Occupational Noise Surveys

April 2007

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Foreword

This is the third edition of this publication, which was first printed in 1996. The second edition was extended because some errors in interpretation of dosimeter results were apparently being made by some noise surveyors. A section was included to help surveyors to interpret dosimeter downloads correctly, particularly with regard to false "peak" sound levels which bore serious implications. Other changes included advice on relocation of the noise dosimeter microphone, as contributions from speech in loud environments could make significant contributions to the overall average sound level near the criterion value if the microphone was located on the collar.

This revision has been necessitated by new editions of international and national standards and by changes to Part 7 of the Occupational Health and Safety Regulation and the OHS Guidelines. The recent edition of the relevant CSA standard incorporates the practical points discussed above.

For ease of use, the previous document (*Occupational Noise Surveying*) has now been split into two separate documents: *Occupational Noise Surveys* and *Basic Noise Calculations*. The first document contains the descriptive part of the original document; the second contains the more technical Appendices, which facilitate noise calculations.

Contents

AIM

Who Should Read This Booklet?

This booklet explains how occupational noise surveys should be done, and how reports should be prepared to meet the requirements of Part 7 of the Occupational Health and Safety (OHS) Regulation and the OHS Guidelines. If you have some technical knowledge and, perhaps, familiarity with noise measurement you may, after reading the booklet, be able to do a noise survey. If you decide you need a consultant's help, the booklet gives you the background to discuss your needs, and the services a competent professional could provide.

You may also wish to read *Basic Noise Calculations*, a companion document that has more detailed information.

Why Do A Noise Survey?

The principal reasons for doing an occupational noise survey are:

- To identify which workers are exposed to noise harmful to their hearing
- To provide information to determine corrective actions, which may include a hearing conservation program and noise control

NOISE EXPOSURE DESCRIPTORS

Introduction

Noise is commonly measured in decibels (written as dB). Sometimes noise meters measuring in dB may give numbers that do not relate well to the subjective impression of the noise heard. To overcome this problem, noise measuring instruments have electronic networks that imitate the frequency response of the ear. The most commonly used network is the *A-weighting,* and a noise meter using the network is called a *sound level meter*. Sound levels are expressed here in dBA but you may see dB(A) written elsewhere. For peak sound level measurement the C-weighting is used, expressed as dBC.

Sound levels in terms of dBA have been in use in B.C. to describe occupational noise for about 30 years. However, with occupational noise, we are concerned with workers' *noise exposure*.

In Part 7 of the Occupational Health and Safety Regulation, a worker's noise exposure is expressed as:

- The energy-averaged sound level (L_{EX} in dBA) and
- Peak sound level (in dBC)

These important terms are discussed in more detail later in this report.

"Energy-average" is the "root-mean-square" (rms) or "effective" average performed in many measuring instruments. For example, a voltmeter connected to the AC line supply

voltage may indicate 110V (rms); however, the actual, instantaneous voltage varies between +155V and -155V.

We use special descriptors for noise exposure because they reflect the hazard to hearing; broadly, the greater the noise exposure, the greater the risk of hearing loss. Common ways to describe noise exposure are discussed below.

Descriptors

L_{eq}

L_{eq} is the **eq**uivalent steady sound **l**evel of a noise energy-averaged over time (see the figure below). Because occupational noise is often a complex signal, the noise level has to be averaged over a minimum sample time. (If you are using an integrating meter, the noise is said to be *integrated* as the meter combines all types of noise in its energy average.) The sampling time can be as short as a few minutes if the noise signal is steady or repetitive over a short cycle; some jobs could require a full day's monitoring.

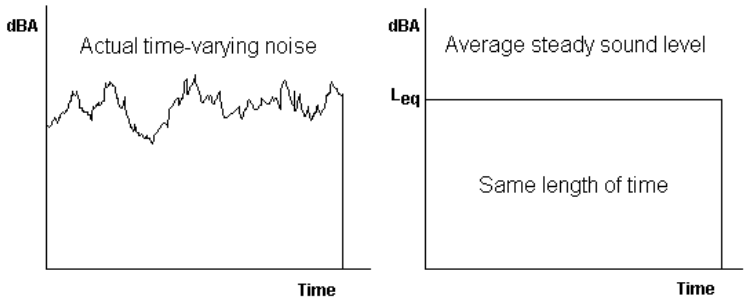


Figure 1. The actual varying noise replaced by equivalent steady level (L_{eq})

There may be cases when even a day is insufficient to characterize a worker's exposure. You may then consider the strategy described in the "Sampling" section. Whatever the actual duration, it should be a representative sample of the entire exposure. If this condition is fulfilled during the sample time sample, then:

$$\text{sample } L_{eq} = \text{shift } L_{eq}$$

If the activity is not typical of the shift, then either you must resample when the condition is fulfilled or make corrections to your measurement. Corrections for some situations are given in a companion report called *Basic Noise Calculations*; others are beyond the scope of this booklet.

The average daily exposure time **and** the average sound level, L_{eq}, during this time can be used to describe a worker's noise exposure. This method was used in the 1978 Noise Control & Hearing Conservation regulations of WCB of BC. This method needs **two** descriptors: time and sound level. One pair of numbers is difficult to compare with another pair. For example, which pair of values represents the greater noise exposure: 96 dBA for 1 hour or 85 dBA for 8 hours?

L_{EX}

L_{EX} is the sound level, energy-averaged over 8 hours, which would give the same daily noise exposure dose as the varying noise over a typical full shift. It is closely related to the L_{eq}, which you actually measure.

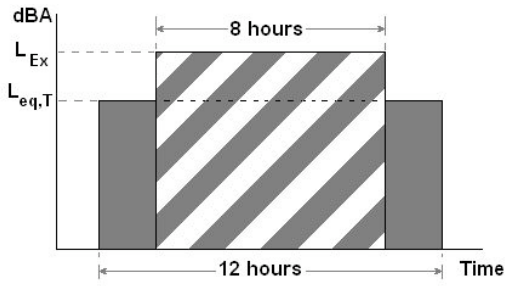


Figure 2. L_{eq} is obtained when the noise exposure in the actual shift length (here T = 12 hours) is adjusted to the standard shift time of 8 hours

L_{EX} is the noise **ex**posure **l**evel. L_{EX} is useful as a **single number** measure of the noise exposure in decibel form.

The L_{EX} of a work shift longer than 8 h is greater than the measured L_{eq}; shifts shorter than 8 h give L_{EX} less than the measured L_{eq}. We could regard L_{EX} as being the measured L_{eq} with a small correction.

Thus: $L_{EX} = L_{eq}$ + correction for shift length

where the correction is given by the chart below.

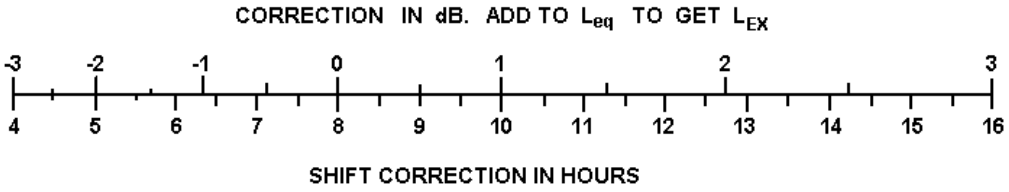


Figure 3. Shift Time Correction to L_{eq}

Example

You measure a worker's noise exposure as L_{eq} = 89 dBA. Let's be clear about times! The shift time is 5 h. You took a noise level *sample* during the shift (perhaps using a noise dosimeter for 3¼ h was sufficient or even 15 minutes with an integrating sound level meter) to get the L_{eq}.

If you collected a **representative** noise sample, then the measured L_{eq} is considered equal to the shift L_{eq}. Then, using the chart, for the 5 h shift the correction is -2 dB. So:

$$L_{EX} = 89 + (-2) = 87 \text{ dBA}$$

It's easier to compare a noise exposure level L_{EX} of 87 dBA with the permissible L_{EX} of 85 dBA rather than compare 89 dBA for 5 hours with 85 dBA for 8 hours.

Note 1: The shift time correction to L_{eq} is zero when the shift duration is 8 h.

Note 2: Although it is preferable to measure and average over an entire shift, but there will be instances when this is either impractical or unnecessary. For example, with

production line workers, the average sound level during a fraction of the shift would be equal to that of the entire shift.

L_{EX} of Non-standard Work Patterns

To obtain the appropriate L_{EX} correction for L_{eq}s of a shift that departs from the standard 8 hours/day, 5 days/week work pattern, the shift shall be assumed to have equivalent daily duration equal to the higher of:

- One-fifth of the average number of hours worked per week, or
- The average number of hours worked per month divided by 21

Noise Dose

Noise dose is not mentioned in the noise regulation, but it is useful to understand this important concept as many noise calculations use noise dose. Also, noise dosimeters are frequently used in occupational noise survey work.

A noise dose is a way of quantifying an amount of noise to which a worker is exposed. A noise dose can be expressed:

- As a percentage of an "acceptable," or "criterion" noise dose, or
- In terms of absolute units, known as Pa^2h (say "pascal squared hours")

A worker exposed to the daily limit of L_{EX} = 85 dBA (over 8 hours/day) receives the criterion dose of 100% (≈ 1 Pa^2h).

Noise dose in terms of a value relative to unity or 100% (of an "acceptable" amount of noise dose) was included in the WCB industrial Health & Safety Regulations of 1978. The daily dose "acceptable" under the current Part 7 of the Occupational Health and Safety Regulation is now 31.6% of the 1978 value.

Some worked examples in *Basic Noise Calculations* show how to obtain an L_{EX} from a series of "partial" noise exposures.

Peak Level

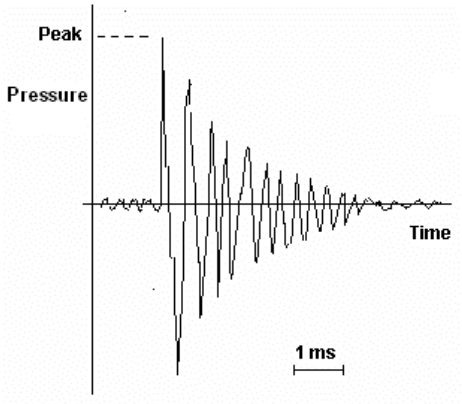


Figure 4. Time Record of an Impact Noise

Part 7 of the Occupational Health and Safety Regulation requires the peak sound level be measured where impulse noise is a hearing hazard. The maximum allowed peak sound level is 140 dBC (Note: the "C" weighting). Noise peaks may only be measured with a noise measuring instrument that has a "Peak" response time constant.

The graph shows how acoustic pressure due to an impact can vary with time. The sound level meter converts the peak pressure to dBC.

Impulse noises most commonly occur when objects collide as in metal forming or in the handling of materials. Discharges from pneumatic cylinders and powder actuated tools can also be classed as impulse noise.

Caution: The time response called "Impulse" on some sound level meters is **not** the same as "Peak." *The "Impulse" response should not be used for peak noise measurements!*

NOISE-MEASURING METERS

Type Classification of Meters

The overall precision with which a noise-measuring instrument (e.g., a sound level meter or noise dosimeter) measures noise is summarized by its Type Classification. To qualify for a certain Type, the various parts of the instrument (microphone, display, weighting network, etc.) must meet certain specifications.

A Type 0 meter has closer tolerances than Type 1. Type 1 has closer tolerances than Type 2. Type Classification is determined by national and international standards. Meters may be marked as complying with standards such as:

ANSI 1.25 1991 (R2002), "*Specification for Personal Dosimeters*"
ANSI 1.4-1983 (R2001), "*Specification for Sound Level Meters*"
IEC 61672-1 (2002-05), "*Electroacoustics- Sound Level Meters- Part 1: Specifications*"
IEC 61672-2 (2003-04), "*Electroacoustics- Sound Level Meters- Part 2: Pattern evaluation tests*"
BS EN 61252:1997, "*Electroacoustics – Specifications for Personal Sound Exposure Meters*"

Some Instrumentation Terms

When selecting a noise meter, you should be aware of these technical terms.

Dynamic range is the range of decibels over which a noise meter will operate to within stated tolerances on a given range switch setting. The meter should have a minimum dynamic range of 50 dB.

Crest factor is a measure of the instrument's ability to handle impact noise. A crest factor measured at midrange of at least 30 dB is recommended.

Criterion level is the steady sound level at which a noise dosimeter will read 100% noise dose after an 8 h exposure.

Threshold level is the sound level above which the noise dosimeter will accumulate noise dose.

Noise-Measuring Meters

Part 7 of the Occupational Health and Safety Regulation specifies noise-measuring instruments used for a noise survey be **Type 2 or better**. If the meter has no Type classification (or is an old Type 3), it is not recognized as a sound level meter and should not be used in formal noise surveys. If in doubt, consult the meter manufacturer.

Basic Sound Level Meters

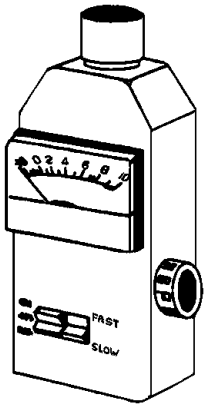


Figure 5. A Basic Sound Level Meter

Basic SLMs have limited averaging capabilities. The standard "time constants" are $^1/_8$ second (known as "Fast") and 1 second ("Slow"). These are *exponential* time constants and give sufficient averaging only for relatively steady noise signals. The exponential averaging times are often much shorter than the representative time needed to determine the rms level of many industrial noises.

If sound levels vary by more than about 6 dB, when using the "Slow" response, averaging by eye tends to noticeably underestimate the L_{eq}; the error increases with the amount of variation around the mean.

Integrating Meters

Integrating meters such as *integrating-averaging sound level meters* (usually just called integrating sound level meters) and *noise dosimeters* with Type 2 Classification or better are the preferred instruments for occupational surveys.

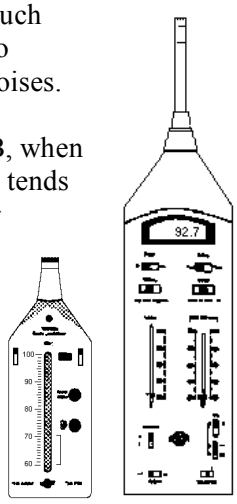


Figure 6. A Type 1 Integrating Sound Level Meter (right) and a Type 2 Integrating Sound Level Meter (left)

Noise Dosimeters

Noise dosimeters are noise integrating devices small enough to be worn by workers. They are used for personal noise sampling over long periods of time. At the end of the sampling time, they indicate the noise exposure dose acquired during that time. Noise dosimeters must be set up as follows:

Criterion Level: L_c	=	85 dBA
Threshold Level: L_t	=	80 dBA or "Off"
Exchange Rate: q	=	3 dB
Time Constant	=	"Slow"

Dosimeters must have the following minimum specifications:

Classification: Type 2
Weighting: A-weighting
Dynamic Range: 50 dB
Crest Factor: 30 dB

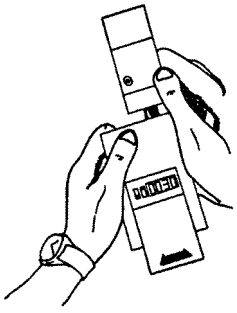


Figure 7. Calibrating a Basic Personal Noise Dosimeter

Data Logging Noise Dosimeters

A noise dosimeter capable of recording the noise history is very useful in occupational noise survey work. These "data logging" instruments usually output the exposure in a variety of terms including % noise dose, L_{EX} and L_{eq} (and many more).

These dosimeters may also project the dose over 8 h from a partial shift exposure on the assumption that the wearer will continue to receive noise energy at the same rate. These instruments are versatile because they can be used as integrating-averaging sound level meters. A sample output is included in *Basic Noise Calculations*.

Table. Summary guide for selection of noise measuring instrumentation

Noise Measuring Instrument	Most Suitable Uses	Limitations
Basic Sound Level Meter	Steady sound levels, when sound level does not vary by more than 6 dB with "Slow" response.	Unsteady noise where averaging by eye underestimates L_{eq}, especially if impulse noise is present
Integrating Sound Level Meter	All noise types. Suitable when short sample times are valid (e.g., repetitive or cyclical events). In interference field. Where peak sound level must be measured	Where worker's movement makes it difficult to follow or where long-term sampling is required
Noise Dosimeter	All noise types. Where worker's movement cannot be followed or accompanied, or where work pattern may be unpredictable and long sample time required	Where it is essential to witness noise accumulation.

Using Noise Measuring Meters

You can assure workers the noise measurement exercise is not intended to infringe on workers' privacy (noise dosimeters do not record speech). The results are not useful in time-motion studies. The data are personal noise exposures only. Also:

- Check the instrument with a field calibrator before and after use
- Check the meter's battery before and after use; replace batteries if necessary
- Note instrument serial number
- Decide on the deployment of the types of instruments available to you (that is, dosimeters and sound level meters)

Using Sound Level Meters

Integrating sound level meters are acceptable for measuring worker L_{eq}. They are most suitable for production or cyclical tasks where short-term (measured in minutes) L_{eq}s are the same as that for any other part of the day. Using hand-held meters ensures the surveyor is present to observe at first hand the noise-generating activities to which the worker is exposed and personal survey times will be shorter.

Before recording data:

- Examine the range of sound levels to be measured/integrated
- Clip the microphone in the worker's "hearing zone" or close to where the worker's ear would normally be during work, even when impractical for the worker to be in position (see illustrations below)
- Adjust the meter range switch to get the L_{eq} in the upper half of the display range without overloading the instrument
- If overloads occur, adjust the range switch setting and restart the measurement
- See if the noise is directional and ensure microphone will not be "shaded"
- Watch out for sudden movements of the worker or product
- Follow the manufacturer's instructions for microphone orientation
- Ensure the bodies of non-participants do not affect the noise at the microphone—stand well back and hold the instrument at arm's length
- Avoid measuring within 1 metre of large noise-emitting or reflecting surfaces

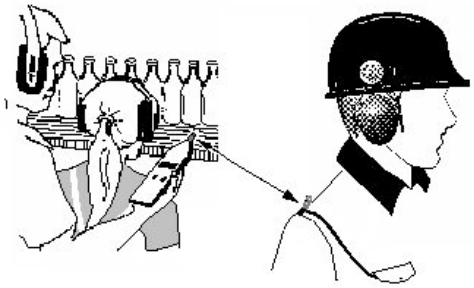


Figure 8. Microphones in the edge of shoulder "Hearing Zone"

- If sound has strong tonal content, the presence of a "standing wave" pattern maybe indicated by variations in level within the hearing zone space. The surveyor should take an average level by moving the microphone throughout the space likely to be occupied by the head.

Using Noise Dosimeters

L_{eq}s obtained by noise dosimeter are preferred over those obtained by integrating-averaging meter because they offer far longer sampling periods.

Note: the dosimeter's advantage is only realized when exercised along with some common sense in the interpretation of the data—see "After Sampling."

- Explain to workers the aims of the measurements, that they should conduct themselves normally, and how to care for and wear the dosimeter

- Ensure the cable of a dosimeter on a worker is not likely to snag (run it under an outer garment or tape it to the worker's clothing)

- Ensure the dosimeter microphone is not obstructed by clothing and that clothing will not rub the microphone housing

- Arrange with the worker a suitable time to retrieve the dosimeter

While Sampling

- If using a basic dosimeter incapable of a noise history, from time-to-time check to see if the instrument's overload indicator has been tripped. If so, you will have to restart the measurement (the sooner the better).

- With a basic dosimeter, take occasional measurements with a sound level meter. Either instrument can be used to give an L_{eq} (see Appendix A). Compare results from the two methods. If large (more than 5 dB) differences between the two methods occur, redo unless you have a good explanation.

- During this time, note the most objectionable noise sources, consider appropriate noise control methods, check the condition of existing noise control measures, ensure conditions are typical by talking to workers and supervisors, and sketch a layout of machines indicating work stations.

After Sampling

Experience has shown that high peak sound levels (130+ dBA) can be readily caused during noise dosimetry by events of non-acoustical origin (such as tapping the microphone). This has lead to surveyors recommending workers be placed on comprehensive hearing conservation programs for non-existent hearing hazards; indeed, the noise may be well below L_{EX} = 85 dBA.

Noise dosimetry is an unsuitable technique for measuring peak sound levels since the bulk of a measurement is not witnessed or attended by the surveyor. **Since a single peak level over 140 dBC is sufficient to constitute an over-exposure**, the surveyor must be certain that the peak is genuine (see later) by direct measurement with a peak reading sound meter at the time of exposure. To have genuine peak levels over 140 dBC is rare, especially with the L_{EX} below 85 dBA.

Typical peaks of high levels include unsilenced pneumatic nail guns (peak sound levels 130 to 135 dBC). Shotgun noise may peak about 145 dBC, while rifle fire peak levels are 150 to 160 dBC. Such peak noise levels, if of genuine acoustical origin, certainly would be noticed by a worker (especially with L_{EX} < 85 dBA).

A dosimeter when tapped or rubbed near its microphone or waveguide can register high peak sound levels. Ironically, non-acoustical "events" can be caused in the fitting or removal of the dosimeter by surveyors themselves! Fortunately, accidental artifacts are few; but only one that passes unrecognized can be sufficient to lead to an inappropriate conclusion.

Immediately upon retrieving the dosimeter, it is advisable to interrogate the dosimeter to see if the L_{eq} and maximum peak levels appear reasonable before processing the results further. If a peak in excess of 140 dBC is recorded by the dosimeter, now would be the time to identify the noise source and seek an explanation and verification of its daily occurrence and value. The person surveyed may be able to aid in this endeavour.

Peak Recognition and Evaluation

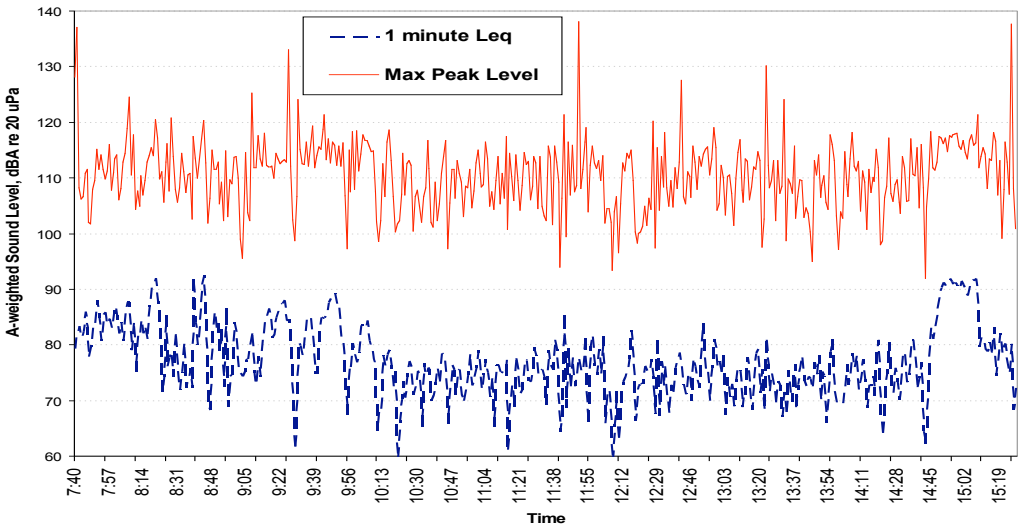
Peak sound levels greater than about 130 dBC can reasonably be assumed to be artifacts and ignored in dosimeter records in the following circumstances:

- If only a few (less than 30) of such events in a shift's record are detected by the instrumentation AND the surveyor has not **witnessed**, **investigated**, **and verified** those same events with a sound level meter equipped with a peak detector

- Where peaks are incurred at the beginning of the sample period while fitting the worker with the instrument

- Where peaks are detected shortly after fitting as the worker gets accustomed to the novelty of wearing it

Figure 9. Data Logging Dosimeter Printout with Peak Artifacts



- Where peaks are detected near the end of the sample period while removing the instrument from the worker or before switch-off

- Where peaks are detected near the beginning or end of a break (washroom, coffee or lunch break); these events are often characterized by high peaks

- Where the surveyor has a reasonable suspicion the worker may have tampered with the instrument deliberately or accidentally

Notes and Hints

The limits 85 dBA for L_{EX} and 140 dBC for peaks are **both** daily limits (i.e., events that generate the levels occur **each** working day and not just on any day).

- Check the record if the dosimeter has been left for pick up. "Exceedance" has been claimed but traced to evening office cleaners bumping a "running" dosimeter left on a desk by a day worker on his way home!

- Where the difference between Peak sound level and the $L_{eq,1min}$ is greater than 40 dB, be particularly suspicious and investigate.

- An artifact event detected as a high peak may be inaudible to the worker, who may remain unaware of the "event" and report all noise was typical.

- When genuine intense peaks can be shown to be **atypical** of daily exposure, the surveyor is justified in ignoring the peak.

- A microphone very close to the worker's mouth; speech can collect sound and raise L_{eq} to above 85 dBA! Under such circumstances, the microphone shoulder be located at the edge of the shoulder.

Artifact Control

Occurrence of some artifacts may be avoided by:

- Determining if the worker is likely to remove jackets, etc.
- Switching on the dosimeter after fitting it to the worker
- Switching off the dosimeter before its removal from the worker
- Using the dosimeter's "Auto" function to start sampling 15 minutes after fitting and end sampling before retrieval.

OCCUPATIONAL NOISE SURVEYS

The Initial Noise Survey

When a worker's exposure to sound levels of 82 dBA or more is likely to last over the entire shift of 8h, or its energy equivalent (see *Trade-Off Rule*), the employer is required to conduct a noise survey. It's a good idea to do an initial survey first before embarking upon a full formal noise survey.

An initial survey should be considered an inexpensive "red flagging" exercise. The report should be concise, but clear. A table (Appendix 1) is suitable for an initial noise exposure report. You could make it more suitable for initial surveys by deleting most noise reporting columns and expanding the "Comments."

The initial survey will show whether the following actions are required:

- **Below 82 dBA**: no further action

- **82 to 85 dBA**: inform the worker of the noise monitoring results, the minimal risk of hearing loss, and the roles of hearing protection and audiometric testing

- **Above 85 dBA**: a more detailed noise survey and other requirements of the Noise regulation, including education on the effects of noise on hearing and training on the use of hearing protectors

One way to start a survey is to walk through the premises to collect an impression of the noise to be assessed, the types of noise generated (steady, intermittent, impulse, the range of levels), and identify quiet areas that can be eliminated from further consideration (e.g., offices). Other useful information would include the numbers of workers, work patterns, break times, shift changes, and unusual conditions (in production, seasonal, environmental) that could affect results.

A resurvey is required when significant noise making machinery is introduced, removed, or modified and when walls are added or removed.

Who Can Do Initial Noise Surveys?

The initial survey could be carried out by a person with little training. You could get more definite information if you used a relatively inexpensive basic sound level meter to help decide if a formal assessment is required (using more sophisticated instrumentation). A listening test you may find useful to indicate sound levels is:

- When the sound level is above 82 dBA, you will find yourself having to shout to be clearly understood by someone at 1 m
- When the sound level is above 88 dBA, you will find yourself having to shout to be clearly understood by someone at ½ m

Noise surveyors must become familiar with their noise-measuring instruments' limitations and proper use. This includes doing a field calibration, selecting the appropriate response time constant(s) and the A-weighting. The surveyor should understand how an increase in noise level can be "traded off" against a reduction in exposure time to get the same noise dose.

Trade-Off Rule

The trading relationship between time and sound level is known as the "3 dB doubling rule"; that is, for every 3 dB increase, the energy content doubles. To keep the noise dose the same, the exposure time must be halved:

82 dBA over 8 hours = 85 dBA over 4 hours = 88 dBA over 2 hours = 91 dBA over 1 hour = 94 dBA over ½ hour etc. (and **each** pair of values is equivalent to half of one day's acceptable noise dose of 50%).

This rule is very useful in judging approximate shift exposure from sample measurements of sound level.

When To Do A Formal Survey

A formal survey will follow an initial survey when:

- The initial survey indicates the noise exposure level, L_{EX}, is likely to be greater than 85 dBA, or noise exposure dose more than 100% per day
- An accurate value of workers' noise exposure is required by Part 7 of the Occupational Health and Safety Regulation (i.e., where L_{EX} is greater than 85 dBA)
- More detailed information is required for noise exposure reduction methods
- More detailed information is required to select adequate hearing protection
- Genuine peak sound levels are above 140 dBA

Standards

Useful measurement information is contained in the following standards:

ANSI S1.13-2005 "*Methods for Measurement of Sound Pressure Levels in Air*"

ANSI S12.7-1986 (R2006) "*Methods for Measurement of Impulse Noise*"

ANSI S12.19-1996 (R2006) "*Measurement of Occupational Noise Exposure*"

CSA Standard Z107.56-06 "*Procedures for the Measurement of Occupational Noise Exposure*"

ISO 1999 (1990) "*Acoustics-Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment*"

Who Can Do Formal Noise Surveys?

If a survey incorrectly identifies a worker as being over-exposed to noise, the employer will be involved in needless expense in complying with the Regulation. If the survey incorrectly identifies the exposure as acceptable, the worker's hearing may be put at risk. Both scenarios demand a competent surveyor.

Companies seeking assistance from noise surveyors should carefully check the qualifications of candidates. Experience has shown surveyors may use inappropriate instrumentation, or adequate instruments in an incompetent fashion, leading to incorrect measurements and conclusions. You can have candidate noise surveyors read this booklet and ask them if they understand and can comply with its requirements. You could also ask to see surveys they have prepared for other clients, check references, qualifications, courses attended and enquire if they are members of any relevant learned societies.

If you understand the material in this booklet, you could tackle the job yourself.

Powerful noise-measuring instrumentation is available, which can produce large amounts of data baffling to the untrained user, and which, **without proper interpretation**, may be valueless to the company receiving the information.

Surveyors should, for the sake of clarity, exclude unnecessary information from the formal report. They should focus on the relevant noise descriptors only and ensure the reasons for the survey are served (see AIM and NOISE DESCRIPTORS - *Introduction*). It is a simple matter to download and present large quantities of noise data from dosimeters; **it is another matter to infer valid conclusions for the company being surveyed to act upon**.

Reporting

As with the initial report, a suitable method of summarizing the exposure data is required. A Results Table (see Appendix 1) is often suitable. An aid to visualizing the worker stations and noise on a site is to write the noise exposure levels on a general layout of the plant (see Appendix 2).

In addition to a table of results, a written report should contain the following:

- Identification of jobs that are over-exposed according to the Noise Control & Hearing Conservation Regulation. The descriptors are either L_{EX} in dBA or peak noise level in dBC
- Final results rounded up to two significant figures. Example: if you measure 96.7 dBA, call it 97 dBA

- Identification of the workers requiring hearing protection and the recommended class of hearing protection
- Identification of workers to be placed on an audiometric program
- Identification of workers to be given training and education in the effects of noise on hearing and hearing conservation techniques
- Identification of areas to be posted with signs warning about high noise levels and the requirement to wear hearing protection
- A statement to the effect that the measurements were taken under typical noise conditions (or otherwise) at the survey time(s)

"Corrections" to the noise measurements to account for unusual or different levels of occupational activity (must be indicated and justified where used). The calculation method should be indicated where daily noise exposures have been calculated from partial noise exposures.

An explanation of the sampling process and a justification of the statistical methodology adopted where noise exposure samples from a "population" of workers have been used to represent all individual workers.

In short:

Keep Things as Simple as Possible,
But No Simpler

Group Sampling

Surveyors should attempt to include **all** workers in measurements. Where many are engaged in essentially similar tasks and exposed to similar noise, sampling all individuals could be laborious without improving measurement precision.

Statistical methods can be used to reduce the sampling by considering workers as members of occupational groups. The groups could all be working in the same room doing different jobs, or engaged in the same trade doing similar work in different locations. The sample size required depends upon the number of workers in the group, the target precision (± 2dB) and the variability between one another's exposure of the sample group's LEX values and the confidence you have in the result (e.g., 95% or 19 times out of 20). One procedure is illustrated in *Basic Noise Calculations*.

APPENDIX 1—Summary Table for Noise Exposure Measurements

Company:	**Division:**	**Address:**
Peacham Pill Co. L td.	*Manufacturing*	*221A Holmes Street, Burnaby B.C. CANADA, V1E 2T4*

Worker's name or job	Number of workers	$L_{Aeq,T}$ dBA	Shift duration, hours	L_{EX} dBA	Peak level dBC	Comments	OK with Regs? Y/N	Recommendations
Bottling								
Feeder	1	83.5	10	84.5	-	(correction to 8h = +1dB)	**Y**	make ear plugs available, etc.
Filler	1	85.5	10	86.5	-	steady noise for long periods	**N**	do Noise Control (NC)
Capper	1	81	10	82	-	no significant impact noise	**Y**	make ear plugs available, etc.
Labeller	1	80	10	81	-	(job rotation would reduce	**Y**	no action required
Packer	1	78.5	10	79.5	-	average L_{EX} to 83.5 dBA)	**Y**	no action required
Tablet Pressing								
Acme Press #1	1	89	7	88.4	129	(correction to 8h =-.6 dB)	**N**	Hearing Conservation Program/NC
Acme Press #2	1	93.5	7	93	133	Signif Impact Peaks	**N**	Hearing Conservation Program/NC
Acme Press #3	1	93.5	8	93.5	138	Signif Impact Peaks	**N**	Hearing Conservation Program/NC
Shipping								
Forklift	1	82.2	12	84	-	(correction to 8 h = +1.8 dB) variable level. No significant	**Y**	make ear plugs available, etc. Fit new muffler to F/L
Truck Driver	1	79	12	81	-	Impact Noise in Shipping	**Y**	no action required

Noise Surveyor: A. N. Other

Signature: Ann Other

SLM/Dosimeter: Valiant **Model:** N1

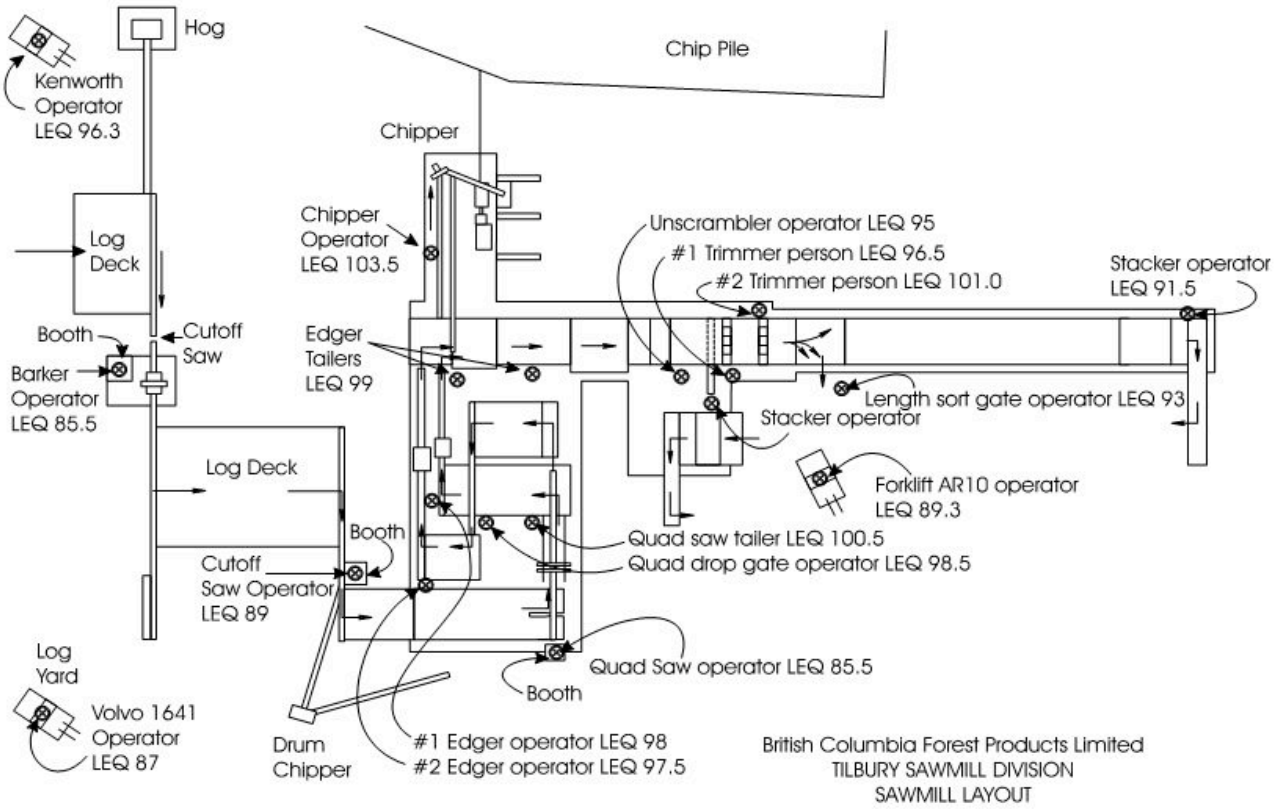
Survey Date: 1994-09-03

S/N: XYZ1234

Calibrator: Valiant **Model:** N2

S/N: ABC987

APPENDIX 2—Noise Survey Results on General Layout Diagram



Showing worker L_{EX} by workstation

AN EXAMPLE OF A GENERAL LAYOUT DIAGRAM