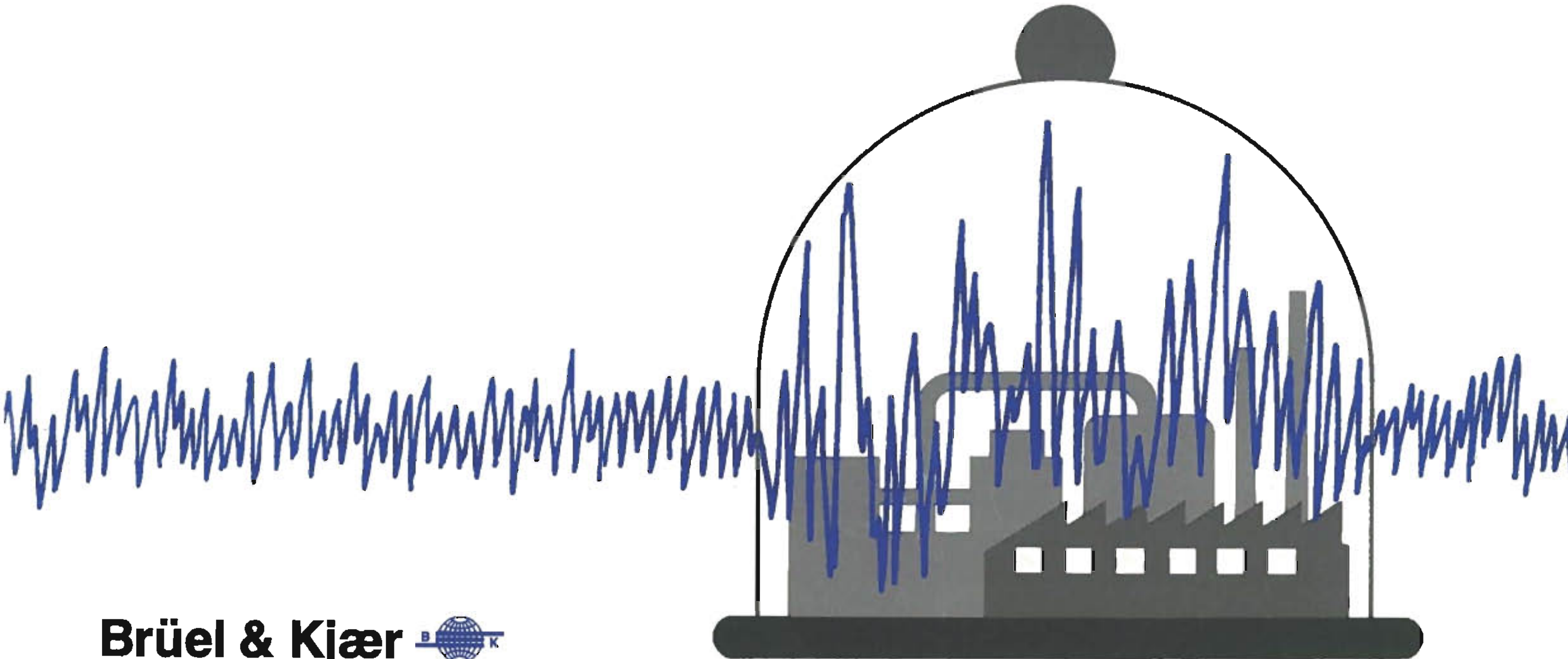
Industrial Noise Control

and Hearing Testing



Brüel & Kjær

Introduction

This booklet answers many of the basic questions about occupational noise exposure and hearing conservation. It gives a brief explanation of the following:

Revision October 1992

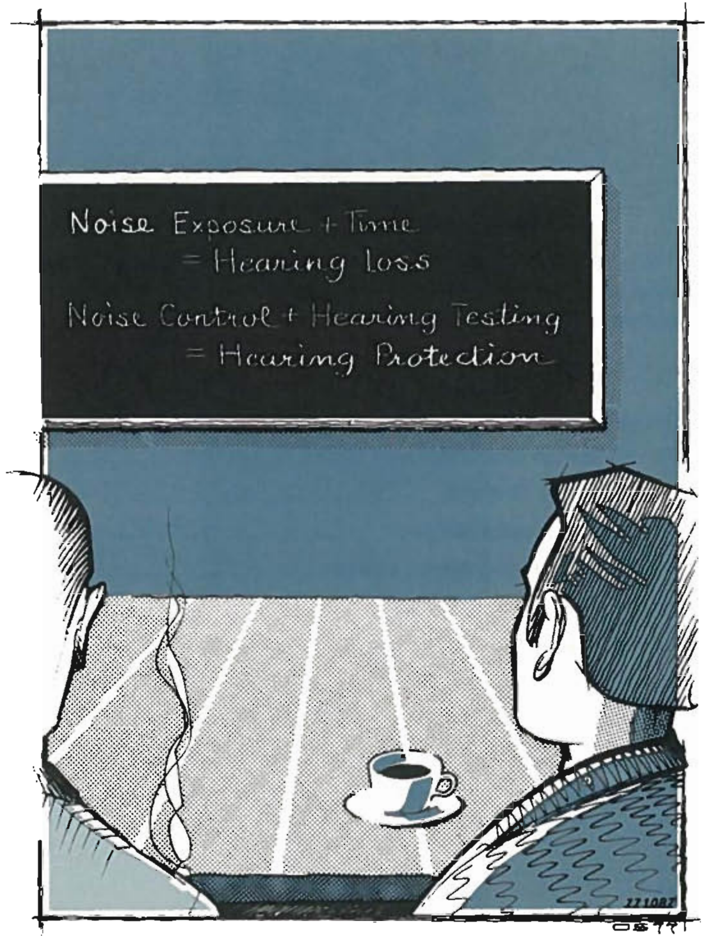
Background

The objective of industrial noise control and hearing conservation programs is to protect employees from permanent hearing loss in the speech frequency range due to exposure to high noise levels.

When we are exposed to high noise levels, even for short periods, we experience a temporary hearing loss known as a *temporary threshold shift*. You may have noticed this after leaving a stock car race or a discotheque. But our hearing soon recovers under normal conditions. However, when employees are exposed to high noise levels every workingday for many years, they gradually develop a permanent hearing loss known as a *permanent threshold shift*. Because the loss develops over a long period, noisy environments are considered to be more of a health hazard than a safety hazard (they do however become a safety hazard when they mask audio warning signals).

Most industrialized countries have established limits for occupational noise exposure. These exposure limits protect most, but not all, employees who are exposed to high noise levels. Assurance of complete protection is the objective of any hearing conservation program.

Hearing conservation programs use periodic hearing tests to identify employees who are highly susceptible to noise-induced hearing loss. These employees can then be given extra hearing protection or assigned to quieter working areas. Successful programs protect employees from noise-induced hearing loss and employers from compensation claims for hearing loss.



Standards for Occupational Noise Exposure

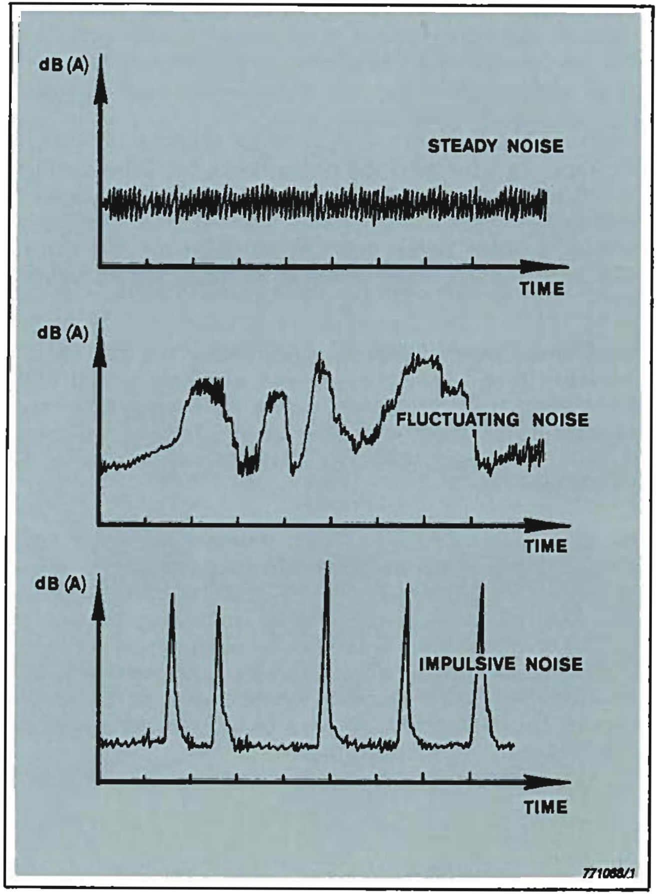
Standards for occupational noise exposure limits are not uniform throughout the world. In some cases they are not even uniform within the same country. Furthermore, some employers voluntarily enforce limits which are stricter than are legally required in order to give added protection to employees and to reduce the risk of compensation claims for hearing loss.

The most widely used criterion is described in ISO R 1999 *Assessment of Occupational Noise Exposure for Hearing Conservation Purposes*. The United States uses a slightly different criterion as required by the *Occupational Safety and Health Administration* (OSHA) which is also used in other parts of North America and Europe.

Both criteria allow a maximum continuous exposure level of 90 dB(A)* in the working environment. For levels above 90 dB(A) the exposure duration is accordingly restricted, ISO being more strict than OSHA. Below 90 dB(A), ISO extends exposure control down to 80 dB(A) whereas OSHA extends exposure control down to 85 dB(A).

The two criteria also differ in how they set out work periods. ISO permits noise exposures to be averaged over a 40 hour working week whereas OSHA permits noise exposures to be averaged over an 8 hour working day.

To cater for all types of industrial noise, exposure criteria cover steady noise levels, fluctuating noise levels and impulsive noise levels.



* Some countries allow only 85 dB(A)

Steady Noise Criteria

Steady noise criteria pertain to employees who are exposed to the same sound level, in dB(A), throughout their working period . Typically, they work at fixed locations in areas where machines run continuously and produce a more or less constant noise level.

ISO imposes a limit on the noise dose, i.e. a percentage of the maximum allowable exposure accumulated in a 40 hour working week at the employee's work station. For example, there is a 100% noise dose at 90 dB(A) for 40 hours per week and a 200% noise dose at 93 dB(A) for 40 hours per week.

OSHA limits the maximum exposure time per day for a given steady sound level, i.e. 8 hours at 90 dB(A) and 4 hours at 95 dB(A). If an employee works an 8 hour day then an exposure to a steady sound level of 90 dB(A) represents a 100% noise dose, similarly 95 dB(A) represents a 200% noise dose.

The table shows that the dose doubles for each 3 dB increase in noise level according to ISO conditions, and that the maximum allowed exposure time reduces by 50% for each 5 dB increase in noise level according to OSHA requirements. The 3 or 5 dB interval is commonly called the "trading ratio" or the "q" value in the governing mathematical equation. OSHA is more lenient because it takes into account the recuperitive powers of the ear during quiet periods between intermittent noise.

ISO Noise Dose (%)	dB(A)	OSHA Max Time (Hrs–Min)
10	80	
15	82	
20	83	
25	84	
30	85	16–0
40	86	13–56
50	87	12–8
60	88	10–34
80	89	9–11
100	90	8–0
125	91	6–56
160	92	6–4
200	93	5–17
250	94	4–36
315	95	4–0
400	96	3–29
500	97	3–2
630	98	2–50
800	99	2–15
1 000	100	2–0
1 250	101	1–44
1 600	102	1–31
2 000	103	1–19
2 500	104	1–9
3 150	105	1–0
4 000	106	0–52
5 000	107	0–46
6 300	108	0–40
8 000	109	0–34
10 000	110	0–30
12 500	111	0–26
16 000	112	0–23
20 000	113	0–20
25 000	114	0–17
31 500	115*	0–15 or less

ISO Criterion Level for max. allowable Noise Dose per 40 hour week (→ 100 / 90 / 8–0)

OSHA Criterion Level for max. allowable exposure time per 8 hour day (← 100 / 90 / 8–0)

* Maximum steady level permitted by OSHA

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Measuring Steady Noise

Steady noise measurements may be performed using a Sound Level Meter set to frequency and time weightings of "A" and "S" (Slow) respectively.

Noise should be measured at the position of the employee's head. We should note that this is an environmental noise measurement. The employee's machine is not the only noise source, and it may not even be the dominant one. Therefore, the microphone must be omnidirectional to ensure that noises from all sources are accurately measured.

General purpose Sound Level Meters may be used. But if there is also a need to measure impulsive noise or perform frequency analysis, a more versatile Precision Sound Level Meter fitted with a set of filters should be used.

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Discretely Varying Noise levels

Many employees are exposed to a certain number of discretely varying noise levels usually because the noise is cyclical or varies stepwise at their work station or because the job requires them to move around the department or plant.

Noise codes describe procedures for summing a series of partial doses that such employees receive during their working period. Take a simple ISO example where an employee is exposed to 90 dB(A) for half of his working period and to 93 dB(A) for the remaining half. Since full working periods at 90 and 93 dB(A) represent doses of 100 and 200% respectively, half period doses are accordingly 50 and 100% giving a total dose of 150%.

In addition OSHA and many other national standards impose an overriding limit of 115 dB(A) "S" which should never be exceeded for any length of time.

One method of determining the noise dose of mobile employees is through the job-study interview. First, a noise survey is conducted throughout the factory to determine the noise level at each working location. Then each employee is interviewed to determine what locations he works at and for how long. This rapidly leads to the determinination of noise doses received by a large number of employees, furthermore periodic updates can be performed quickly. The job-study interview method readily lends itself to computerized record keeping. It is also a valuable aid for setting priorities in noise control schemes by identifying locations where the noise doses are excessive.

EMPLOYEE NOISE EXPOSURE RECORD

EMPLOYEE NAME: L W Jones

DATE: 7.12.92 SIGNED: AGS

INTERVIEW		COMPUTATION		ISO
WORK LOCATION	% TIME	dB (A)	8 Hr DOSE	PARTIAL* DOSE
A-5	60	85	30%	18%
A-8	5	95	315	16
B-21	10	88	60	6
D-13	25	91	125	31

TOTAL DOSE: 71%

RECOMMENDATIONS:

Within ISO limits

$$^{*}\text{PARTIAL DOSE} = \frac{\%\ \text{TIME}}{100} \times 8\ \text{Hr DOSE}$$

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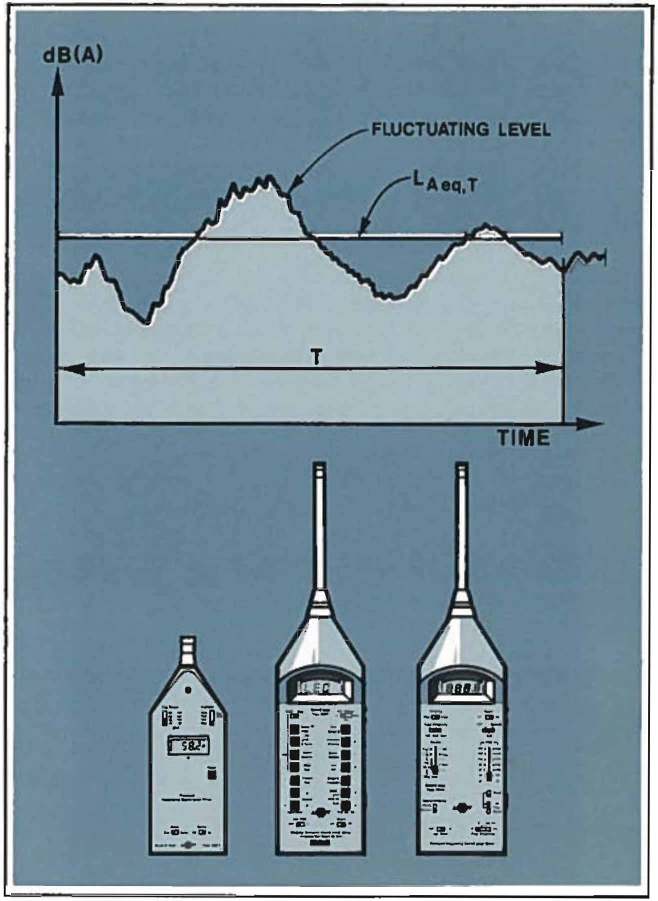
Equivalent Continuous Level: $L_{Aeq,T}$

Where noise levels fluctuate unpredictably they can be represented by an *Equivalent Continuous Level* which has the same acoustic energy and noise dose as the original fluctuating levels for the same period of time *T*. This principle of equal energies is adopted by the ISO standard in its criterion for evaluating noise dose, and, since all measurements are A-weighted, the Equivalent Continuous Level, $L_{Aeq,T}$, is also A-weighted.

$L_{Aeq,T}$ can be measured directly using an Integrating Sound Level Meter. A sample of fluctuating noises of workshop processes can be represented by a single $L_{Aeq,T}$ value which can then be compared with the criterion level of 90 dB(A). This will indicate whether there is a danger of exceeding a 100% noise dose ($L_{Aeq,8h} > 90$ dB(A)) if the fluctuating levels persist unabated throughout the working period.



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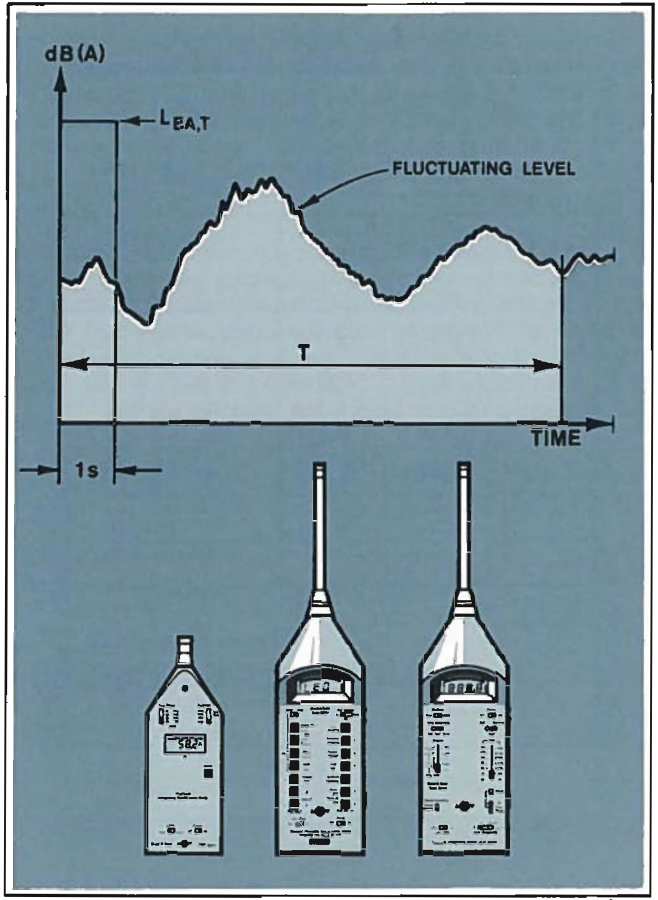
Sound Exposure Level: $L_{EA,T}$

Another useful parameter found on more elaborate Integrating Sound Level Meters is the *Sound Exposure Level* (often referred to as SEL), $L_{EA,T}$, also measured in dB(A). This is defined as that level which lasting for one second has the same acoustic energy as a given noise event lasting for a period of time *T*. It is a measure of acoustic energy and can therefore be used to compare unrelated noise events, this is because the time element in its definition is always normalised to one second.

If the Sound Exposure Levels of various noise events throughout a working period are known together with the duration when they occur then it is a simple matter, using the nomogram provided with the Sound Level Meter, to obtain the total energy contributed by these events and hence their combined $L_{Aeq,T}$ and noise dose for a full working period.



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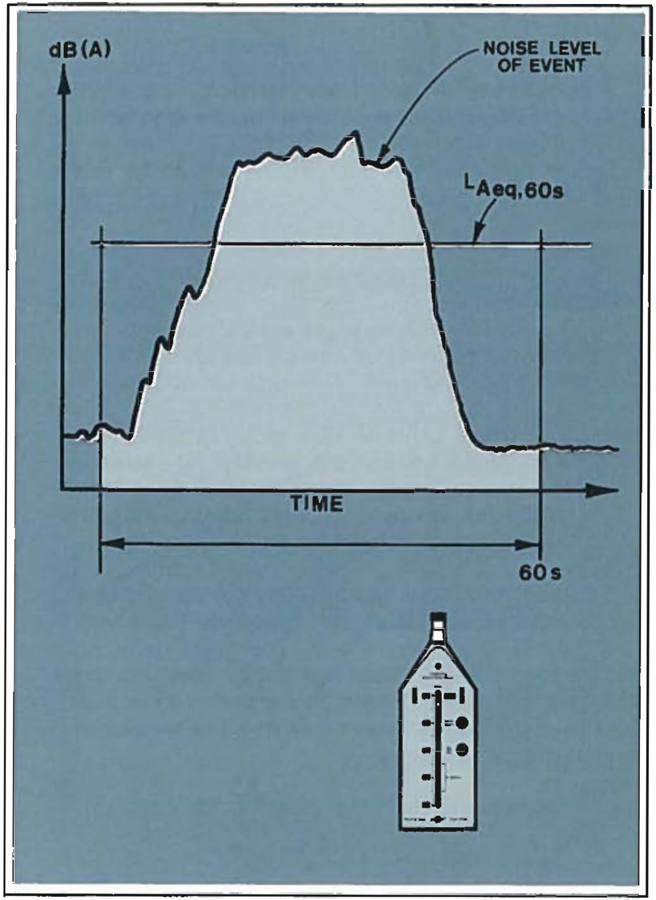
$L_{Aeq,60s}$

Some Sound Level Meters measure the Equivalent Continuous Level over a fixed period of sixty seconds. There is a certain similarity in use between the quantities $L_{Aeq,60s}$ and the Sound Exposure Level described on the previous page. The chief reason for this being that both are based on fixed time intervals. For any noisy event lasting no more than 60 s there is a fixed difference between its Sound Exposure Level and its $L_{Aeq,60s}$, i.e. the former is greater by 17,8 dB.

The $L_{Aeq,60s}$ is also a good measure of the mean value of widely fluctuating noise levels when making surveys in various locations around the factory.



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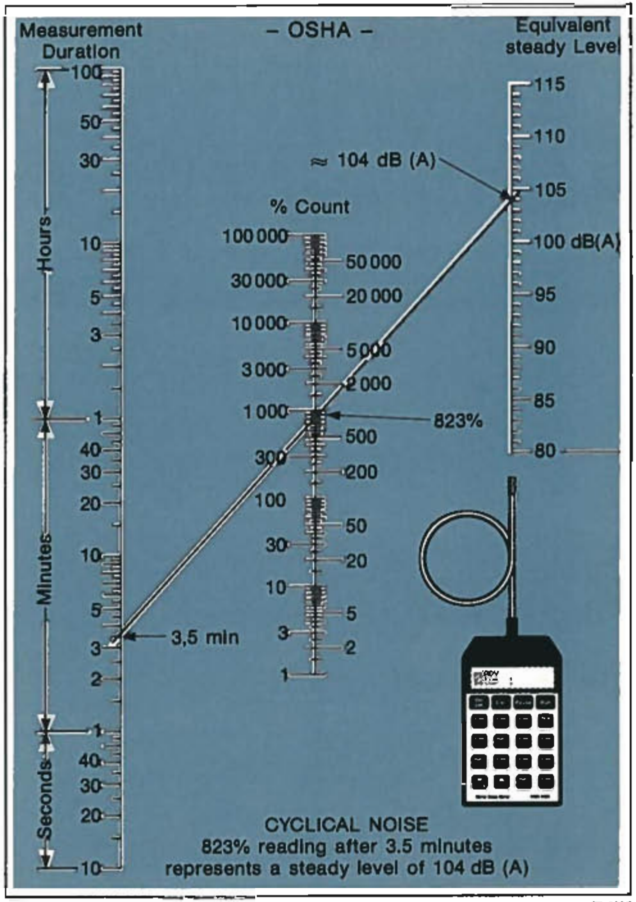
Measuring Noise Dose

Personal Noise Dose Meters are used to measure directly the noise dose of randomly fluctuating noise levèls and to indicate when certain levels are exceeded, i.e. 115 dB(A) "S" and 140 dB "Peak". Personal Noise Dose Meters are miniature integrating sound level meters which are worn by the employee either in his shirt pocket or on his belt. For maximum accuracy the microphone should be remotely located on the shirt collar or on a safety helmet (if worn) near the ear.

Noise Dose Meters measure noise continously and at the same time read out the dose as a percentage of the maximum allowable (100%) over an exposure period of 8 hours. Where representative data can be obtained in less time, the reading can be converted to an equivalent 8 hour exposure.

The use of Noise Dose Meters requires administrative surveillance to guard against the creation of extraneous noise during the measurement. Noise Dose Meters that read out continuously can be read several times during the day to check the validity of the data.

If the noise is cyclical, as is often the case, the measuring time can be greatly reduced if the Noise Dose Meter has an accelerated measuring mode. The total daily noise dose can be extrapolated from just a few machine cycles. This permits many work stations to be surveyed in a day, and it has the added advantage of having the measurements supervised at all times.



Criteria for Impulsive Noise

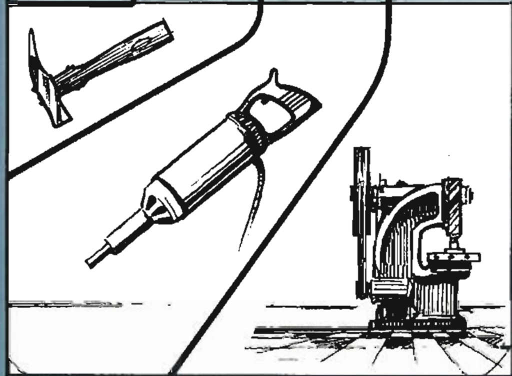
Criteria for assessing the risk of hearing loss due to impulsive noise are not broadly standardized. ISO suggests that an approximation of the partial noise dose for a series of impulsive sounds such as for hammering and riveting may be obtained by adding 10 dB to the measured dB(A) "S" value, but it does not cover single impulses such as those from drop hammers and hydraulic presses. Consequently, widely differing supplementary criteria have been adopted in various countries. Some national standards impose impulsive noise limits in terms of dB(A) "I" (Impulse) level.

OSHA classes repetitive events as continuous noise if the interval between maxima is 1 s or less. This would imply that maxima occurring at intervals of more than 1 s are classed as impulses. Exposure to impulsive or impact noise should not exceed 140 dB "Peak" sound pressure level.

Because the various exposure criteria for impulsive noise are not uniform, exposed personnel should be given extra attention in the early stages of hearing conservation programs.

READINGS DIFFER WIDELY, DEPENDING UPON THE IMPULSE MEASUREMENT MODE SPECIFIED IN YOUR NATIONAL STANDARD

Time Weighting \ Noise Source	Carpenter Hammer	Pneumatic Nailing Machine	Punch Press
F	105 dB(A)	112	93
I	112 dB(A)	113	97
Peak	131 dB SPL	128	121



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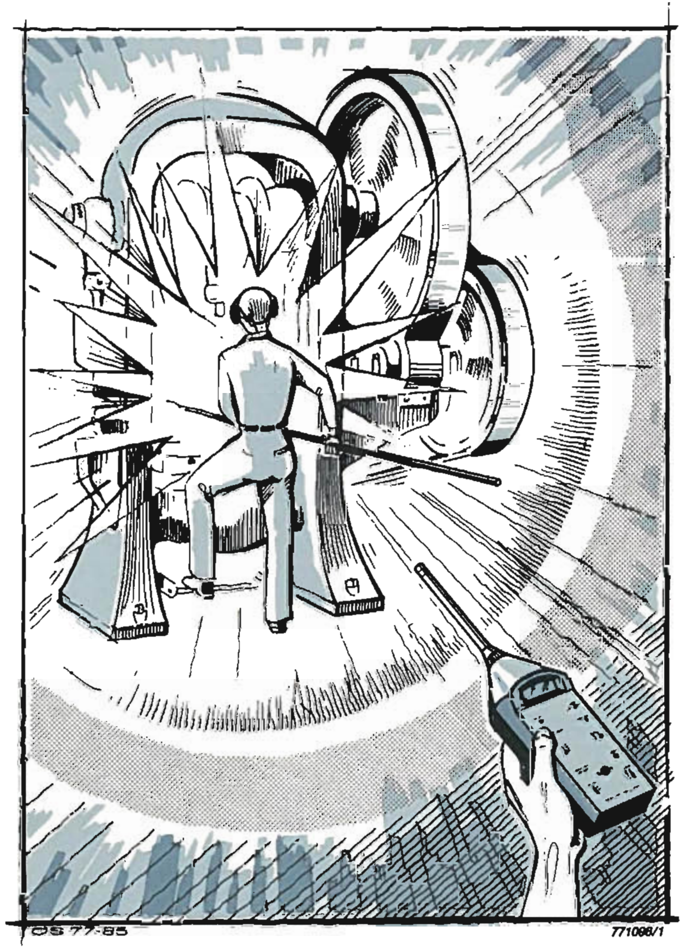
Measuring Impulsive Noise

The less elaborate Sound Level Meters with only "F" (Fast) and "S" (Slow) time weightings are not adequate for measuring impulsive noise because their responses are too slow.

Some national standards specify the use of Sound Level Meters having an "I" (Impulse) time weighting for measuring impulsive noise. When set to the "I" time weighting these Sound Level Meters will respond four times faster than for the "F" time weighting. The "I" time weighting is normally used to simulate the loudness response of the human ear to impulsive sounds and is therefore not necessarily the appropriate time weighting for assessing the risk of hearing damage.

OSHA requires that impact noise be measured by a Sound Level Meter having a linear frequency response, a peak detection circuit, and a response about 1000 times faster than for the "I" time weighting. This results in a purely physical measurement of the peak value of the acoustic wave. The more elaborate Sound Level Meters equipped with a "Peak" detector are capable of making such measurements.

In either case, the Sound Level Meter automatically captures, holds and displays the numerical value of the highest measured level.



Acoustic Calibration

Acoustic calibration is an essential part of all occupational noise exposure measurements. Most regulations require a calibration check before and after each day's measurements. Without a verifiable statement of calibration the measurements would be of little or no value in the defence against hearing loss compensation claims.

Handy portable Sound Level Calibrators (illustrated here) and Pistonphones are available for calibration in the field.

Calibrating Sound Level Meters and Noise Dose Meters is a simple task because they read directly in dB(A) and can be adjusted easily, if necessary, to agree with the output of the calibrator.

To preserve the calibrated status of the Noise Dose Meter, windscreens are often mounted on the microphone for the duration of the measurements. Windscreens offer good protection against oil spray and flying swarf, and they can be washed readily and re-used.

The Measurement Survey Report

The measurement survey report is one of the most important documents in the entire hearing conservation program. Costly noise control investigations may be initiated by the noise survey. Adminstration procedures such as periodic hearing tests and the rotation of personnel may be implemented following the report which must also serve as a permanent record of employee exposure. The measurement report should include at least the following information.

1. Sketch of site showing machine location and dimensions, operator position and microphone position.
2. Model and serial number of Sound Level Meter and statement of calibration verification.
3. Frequency weighting network (usually A) and time weighting ("F", or "S") used.
4. Operator's name and number.
5. Noise level and duration.
6. Useful description of area, noise characteristics and operator habits.
7. Time, date and signature.

The report form should be filled in legibly and kept safely so that it can be used as a permanent entry in the employee record file.

NOISE SURVEY RECORD

DATE: 27.8.92 TIME: 09:15

INSTRUMENTATION:
Precision Integrating S.L.M-2230. Ser.No. 1028340
Octave Filter Set type 1624 -- 1032480

LOCATION: Bay # 23

EMPLOYEE'S NAME: L Dorsay

SHIFT: 1 st

SOUND LEVEL, dB(A) 92 dB(A) operate - 6 hrs.
83 dB(A) load - 2 hrs.

DAILY NOISE DOSE % EXPOSURE 125

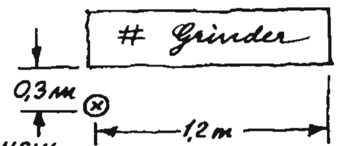
IMPACT NOISE, dB: None

OCTAVE ANALYSIS, IF STEADY LEVEL:

Hz	31,5	63	125	250	500	1k	2k	4k	8k	16k	LIN
dB	59	74	76	90	87	72	68	67	63	41	92

REMARKS: 3min Operating Time
1min Loading Time

SKETCH ⊗ SLM & Operator position



SIGN.: WPW

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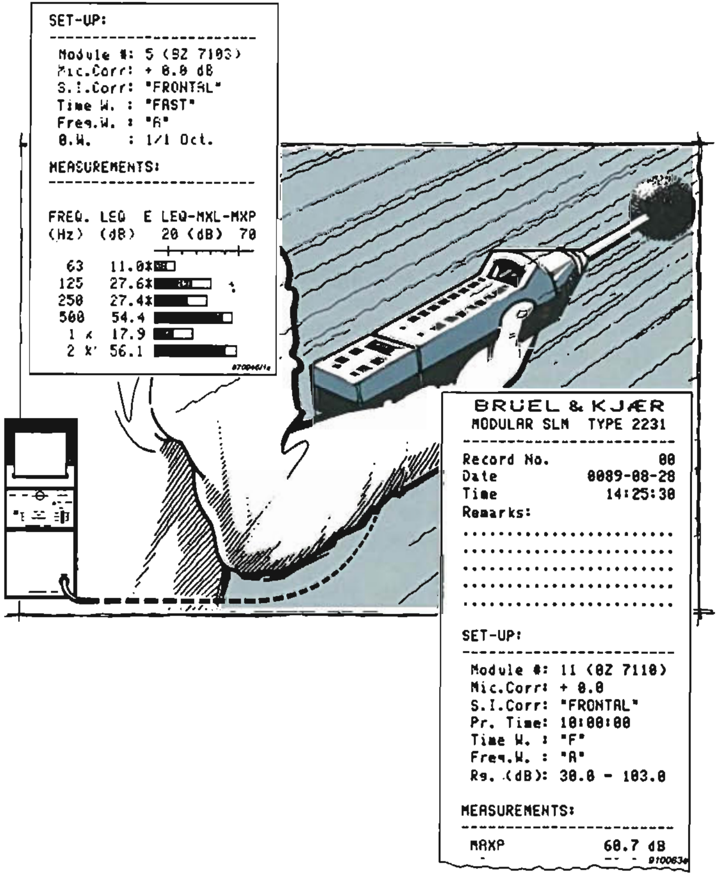
Frequency Analysis

Acoustically treated surfaces, noise enclosures and ear protectors are all more efficient at some frequencies than at others. Therefore, the frequency spectrum of the environmental noise must be measured first before selecting ear protectors or absorbing materials. For the same reason the frequency spectrum of a machine must also be measured first in order to design an enclosure or a noise barrier. Frequency analysis is also valuable in proving the effectiveness of installed enclosures and in trouble-shooting during their installation. In general Octave Band Filters are used for these purposes and are therefore an essential part of noise control instrumentation.

Some methods of noise control require more detail than that provided by octave band analysis. One Third-Octave and Narrow Band Filters are used to identify specific noise sources, to measure the effectiveness of internal machine modifications and to trace sources of noise induced by vibration.

When many frequency analyses are to be performed, it is convenient to use a Graphic Level Recorder to plot frequency spectra on preprinted charts. Graphic Level Recorders speed up the work and reduce the probability of errors. Later, "before" and "after" charts can be overlaid to show the effeciveness of noise control methods.



Low-Cost Noise Control

Noise control procedures need not be expensive. There are many examples of low-cost noise control, and some which can even reduce operating costs.

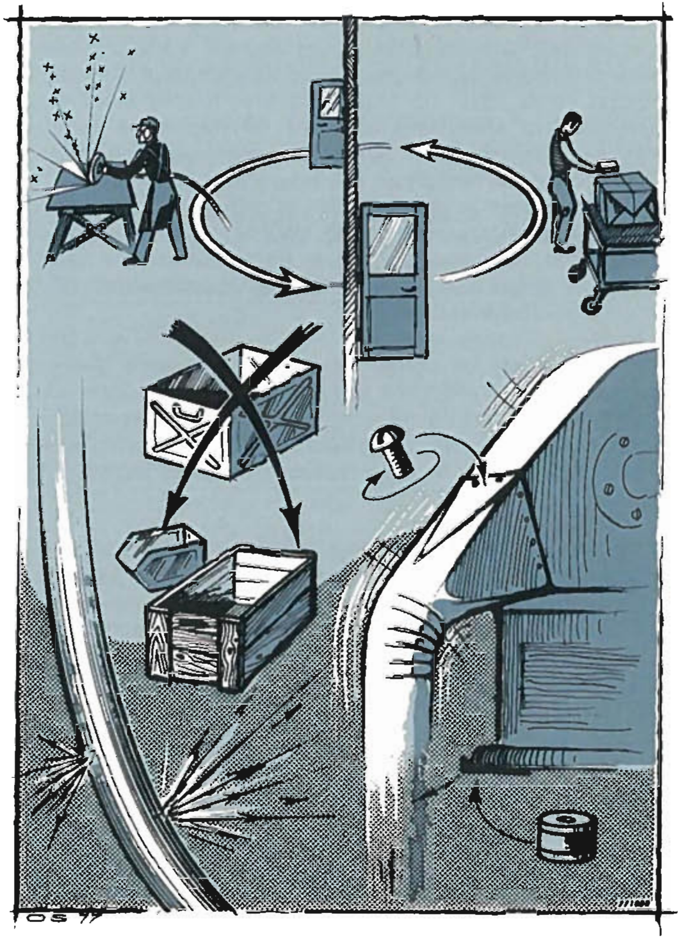
A common administrative procedure is personnel rotation. In high noise environments where noise control is impractical, the work, and consequently exposure, can be shared among several employees who otherwise work at quieter work stations for the rest of the day.

Compressed air leaks are significiant noise sources in many industries. Another source of noise is the use of air pressures far greater than necessary to perform tasks such as parts ejection and swarf blow-off. When leaks are repaired or pressures reduced, noise levels drop: so too does energy consumption, this is a good example of noise control reducing operating costs as well as noise levels.

Press noise can often be reduced by lowering hydraulic pressures used to form or cut metal parts. There are prospects too of lowering costs through longer tool life.

Marginal over-exposure can often be avoided at low cost by replacing metal tote pans by ones made of hard rubber, by tightening loose parts on machines and by replacing defective mufflers and ineffective vibration isolation mounts.

The list of low-cost noise controls goes on and on. Noise control engineers should exhaust these methods before turning to more expensive procedures.



Noise Insulation

If the source of noise cannot be controlled, then the only alternative is to prevent as much of the noise as possible from reaching the employee.

Sound absorbing materials can be put on walls or hung above the work area to reduce reflections, but the results will be marginal and will be of no help to persons who work close to a noise source. Acoustic barriers can be installed, but they shield only employees who work in the acoustic shadow of such barriers.

The most effective way of reducing noise is to enclose the noise source. Noise enclosures must be tightly sealed since even small leaks will reduce their effectiveness considerably. Enclosures, effective though they are, can easily create temperature and work loading problems which will need resolving.

The first step in designing an enclosure is to perform an octave band analysis of the noise generated by the source. This often necessitates operating the source in the absence of other noise sources. The second step is to calculate the spectral changes required to reduce the noise to a satisfactory level. The final step is to design an enclosure whose insulation characteristics provide the necessary spectral changes. When the job is completed an octave band analysis of the enclosed noise source should be performed and compared with the original data to prove the effectiveness of the enclosure.

OCTAVE BAND CENTRE FREQ. Hz	MEASURED A-WTD. LEVEL dB	MINIMUM DESIGN LEVEL dB A	NOISE ATTEN-UATION REQUIRED dB
31,5	63	63	–
63	80	80	–
125	85	80	5
250	85	80	5
500	85	80	5
1 k	90	80	10
2 k	81	80	1
4 k	77	77	–
8 k	59	59	–
TOTAL	94	88	

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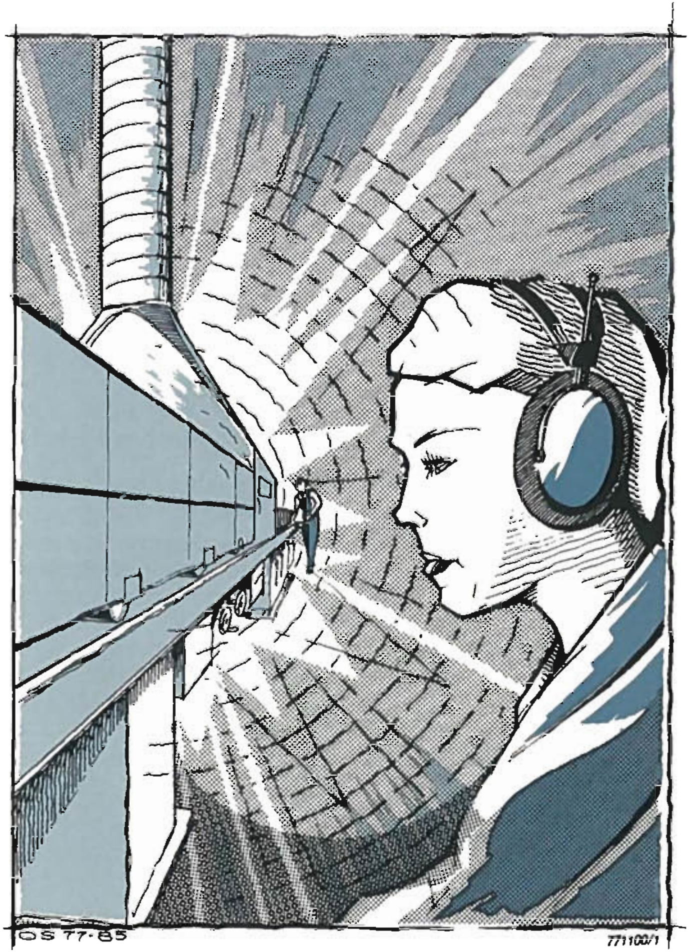
Ear Protectors

Ear protectors reduce the amount of noise actually entering the ear canal. Some national standards permit their widespread use whereas others limit their use to an interim measure until engineering methods of noise control are carried out and in cases where engineering control is not feasible.

OSHA requires their use for employees exposed to a noise dose of 50% and upwards. A noise dose of 50% in the OSHA sense is equivalent to 85 dB(A) for 8 hours and is referred to as the "action level".

The effectiveness of ear plugs and ear muffs depends upon how well they fit and how carefully they are worn. A loss of attenuation of up to 10 dB can occur if the path to the ear canal is not tightly sealed.

As with any acoustic barrier, different types of ear protectors have different curves of noise attenuation vs. frequency. Therefore, ear protectors should be selected by matching their attenuation characteristics to the octave band analysis of the sound field.



Hearing Conservation Programs

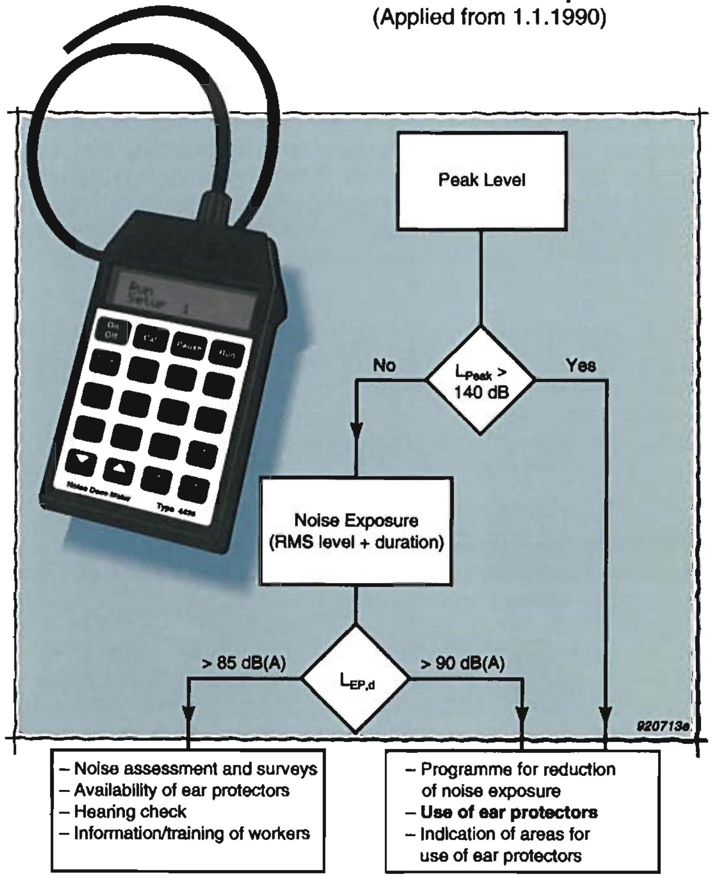
Although noise codes can be quite strict and carry severe penalties for non-compliance, they do not ensure that all employees are completely protected. Because of the wide variation in human response to noise, it is totally unrealistic to set a limit which protects everyone. So limits are set to protect the vast majority of employees, and hearing conservation programs are desiged to ensure that all employees are protected.

The design of a comprehensive hearing conservation program will call for at least the following: plant noise surveys, pre-employment and periodiic hearing tests, interpretation of hearing tests and official record-keeping of noise exposure and hearing tests. OSHA requires the implementation of hearing conservation programs for all employees exposed to and above a 50% noise dose (i.e. 85 dB(A) for 8 hours). EEC Directive 86/188 also lays down guidelines for the implementation of hearing conservation programs.

Hearing tests, usually called audiometric tests, are the key to protecting all employees. Audiologists use them to identify employees who are highly susceptible to noise-induced hearing loss, so these individuals can be given better protection long before their loss becomes permanent. Audiometric tests are usually conducted at 6 monthly intervals on employees who work in high risk areas.

Hearing tests also provide other benefits. Pre-employment tests protect employers from assuming responsibility for hearing damage incurred on a prior job. Periodic tests, normally once a year, on employees exposed to low-risk environments can detect hearing loss due to off-the-job activities or to medical disorders.

EEC - Directive 86/188 A representation
(Applied from 1.1.1990)



Audiometric Test

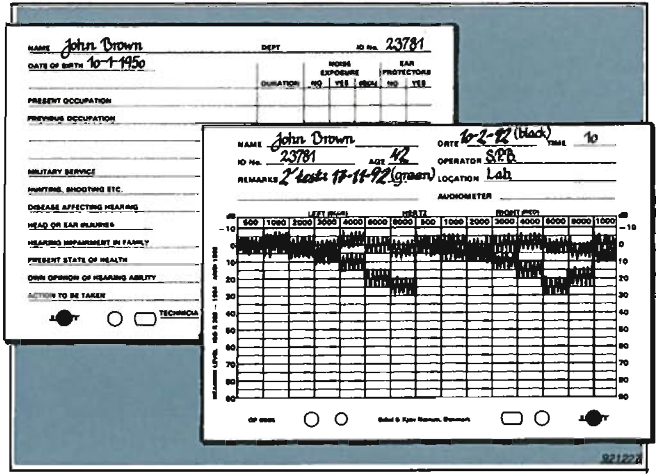
Audiometric tests measure a person's threshold of hearing at selected frequencies. The test instrument is called an Audiometer, and the record is called an Audiogram.

The Audiometer presents a variable sound pressure level in an earphone and measures at preselected frequencies the minimum audible sound pressure level (threshold) that the person can hear and compares it with the average threshold of hearing of young persons with no hearing impairment. The difference in decibels between the two thresholds is reported as Hearing Level, or Hearing Loss, at each frequency and for each ear.

All employees are expected to show some hearing loss because there is a natural loss in hearing acuity as we grow older (presbycusis). Compensation for hearing loss for industrial employees is in many cases based upon the loss within the speech communication frequency range in excess of the average loss of a non-exposed person of the same age.

OSHA requires audiometric tests to be carried out on employees exposed to a noise dose of 50% and above and on employees obliged to wear ear protectors.

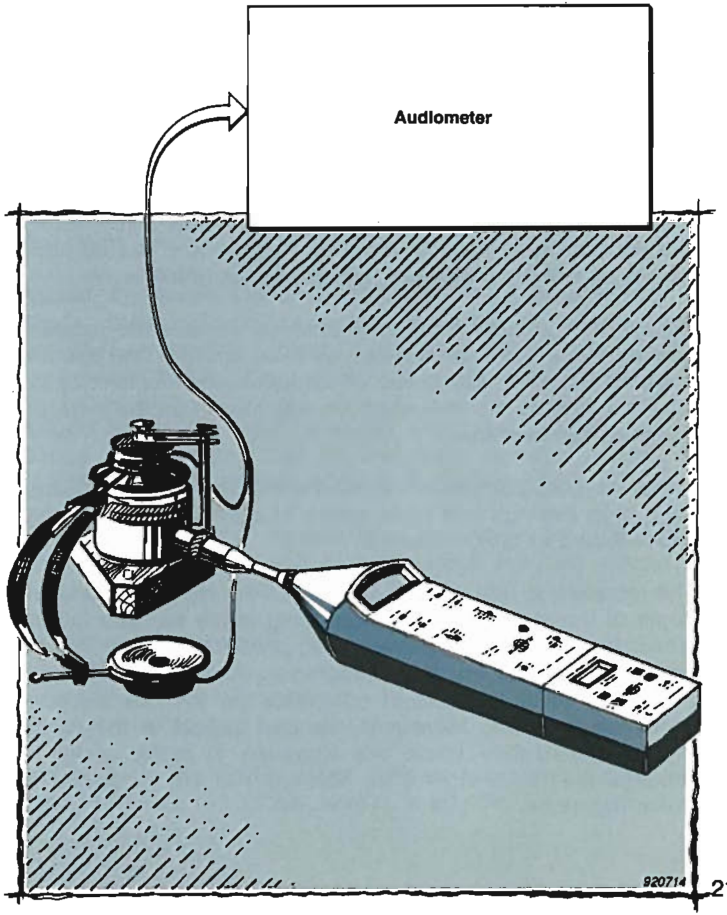
Audiometric tests must be conducted under quiet conditions (e.g. in a sound proofed booth) to ensure that ambient noise does not invalidate the tests. Octave band measurements are used to analyse the background noise under which audiometric tests are conducted.



Calibrating Audiometers

The accuracy of Audiometers must be carefully checked and documented to verify the validity of Audiograms. Audiometers are usually calibrated acoustically and certified by a calibration laboratory once a year. Users normally verify the acoustic calibration themselves at more frequent intervals and perform biological calibrations weekly or daily. A biological calibration is an Audiogram of a normal-hearing adult who has not been exposed to industrial noise and has no history of ear disease.

Acoustic calibration consists of measuring the output of the earphones using a standardized microphone inside a standardized coupler called an Artificial Ear. Because it is important to calibrate down to low hearing thresholds, Octave or One-Third Octave Band Filters are used to reject ambient noise picked up in the coupler.



Planning for the Future

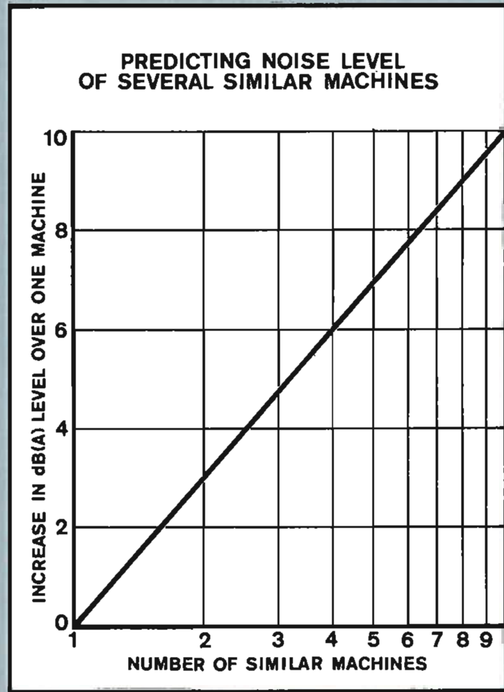
Plans for future factory construction and modernization should give careful consideration to minimizing environmental noise. It is much less expensive to design a quiet factory than it is to exercise noise controls after the plant is in operation.

Orders for new machinery should carry a purchase specification setting a noise emission limit at least 5 dB and preferably 10 dB below the allowable noise limit. This safety margin guards against reverberant buildup and the additive effects of nearby machines having similar noise levels.

Department layouts should be planned so that the noisiest machines are not located near walls or corners and are not grouped together. Machines which induce low frequency vibrations should be mounted on vibration isolators or on separate foundations.

As far as construction costs will permit, noisy plants should have high ceilings and wide aisles to prevent noise buildup experienced at close quarters.

The increase in initial costs can be off-set by the alternative costs of constructing and maintaining noise barriers or enclosures, and possible increases in production costs due to limited access to enclosed machines. And the quieter the plant, the lower the cost of administering the hearing conservation program. Moreover, we can expect in the future that administrative costs will increase in noisy plants if physical disorders other than hearing loss are attributed to noise exposure.



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Glossary of Terms

Absorption: The dissipation of sound energy into another form of energy, usually heat, when passing through an acoustic medium.

Acoustics: The science of the production, control, transmission, reception and effects of sound and of the phenomenon of hearing.

Ambient noise: The total noise in a given environment.

Audibility threshold: The sound pressure level, for a specified frequency, at which persons with normal hearing begin to hear.

Background noise: The ambient noise level above which signals must be presented or noise sources measured.

Damping: The dissipation of vibration within a vibrating body to make it an inefficient acoustic radiator.

Dose %: The amount of sound received by a worker, expressed as a percentage of the daily allowed dose.

Equivalent Continuous Level, $L_{Aeq,T}$: That constant level in dB(A) which lasting for as long as a given A-weighted noise event, i.e. for a period of time T, has the same acoustic energy as the given event.

Hearing loss: An increase in the audibility threshold due to disease, injury, age or exposure to intense noise.

$L_{EP,d}$: The Daily Personal Noise Exposure. A parameter recommended by **EEC Directive (EEC/86/188)**. It is derived from the L_{eq}, the daily duration of a worker's exposure to noise and the A-weighted sound pressure in Pascals to which a worker is exposed. In **IEC Draft 29c**, the $L_{EP,d}$ is referred to as L_{A8hn}.

Pa^2h: The Sound Exposure, measured in the linear unit Pascal Squared Hours, which is a linear unit recommended in **IEC Draft 29c.**

Sound Exposure Level (SEL), $L_{EA,T}$: That constant level in dB(A) which lasting for one second has the same amount of acoustic energy as a given A-weighted noise event lasting for a period of time T.

Sound level: The level of sound pressure measured with a Sound Level Meter and its weighting network. When A-weighting is used, the sound level is given in dB(A).

Sound Level Meter: An electronic instrument for measuring the RMS level of sound in accordance with an accepted national or international standard.

Sound pressure level: The fundamental measure of sound pressure. Defined as:

$$L_p = 20 \log \frac{p}{p_o} \text{ dB}$$

where p is the RMS value (unless otherwise stated) of sound pressure in pascals, and p_o is 20 μPa.

We hope this booklet has answered some of your questions on occupational noise exposure and hearing conservation, and we hope it will continue to serve as a handy reference guide. If you have any questions on measurement techniques and instrumentation, contact your local Brüel & Kjær representative, or write directly to:

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