearing loss

Sound waves, tiny hair cells, neural signals — it may all seem a bit abstract at this point.

Think of the tiny hair cells in your cochlea as a little plot of grass. When your hearing is good, your hair cells are bristling and waving around happily, like a well-kept lawn. When you hear a sound, your hair cells flex and bend, just like grass does if someone walks on the lawn. A little flexing and bending won't hurt your hair cells, but too much sound can stress the hairs to the point where they will never recover, and you will hear less and less.

QUIET SOUND
Exposure to a quiet sound is like having two people walk barefoot across the lawn — the grass is disturbed a bit, but can easily spring back.

LOUD SOUND
Exposure to a loud sound is like having a large group of people in hiking boots trudge across the lawn — the grass is flattened out to the point where it may not be able to recover from the damage.

MODERATE SOUND
Exposure to a moderate sound is like having a small group of people in shoes walk across the lawn — the grass is flattened, but can usually recover after being trampled down. But imagine if that small group of people trooped back and forth across the lawn eight hours a day for months at a time. Chances are the grass would soon be flattened out completely and die. Unfortunately, unlike a dead lawn, your ears can't be reseeded.

1.3 Intensity (loudness)

Intensity is the term used to describe how loud a sound is. We perceive a sound's intensity as *loudness*.

A common misconception is that you can judge whether or not a sound is dangerous based on whether or not you find it painful. Wrong! The human ear's pain threshold is between 120 and 140 dBA. Most experts agree that repeated exposure to sounds as low as 85 dBA (the intensity of typical city traffic) over eight-hour periods can lead to permanent hearing damage. You don't have to feel pain for damage to occur.

THE DIFFERENCE BETWEEN DB AND DBA

Intensity is measured in *decibels (dB)*. The problem with dB sound meters, though, is that the dB measurement doesn't always match the human ear's impression of the sound being measured. The solution to this problem is the A-weighting electronic network, which approximates the frequency response of the human ear and expresses sound in dBA.

The three-decibel rule

It seems obvious enough that 88 dBA is more intense than 85 dBA. The deceptive thing about the decibel, though, is that it's a logarithmic measurement: With every three-dBA increase, sound intensity doubles. Sounds at 88 dBA are actually twice as intense as they are at 85 dBA. The higher you go, the worse it gets — 115 dBA is 1000 times as intense as 85 dBA.

Although our ears have an amazing ability to hear minute differences in pitch, our perception of differences in intensity is not as refined. For instance, even though an 88 dBA sound is twice as intense as an 85 dBA sound, we don't perceive it to be twice as loud. In fact, it takes an increase of about 10 dBA before we perceive a sound to be twice as loud.

Unfortunately, the cochlea's tiny hair cells do notice such differences in intensity — more intense sounds increase the likelihood of hearing damage.

Research indicates that prolonged exposure to loud sounds is a major preventable cause of hearing loss.

1.4 Sound-exposure limits

There are limits to how much sound your ears can take. How much sound is too much?

Intensity and duration: How loud, how long?

Many people tend to focus on how loud sounds are, but the intensity of a sound is only half the equation. The length of time you are exposed to a sound plays a big part in determining how much hearing loss you might suffer.

Spending three minutes a day in a car with a 100-dBA audio system (enhanced by a kidney-rattling subwoofer that causes small animals to flee in terror) probably won't damage your hearing, but cruising around with the same system for 30 minutes a day probably will.

Even playing an instrument as relatively quiet as the flute could affect your hearing if you practice hours a day over a period of years. The effect of sound exposure on hearing is cumulative, meaning it's not just the intensity of the sound, it's how long you are exposed to it.

WCB sound-exposure limits

The WCB sets limits on the amount of sound a worker can be exposed to on a daily and weekly basis. In British Columbia, the Occupational Health and Safety Regulation specifies a maximum allowable daily sound-exposure limit of 85 dBA over an eight-hour period, with a maximum allowable instantaneous peak of 135 dBA. If the sound level is more than 85 dBA, the allowable exposure time is reduced.

SOUND-EXPOSURE LIMITS

dBA level	Maximum allowable exposure time
82	16 hours
85	8 hours
88	4 hours
91	2 hours
94	1 hour
97	30 minutes
100	15 minutes
103	7.5 minutes

If sound levels exceed allowable limits, employers must implement a hearing conservation program that includes the following components:

- Reduction of sound levels
- Hearing protection
- Worker education and training
- Hearing tests
- Program review

WHAT DID YOU CALL ME?

Contrary to what your parents may have said when you first told them you intended to pursue a professional career in the performing arts, musicians are workers too — as are actors, designers, directors, and others you might not always think of as workers. Performer, artist, craftsperson, designer — however you or your industry choose to label what you do for a living, you are still a worker.

Arts production and entertainment workers and their employers are responsible for following the relevant requirements in the WCB Occupational Health and Safety Regulation. (For a detailed definition of *worker*, see the *Workers Compensation Act* excerpt on page vii of the WCB Occupational Health and Safety Regulation, Book 1.)

Strong ears, weak ears

WCB sound-exposure limits are based on the average person's ability to hear and their susceptibility to sound-induced hearing loss. All ears are not created equal, though. Some people are fortunate enough to have been born with "strong" ears, and they may be less susceptible to hearing damage. On the other hand, those unlucky souls born with "weak" ears are more sensitive to sound exposure.

Before you go thinking, "I must have strong ears because I've mixed live sound for over 20 years and I can hear just fine," keep this in mind: Your hearing might be damaged and you might not even know it. The only way to know for sure is to get tested.

1.5 Typical sound levels

Whether we live in a big city or a small town, most of us are surrounded by sound. You may be surprised by the actual intensity of some of the typical sounds you are exposed to on a daily basis.

TYPICAL SOUND LEVELS

Approximate dBA level	Sound
45 – 55	Normal conversation at arm's length
60 – 70	Piano played at moderate levels
75 – 85	Chamber music in small auditorium
80	Telephone dial tone
85	City traffic from inside car with open windows
90	Train whistle at 150 m (500 ft.)
92 – 95	Piano played loudly
94	Average personal stereo on 5
95	Subway train at 60 m (200 ft.)
105 – 120	Amplified rock music at 1 – 2 m (4 – 6 ft.)
107	Lawnmower
110	Power saw
120 – 137	Symphonic music peak
140	Jet engine at 30 m (100 ft.)
150	Rock music peak

Difficult sound settings

Sound exposure can be difficult to measure in arts and entertainment settings, particularly over extended periods of time. This is because sounds such as those produced by instruments typically have alternating quiet and loud passages, as opposed to the continuous sounds typically generated by machinery in industrial settings.

1.6 Frequencies and notches

The average person is born with the ability to hear frequencies from about 20 Hz – 20,000 Hz. We won't delve too far into the weird world of science here: 20 Hz is a very low pitch (think subwoofers, bass, Barry White); 20,000 Hz is a very high pitch (high hats, helium, the Chipmunks).

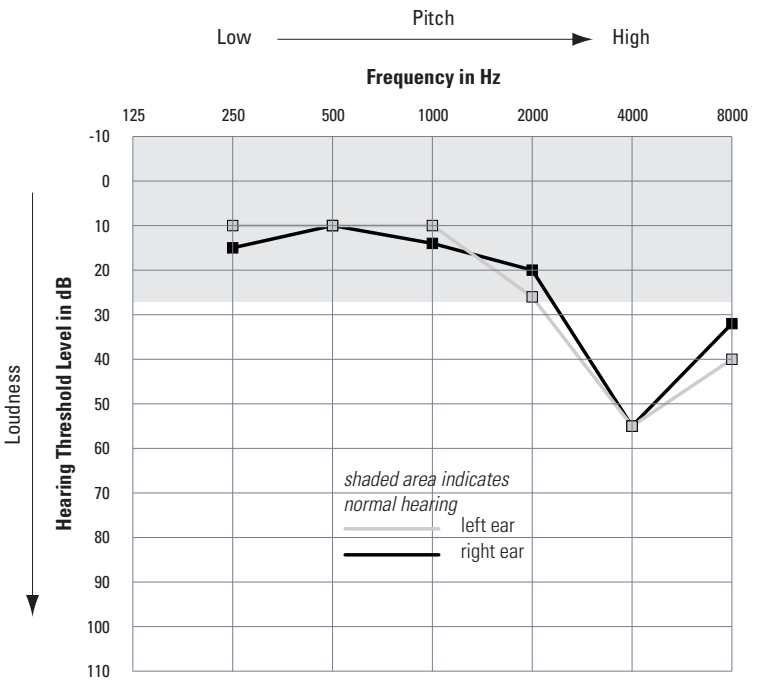
Because we live in a noisy world, most people lose the ability to hear the full range from 20 – 20,000 Hz by the time they reach adulthood, probably much earlier in most cases.

Hearing loss starts with a notch

The human ear is most sensitive to the frequencies between 600 and 6000 Hz, and less sensitive to very low or very high frequencies.

Sound-induced hearing loss usually starts in the higher frequencies, somewhere between 3000 and 6000 Hz, and then progresses to lower frequencies. Many people don't notice they have a hearing loss until they start having difficulties with everyday conversation.

A hearing loss at a specific frequency is called a notch because a graph showing hearing response will dip sharply at the frequency where the loss has occurred. If you have a notch in your hearing and you do not reduce or protect against sound exposure, your hearing loss may spread from the notch into lower frequencies.



This audiogram indicates a notch – the individual has suffered a 40 dB hearing loss at 4000 Hz.

AGE CAN INTENSIFY LOSS
Sound-induced hearing loss becomes especially problematic when combined with age-related hearing loss (presbycusis). Presbycusis usually starts in the higher frequencies — from 8000 – 20,000 Hz — and progresses down to lower frequencies.

How will a higher-frequency loss affect you?

If you suffer a loss that leaves a notch in your higher-frequency hearing response, you may have trouble hearing or be completely unable to hear:

- Normal conversations in crowds
- Higher-pitched voices such as women's and children's
- Whispered or quietly spoken words
- Consonant sounds such as the sounds associated with the letters p, t, k, f, s, and sh
- The highest notes of a piano keyboard
- High harmonics that contribute to a sound's overall quality

1.7 Temporary and permanent threshold shifts

Your *hearing threshold* is the point at which you begin to hear sound. A person with a low hearing threshold will be able to hear relatively quiet sounds, for example, a 30-dBA whisper. A person who has suffered some hearing loss and whose speech-reception threshold is 50 dBA will not be able to hear the same whisper or many other sounds below 50 dBA.

A *threshold shift* is when a person's hearing threshold moves from a lower threshold to a higher threshold. This means that their hearing becomes less sensitive than it was. In addition to hearing loss, threshold shifts are often accompanied by other signs and symptoms of hearing damage (see "1.8 Warning Signs of Hearing Damage" and "1.9 Symptoms of Hearing Damage").

Temporary threshold shift

A *temporary threshold shift* is a temporary hearing loss that usually occurs after exposure to intense sound levels. If you've ever been to a loud concert or around loud machinery for an extended period of time, you may have noticed after-effects that can accompany a temporary threshold shift: muted hearing, a ringing or buzzing in your head, or even a punchy, dazed feeling.

The good news is that if you give your ears a rest they will recover, for the most part, after a temporary threshold shift and that these effects will go away. The bad news is that repeated overexposure to sound will eventually lead to a permanent threshold shift.

ASPIRIN CAN CAUSE RINGING IN EARS
Researchers have found that high doses of aspirin (acetylsalicylic acid) can cause a temporary threshold shift, with symptoms including ringing in the ears. These effects go away after the aspirin use is discontinued.

Permanent threshold shift

A *permanent threshold shift* is — you guessed it — a permanent hearing loss. If you've pummelled your ears repeatedly and ignored the warning signs and symptoms, one day the ringing in your head or the muffled hearing might not go away.

1.8 Warning signs of hearing damage

Hearing loss can be insidious. Most people don't realize they have lost some hearing until they have trouble with everyday conversation. There are, however, a number of warning signs that may appear after exposure to loud or prolonged sound levels. These signs usually subside after a little while (see "Temporary Threshold Shift" on page 15), but this doesn't mean you should ignore them.

Ringing in ears

Some people hear this sound as a ringing in their ears, while others describe it as a buzzing or even a rushing sound. Whatever the description, the technical term for it is *tinnitus* (see "1.9 Symptoms of Hearing Damage").

Muted hearing

Sounds that would normally be clear sound muted or muffled.

Difficulty with everyday conversation

Many people first discover they have a hearing loss when they start having difficulty distinguishing between similar-sounding words during normal conversations, or when they find themselves frequently asking others to repeat what they just said. Another sign of hearing loss is having to concentrate harder when background sounds are present — maybe even cupping your hand to your ear to "capture" the sound you want to hear.

Speaking loudly

If you have trouble hearing others, you may have trouble hearing yourself. Hearing-loss sufferers sometimes compensate by speaking loudly.

Sound distortion

Music and other sounds may appear distorted, especially following sound overexposure. After a particularly loud concert, you may have noticed that the music on your car radio sounds grungy or distorted.

1.9 Symptoms of hearing damage

While none of the symptoms of hearing damage are pleasant, some are more unpleasant than others. Hearing damage can have a significant negative impact on your quality of life.

Hearing loss

One of the main symptoms of hearing damage is *hearing loss*. This may seem incredibly obvious, but it's mentioned here because many people don't notice that they've suffered hearing damage until they have trouble hearing everyday conversation.

PERMANENT MEANS FOREVER

Although hearing-aid technology has improved over the last 20 years, hearing aids cannot restore sound-induced hearing losses in the same way that eyeglasses can correct vision. Hearing is simply too complex. While a hearing aid can amplify sound input, it will also alter the quality of the sound. The term *hearing aid* says it all — it can help but it cannot correct the problem.

And there are no other solutions — no drugs, no therapies, nothing can repair your hearing once you've lost it.

Tinnitus

Tinnitus is commonly described as a ringing, buzzing, or rushing sound in the ears, even in the absence of any external sound. It is one of the most common symptoms of sound overexposure.

Even with relatively normal hearing, you may be aware of a slight background hum in your head, most noticeable when you're in quiet surroundings. If you want an idea what it's like to live with tinnitus, imagine that this background hum has become loud enough to distract you every minute of every day. Some tinnitus sufferers need to sleep with a TV set tuned to an off-air channel so the white noise will drown out the sound in their head.

Recruitment

With *recruitment*, most sounds seem normal to the sufferer, but louder sounds seem extra-loud and become painful. Recruitment is a relatively common symptom of sound-induced hearing loss.

Diplacusis

Diplacusis is a relatively rare symptom, but it's one that should scare musicians, vocalists, sound engineers, and lovers of music in general. Diplacusis is an abnormal perception of sound, either in time or in pitch. *Binaural* diplacusis is when the listener perceives a single tone as a different sound in each ear. *Monaural* diplacusis is when the listener perceives a single tone as multiple sounds in one ear.

Other (nonauditory) symptoms

Although the research is not conclusive, sound overexposure has been linked to a number of other symptoms, including:

- High blood pressure
- High blood-cholesterol levels
- Gastric (stomach) disorders
- Chronic headaches
- Sleep-pattern disturbances
- Irritability
- Fatigue

Part 2
Sound Sources: Identifying Music-Related Sound Hazards

Overview

Part 2 identifies some of the more common sources of sound exposure that performers and other workers may encounter while playing or working around music.

You will find information in Part 4 and 5 that explains how you can conserve your hearing by reducing your exposure to sound hazards or by using hearing protection.

This part includes the following sections:

Although most of the material in Part 2 is intended for performers and other workers who play, produce, or work around music, other readers may also find information that is of use to them.

Note Your exposure to sound does not end when you leave work. For information on hazardous sound sources that you may encounter away from your job, see "3.3 Off-Hours Exposure."

WHEN IS IT TOO LOUD?

Sound levels in your workplace may be hazardous if:

- The sounds are louder than busy city traffic
- You have to raise your voice to talk to someone who is arm's length away
- At the end of your work shift you notice that your hearing seems muffled, sounds seem distorted, or you hear a ringing or buzzing in your ears
- At the end of your work shift you have to turn your stereo or TV volume up to a level that is too loud for others who have not been exposed to your workplace sound levels

2.1 Orchestras and ensembles

Part of what makes performances by symphony orchestras and other large ensembles so impressive is the volume produced by so many musicians playing at once. Unfortunately, big volume equals big hearing hazards for the performers, conductors, and others who work around large ensembles.

Sound levels measured from the conductor's position in school bands have registered as high as 110 dBA.

Close positioning

Some performers in large ensembles have more reason than others to worry about their hearing. Sound levels can vary widely depending on the performer's physical position in a group.

Performers positioned in front of brass sections are potentially more at risk than other performers because trumpets and trombones project intense sound out in front of their section. Performers positioned near timpani or percussion sections also have reason to worry. Drums, cymbals, glockenspiels, and other percussion instruments can produce high-intensity impact sounds that leave ears ringing.

Brass and percussion players are not alone in their ability to damage hearing. Most instruments have the potential to produce hazardous sound levels. Depending on the number of players in a particular section and your proximity to that section, your hearing may be at risk.

Life in the pits

Orchestra pits are often cramped and almost completely enclosed spaces. Tight positioning means the musicians are often playing into each other's and their conductor's ears. Enclosure means less sound escapes to the audience, necessitating louder playing levels or even amplification within the pit itself.

STRESS INCREASES RISK OF TEMPORARY HEARING LOSS

Some researchers have found that listeners exposed to sounds they find annoying or stress-producing (such as machine noise or music they don't like) suffer a significantly higher temporary threshold shift than listeners exposed to sounds they find enjoyable (such as music they like) at the same volume.

The jury is still out regarding whether stress-producing sounds are more likely to have a permanent effect on hearing. If this does prove to be the case, pit-orchestra musicians and conductors may be more at risk because they usually have to play the same show several times a week, often for months at a time. Not surprisingly, many performers come to view performing the music more as work than play — in other words, as a less than pleasurable experience.

Bigger instruments

Orchestral music has become louder over the last several centuries as a result of changing instrument designs. When music moved out of aristocratic courts and drawing rooms into larger public venues, instrument designs evolved to accommodate the larger spaces. Brass and woodwind instruments got heavier and louder. Percussionists began to use bigger drums and cymbals. Violinists changed from gut strings to metal strings so that they could continue to be heard along with the other instruments.

IT'S ALL THE SAME TO YOUR EARS

Many people think of classical music, and much jazz as well, as cultured and refined, and view rock music as the musical equivalent of the wrong side of the tracks. If there's anyone that should be worried about their hearing, it's the legions of metalheads armed with high voltage and backed by monolithic speaker stacks, right? Don't believe the hype.

Classical and jazz music can — and has — led to significant permanent hearing damage in performers and conductors. Studies indicate that orchestral players can reach their maximum limit of safe sound exposure by performing for as little as 10 – 25 hours a week.

Tune up, plug in, turn on

In recent years, large multi-use venues have prompted opera companies and symphony orchestras to incorporate amplified sound reinforcement systems.

2.2 Acoustic instruments

Each instrument, including the human voice, has unique physical qualities and characteristics, some of which present sound hazards to performers and those around them. This section summarizes a few of the risks associated with specific instruments.

Note The information in this section applies not only to those who play the instruments being discussed, but also to performers and other workers who may be positioned near the instruments.

Brasses and woodwinds

Some studies have found a higher incidence of hearing damage in trumpet, trombone, bassoon, and French-horn players.

Trumpets and trombones
Trumpets and trombones can be extremely loud. Measurements taken in one study during Mahler's *Ninth Symphony* indicated that trumpets played some passages as loudly as 112 dBA.

Trumpets and trombones are also highly directional — the bells of the horns project the higher frequencies outward and forward, away from the players and toward other performers positioned in front of the brasses.

Flutes and piccolos
Flutes and piccolos tend to cause more hearing loss in a player's right ear as a result of the way the instruments are held. One unfortunate consequence of this uneven loss is that the left ear is then able to hear high-frequency harmonics better than the right, and the player may perceive this harmonic imbalance as distortion.

Stringed instruments

Violins and violas, when measured at a player's left ear, usually produce sound levels of at least 80 dBA, with some peaks exceeding 110 dBA. Cellos and basses are quieter overall than violins and violas.

Violinists and violists tend to lose more hearing in the left ear than the right because of the way they hold their instruments, with the left ear closer to the soundboard.

Percussion instruments

Percussionists have a veritable arsenal of instruments at their fingertips: snare and bass drums, tom-toms, congas, bongos, cymbals, gongs, shakers, triangles, woodblocks, vibraphones, xylophones, and more. Some of these instruments can produce tremendously powerful impact sounds.

Drum kits usually put the player's left ear more at risk because the high-hat cymbal is usually positioned on the left (with right-handed drummers), fairly close to the drummer. The snare drum can also produce intense impact sounds.

Pianos and harpsichords

"Tickling the ivories" doesn't exactly bring to mind high sound levels, but in the hands of the right performer a full-size piano is capable of producing up to 110-dBA levels.

Harpsichords are quieter than pianos for several reasons:

- Harpsichords use thinner strings.
- The strings are plucked rather than struck with a felt hammer.
- The air cavity below the soundboard is enclosed.
- Because harpsichord strings are plucked rather than hammered, playing the keyboard lighter or harder has no effect on the instrument's limited dynamic range; on a harpsichord, "hard hitters" cannot generate the higher sound levels they can on a piano.

Vocals

Vocalists can generate surprisingly high sound levels without amplification. Many sopranos can generate levels of 105 – 110 dBA, and some can reach peak levels over 115 dBA.

If you are singing in an ensemble such as a choir or a group of backup vocalists, you need to be aware not only of your own voice but also of those around you. A vocalist singing directly behind or beside you may present more of a risk to your ears than you would to yourself.

2.3 Electric instruments

The beauty of electric instruments and amplification is that they allow for a great deal of control over the sound you're producing. The flip side is that amplification can easily get way out of control, sometimes literally at the flick of a switch. Rock may be music "for the neck downwards," as Rolling Stones guitarist Keith Richards so aptly commented, but it poses serious risks to the territory above the neck.

Of the numerous reasons given for playing at top volume, few are justifiable. In many cases, it's possible to take a moderate approach to amplification that will help save your ears without sacrificing your sound.

HE SAID IT HIS WAY

> *The most brutal, ugly, desperate, vicious form of expression it has been my misfortune to hear.*
>
> —*Frank Sinatra, quoted in* Sound Effects: Youth, Leisure and the Politics of Rock *by Simon Frith (1979)*

Drum kits

Ask musicians in small ensembles and many will be quick to tell you they have to play loudly to compete with the drum kit. Most rock and pop drummers will tell you that hitting hard is part of their sound or part of their job. Whatever the case may be, there are several hearing conservation strategies that drummers and other musicians can try.

Guitars

Drummers aren't the only musicians who will argue that high volume is integral to their sound. Electric guitarists, especially those who like their distortion extra-thick and chunky, may insist that they need to crank their volume to get their sound just right. Some musicians just like it loud.

A lot of guitar sounds are heavier in the mid-range frequencies, which helps the guitar cut through other instruments in the mix. Problem is, loud onstage guitar often forces other performers to turn up their volumes, which adds to the overall onstage volume.

DIDN'T DIE BEFORE HE GOT OLD

The real reason that I haven't performed live for a long time is that I have very severe hearing damage. It's manifested itself as tinnitus — ringing in the ears at the frequencies that I play the guitar. It hurts, it's painful and it's frustrating.

—The Who guitarist Pete Townshend, quoted in Rolling Stone*, July 1989*

Electric basses

Electric bassists have difficulty cutting through amplified-music mixes because the human ear doesn't pick up lower-frequency sounds as easily as it does sounds in the mid-range and higher frequencies. Electric basses typically need more intense sound levels to compete with other amplified instruments such as guitar.

Keyboards, samplers, and turntables

Pianos, organs, synthesizers, samplers, and turntables cover a much larger frequency range than most other electric instruments. If you're trying to compete with drums, guitars, or a loud overall mix, you could be endangering your ears and the ears of those around you.

2.4 Speakers and monitors

The basic problem with many modern sound systems is that they can produce audio levels that go beyond the human ear's physical limitations. Live rock and pop music regularly reaches sound levels of 100 – 120 dBA. Heavily amplified sound levels can reach 120 – 140 dBA or higher directly in front of loudspeakers. One company sells a car-audio system that they claim can output up to 164 dBA.

FOR YOUR LISTENING PLEASURE?

"Punch up the bass till it hurts!" "No pain, no gain..."
"Xplod Series 10" sub in a tuned box – More power than you can legally handle!"

–Lower Mainland retail audio ads

On the stage

Musicians and vocalists use speaker monitors to hear themselves and each other. Aside from onstage monitors, most amplified groups also use speakers to carry their sound out to the audience (and to workers such as sound and lighting engineers as well as venue staff). Typically, the bigger the venue, the bigger that speaker setup.

When faced with the potential to be REALLY LOUD, some musicians and sound engineers will crank it immediately rather than starting at zero and increasing the volume as necessary for the situation. Most of the time loud sound equals bad sound, especially for those audience members who are unfortunate enough to be closer to the speakers than the musicians or sound engineers.

BETWEEN A HARD ROCK PLACE

Could I have everything louder than everything else?

–Deep Purple vocalist Ian Gillan (circa early 1970s)

In the studio

It doesn't have to be live to be loud. When recording, some performers like to play at high volume off the floor. Monitor levels inside the control booth may be just as loud. Even after tracking, overdubs may be recorded at loud levels and performers, producers, or engineers may insist on high monitor levels when it comes time to mix or remix tracks.

The obvious danger, of course, is that if you spend enough years recording or mixing at high volumes, you'll damage the most valuable piece of precision equipment you own: your ears. In an environment where clarity and precision are crucial to creating quality music, this is not a good thing.

TESTING, TESTING, 3-2-1-0

My left ear — the doctors used to test it. But now, they kind of go [flicks ear with finger], "Yeah, it's still there." It's not functioning at all.

—*Ted Nugent, rock guitarist and vocalist,* Can't Hear You Knocking *video*

Headphone monitors

Most headphones are pretty straightforward — they're worn over the ears and used to feed a direct signal into your head. Headphones are useful in studio situations, for mixing live sound, and for communication purposes during live performance.

The main advantage of headphones when used for music applications is that you can customize your mix — no one else has to hear what you're hearing.

On the other hand, headphones — whether used for music or communication purposes — can damage your hearing if you turn the volume up to overcome background sounds. More expensive models use noise-cancellation technology to block out undesired background sound, which allows the user to monitor their mix at lower levels.

In-ear monitors

In-ear monitors are earplugs with built-in miniature monitors. The earplugs help block outside sounds, which allows the user to hear their monitor mix clearly at a lower volume.

Despite their potential to reduce sound exposure in live situations, in-ear monitors are capable of producing sound levels as high as 120 dBA at the eardrum. If not fitted and used properly, in-ear monitors can be just as dangerous as speaker monitors, perhaps even more so.

REELING IN THE EARS

When he first used in-ear monitors to perform live, Donald Fagen of Steely Dan noticed an unsettling side effect: he couldn't hear any crowd noise and felt isolated from the audience. The solution? He had the sound engineer mike the crowd and feed just enough audience noise into his monitor mix to bring his ears back into touch with the crowd.

2.5 Performance venues

It's important to be aware not only of what you're playing, but where you're playing. Room size, design, and building materials can all have a significant effect on the sounds you're producing.

Amplified music and "dead" rooms

Sound engineers working with amplified music generally prefer acoustically "dead" rooms — those that have very little reverb. This is because the performers or engineers can add their own reverb to the mix, which allows for greater control over the sound.

"Hard" rooms and bouncing sound

Unfortunately, many performance venues such as bars, hockey arenas, and community halls are made of concrete or other hard, smooth materials that increase reverb times. Sound may bounce around in a "hard" room for as long as four seconds after it leaves the stage, which increases sound levels in the room and makes effective onstage monitoring difficult or near-impossible. If you're using amplification, electronics are great for adding reverb, but they can't do much when you want to take it away.

Consider alternative stage setups

When setting up for a rehearsal or performance in a venue that does not have a specific, fixed stage or performance area, don't base all your staging decisions on visual aesthetics alone. Consider sound-exposure levels for performers and other workers when deciding on staging. If you have some options, give thought to the relative positions of performers, monitors, PA speakers, the audience, and other workers.

Some of the suggested prevention strategies in Part 4 may not be appropriate, depending on the environment in which you find yourself. Practice or rehearsal spaces sometimes allow for more control over your staging setup.

Part 3
Sound Sources: Identifying Non-Musical Sound Hazards

Overview

Part 3 identifies some of the more common sound sources, other than music, that performers and other workers may be exposed to on the job as well as away from work.

You will find information in Part 4 and 5 that explains how you can conserve your hearing by reducing your exposure to sound hazards or by using hearing protection.

This part includes the following sections:

WHEN IS IT TOO LOUD?

Sound levels in your workplace may be hazardous if:

- The sounds are louder than busy city traffic
- You have to raise your voice to talk to someone who is arm's length away
- At the end of your work shift you notice that your hearing seems muffled or sounds seem distorted
- At the end of your work shift you have to turn your stereo or TV volume up to a level that is too loud for others who have not been exposed to your workplace sound levels

3.1 Mechanical sound

Mechanical sound refers to sounds made by tools, machinery, and equipment. For example, power tools, generators, and lifts all generate mechanical sound. Other sounds such as gunshots or explosives are also considered mechanical sound for the purposes of this manual.

MECHANICAL SOUND VERSUS INDUSTRIAL NOISE
This manual uses the term *mechanical sound* rather than the term *industrial noise* because the latter is usually used in industries such as construction or heavy manufacturing, which are unlike the arts production and entertainment industries.

Live performance

Sound-exposure hazards are less common when music is not central to a performance. However, cast, crew, and other workers involved in theatre and other live-performance situations may find themselves exposed to hazardous mechanical-sound levels when working around machinery, equipment, or sound effects.

Set and prop construction can generate high sound levels. Carpenters and other specialists may work with or around power saws, drills, and other loud power tools. The use of special effects such as gunshots or explosives can present sound-exposure hazards as well.

PUMPING UP THE VOLUME
Live-performance workers who use amplified sound sources such as monitors, headphones, or headsets need to be aware of sound-exposure levels and the potential long-term effects that monitoring and communications equipment can have on their hearing. See "2.4 Speakers and Monitors" for information on the hazards associated with amplified sound sources.

Mechanical continuous sound

Power drills, generators, fans, and other motorized tools and equipment produce continuous sound.

The two factors that you need to be aware of when it comes to protecting your ears around continuous-sound sources are intensity (loudness) and duration (length of time). Intense sounds can be especially hazardous to your hearing, but even quieter sounds can be damaging if you are exposed to them for long enough periods.

Mechanical impulse sound

You may find yourself working around mechanical impulse sounds, which can include hammering sounds, gunshots, explosions, and other abrupt sounds. Impulse sounds have very short durations (one second or less) but they can still damage your hearing, especially if they are intense.

3.2 Background sound

Background sound refers to the sounds around you other than the music, dialogue, or sound effects that you are focussing on as part of your work. Background sound such as crowd noise or machinery can be a problem because it may add to the overall sound levels in your environment and cause you to compensate by boosting your own audio levels.

In many work situations, you may have little control over the background sound that surrounds you. Even though you may not be able to control background sounds at their source, hearing protection can help save your ears.

Background sound is something you need to be aware of away from work as well. The following section, "Off-Hours Exposure," discusses background sound and other types of exposure you may encounter away from your job.

3.3 Off-hours exposure

Your risk of hearing loss is not eliminated at the end of each work shift. You can damage your hearing at home, around town, while on holiday — pretty much anyplace where you are exposed to sound. It's important to think about off-hours sound exposure because sound-induced hearing loss is cumulative; it includes all the sounds you are exposed to during each day.

How much is too much?

It's difficult to determine exactly how much sound workers are exposed to in their off-hours. Exposure can vary widely depending on where you live, where you spend your spare time and holidays, and what your hobbies are. Basically, it's up to you to think about how much strain you're putting on your ears off the job. You don't have to be scientific about it; just use common sense and be honest about the types and durations of activities that you engage in on your own time.

Off-hours risks

A few of the more common off-hours sound-exposure risks are described here.

Consumer audio and video

Consumer audio and video equipment has become far more sophisticated in recent years. Now-common features such as extra bass and surround sound have brought better — and louder — sound to home and car stereo systems, televisions, computer speakers, and boom boxes. Portable-audio devices can be particularly hazardous because users may turn up their headphone volume to overcome background sounds such as city traffic.

Concerts and clubs
If you're a live-music fan or enjoy clubbing you may be adding significantly to your overall sound exposure, depending on how frequently and where you attend events. Big arena and stadium concerts can be loud, but small clubs can be just as dangerous.

Movie theatres
Movie theatres weren't always associated with loud sound, but technological advances and the general Hollywood ethos of bigger, brighter, and louder have brought us to the point where some action movies reach sound-level peaks as high as 110 dBA.

Sporting events
Indy races are an obviously loud event if you've ever found yourself in the same city as one, but other organized sporting events such as hockey and basketball can also be hazardous to your hearing. It's not just the crowd noise that presents a hazard — between-play entertainment and halftime shows all add to sound-exposure levels.

Power tools and other equipment
You might be saving money if you do your own home renovation and yard work, but you may also be losing your hearing in the bargain. Power drills, saws, lawn mowers, leaf blowers, trimmers, snow blowers, and similar equipment are all capable of producing dangerously loud sound.

Noisy hobbies
Driving or riding cars, trucks, motorcycles, ATVs, snowmobiles, and all sorts of other motorized toys can be hard on your hearing. Firearm use such as hunting and target shooting has proven to be the most significant non-occupational contributor to hearing loss.

Part 4
Prevention: Reducing or Eliminating Exposure to Sound Sources

Overview

Employers are legally responsible for conserving workers' hearing by providing a safe working environment. If workers are exposed to hazardous sound levels, employers must find ways to prevent or protect against such exposure. An effective hearing conservation program will help the employer conserve their workers' hearing. For more information on hearing conservation programs, see Part 6.

Workers are responsible for understanding their training, following safe work practices and procedures, and notifying supervisors or employers of new hazards or other problems.

Prevention strategies are the first line of defense in any effective hearing conservation program. Prevention strategies are referred to as *engineering controls* when they involve changes in the physical work environment and *administrative controls* when they involve changes in work practices or procedures.

Part 4 provides employers (and workers, in some cases) with possible prevention strategies that may help reduce or eliminate the sound hazards identified in Part 2 and 3.

This part includes the following sections:

4.1 Prevention strategies for performers

4.2 Prevention strategies for other workers

Whenever possible, employers should implement prevention strategies to prevent exposure to loud sounds. If it is not possible to reduce or eliminate a sound hazard through prevention methods, employers must ensure that workers use appropriate hearing protection (see Part 5 for hearing protection strategies).

GUIDELINES FOR AVOIDING HEARING LOSS

Follow these guidelines to help prevent or minimize hearing loss:

1. Prevention — Avoid prolonged exposure to sounds that are 85 dBA or louder. If loud sounds are present, try to reduce the sound levels at their source or distance yourself from the sounds.
2. Protection — If it is not possible to reduce sound levels or distance yourself from the sounds, wear appropriate hearing protection.
3. Recovery — Give your ears a chance to rest (for at least 16 hours, if possible) after exposure to high sound levels.
4. Testing — Have your hearing tested at least once a year to determine if prevention and protection efforts are effective.

4.1 Prevention strategies for performers

This section outlines some of the prevention strategies that have been tried, with varying degrees of success, in situations where musicians, vocalists, and other performers have been exposed to hazardous sound levels. Possible prevention strategies that other workers may find useful are outlined in "4.2 Prevention Strategies for Other Workers."

Have you found an innovative prevention strategy that helps conserve your hearing? If so, contact SHAPE (see "Organizations" on page 60) and share your wisdom.

In order to conserve workers' hearing, employers should consider and, if necessary, implement one or more of the prevention strategies described here.

Workers themselves may even be able to implement some of the following strategies. For example, conductors, ensemble leaders, or even performers themselves may be able to make practical changes such as repositioning performers or speakers, or even just saving their ears for performances.

Consider all possible strategies

Both employers and workers should keep in mind that some prevention strategies may not be feasible or even effective in reducing sound-exposure levels, depending on the circumstances. Several different strategies, or a combination of strategies, may need to be tried in order to find the best way to reduce sound-exposure levels.

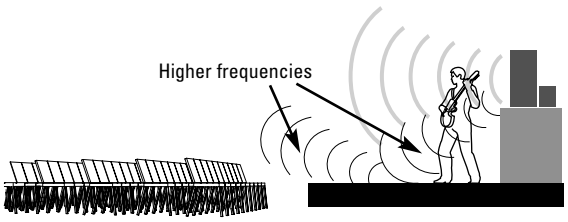
When looking at possible prevention strategies, consider factors such as the types of instruments being played, the number and positions of performers, whether amplification is being used, and the acoustics of the venue.

Dampen spaces with sound-absorbent materials

Reduce sound hazards in performance venues and other spaces that have hard, highly reflective surfaces by installing carpeting, acoustic panelling, and other sound-absorbent materials.

Leave space between performers and audiences

If there is enough room onstage, pull the performers back a few metres. Depending on the physical characteristics of the venue, the unoccupied space at the front of the stage may reflect higher frequencies and project them toward the audience, which will allow the performers to play at a slightly lower sound level.



Leaving empty space at the front of the stage may help reflect higher frequencies toward the audience.

Position performers strategically

If there's room, separate performers from one another. For example, leave a couple of metres between the percussion section and other performers, which will help lessen the effect of the sound levels coming from the percussion section.

Position your head strategically. Violin and viola players can reduce sound levels at their left ear by keeping their head upright. Leaning too far over the soundboard exposes one ear to higher sound levels.

Positioning is especially crucial in orchestra pits because they are often cramped and completely enclosed spaces:

- Do not position stringed instruments such as violins and violas under an overhang because the overhang will absorb the higher frequencies and cause the musicians to compensate by playing louder.
- Position loud instruments or sections in open-ceiling areas of the pit so their sound can escape out of the pit.
- Seat brass players near the front of the pit, around the conductor, so the other musicians will not be exposed to loud, highly directional sound coming from the brass.
- Stand the conductor on a riser above the brass section to keep the conductor's ears out of harm's way.

Position speakers strategically

You can turn down amplifiers, onstage monitors, and front-end speakers and still achieve essentially the same acoustic effect if you give some thought to positioning:

- Place monitors to one side and aim them so sound is directed at your ears, not at your face, knees, or the back of your head.
- Point really loud speakers away from your ears, even facing a wall or another sound-absorbing object. (This may not be possible if you need to position the speakers to produce controlled feedback or to achieve a visual effect.)
- Place front-end speakers parallel to and in front of you. You've got your monitors; the front-end speakers are for the audience.

Elevate speakers

Raise monitors and other speakers off the floor. This puts them closer to ear level and prevents low frequencies from travelling through the floor, which is a lower-impedance pathway. When speakers are not elevated, the low-frequency loss through the floor is 6 – 8 dB. To compensate for this loss, musicians and engineers usually turn up the overall volume, which unnecessarily boosts mid- and high-frequency levels.

Note Before elevating speakers, be sure to check the manufacturer's specifications. Some speakers are not designed for elevated use.

Elevating monitors and other speakers helps prevent low-frequency loss through the floor.

Use shakers to enhance the low end

Shakers look like large hockey pucks, but they are actually electrical devices that pick up low-frequency sound and extend it to even lower frequencies. This low-end enhancement helps drummers and electric bass players monitor their sound. Shakers can easily be attached to drum-seat bottoms or small plywood boards placed on the floor.

Save your ears for performance

Some live situations may call for louder sound levels, but solo practice and group rehearsals don't need to match those levels, especially if your practice or rehearsal space is a shoebox.

Save your ears during those countless hours of practice:

- Turn down amplification equipment or playing quieter.
- Wear appropriate hearing protection.
- Give your ears a chance to recover by planning time away from music (take breaks during practice) and other sound-related activities.
- Use alternative drum equipment (for example, rubber pads or electronic drums) when you're practising on your own and tone is not a concern.

MUSICIAN, HEAL THYSELF

And Silence, like a poultice, comes
To heal the blows of sound.
—*Oliver Wendell Holmes, Sr.,* The Music-Grinders

Dampen drum kits during rehearsals

Dampening a drum kit can help reduce overall sound levels, especially in a cramped rehearsal room:

- Tape small pieces of cloth or other sound-absorbent material inside the drumheads.
- Place rubber rings on the tops of the drumheads.

Note If taping cloth or placing rubber rings directly on the drumheads alters the feel of your drums too much, try taping small pieces of cloth to the rims so the cloth hangs loosely over the skins.

- Stuff foam rubber inside the drums or hang it from the inside of the drumheads.
- Stuff the bass drum with a pillow, towel, or shredded newspaper.
- Hang small strips of cloth from each cymbal's centre nut.
- Position a clear acrylic shield between the drum kit and the other musicians.

Another useful prevention strategy is to place cymbals so they are not in a direct horizontal line with the drummer's (or other people's) ears. If you're not married to the idea of setting up cymbals at one particular height, experiment with raising or lowering them as necessary to protect the hearing of everyone who is close to the drum kit. Drummers can also use lighter sticks and try playing less aggressively during rehearsals.

Use shields and baffles to isolate sound

In orchestral settings, individual acoustic shields and baffles (for example, clear acrylic shields on the backs of musician's chairs) have been used, with varying degrees of success, to help protect performers from surrounding sound.

Note Individual acoustic shields and baffles are only effective if placed within 18 cm of the performer's head.

Use large shields or baffles to isolate percussion sections from other performers. In situations where the sound is amplified and performers are using monitors, place a large, clear acrylic shield in front of the drum kit to help isolate the drummer's sound from the rest of the performers.

Employers will need to take into account these potential problems if they are considering installing shields or baffles:

- There may not be enough room for shields or baffles onstage.
- Shields and baffles can reflect sound back at the performers seated behind them.
- Shields and baffles may produce distortion and make it difficult for the performer to hear other instruments.

Keep a lid on it. Grand pianos have a built-in acoustic shield: the lid. During practice, try lowering the lid to trap some of the sound inside the piano.

Elevate brass sections on risers

Trumpets produce sound that contains a lot of damaging higher frequencies. Using risers to elevate trumpet and trombone sections may help to project their sound, which is highly directional, over the heads of the musicians in front of them.

Raise your bells. Trumpet and trombone players can raise their bells during loud passages to project their sound over other performers.

4.2 Prevention strategies for other workers

Theatre and other live-performance workers who are exposed to high sound levels may benefit from the following prevention strategies.

In order to conserve workers' hearing, employers should consider and, if possible, implement one or more of the prevention strategies described here.

Consider all possible strategies

Employers should keep in mind that some prevention strategies may not be feasible or even effective in reducing sound-exposure levels, depending on the circumstances. Several different strategies, or a combination of strategies, may need to be tried in order to find the best way to reduce sound-exposure levels.

If you are unable to find a prevention strategy that will reduce sound to safe levels, use hearing protection (see Part 5).

Have you found an innovative prevention strategy that helps conserve your hearing? If so, contact SHAPE (see "Organizations" on page 60) and share your wisdom.

Switch ears when using monaural headphones

If you use monaural headphones (headsets with one earpiece, typically used for communication purposes), switching the earpiece from one ear to the other helps cut down your sound exposure by dividing the exposure between both ears.

Isolate loud equipment

If possible, build shields or walls around loud equipment. Sound-absorbent materials similar to those used for live-performance purposes may also be useful in areas where loud equipment is operating.

Turn off loud equipment when it is not in use.

Isolate impulse sounds

Isolate impulse sounds such as explosives or power tools by using shields, walls, or simply by maintaining a sufficient amount of distance between the source of the sound and the workers.

Don't overdo special effects

If you need to use pyrotechnics or other explosive special effects, use the smallest possible charge to achieve the desired effect.

Part 5
Protection: Working Safely Around Sound Sources

Overview

Employers are legally responsible for conserving workers' hearing. If an employer is unable to reduce sound exposures to safe levels using prevention strategies (see Part 4), the employer must provide and maintain hearing protection to affected workers and ensure that hearing protection is worn effectively.

Workers are responsible for using hearing protection in accordance with instructions provided by their employer.

Note Many performing-arts workers (for example, musicians) work for more than one employer or are self-employed. Workers who have received one type of hearing protection from an employer, such as generic-fit earplugs, may want to consider supplying themselves with another option, such as custom-fit earplugs, especially if they are exposed to hazardous sound levels for long periods of time and need hearing protection that is potentially more comfortable as well as effective.

Part 5 provides you with hearing protection strategies that will help protect your ears against the sound hazards identified in Part 2 and 3.

This part includes the following sections:

5.1 Hearing protection strategies for live performers

Most music contains a lot of higher frequencies, which necessitates unique hearing protection strategies for those who work with or around music. Performers, sound engineers, and other workers need to reduce sound levels without interfering with the higher frequencies that are so important to the quality of the sounds they are producing or working with.

Some people think earplugs are aesthetically unappealing on live performers.
Some people think permanent hearing loss is unappealing.

What's the problem?

The basic problem for musicians and vocalists is that inserting something into the ear canal alters the ear's natural acoustic properties. Conventional earplugs tend to reduce higher frequencies more than lower frequencies. A compressible foam plug that reduces sounds in the 125 Hz range by 25 dB may reduce sounds in the 4000 Hz range by almost 40 dB.

Fortunately, hearing protection technology has evolved to the point where specialized products can reduce sound levels while maintaining even frequency response. The table starting on page 44 summarizes typical problems for different situations and directs you to possible strategies that are explained further in this part.

THE OCCLUSION EFFECT

The *occlusion effect* occurs when you insert an object into your ear. Blocking the ear canal improves the jawbone's ability to conduct lower-frequency sound and makes the sound of swallowing, chewing gum, or your own voice seem loud or hollow.

Players of reeded woodwind and brass instruments generally can't use compressible earplugs because the resulting occlusion effect amplifies the natural jaw resonance that occurs when they play. Vocalists also find compressible earplugs make the voice sound hollow.

There are two possible strategies for dealing with the occlusion effect:

- Use a deep-fitting custom-fit earplug that reaches the inner, bony portion of the ear canal and reduces potential vibration and jaw resonance.
- Use an earplug with a large hole or vent that allows the trapped low-frequency sound to escape.

Typical problems and possible hearing protection strategies for live performers

Note This table provides general guidelines only. While these problems and strategies are relatively common, personal and environmental factors can vary widely depending on the situation. Performers and other workers should consider their hearing protection options carefully before deciding on a particular strategy.

Situation	Typical problems	Possible strategies
Amplified instruments or sound systems	• Just plain loud	• Uniform attenuator earplugs (Section 5.3) • Premoulded earplugs (Section 5.5) • In-ear monitors (Section 5.6)
Vocals	• Own voice can be dangerously loud • Other instruments make monitoring voice difficult	Solo: • Vented/tuned earplugs (Section 5.4) Accompanied: • Uniform attenuator earplugs (Section 5.3) • Premoulded earplugs (Section 5.5)
Reeded woodwinds	• Proximity to trumpet or percussion sections • Jaw resonance (occlusion effect) makes it difficult to monitor instrument while using conventional earplugs	Near trumpet or percussion sections: • Vented/tuned earplugs (Section 5.4) Near amplified speakers: • Uniform attenuator earplugs (Section 5.3) • Premoulded earplugs (Section 5.5)
Flutes and piccolos	• Loud peak levels, intense high frequencies • Existing right-ear hearing loss results in perceived distortion	Generally: • Uniform attenuator earplugs (Section 5.3) • Premoulded earplugs (Section 5.5) Right-ear hearing loss: • Asymmetrical vented/tuned earplugs (Section 5.4)
Brasses	• Jaw resonance (occlusion effect) makes it difficult to monitor instrument while using earplugs	Near percussion or other brass instruments: • Vented/tuned earplugs (Section 5.4) Near amplified speakers: • Uniform attenuator earplugs (Section 5.3) • Premoulded earplugs (Section 5.5)

Situation	Typical problems	Possible strategies
Violins and violas	• Conventional earplugs remove higher-frequency sounds	• Uniform attenuator earplugs (Section 5.3) • Premoulded earplugs (Section 5.5)
Basses, cellos, and harps	• Proximity to trumpet section	• Vented/tuned earplugs (Section 5.4)
Pianos and harpsichords	• Conventional earplugs remove higher-frequency sounds	• Uniform attenuator earplugs (Section 5.3) • Premoulded earplugs (Section 5.5)
Drums and percussion	• High sound levels, intense higher-frequency sounds such as cymbals • Conventional earplugs reduce sound levels too much, wrist strain results from overhitting to compensate	• Uniform attenuator earplugs (Section 5.3) • Premoulded earplugs (Section 5.5)
Pit-orchestra performers	• Just plain loud	• Uniform attenuator earplugs (Section 5.3) • Premoulded earplugs (Section 5.5) • Headphone monitors (Section 5.7)
Conductors and music teachers	• Conventional earplugs remove higher-frequency sounds	• Uniform attenuator earplugs (Section 5.3) • Premoulded earplugs (Section 5.5)

HUM A FEW BARS FOR ME

This may seem a tad unbelievable, but researchers have found that humming to yourself just before the start of a loud sound and continuing to hum through the sound provides several decibels of hearing protection for 5 – 8 seconds. Humming activates the *stapedial reflex*, something that evolution provided to protect us from our own voices. This reflex, however, only has a short-term effect because the parts of the ear involved tire fairly rapidly.

Caution The stapedial reflex does not usually provide sufficient protection by itself. Use hearing protection when necessary.

THE VALSALVA MANOEUVRE

When woodwind and brass players play, they are constantly blowing against a resistance, which creates a slight positive middle-ear pressure. This is called the *valsalva manoeuvre*. This pressure acts as a mild, temporary plug that reduces the musician's sound exposure.

Players of double-reed instruments (bassoons and oboes) gain about 2 – 4 dB protection. Players of single-reed instruments (saxophones and clarinets) and brass instruments (such as trumpets and trombones) gain about 1 – 2 dB protection.

Caution The valsalva manoeuvre does not usually provide sufficient protection by itself. Use hearing protection when necessary.

5.2 Hearing protection strategies for other performers and workers

For performers and other workers who need to hear quality sound but are not concerned about the visibility of their hearing protection, possible strategies tend to be simpler.

Performers and other workers who are unconcerned about sound quality can generally implement strategies that are both simple and inexpensive.

Mechanical sound

Workers who are exposed to high levels of mechanical or background sound generally have one concern when it comes to hearing-protection devices: block out as much of the sound as necessary (keeping in mind that the worker may still need to communicate with others or hear warning signals).

Typical problems and possible hearing protection strategies for other performers and workers

Note This table provides general guidelines only. While these problems and strategies are relatively common, personal and environmental factors can vary widely depending on the situation. Performers and other workers should consider their hearing protection options carefully before deciding on a particular strategy.

Situation	Typical problems	Possible strategies
• DJs and live sound engineers • Studio performers and engineers	• Just plain loud • Competing external sounds	• Headphone monitors (Section 5.7) • In-ear monitors (Section 5.6) • Uniform attenuator earplugs (Section 5.3) • Premoulded earplugs (Section 5.5)
Theatre and other live-performance cast and crew	• Continuous sounds (generators) • Impulse sounds (pyrotechnics, gunshots, other things that go boom)	• Earmuffs (Section 5.9) • Compressible earplugs (Section 5.8) • Premoulded earplugs (Section 5.5)
Bar, club, and concert venue workers	• Need protection against high sound levels while retaining ability to communicate	Communication not an issue: • Compressible earplugs (Section 5.8) Need to communicate: • Premoulded earplugs (Section 5.5) • Uniform attenuator earplugs (Section 5.3)

5.3 Custom-fit uniform attenuator earplugs

Uniform attenuator earplugs, or flat response earplugs, reduce sound levels while maintaining an even response across frequencies up to about 6000 Hz. In other words, they uniformly attenuate sound so that you hear the higher frequencies as audibly as the lower frequencies.

How do uniform attenuator earplugs work?

Uniform attenuator earplugs consist of a silicone earplug that is moulded to the shape of the user's ear canal, bored out, and then capped with a button-sized filter attached to the outer end of the earplug. The filter, in conjunction with the air inside the bored-out section, offsets the loss of high frequencies that normally occurs when an object is inserted into the ear.

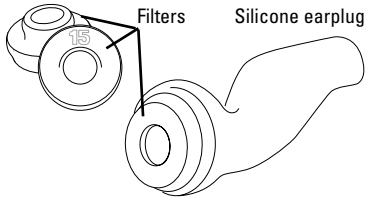
The custom-fit silicone earplugs are typically made by a laboratory that supplies local audiologists and hearing clinics. The filters are manufactured by Etymotic Research, which calls its ER-series filters (when combined with a custom-fit earplug) "Musician's Plugs" because they are so useful to musicians who need protection and even frequency response.

The ER-9, ER-15, and ER-25 reduce overall sound levels by 9, 15, and 25 dB, respectively. A newer, smaller version called the ER-15SP has less high-frequency attenuation, which makes it a good earplug for users who already have some high-frequency hearing loss. Because it reduces high frequencies less, the ER-15SP may even help make conversation clearer in a loud environment.

Once you've been fitted with the custom-fit earplug itself, you can use any of the ER-9, ER-15, or ER-25 filters, depending on the degree of protection you want. The ER-15SP uses a bore opening that is physically smaller than that required for the other ER earplugs.

Advantages

- Provide even attenuation of frequencies up to about 6000 Hz (except for the ER-15SP)
- Mould can be modified to adjust high-frequency attenuation
- Very little occlusion effect, as long as the plug fits deeply in ear
- Flesh-coloured (beige or brown) and unobtrusive



Custom-fit uniform attenuator earplugs consist of a button-sized filter attached to the outer end of a silicone earplug moulded to the shape of your ear canal.

Disadvantages

- Expensive
- Need custom fitting by a qualified professional

Useful for

- Musicians playing instruments that produce higher-frequency sounds (for example, violins, trumpets, piccolos, and pianos)
- Anyone working with or around amplified sound (for example, musicians, vocalists, DJs, sound engineers, conductors, and teachers)
- Anyone who needs sound reduction with even frequency response

Products

ER-series filters are manufactured by Etymotic Research, while the silicone earplugs that hold the filters are typically custom-made by laboratories who supply local audiologists and hearing clinics. Contact SHAPE (see "Organizations" on page 60) for a list of audiologists, hearing clinics, and other suppliers of ER-series products and custom-fit earplugs.

A LESS-EXPENSIVE ALTERNATIVE

If you want flat response earplugs but don't want to spend the money on a custom-fit option, consider inexpensive premoulded earplugs that provide relatively uniform attenuation, such as the ER-20 HI-FI earplugs or the E·A·R UltraTechs. For more information, see "5.5 Premoulded Earplugs."

5.4 Custom-fit vented/tuned earplugs

Another custom-fit option is the vented/tuned earplug, which does not reduce sound levels up to about 2000 Hz, but reduces higher frequencies significantly.

How do vented/tuned earplugs work?

Vented/tuned earplugs consist of an earplug that is moulded to the shape of the wearer's ear canal, bored out, and fitted with an adjustable vent in the centre bore. Some ear-mould laboratories use filters rather than adjustable vents.

Typically, vented/tuned earplugs attenuate higher frequencies by about 20 dB when the adjustable vent is wide open. Closing the vent increases higher-frequency attenuation to as much as 28 dB (giving a frequency response similar to compressible or industrial-strength earplugs).

SIMULATING THE EFFECT OF A VENTED/TUNED EARPLUG

If you have a uniform attenuator earplug, you can simulate the effect of a vented/tuned earplug by removing the filter cap and using the moulded earplug by itself. The open bore of the uniform attenuator earplug will operate in roughly the same way as a vented/tuned earplug with the vent set wide open.

Advantages

- Allow musicians playing lower-frequency instruments to hear themselves while screening out surrounding higher-frequency sounds
- Very little occlusion effect
- Right and left earplugs can be adjusted separately to compensate for right-ear hearing loss in flute and piccolo players
- Small 500 Hz resonance improves vocalist's ability to monitor voice

Disadvantages

- Expensive
- Need custom fitting by a qualified professional

Useful for

- Musicians playing bass and lower-frequency instruments (for example, lower strings, reeded woodwinds, and low brasses) who wish to shield themselves against high-frequency sounds from percussion or trumpet sections
- Solo vocalist who needs protection against own voice

Products

Most ear-mould laboratories can make custom-fit vented/tuned earplugs. Contact SHAPE (see "Organizations" on page 60) for a list of audiologists, hearing clinics, and other suppliers of custom-fit earplug products.

5.5 Premoulded earplugs

Premoulded earplugs are generic-fit earplugs shaped for the average user's ear canal. Most premoulded earplugs have a triple-flanged, reusable plug that looks a bit like an elongated beehive.

Advantages

- Less expensive than the custom-fit earplugs
- Last longer than compressible earplugs
- Do not require custom fitting — available off-the-shelf
- Reusable

Most premoulded earplugs have a triple-flanged plug that fits inside the ear canal.

Disadvantages

- More expensive than compressible earplugs
- Frequency response generally not as flat as custom-fit earplugs

Useful for

- Musicians and vocalists who want a relatively inexpensive earplug with relatively even frequency response for practice and rehearsals
- Other performers and workers who want a relatively inexpensive earplug that doesn't muffle voices and other higher-frequency sounds as much as compressible plugs do

Products

- *E·A·R UltraTech series*
  Triple-flanged earplugs with relatively even frequency response.
- *Etymotic Research ER-20 HI-FI*
  Triple-flanged earplugs with relatively even frequency response.

NOISE REDUCTION RATINGS (NRRs)
Many American earplug manufacturers use the noise reduction rating (NRR) system to indicate the amount of protection an earplug offers. Users should be cautious of such ratings — a commonly used safe practice is to divide the stated NRR by two to arrive at a reliable attenuation level.

5.6 In-ear monitors

In-ear monitors are essentially earplugs with built-in miniature monitors (speakers).

How do in-ear monitors work?

In-ear monitors usually consist of custom earplugs moulded to fit your ears and a wireless transmitter-receiver system you can wear on a belt. Less-expensive in-ear monitors may use generic "ear buds" rather than a custom-fit plug. The use of ear buds is not recommended because the earpieces do not fit snugly and they will let in more outside sound, which leads to higher monitor levels.

Keep it tight, keep it reasonable

With custom models, the moulded earplugs must fit tightly beyond the second bend in the ear canal or they will allow background sound to leak in. An improper fit may cause the user to turn the monitors up to overcome the undesired background sound.

Even if the earplugs fit well, users need to keep the volume down to a reasonable level. One newly fitted wearer was using his in-ear monitors at 119 dBA just because he liked it loud. Moderation is the key here.

Advantages

- Custom-fit earplug protects against undesired background sound
- Belt-clip transmitter-receiver feeds direct signal into ears, eliminating need for onstage monitors and reducing onstage sound levels
- Wireless transmitter-receiver provides freedom of movement
- Smaller and lighter than headphone monitors

Custom-fit in-ear monitors send an audio signal from a wireless transmitter-receiver system to earplugs moulded to the shape of your ear canals.

Disadvantages

- Expensive
- Can be used improperly (capable of producing sound levels up to 120 dBA at eardrum)
- If earplug is not fitted properly, background sound leaks in, leading to higher monitor levels

Useful for

- Live music performance — sound-level reduction and personalized monitoring

Products

- *Etymotic Research ER-4 MicroPro series earphones*
  Two-way drivers inside premoulded, triple-flanged earplugs.
- *Futuresonics Ear Monitors*
  Two-way drivers inside custom-fit earplugs.
- *Sensaphonics ProPhonic series*
  Two-way drivers inside custom-fit earplugs. Also available in a generic-fit model with triple-flanged or foam adapters.
- *Westone Labs UltimateEars series*
  Custom-fit earplugs. UE-3 Stage earplugs use a single-driver system. UE-5 Pro earplugs use two-way drivers.

5.7 Headphone monitors

Headphone monitors are used for music applications such as studio work where the visibility of the headphones is not an issue. Technicians and other workers also use headphones to communicate with one another in theatre and other live-performance situations.

Although many headphones include earmuffs that provide some degree of protection against background sound, the best headphones for hearing protection are those that incorporate noise-cancellation technology. Noise-cancellation technology helps block background sound, which allows for lower monitor levels.

Advantages

- Easier to slip on and off than in-ear monitors
- Do not require custom fitting
- Noise-cancellation models help block background sound

Disadvantages

- Heavier and more obtrusive than in-ear monitors
- Many noise-cancellation models create a feeling of "fullness" in the ears
- Expensive

Useful for

- Studio applications (musicians, vocalists, and sound engineers)
- Live applications (DJs and sound engineers)
- Live-performance communication purposes

5.8 Compressible earplugs

Compressible earplugs are made of a soft material — foam, waxed cotton, or glass down — that you compress with your fingers and insert in your ear. The compressed plug then expands to fit the shape of your ear canal. Compressible earplugs are generally disposable.

Advantages

- Inexpensive and simple to use
- Effectively protect against high sound levels
- Smaller than earmuffs — can be carried in a pocket
- More comfortable than earmuffs in hot environments

Disadvantages

- Provide uneven frequency attenuation — remove more high frequencies than low
- Occlusion effect distorts sound perception for reeded woodwind and brass musicians
- Interfere with speech communication

Useful for

- Cast and crew members, venue staff, and other workers in situations in which sound quality and speech communication are not issues (especially non-music applications)

Products

Most drugstores and similar retail outlets carry several different brands of compressible earplugs.

5.9 Earmuffs

Earmuffs, the classic industrial hearing-protection device, are a great choice if you're not concerned about appearance or frequency response. Many earmuffs provide high levels of sound protection.

Advantages

- Inexpensive and simple to use
- Effectively protect against high sound levels
- Easier to slip on and off than earplugs
- More comfortable than earplugs in cold environments
- Less occlusion effect than with compressible earplugs

Disadvantages

- Heavier and more obtrusive than earplugs
- Most models provide uneven attenuation of frequencies

Useful for

- Crew members who need protection while working around loud sound such as music or pyrotechnic effects and who are not concerned with visibility of hearing protection

Products

Dozens of different brands of earmuffs are available.

LONG HAIR CAN REDUCE SOUND EXPOSURE

Attention, rockers! In a 1992 study, Chasin and Chong found that relatively thick hair covering the ears can reduce sound exposure in the middle frequencies by 3 – 5 dB, although they noted that this effect can vary widely.

Caution Long hair does not usually provide sufficient protection by itself. Use hearing protection when necessary.

5.10 Choosing and using hearing protection properly

There are four basic things to keep in mind when selecting and using hearing protection properly: quality, comfort, design, and technique.

Quality: Get the right stuff

Product quality is not so much a concern when it comes to inexpensive compressible foam plugs. However, when it comes to expensive custom-fit earplugs or in-ear monitors, make sure that you are buying a good product and that the person taking a mould of your ear is trained (for example, as an audiologist) and experienced.

When you are looking at earmuffs or headphones, consider the depth of the ear domes and the materials used in the domes, cushions, and headband.

Comfort: Find a fitting earplug

When selecting earplugs, choose a comfortable product that fits well. Comfort is especially important if you will be wearing the earplugs for long periods.

When selecting earmuffs or headphones, consider their weight. Lighter products are more likely to remain comfortable over longer periods. The headband on a set of earmuffs or headphones should be comfortable, yet tight enough to keep the equipment from falling off. Earmuff and headphone cushions usually contain a plastic foam. Try a few different types to determine which product you find more comfortable.

Whatever the type of hearing protection, wear it before you really need it to get used to the way it feels and the way it alters sound.

Design: Use as directed

Use the product as it was intended to be used:

- Do not alter hearing protection devices.
- Do not reuse disposable earplugs if they are dirty. (Disposable earplugs generally last about a day — less if you are working in a dirty environment.)
- Do not use earmuffs if the domes are cracked or the cushions are torn.

Make sure earplugs are not so tight that they are uncomfortable or so loose that they let sound leak in. If a particular earplug does not fit your ear canal well (especially with premoulded earplugs) try a different brand or a different type of hearing protection altogether.

Technique: Stick it in yer ear

Insert earplugs and in-ear monitors properly so that they can do their job effectively:

1. If you are using a compressible earplug, roll it in your fingers to compress it.
2. Reach over your head with your other hand and pull the top of your ear up and back to straighten out your ear canal.
3. With your ear canal straightened, insert the plug or monitor until it is seated firmly in your ear (not too far in!).

Hint For greater attenuation, open your mouth while inserting the earplug. This will allow for a deeper fit.

4. If you are using a compressible earplug, hold it in your ear until it fully expands to fit your ear canal.

Note If the earplug or in-ear monitor does not fit snugly in your ear canal, you will not receive the full benefit of the hearing protection.

When using earmuffs or headphone monitors, make sure the cushion fits evenly and firmly around your ears so that they won't let in outside sounds.

When inserting an earplug, straighten out your ear canal by pulling the top of your ear up and back.

Part 6
Get with the Program: Hearing Conservation Programs

Overview

An effective hearing conservation program helps control workplace sound exposure and can prevent damage to workers' hearing.

Employers must develop and implement a hearing conservation program if workers are exposed to workplace sound levels that exceed WCB limits (for more information, see "WCB Sound-Exposure Limits" on page 11).

This part includes the following sections:

6.1 Hearing conservation program components

An effective hearing conservation program must be written down and must include the following components:

- *Sound measurement* — Determine the sound exposures in your workplace.
- *Education and training* — Educate workers about sound exposure and train them in hearing conservation strategies.
- *Engineered sound control* — Use prevention (engineering) strategies to reduce sound at the source.
- *Hearing protection* — If prevention strategies are not enough to reduce sound to safe levels, provide workers with hearing protection such as earplugs or earmuffs.
- *Notification of sound-hazard areas* — If prevention strategies are not adequate, post signs warning of the sound hazard. If this is not appropriate in a performance venue, use some other effective means of notifying workers.
- *Hearing tests* — Test workers' hearing annually to determine if your hearing conservation program is effective.
- *Annual program review* — Review your hearing conservation program every year to ensure that it is effective.

For more information on hearing conservation programs, see the WCB publication *Sound Advice* or Part 7 of the Occupational Health and Safety Regulation.

SOUND MEASUREMENT

Employers are responsible for determining the sound-exposure levels that workers are exposed to on the job. Measuring sound-exposure levels for individual workers helps establish each worker's level of risk.

The only way to accurately determine sound-exposure levels is to use personal-exposure measurements that are averaged over time. Spot measurements (single measurements taken near the sound source) are insufficient because they do not incorporate information about the length of exposure.

Personal-exposure measurements are taken using noise dosimeters or integrating sound-level meters, measuring devices that average sound levels over time. Noise dosimeters, small devices that can be worn, are typically used to measure sound-exposure levels for musicians and other performers. Integrating sound-level meters are handheld instruments.

For more information on sound-measurement techniques and devices, see the WCB publications *Sound Advice: A Guide to Hearing Conservation Programs* and *Occupational Noise Surveys* (see "Publications and Videos" on page 62).

6.2 Sound check: Hearing tests

If you are exposed to loud or even moderately loud sound levels on a regular basis, you should have your hearing tested at least once a year. Hearing tests identify subtle changes in your hearing that you would not otherwise notice until your hearing was further damaged and the changes became more dramatic.

If you've never had your hearing tested, the first test will provide you with a baseline against which you can compare future test results. Your first test should indicate whether you've suffered some hearing loss already.

Getting a hearing test

To get your hearing tested, make an appointment with a WCB-authorized audiometric technician at a permanent or mobile testing facility. The test will take about 20 minutes and is painless (this isn't giving blood). As soon as your test is over, the technician will go over your audiogram and explain the results to you.

Here are some more facts about hearing tests:

- Test results are sent to the WCB as well as to employers so they can measure the effectiveness of their hearing conservation programs.
- Hearing tests are confidential.
- Employers in B.C. must pay for their workers' hearing tests if the workers are being exposed to sound levels above the WCB limits (see "WCB Sound-Exposure Limits" on page 11).
- SHAPE offers free hearing tests, conducted by Able Mobile Hearing, for performing-arts workers.
- Standard hearing tests measure frequencies from 500 – 8000 Hz because these frequencies are the most important for communication. Frequencies above 8000 Hz are generally not tested because it is technically difficult to test them.
- The audiometric technician will explain hearing protection options to you.

Resources

Organizations

British Columbia Association of Speech-Language Pathologists and Audiologists
9912 Lougheed Highway
Burnaby, BC V3C 1N3
Phone: 604 420-2222
Fax: 604 420-9559
E-mail: ExecutiveDirector_BCASLPA@telus.net
Web site: www.bcaslpa.bc.ca

Canadian Hearing Society
271 Spadina Road
Toronto, ON M5R 2V3
Phone: 416 964-9595
TTY: 416 964-0023
Fax: 416 928-2525
Web site: www.chs.ca

Hearing Education and Awareness for Rockers (H.E.A.R.)
PO Box 460847
San Francisco, CA 94146 USA
E-mail: hear@hearnet.com
Web site: www.hearnet.com

Musicians' Clinics of Canada
HAMILTON
565 Sanatorium Road, Suite 205
Hamilton, ON L9C 7N4
Phone: 905 574-5444
Fax: 905 574-1119
Web site: www.musiciansclinics.com

TORONTO
340 College Street, Suite 440
Toronto, ON M5T 3A9
Phone: 416 966-8742
Fax: 416 966-9288
Web site: www.musiciansclinics.com

Workers' Compensation Board of B.C.
PO Box 5350 Stn Terminal
Vancouver, BC V6B 5L5

Hearing Conservation Section
Phone: 604 276-3136 in the Lower Mainland
1 800 661-2112, local 3136, toll-free in B.C.
Fax: 604 276-3106

Publications and Videos Section
Phone: 604 276-3068 in the Lower Mainland
1 800 661-2112, local 3068, toll-free in B.C.
Fax: 604 279-7406
Email: pubvid@wcb.bc.ca

SHAPE (Safety and Health in Arts Production and Entertainment)
Suite 280 – 1385 West 8th Avenue
Vancouver, BC V6H 3V9
Phone: 604 733-4682 in the Lower Mainland
1 888 229-1455 toll-free in B.C.
Fax: 604 733-4692
Web site: www.shape.bc.ca

Product suppliers

Custom-fit earplugs
Contact SHAPE (see "Organizations" on page 60) for a list of audiologists, hearing clinics, and other suppliers of custom-fit earplug products.

Conventional earplugs
Safety-supply companies are the best place to buy hearing protection equipment other than custom-fit earplugs. Many drugstores and similar retail outlets carry compressible and premoulded earplugs.

HEARING PROTECTION CATALOGUE
The WCB publishes a catalogue of hearing protection products and suppliers in B.C. Contact the WCB Hearing Conservation Section (see "Organizations" on page 60) and ask for *Hearing Protection in British Columbia: A Product Catalogue*.

Publications and videos

A Guide to Noise in the Music Entertainment Industry (electronic PDF document)
Division of Workplace Health and Safety, Queensland Government, Australia
Web site: www.detir.qld.gov.au

Can't Hear You Knocking (video)
Hearing Education and Awareness for Rockers (H.E.A.R.)
(see "Organizations" on page 60)

Hear for Good: Information on Hearing Protection (pamphlet)
Workers' Compensation Board of British Columbia
(see "Organizations" on page 60)

Hearing Protection in British Columbia: A Product Catalogue (booklet)
Workers' Compensation Board of British Columbia
(see "Organizations" on page 60)

Hear the Music (book)
by Marshall Chasin
(order from the Canadian Hearing Society, Information Services — see "Organizations" on page 60)

Musicians and the Prevention of Hearing Loss (book)
by Marshall Chasin
Singular Publishing Group
Phone: 1 800 521-8545
(or order from the Canadian Hearing Society, Information Services — see "Organizations" on page 60)

Noise Control: A Primer (book)
by Alberto Behar, Marshall Chasin, and Margaret Cheesman
Singular Publishing Group
Phone: 1 800 521-8545
(or order from the Canadian Hearing Society, Information Services — see "Organizations" on page 60)

Occupational Noise Surveys (booklet)
Workers' Compensation Board of British Columbia
(see "Organizations" on page 60)

Sound Advice: A Guide to Hearing Conservation Programs (booklet)
Workers' Compensation Board of British Columbia
(see "Organizations" on page 60)

Testing Your Hearing: How and Why (pamphlet)
Workers' Compensation Board of British Columbia
(see "Organizations" on page 60)