Occupational Health Clinics for Ontario Workers Inc.

Doing Something about Noise

Some of the materials in this workbook were translated from sections of a booklet (http://www.emploi.belgique.be/WorkArea/DownloadAsset.aspx?id=3866) published by the Directorate-General 'Humanisation of Working Life' of the Federal Public Service Employment, Labour and Social Dialogue in Belgium. This publication is part of a series called the SOBANE Strategy Series. **SOBANE** is an acronym for **S**creening, **OB**servation, **AN**alysis, and **E**xpertise. Jacques Malchaire is the proponent of this strategy and has outlined the philosophy behind it in a paper titled:

"**The SOBANE risk management strategy and the Déparis method for the participatory screening of the risks**", *International Archives of Occupational and Environmental Health* 77: 443–450(2004)

Dr. Malchaire also wrote a paper directly applying the strategy to noise:

"Strategy for prevention and control of the risks due to noise"
Occupational and Environmental Medicine 57:361-369 (2000)

The picture on the front cover was taken from a European Union initiative called "Stop that Noise". The image itself was downloaded from: http://www.tueip.dircon.co.uk/er32-page7.html

March 8, 2017

Index

Introduction

Step #1 Identifying and Characterizing Noise Sources
Step #2 Assessing the Hazard and Prioritizing
Step #3 Considering Controls
Step #4 Making Recommendations
Step #5 Checking Progress

Appendix

Noise Assessment Worksheet

Info sheet 1 Noise
Info sheet 2 Noise Legislation
Info sheet 3 Noise Reduction Materials
Info sheet 4 Noise Transmission
Info sheet 5 Noise Control at the Source
Info sheet 6 Personal Protective Equipment
Info sheet 7 Testing Your Hearing

DOING SOMETHING ABOUT NOISE – A GUIDEBOOK

Why is noise still a problem?

Statistics show that over 40% of men aged 60-69 have a significant hearing loss. About half of these disabilities have been caused to exposure to too much noise in the workplace. We all know noise causes hearing loss and researchers can even tell us how much noise causes how much hearing loss. We've know this for many years (since the 1950's & 60's at least). We've also known for years how to reduce noise and how to protect individuals from too much exposure. So, why are workers still going deaf because of workplace noise?

The answer is, because we haven't applied what we know. Knowledge of itself is not sufficient – to prevent exposure one needs to act. The will to act can come from a number of motivators; the desire to avoid adverse health effects, the moral or ethical will to "do the right thing", the objective of optimizing the workplace environment (best practice), the goal to contain costs, the legal advice to practice "due diligence" to avoid culpability, or simply to minimally comply with the law.

July 1, 2016, the Ministry of Labour in Ontario expanded the coverage of its noise Regulation for all workers in Ontario. These changes will provide an opportunity for workplaces to renew their efforts to reduce noise exposures and thus prevent the ill effects associated with exposure to too much noise. In the past efforts to reduce noise exposure have been sidetracked by technical issues around noise measurement, the lack of practical knowledge about noise control options, focusing only on hearing protection, or the simply the lack of will to address the problem.

SOBANE: A different approach to solving health & safety concerns:

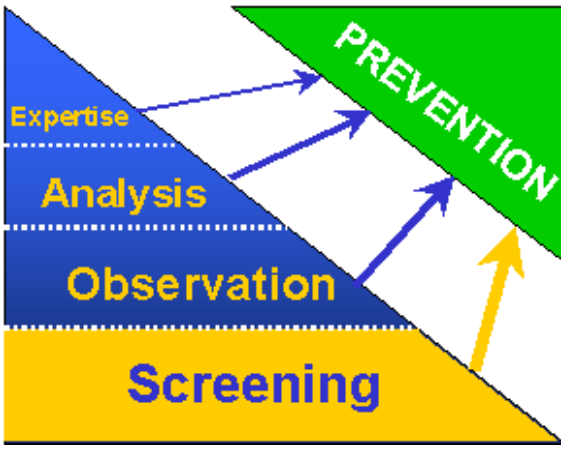
This guidebook is designed to help those interested in reducing workplace noise levels. It is based on materials produced in Belgium by Jacques Malchaire. The info sheets are largely direct translations from materials available on the web (in French or Dutch). The main body of the guide is an adaptation of the SOBANE approach and specific noise techniques applied to Ontario workplace context. SOBANE is an acronym for **Screening**, **OBservation**, **ANalysis**, and **Expertise** and represents an approach to workplace health & safety problem solving which stresses providing an appropriate level of expertise:

1) **Screening** is the shop-floor level where workers and supervisor recognize hazards and deal with them directly.

2) **Observation** is the next level up, where simple assessment tools are used to evaluate the seriousness of the hazard and make recommendations for improvement – the Health & Safety Committee/Representative and coordinator level of expertise (a few hours of training with practical experience)

3) The **Analysis** level implies specialists with formal training in occupational hygiene and/or ergonomics

4) **Expertise** refers to recommendations provided by experts (usually outside consultants) with highly technical knowledge to resolve particularly difficult control problems



The philosophy behind the SOBANE approach is that the lower levels are supported by the higher levels in their practical efforts to resolve health and safety issues. Ideally the majority of health and safety issues can be resolved on the shop floor with the health and safety committee/representative and coordinators only getting involved when the shop floor parties need support. Similarly, specialists and experts are called in only when the observation level techniques require further assistance to identify, assess and control particular hazardous situations. Thus the specialists and experts are only called in for the really tough problems where their training and expertise is needed. Simple determinations of whether or not some hazard needs to be addressed do not require specialists or experts. Rather such determinations are either quite obvious to the worker doing the job, or can be assessed using simple "rules of thumb". Malchaire estimates that up to 80% of concerns can be addressed in the Screening and Observation stages.

This guide is intended to provide tools for these early stages so that workplaces will be able to address noise concerns efficiently and recognize when they require the support of specialists and experts.

How to use this guide:

Looking over the myriads of publications available on noise, a pattern noticed by the authors of this guidebook, was how quickly one can get bogged down in the technical details of noise. In an effort to avoid this, we have struggled to keep only the essentials in the main body of the text and move the technical aspects into Info Sheets in the Appendix.

Our intention was to provide a simple technique for workers, health & safety representatives and supervisors to determine whether a noise source needs to be addressed and what noise control options to consider. To this objective this booklet is structured into five steps to address noise control:

1. identify the noise source
2. prioritize
3. review control options
4. make recommendations
5. check progress

In the Appendix are a number of Info Sheets which deal with particular topics in further detail. The goal of this guidebook is to provide the essential information needed to get workplaces started on the road to controlling noise exposure and provide the information of additional interest in the Info Sheets. One of the options in addressing particularly difficult noise control problems is to enlist the help of specialists and experts for extra support.

Step #1: Identifying and Characterizing Noise Sources

Locate sources on a map of the workplace: Sketch a layout of the work area and locate the position of the noise sources (see the Appendix for sample worksheet). On the sketch also identify the workstations and the location of the workers in relation to the noise sources. Identify activities that create noise.

Characterize noise sources: Describe the noise using the following categories (see Info Sheet 1 for more details):

> **Constant:** a noise that's always there and doesn't really change all that much (e.g. exhaust fan)
>
> **Fluctuating:** a noise that changes by a regular pattern (e.g. the cycling of a production machine)
>
> **Periodic:** noise that is created occasionally (e.g. using a saw infrequently)
>
> **Impact Noise:** noise caused by two things hitting each other (e.g. using a hammer or dropping a metal part into a metal bin)
>
> **Pure Tone:** a noise that corresponds to a particular frequency (e.g. siren)
>
> **Resonance:** a particular frequency that causes vibration in something receiving the noise (e.g. feeling one's insides vibrate when exposed to loud noise/music)
>
> **Vibration Transmission:** low frequency noise which travels through floors, walls and other structures and is felt as vibration (e.g. dropping something heavy on the floor and feeling the vibrations far away from the impact – a press)
>
> **Room Reverberation:** an echo in a room that causes the noise to "bounce back"

The category (categories) you use to describe the noise can help in determining what type of controls may be needed to control it.

Step #2: Assessing the Hazard and Prioritizing

Deciding which noise source needs to be addressed first depends on a number of factors which include:

Which source is the loudest?
Which is the loudest at the workers ear?
Which source are workers exposed to most often/for the longest periods of time?
Which are the easiest to fix ("pick the low hanging fruit first")?
Which would make the biggest impact on workers (to show progress)?
Which source creates the greatest hazard for workers?

There is no single correct way of prioritizing noise sources; each workplace needs to assess the options and approaches in a manner unique to its situation – i.e. what will work best in your situation. For some workplaces it will be important to get some quick results so that others will be convinced that the efforts are not futile. Other workplaces where workplace parties are already convinced of the feasibility of noise control will need to focus on impacting the greatest number of workers. Still other workplaces will need to deal with sources of particularly annoying sounds.

Do we need to take noise measurements?

The answer to this questions depends on the purpose of collecting the measurements. The Ontario regulations dealing with noise require areas where the noise levels exceed an 8 hour time weighted average equivalent of 85 dBA to be posted. In some workplaces where the noise levels are close to 85 dBA, it may be necessary to take measurements to determine which areas are above or below. On the other hand, anything over an 8 hour equivalent to 80 dBA can cause hearing loss, so a workplace that is truly concerned with preventing noise induced hearing loss may want to post all areas above 80 dBA.

However, you don't always need a noise measurement to determine whether the noise level warrants attention. As a simple rule of thumb, if you need to raise your voice significantly at an arm's length away in order to be understood, you're probably exposed to a level of noise that would eventually affect your hearing. The following chart was published by Jacques Malchaire to assist workplaces in assessing noise levels without using a meter:

voice level: (at 1 meter away)	**normal**	**loud**	**very loud**	**shouting**	**maximum shouting**
noise level: (in dB(A))	**50**	**70**	**85**	**90**	**100**
perception:	☺	😐	☹	☹☹	☹☹☹
hazard level:	**slight distraction**	**annoying, unpleasant**	**some risk of hearing loss**	**medium risk of hearing loss**	**high risk of hearing loss**

If your only need for measurement is to determine whether you need to consider noise control, simply asking workers may be sufficient (although some workers do accept excessive noise exposure as "just a part of the job"), or using the table above based on the voice level needed for communication.

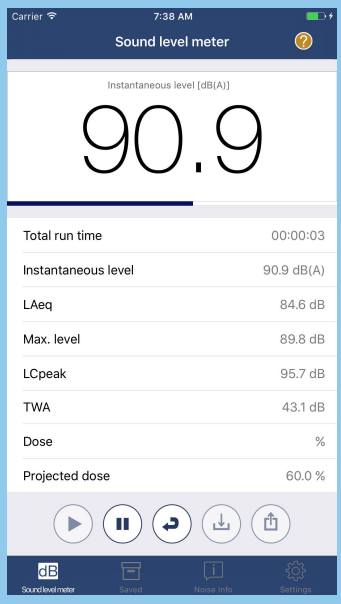
Quick & simple measurements:

If you decide that actual measurements with a noise meter are needed, the resources you need may vary. For instance if you just want a quick measurement to compare different noise sources or a rough idea of what the noise levels are in a certain area, there are smart phone applications ("apps") which you can download (some for free). The accuracy may not be sufficient to "stand up in court", however, these apps will help you identify sources of noise and "ball park" area noise levels (C. A. Kardous and P. B. Shaw, "**Evaluation of smartphone sound measurement applications**", J. Acoust. Soc. Am. 135 (4) EL 186-192, April 2014). Simply walking around and taking note of how noise levels change under different conditions is a helpful educational activity. Anyone should be able to successfully measure noise with such an app.

SPLnFFT Noise Meter APP by Fabien Lefebvre

"Official" measurements:

If you need numbers that will "stand up in court", a more sophisticated noise meter is needed (at least a type II machine). Also there is a protocol to follow in collecting noise exposure data, which the operator will need to be trained in. The setting up and calibration of the machine, the location and orientation of the microphone, the interpretation of the results, all require a certain degree of training. Ideally, an occupational hygienist or hygiene technician would be ideal for such measurements, although workers can easily be trained to do routine measurements. These machines can cost from $700 – $5000. Having consultants come in to assess noise levels can cost a few thousand dollars. One will need to weigh the cost-benefit of purchasing such a noise meter and getting the appropriate training against retaining a consultant. The other issue associated with devoting this level of resources to assess noise exposures, is whether the money might better be spent on noise control. If the only purpose for measuring noise is to determine whether controls are needed, a simple noise meter smart phone app or using the voice level "rule of thumb", may be sufficient for such purposes. When measuring noise at this level of expertise, Malchaire recommends (J Malchaire, "**Strategy for prevention and control of the risks due to noise**"*, Occupational and Environmental Medicine* 57:361-369 (2000)) that the results be reported in terms of the risk of hearing loss, for instance: at 85 dBA a 60 year old worker exposed for 40 years would be at a 4-14% risk of having noise induced hearing loss (table 3-4 (page 24) NIOSH criteria document https://www.cdc.gov/niosh/docs/98-126/pdfs/98-126.pdf).



NIOSH SLM Noise Meter App by EA LAB

Complex measurements:

The most sophisticated level of noise measurement is the octave band analysis. This requires even more expensive machinery and more expertise to interpret the data properly. These measurements are usually collected by noise control or acoustic experts and are usually only needed to address serious noise/acoustics problems.

Lists and databases:

There are also databases or manufacturers' information sheets available which detail the noise levels created by particular tools or pieces of equipment. These can be accessed online or from manufacturers/distributors directly. There may also be published investigations of noise in workplaces which are similar to the process you may be considering, again these may be available online or at a technical library (college/university library). Some of these are simply lists of sources with the measured noise levels while others are more sophisticated measurements which may need some mathematical treatment before they would represent usable exposure information.

Step #3: Considering Controls

Most workplace noise efforts can be characterized as an attempt to measure noise levels and a directive to exposed workers indicating where they must wear hearing protection. The section of the Ontario regulations pertaining to noise clearly indicate that hearing protection (ear plugs and muffs) are only to be used if engineering controls are not practical to use. The greatest weakness in most workplace programs addressing noise is addressing noise control. Workplaces who have addressed noise control with vigorous efforts have enjoyed significant successes. Especially the first few decibels of noise reduction are usually relatively inexpensive and usually have many side benefits not originally intended (e.g. improved preventive maintenance).

The following list of noise control options are taken from an article by Jacques Malchaire:

NOISE SOURCE	POSSIBLE NOISE CONTROL MEASURES
Vibrations of parts or panels	ÅTighten parts or panels • Cover them with a rubbery material
Ground transmission of vibration	ÅInstall isolation dampers (springs, cork, etc.)
Impacts of parts on a hard surface	ÅTilt the plate on which the parts are falling • Cover it directly or in a sandwich with a rubbery material
Mechanical noise	ÅUse helicoidal gears instead of toothed gears • Use plastic materials • Balance (equilibrate) rotating parts
Aerodynamic noise	ÅAvoid discontinuities (elbows) or sharp edges in the air stream • Use silencers in ducts
Air jets	ÅUse exhaust mufflers for decompression air jet • Use special air guns • Reduce the air velocity of the jet • Avoid the impact of the air jet on a sharp edge or perpendicular to a surface
Acoustic enclosure on the machine	ÅUse hermetic enclosure covered with rubbery materials • Install sound absorbing materials inside the cover
Pure tones	ÅRegulate the speed of rotating parts to minimize pure tones • Balance (Equilibrate) rotating parts • Dampen the blade on power saws • Use rubbery materials on resonating parts

Distance from the source	ÅMove the source away from the workers • Install a noise barrier between sources and workers
Reverberation of noise in the room	ÅAdd some absorbing materials if the room is highly reverberant • Check noise transmission from adjacent rooms or from the outside

Some aspects of these noise control options may be technically challenging for workers/supervisors to fully grasp. Maintenance personnel and sales representative of noise control products may be able to assist workers/ supervisors when considering different control options.

Occupational Health and Safety Council of Ontario (OHSCO) established a working group on noise who produced a booklet on noise control titled, Noise Control Tool: Concrete Actions and Specific Recommendations, which can be downloaded at:
https://www.pshsa.ca/wp-content/uploads/2015/09/NoiseControl.pdf

The Health and Safety executive in the UK have been promoting a "Buy Quiet" program which encourages employers to purchase quieter machinery. While this is obviously the best strategy to reduce noise in the workplace (i.e. eliminating noise at the source when purchasing new equipment), a review of the effectiveness of the program revealed that purchasers needed to have a very sophisticated knowledge of noise and noise control technology, plus they had to be very motivated to accomplish meaningful reductions. Furthermore, the data provided by suppliers was "often flawed" and so it was recommended that purchasers need to check themselves to ensure they are getting the reductions they anticipated. *(Brereton & Patel, "Buy Quiet as a Means of Reducing Workplace Noise", Acoust Aust DOI 10.1007/s40857-016-0051-x, online Mar 29, 2016)*

Step #4: Making Recommendations

Using the information collected from the worksheets (see Appendix) filled out for all significant noise sources, arrange the source in order of priority. It should be remembered that different workplace parties (shop floor workers, health and safety reps, supervisors, H&S coordinators and managers) may have different perspectives and thus different priorities. Don't let arguing about assigned priorities gridlock the process.

A. DESCRIPTION OF SOURCES/ACTIVITIES CAUSING NOISE

Sources		Worker concerns Management concerns
Number	**Description**	
1		
2		
3		
4		
5		
…		
…		
…		

Next fill in the following chart identifying the source, the noise level, noise type and possible control options:

B. NOISE CHARACTERISTICS AND SOURCE REDUCTION OPTIONS

	Source #1	Source #2	Source #3	Source #…
type of noise				
voice level				
dB(A)				
impacts (deaden)				
pure tone (alter)				
vibration (absorb)				
ground vibrations				
chute impacts				
mechanical noise				
compressed air				
moving air				
air exhaust (muffle)				
enclose source				
move source away				

C. TREATMENT OF THE ROOM

- current building materials
- reverberation
- sound absorption materials

D. SYNTHESIS

work station	judgment		further analysis priority	objectives
	current risk	residual risk		

E. WHO DOES WHAT, WHEN, AND IN WHAT PRIORITY?

Who	What	By When

F. SHORT TERM MEASURES: INDIVIDUAL PROTECTION

- What kinds of PPE?
- Who needs to wear it?
- When will they wear it?
- Until when?

Step #5: Checking Progress

Schedule a review in a month's time. Remind those who haven't met their deadlines and check on the progress of those whose deadlines are still coming up. Check in again in at 3 month intervals (or shorter).

If residual noise risks are still present after noise control efforts have been accomplished (i.e. workers still at risk of losing hearing), review noise control options on an annual basis (to check if there are new noise control developments, process changes, new ideas …). If noise increases in a particular work area, reassess risks (go back to Step #1 and follow through the process again).

Follow-up on issues/situations referred to the Analysis (serious measurement and expert noise control recommendations) stage. Ensure the reports are consistent with the objectives outlined in the Synthesis summary table. Get commitments to act on any recommendations provided by those conducting the Analysis.

Appendix

Noise Assessment Worksheet

Info sheet 1 Noise
Info sheet 2 Noise Legislation
Info sheet 3 Noise Reduction Materials
Info sheet 4 Noise Transmission
Info sheet 5 Noise Control at the Source
Info sheet 6 Personal Protective Equipment
Info sheet 7 Testing Your Hearing

DOING SOMETHING ABOUT NOISE

Noise Assessment Worksheet

date: _____

JH&SC member(s): _____

workers consulted: _____

1. WHERE IS IT COMING FROM?

diagram (draw a layout of the work area and locate noise source(s) and exposed worker locations)

2. WHAT TYPE OF NOISE IS IT? (check all appropriate)

☐ **constant** ☐ **fluctuating** ☐ **periodic** ☐ **impact noise** ☐ **pure tone**
☐ **resonance** ☐ **vibration transmission** ☐ **room reverberation (echo)**

3. HOW LOUD IS IT? (circle estimate)

voice level: (at 1 meter away)	**normal**	**loud**	**very loud**	**shouting**	**maximum shouting**

(indicate on the diagram where the voice level test(s) was done)

4. HOW HAZARDOUS IS IT? (circle estimate)

hazard level:	**slight distraction**	**annoying, unpleasant**	**some risk of hearing loss**	**medium risk of hearing loss**	**high risk of hearing loss**

As a short-term interim control measure, should exposed workers be wearing **hearing protection** until noise levels are controlled? ☐ **yes** ☐ **no**

5. HOW CAN THIS NOISE BE CONTROLLED?

look over the check list to see how best to reduce the noise

place an ✗ for not applicable, ✓ for applicable and ? for not sure

Vibrations of parts or panels	☐ Tighten parts or panels
	☐ Cover them with a rubbery material
Ground transmission of vibration	☐ Install isolation dampers (springs, cork, etc.)
Impacts of parts on a hard surface	☐ Tilt the plate on which the parts are falling
	☐ Cover it directly or in a sandwich with a rubbery material
Mechanical noise	☐ Use helicoidal gears instead of toothed gears
	☐ Use plastic materials
	☐ Balance rotating parts
Aerodynamic noise	☐ Avoid discontinuities (elbows) or sharp edges in the air stream
	☐ Use silencers in ducts
Air jets	☐ Use exhaust mufflers for decompression air jet
	☐ Use special air guns
	☐ Reduce the air velocity of the jet
	☐ Avoid directing air jet on a sharp edge or perpendicular to a surface
Acoustic enclosure on the machine	☐ Use hermetic enclosure covered with rubbery materials
	☐ Install sound absorbing materials inside the cover
Pure tones	☐ Regulate the speed of rotating parts to minimize pure tones
	☐ Balance rotating parts
	☐ Dampen the blade on power saws
	☐ Use rubbery materials on resonating parts
Relocation of the source	☐Move the source away from the workers
	☐ Install a noise barrier between sources and workers
Acoustic treatment of the room	☐ Add some absorbing materials if the room is highly reverberant
	☐ Check noise transmission from adjacent rooms or from the outside

7. SELECT A NOISE CONTROL STRATEGY: _____

_____

8. WHO WILL MAKE SURE IT GETS DONE?

Person(s) assigned responsibility: _____

Date when it will be completed: _____

9. DO WE NEED ANY EXTRA HELP? ☐ yes ☐ no

If so, what do we want them to do? _____

_____

10. WHEN SHALL WE REVIEW OUR PROGRESS? Date: _____

INFO SHEET 1

NOISE

Definition

Noise begins with vibrating source. These vibrations get transmitted through the air (or something else like steel, water, etc.) to the hearer. In the ear, the pressure variations move the ear drum which is connected through a series of small bones to an organ which translates these pressure changes in an electrical nerve signal. This signal then goes to the brain where it is interpreted.

Discomfort (Annoyance)

Generally one thinks of noise as unwanted sound. Noise caused by others (words, music …) is considered much more annoying than noise we intentionally generate ourselves. By preventing the background noise of one workstation from reaching another, the annoyance factor of the noise is reduced.

Noise-Induced Hearing Loss (NIHL)

Beyond a certain level of loudness (75-80 dBA) all forms of noise (sound, music, conversation – whether or not these sounds are annoying) can cause hearing loss. Therefore, it may not be sufficient to merely reduce intruding noise from other workstations (annoyance), if the source is loud enough, it may also be necessary to reduce exposure to the sounds one generates as a part of doing ones work.

Pitch/Tone and Frequency

Sound has two aspects to it; loudness and pitch or tone. Examples of various tones or pitches of noise are:

- **low Pitch:** the sound of a diesel engine, a truck or a compressor. These are so-called "**low frequency**" noises, which are difficult to dampen in an enclosed space and they also are easily transmitted by vibration through floors and walls
- **mid Range Pitch:** these are the same frequencies as the sounds generated by the human voice (generally female slightly higher than male), therefore, noise in this frequency range can particularly be a problem for hearing conversation.
- **high Pitch:** the sound of a circular saw. These noises are particularly damaging to the ear and can cause hearing loss quickly.
- **very High Pitch:** shrieking noise like a high pitched whistle; high frequency noise.
- **Pure Tone:** a noise that is dominated by a single frequency;

Beyond the range of sounds that the human ear can hear we refer to
- infrasound for the very low frequencies (low frequency vibration)
- ultrasound for the very high frequencies (dogs can hear these sounds).

The human ear cannot hear these.

Units

Noise is measured in decibels (dB). However, the ear does not hear the same at all frequencies. The shape of t he outer ear actually emphasizes (amplifies) sounds within the speech frequencies while at either end of the hearing frequency range sounds are dampened. To account for this phenomenon, measurements of noise are filtered to mimic the response of the human ear.

This adjustment is referred to as the "A" weighted scale and "A" weighted adjusted decibels are expressed in units of dB(A).

Speed, Resonance and Reverberation

Noise travels in air at a speed of 340 meters per second (1224 km/hr)

- when sound is reflected off an obstacle (wall, canyon, row of trees, …) we call it an echo. The reflected sound is the same as the original sound except with a lower intensity or loudness.
- when the frequency of the noise matches the some characteristic of an object which then causes the amplification the noise vibrations in the object, we call this "resonance" (e.g. a singer hitting a note which breaks a glass).
- when noise is reflected off the walls, floor and ceiling of a room in such a way that the original sound is distorted and gradually tapers off, we call this "reverberation".

Levels of Sound Intensity (Loudness)

The following table illustrates the differing levels of sound intensity

Conversation level	Acoustic Impression	Noise level (in dB(A))	examples
Whisper	Very quiet	<30	indoors in a quiet neighbourhood
Normal voice	Rather quiet	50	quiet restaurant very quiet street
Raised voice	Noisy but bearable	70	noisy restaurant considerable traffic
Very loud voice	Unpleasant, annoying	85	very loud radio very busy traffic
Shouting	Not very bearable	90	forge very intense traffic
Maximal shouting	Unbearable	100	circular saw jack-hammer
Impossible	Threshold of pain	120	test bank of engines aircraft noise at takeoff

Adding and Subtracting Decibels

The decibel scale is difficult to use (it is logarithmic). For example, when you add two identical 60 dB(A) sounds together, the total noise is 63 dB(A), not 120 dB(A).

If a third noise source of 60 dB(A) is added, the total noise is 65 dB (A) and the additional noise of the third source is difficult to distinguish from the combined noise of the other two sources.

The logarithmic nature of the decibels scale means that:

- for noises with identical frequencies, the sound from one source can be completely masked (unable to be heard) if the other source is approximately 10 dB(A) louder than the other;
- when a noise source is reduced or removed, other noises which were previously masked can appear.

In order to add and subtract noise levels precisely, one must be familiar with the mathematics of logarithms and the definition of the decibel. In most cases this requires some specialized training.

Continuous, Fluctuating and Intermittent Noises

- some sounds are constant (continuous), such as a fan
- others fluctuate (a constant background with regular louder levels of noise); using a table saw to cut pieces of wood
- still other are intermittent (on and off); airplanes taking off at an airport.

This time characteristic of the noise may be important when making precise noise measurements, however, in general these distinctions are seldom useful.

Impact Noise

Impact noise is due to:

- intense impacts on surfaces which reverberate: a hammer on a steel plate, the impact of an object which drops
- or, an explosion or shot...

These very intense sounds can cause immediate damage to the ear and, if loud enough, cause immediate irreversible hearing loss. These sounds, therefore, involve immediate (acute) risk to the hearing, whereas regular noise causes hearing loss gradually, over time (chronic risk).

INFO SHEET 2

NOISE LEGISLATION

This information sheet describes the legislation regarding occupational noise exposure in Ontario.

Ontario Regulation 831/15 requires (as of July 1, 2016):

- employers take all measures reasonably necessary in the circumstances to protect workers from exposure to hazardous sound levels.
- protective measures against noise exposure include engineering controls, work practices and personal protective equipment.
- assessment of noise levels in the workplace shall be done without regard to any use of personal protective equipment.
- every employer shall ensure that **no worker is exposed to a sound level greater than an equivalent sound exposure level of 85 dBA, $L_{ex,8}$.**
- the employer shall protect workers from exposure to a sound level greater than 85 dBA, $L_{ex,8}$ **without requiring the use of personal protective equipment.**
- personal protective equipment is only to be used if engineering controls,
  - (a) do not existence or are not obtainable;
  - (b) are not reasonable or not practical to adopt, install or provide because of the duration or frequency of the exposures or because of the nature of the process, operation or work;
  - (c) are rendered ineffective because of a temporary breakdown of such controls; or
  - (d) are ineffective to prevent, control or limit exposure because of an emergency.
- if engineering controls can't be used then workers shall wear and use personal protective equipment appropriate in the circumstances to protect them from exposure to a sound level greater than 85 dBA, $L_{ex,8}$
- a clearly visible warning sign shall be posted at every approach to an area in the workplace where the sound level regularly exceeds 85 dBA.

The **formula prescribed** by the regulation to calculate the used to calculate the **85 dBA, $L_{ex,8}$** (8 hour time weighted average) is as follows:

$$L_{ex,8} = 10\ \mathrm{Log}_{10}\left(\frac{\left[\sum_{i=1}^{n}\left(t_i \times 10^{0.1\ SPL_i}\right)\right]}{8}\right)$$

Calculations using this formula were performed for different exposure levels and tabulated in the table on the following page:

Noise Exposure Levels: The following chart outlines the amount of exposure time to reach an equivalent 8-hr exposure ($L_{ex,8}$) of 85 dB(A) or an $L_{ex,8}$ of 80 dB(A).

Sound Level (in db(A))	Duration – 85 dBA $L_{ex,8}$ (hrs/24 hr day)	Duration 80 dBA $L_{ex,8}$ (hrs/24 hr day)
80.2	24	7½
81.5	18	5½
82.0	16	5
83.2	12	4
84.0	10	3
85.0	8	2½
86.2	6	2
88.0	4	1¼
89.3	3	1
91.0	2	40 min
92.3	1½	30 min
94.0	1	20 min
97.0	30 min	10 min
100.0	20 min	5 min
101.8	10 min	3 min
104.8	5 min	1½ min
111.8	1 min	20 sec
114.8	30 sec	10 sec

The number in the yellow column correspond to the levels stipulated by the formula given in the regulation and are all equivalent to 85 dBA, $L_{ex,8}$ (8 hour time weighted average). The green column corresponds to exposures equivalent to 80 dBA, $L_{ex,8}$, the threshold at which long term hearing loss begins.

OHCOW has created a **Excel spreadsheet** which will calculate time-weighted averages for differing levels of exposure. The spreadsheet also calculates the amount of time it will take to reach 85 dBA, $L_{ex,8}$ and 80 dBA, $L_{ex,8}$ exposures for a given level of noise.

www.ohcow.on.ca/edit/files/general_handouts/noisecalculator.xls

INFO SHEET 3

NOISE REDUCTION MATERIALS

There are 3 types of noise reducing materials:

1. Noise Absorbing Material:

mineral wools, foam, expanded wood, porous materials

- They are used to reduce the reverberation inside a room
- The material must be porous to absorb the noise:
    - concrete does not absorb noise well (absorption coefficient ≈ 0)
    - porous materials are good for absorbing high frequency noise

2. Noise Insulating Materials:

concrete, bricks, plaster, high density materials

- They prevent the noise from passing from a room to the other
- The material must be dense not to vibrate:
    - foam is very light and does not insulate at all
    - heavy materials are better at blocking high frequency noise (some low frequency vibrations are transmitted through the insulating material).

3. Vibration Damping (Isolation) Materials

felt, cork, rubber, springs...

- They prevent the mechanical vibrations: the hand on the bell or the sheet which vibrates stops the emitted vibrations and noise
- the material must be rubbery (resilient), not compressed or crushed
    - stiff concrete doesn't stop anything, on the contrary it will carry the vibration so that an impact against a wall can be heard all along the wall
    - if foam is crushed and it will not stop any noise
    - resilient materials are better at absorbing high frequency than low frequency vibrations

INFO SHEET 4

NOISE PROPAGATION

Noise can travel (be propagated) through a workspace in three different ways. Control strategies differ according to how the noise is transmitted.

1. Direct Propagation

Noise travels directly, in a straight line from the source to the worker's ear. In this case the loudness (intensity) depends on how close the worker is to the source. One can reduce exposure to noise transmitted directly by:

- placing a barrier between the source and the worker (e.g. noise barriers along highways)
- moving the worker further away from the source

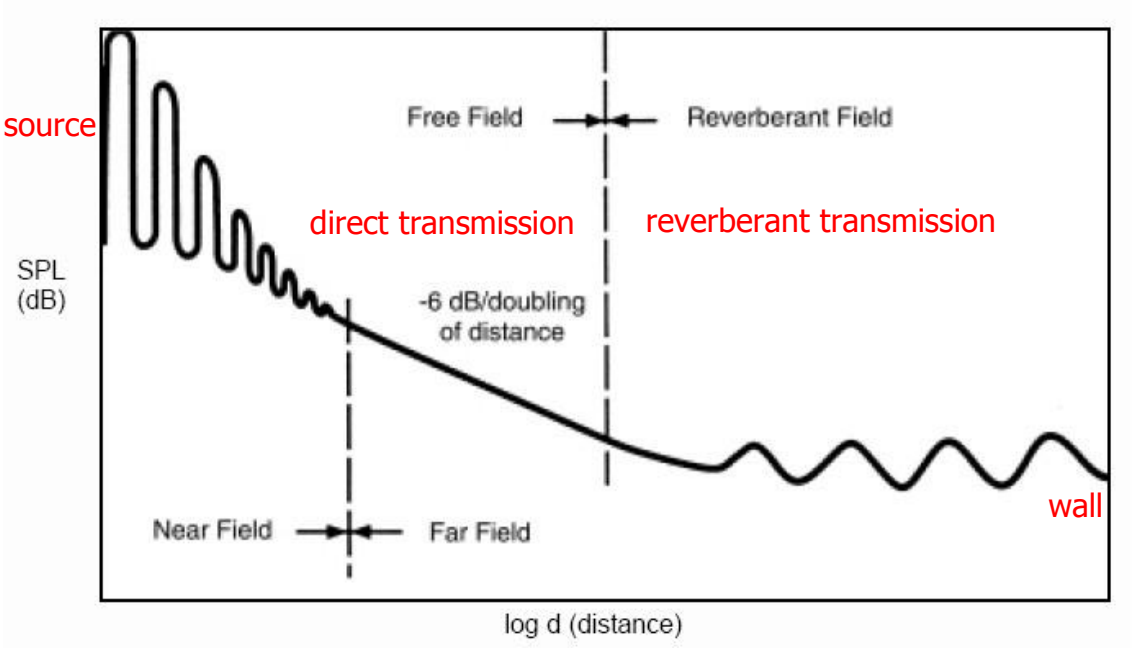
2. Reverberation

Noise is bounced off walls, ceilings, floors and other large objects and reaches the worker's ear along indirect paths. The solution to reverberated sound is to decrease the reflections by covering noise reflective surfaces with sound absorbing materials. Suspending noise absorbing baffles from the ceiling is often helpful.

3. Vibration Transmission

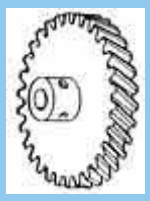
Vibrations travel along structures, floors to surfaces which emit noise when vibrated (e.g. rattling fan cover). The transmission of vibrations can be absorbed by vibration isolating/damping materials (described in Info Sheet 3).

A worker's noise exposure is the sum of these three transmission paths – if all three noise transmission paths are present it can be difficult to determine exactly where the noise is coming from.



INFO SHEET 5

NOISE CONTROL AT THE SOURCE

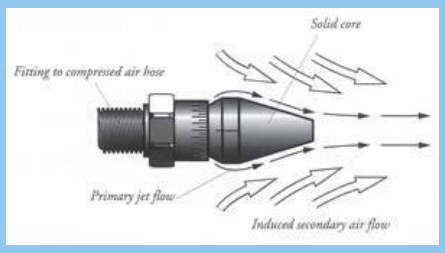


1. Reduce vibrations and mechanical noise

- balance rotating parts to prevent imbalances
- use helicoidal gears instead of toothed gears in order to reduce the impacts associated with the interlocking gears and the associated noise and vibration
- install isolation dampers (springs, cork, etc.)
- tighten parts or panels
- use flexible connections for electrical, compressed air or hydraulic piping
- use plastic (non-metal) materials
- change the speed of rotating parts to minimize pure tones

2. Elimination or reduction of the shocks and impacts

- reduce the falling distances of metal objects on metal
- tilt the plate on which the parts are falling so that parts fall on an angle rather than perpendicularly
- ease two objects into contact together before pushing one with the other (change work habits)



3. Compressed air

- find another way to do the work without using compressed air
- reduce air pressures and velocity
- use air guns specially designed to be quieter
- design process (and/or change working habits) to avoid the impact of the compressed air stream on a sharp edge or perpendicular to a surface

4. Exhausting compressed air

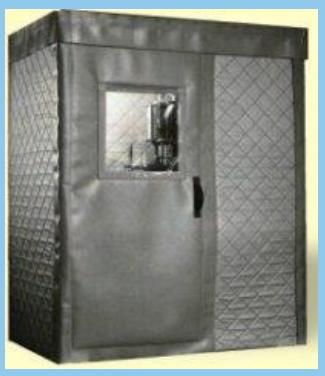
- use a larger exhaust opening to reduce air speed
- place a silencer on the exhaust
- do not direct the exhaust towards a wall or at an object.

5. Ventilation noise

- balance the rotating parts in fan (see point1)
- isolate air handling unit from building structure and ducting system (see point 1)
- place materials noise absorbing materials inside the ducts and inside air handling unit
- eliminate any unnecessary bends or sharp angles in ducting

6. Metal surfaces and containers

- cover them with noise dampening material (old rubber belting)
- dampen the blade on power saws
- construct bins, conveyors and chutes with "noise-less" steel (resilient material such a rubber sandwiched between two sheets of steel)
- construct with wood, plastic or other similar materials

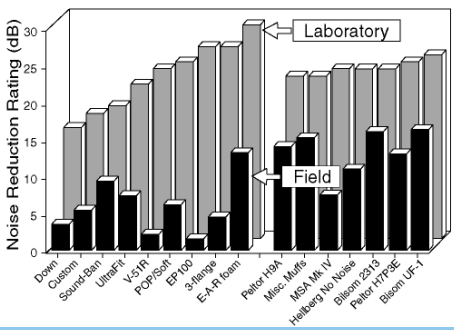


7. Enclosure noise source

- an enclosure can be effective to reduce the noise only if:
    - it constructed of a sufficiently dense material
    - it is covered on the inside with a noise absorbing material
    - the openings are to the minimum reduced
    - it is not directly connected to the machine (or, if connected it is made from or covered with a resilient material (plastic, rubber, noise-less steel, etc.).

8. Preventive maintenance

- ensure moving mechanical parts are serviced regularly
- ensure periodic overhauls are conducted on a timely schedule (semi-monthly, annual...)
    - by a qualified person
    - replace deteriorated parts before they break.



www.cdc.gov/niosh/docs/96-110/personal.html

INFO SHEET 6

PERSONAL PROTECTIVE EQUIPMENT (HEARING PROTECTORS)

Personal protective equipment is always considered the least desirable exposure control option in the hierarchy of controls.

1) The best control strategy is control at the source (elimination, process re-engineering, substitution, enclosure, etc.).
2) The second best control strategy is along the path (from the source to the worker – barriers, acoustical treatment of room with noise absorbing materials, etc.).
3) Only when these options are not practical to implement should personal protective equipment (hearing protection) be considered.

Types of hearing protectors

Ear plugs:

- plastic semi-rigid
- semi-porous foam
- custom moulded plugs

Ear muffs

Selection

- since hearing loss begins with long term exposures to noise as low as 80 dB(A), ideally 80 dB(A) should be the maximum exposure workers experience when wearing their hearing protection (set target at 75-80 dB(A))
- the protection (attenuation) factors claimed by manufacturers are often not realized in the workplace because hearing protectors are commonly poorly inserted and/or they work themselves loose due to body movements while working

-hearing protectors should not be selected by theoretical attenuation factors alone, but also by

- worker acceptance,
- ability to achieve a proper fit, and,
- those that will be worn the longest periods of time

- ensure that the protection factor is appropriate to the noise exposure – over protecting will often lead to workers removing their protection so that they are able to carry on a conversation

-the following table gives the percentage of the time hearing protection must be worn to limit exposure to 80 dB(A) at different levels of noise.

Level of noise (in dB(A))	**80**	**82.5**	**85**	**87.5**	**90**	**92.5**	**95**
% of time PPE worn	**0%**	**44%**	**68%**	**82%**	**90%**	**96%**	**97%**

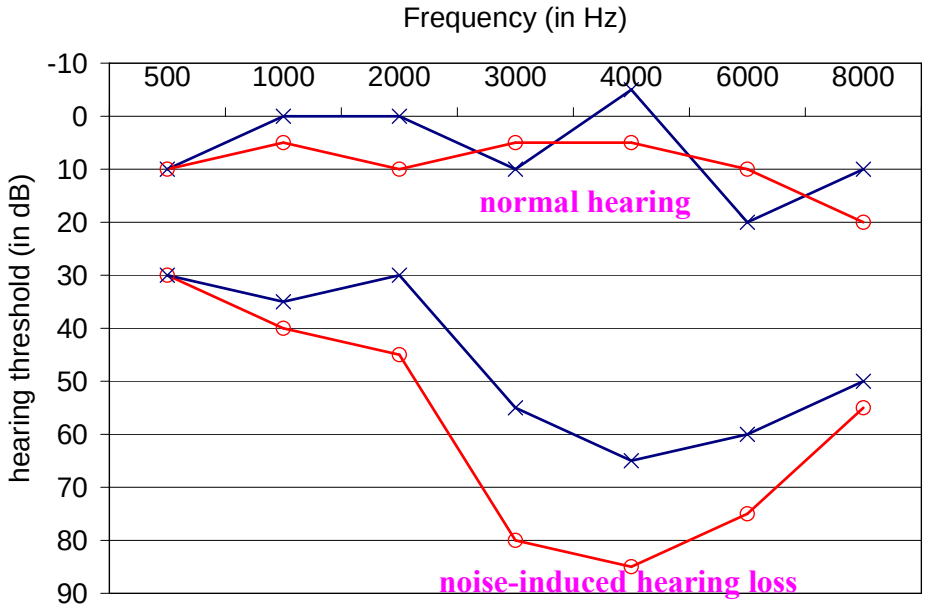
- practically, the theoretical protection factors of different hearing protectors is of little consequence if one only requires a 10 to 15 dB reduction.

INFO SHEET 7

TESTING YOUR HEARING (AUDIOMETIRC TESTING)

There is a way of testing how well you can hear. During an audiometric test you are asked to wear a set of headphones inside a sound-proof booth. A technician uses an audiometer to send a beeping sound to one of your ears. When you hear the sound you either raise your hand or press a button. The technician then decreases the volume of the sound until they can determine the level at which you no longer hear the beep. This is repeated at different tones (frequencies) and for both ears. At the end of the process the results are plotted on a chart that indicates your hearing threshold at specified frequencies.

Audiogram



If these tests are done routinely (every year or two) one is able to monitor whether noise is affecting a worker's hearing. If there are early signs of a deterioration in the 3000-6000 Hz range, this would be a signal that noise exposure must be reduce or else we would expect further deterioration and ultimately a case of noise-induced hearing loss. It is important to remember, once a certain degree of hearing is lost, it doesn't come back even if exposure is stopped.