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Note: ANSI Standards cited in the text may be purchased from the American National Standards Institute, 1430 Broadway, New York, N. Y., 10018.

GR Type 1939 Audiometric Examination Room for hearing tests isolated from plant noise.

hearing test is being conducted inside. It shows the isolation offered by the 1939.

In addition, a safety factor of at least 10 dB should be included. Frequently the ambient conditions that have been measured in an area fluctuate. Moreover, they may increase with time. Therefore, the use of a safety factor is good planning and will assure the long-term adequacy of the audiometric-testing facility.

Data in the table below are based on the present ANSI Standard* for maximum allowable background sound-pressure levels. Therefore, if the recommendations are followed, an octave-band analysis of the proposed site should indicate levels that are lower than those shown in the right-hand column.

*ANSI S3.1 1960 "Background Noise in Audiometer Rooms."

Permissible Background Noise Levels

Octave Band Center Freq. (Hz)	Test Room Level (dB)		GR 1939 Attenuation (dB)	Level Outside GR 1939 (dB)	
	Max	10-dB Margin		Max	10-dB Margin
500	40	30	46	86	76
1000	40	30	53	93	83
2000	47	37	58	105	95
4000	57	47	61	118	108
8000	67	57	63	130	120

PART V
Valid-Data Insurance

Although GR instruments are basically reliable and stable, to insure that the data taken are accurate, it is wise to include a daily program of quick checks of instrument performance.

The vast majority of these checks will confirm that the instruments are indeed working properly, hence the term insurance seems more appropriate than calibration, although the instruments used are referred to as calibrators.

The virtue of such daily checks is that they safeguard the investment in the collection of days or weeks of data. Otherwise, serious equipment errors may be discovered only by the full-fledged calibration done once or twice a year.

The GR 1562-Z Audiometer Calibration Set consists of a 1565 Sound-Level Meter, a 1562 Sound-Level Calibrator, and a coupler for acoustically connecting the SLM to the audiometer earphone.

These instruments can be used to perform all of the calibration checks needed in an industrial hearing-conservation program, since the 1562 will also calibrate the 1565 SLM and the 1934 Noise-Exposure Monitor. Of course, the 1565 can also be used for the noise-survey work, in addition to calibration of the 1703 Audiometer.

PART VI
The Next Step

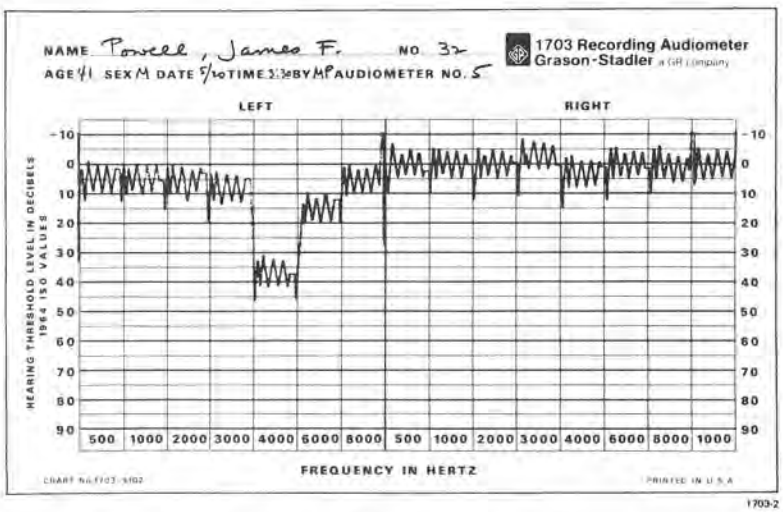
The purpose of this booklet is to acquaint you with the basics of an effective industrial hearing-conservation program. Actual establishment of such a program in your plant is a significant undertaking. GR is ready to help you successfully accomplish this with complete hardware and software packages tailored to your specific needs.

If you're ready to proceed with a hearing-conservation program and would like to discuss it in detail with us, please get in touch at any of the locations listed on the back cover.

ear. Before termination of the testing, the right ear is rechecked at 1 kHz, as a measure of the test validity. Total testing of both ears requires about 7 1/2 minutes.

The record of hearing threshold is obtained by means of a pen, which is moved along the hearing chart's horizontal axis (as a function of time) for each frequency. In the absence of a response, an automatic attenuator, associated with the hand switch, increases the sound level in the earphones, while simultaneously moving the recording pen down along the chart's vertical axis. In the presence of a response, the attenuator decreases the sound level and moves the recording pen up along the chart's vertical axis. At the start of each test frequency, the sound level is changed more rapidly than it is after the approximate hearing threshold is reached. This unique feature means that less time is spent attaining the threshold-level, with the result that the audiogram so produced contains more information about the threshold and is less subject to retest variation than audiograms produced by other techniques.

A person's hearing threshold is not a single point; it is a band of levels. When an audiogram is taken manually, a decision as to the average threshold value has to be made by the operator. An automatic audiometer plots the entire threshold band, thereby eliminating this potentially questionable decision.



1703 Audiogram showing left-ear hearing loss due to acoustic trauma.

An automatic audiometer is more expensive than manual types, which also are used in industrial programs. Automatics offer the following advantages:

1. The constant presence of a skilled operator is not required.

2. Audiometric data taken are more reliable and repeatable, because operator variations due to human inconsistency are eliminated.

3. A chart record is automatically obtained without the transcription errors possible in a manual system.

4. Large organizations can conduct multiple tests with a single skilled operator, since the employee is testing himself.

Audiometric Test Environment

It is hard to measure hearing in noisy areas, because background noise tends to mask the test signals, particularly at the lower frequencies, where earphone cushions provide less effective attenuation. The recommended installation involves an acoustically treated room located in a reasonably quiet place. Normally, the audiometer and its operator are situated outside the room. Bear in mind, however, that an acoustically treated environment merely attenuates noise, it does not eliminate it. You should, therefore, remain alert for any signs that ambient noise at the employees' ears has reached objectionable levels, i.e., sufficient to cause *apparent* hearing loss at low frequencies.

Both ANSI and ISO (International Standards Organization) specify maximum octave-band background-noise levels that are permissible, if accurate threshold determinations are to be made. With few exceptions, reliable, continuous achievement of these levels requires use of an audiometric examination room.

To meet this need, GR offers two audiometric examination rooms. They are manufactured for GR by Industrial Acoustics Company, a pioneer in prefabricated audiometric examination rooms and the leading producer. The attenuation of one, the GR 1939 Audiometric Examination Room, exceeds 45 dB in the octave bands of interest (500 Hz and higher).

The following table shows the maximum background levels that can be present outside the room while a valid

PART IV
Measuring Hearing

Facility

A hearing-testing facility, used both for preemployment and periodic follow-up checks for employees in noise-hazardous jobs, is the other half of a hearing-conservation program.

Such a facility should include an audiometer, located in a sound-isolated environment, and plant personnel trained to make the test, to certify the results, and to refer those with a possible hearing problem to hearing specialists for definitive tests.

Those who work in areas where the sound level regularly goes over 90 dB(A) should be tested at least every six months (every 90 days if possible), while others working in quieter areas can get by with annual checks.

The audiometer records, called audiograms, provide useful reference data to establish both the initial level and the continuing history of an individual's hearing acuity.

Training

All plant personnel responsible for hearing tests should receive formal training in the basics of audiometry and the hearing mechanism. Satisfactory courses generally range in length from a few hours to a week. A listing of sources of regularly scheduled courses is available from:

Amer. Acad. of Opthalmology and Otolaryngology
Committee on Conservation of Hearing
c/o Callier Center
1966 Inwood Road
Dallas, Texas 75235

Audiometers

The audiometer is an electronic instrument that converts electrical energy into sound energy, in precisely variable amounts, to measure hearing. For use in a well-run program, it should meet standards set forth in American National Standards Institute, S3.6-1969 "Specifications for Audiometers."

Recording Audiometer

The Grason-Stadler 1703 Automatic Recording Audiometer is designed with special attention to reliability, simplicity of operation, and permanence of calibration. Its performance meets or exceeds the audiometer specifications of ANSI S3.6-1969. It implements simple, rapid, and accurate hearing tests of the type needed in industrial programs. The unit provides fixed frequency, pure-tone signal presentations and Békésy-type recordings of response.

To perform a hearing test, the operator places an audiogram form on the chart bed of the audiometer and pushes the test button. The unit then automatically presents test tones in succession, first at the left ear, then at the right

1703 Automatic Recording Audiometer, showing a freshly plotted audiogram of actual hearing-acuity response. The subject is seated in the GR 1939 Audiometric Examination Room.

The Wearable Noise-Exposure Monitor

In many working environments it may not suffice to measure noise exposure at a fixed location for the duration of a workday. This is evident when you consider the worker who moves about to several locations in the course of his duties or performs a variety of operations during the day, each generating different noise levels.

The practical way to measure the noise exposure in these circumstances is with a noise-exposure monitor that can be worn by the worker and which moves about with him during the day. GR's 1944 Noise-Exposure Monitor is a wearable instrument that does not hinder the worker in any way. It weighs less than eight ounces and is small enough to fit into a shirt pocket.

The 1944 is a complete monitor with a built-in microphone and its own battery power. It detects noise, weights it and accumulates total noise exposure for the workday, based on OSHA criteria. Tamper-proof operation is assured

1. The GR 1944 Noise-Exposure Monitor, in worker's pocket, automatically measures noise exposure.

since there are no displays or visible controls on the unit. A concealed on-off switch is activated by a pin that is controlled by the supervisor of the noise-measurement program. The pin also serves to lock the battery in place; the single 9-V battery provides about 300 hours of operation.

Retrieving the information detected and stored in the monitor is accomplished with the companion 1944 Noise-Exposure Indicator. The procedure is simple. At the end of the workday, the wearable monitor is plugged into the indicator. A button is pressed and the cumulative noise exposure is displayed on a light-emitting diode readout. The number displayed represents the accumulated percentage of noise exposure a worker has experienced . . . 100% being the maximum permissible in accordance with OSHA. A lamp on the indicator is energized in the event that 115 dB(A) has been exceeded at any time during the work period.

A simple and convenient means of periodically checking calibration is a must when noise-exposure measurements are made. The 1944 indicator unit contains a built-in calibrator to permit rapid calibration verification at the start and end of each day's measurements.

2. Monitor positioned on 1944 Noise-Exposure Indicator for read-out of accumulated noise exposure.

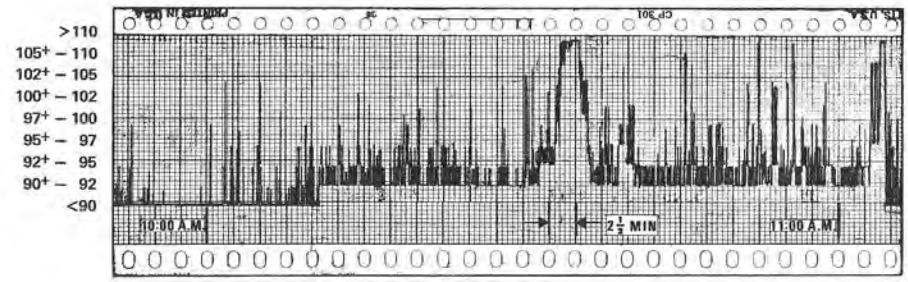
Such an instrument is General Radio's 1934 Noise-Exposure Monitor. The unattended 1934 automatically measures the noise exposure to the official criteria and continually calculates how much of the daily maximum legal exposure you've accumulated. Its digital readout not only tells you the percentage of the exposure limit that has been accumulated but also indicates whether the instantaneous 115-dB(A) and impact (140-dB peak) levels have been exceeded.

At the end of the test period, the instrument automatically stops measuring but retains the data until you can record the results. Because the 1934 measures noise exposure to the applicable portions of governmental, ANSI, and IEC standards, all data are legally defensible.

A strip-chart recorder can be connected to produce a permanent plot of the sound level vs time. This faciliates the implementation of noise-control procedures. A typical plot obtained is shown.

If security concerns you, the exposure meter can be operated in an office while the data are gathered by a re-

The GR 1934 Noise-Exposure Monitor, shown in an industrial application.



An actual strip-chart record made with the Noise-Exposure Monitor in the course of an hour at a relatively noisy work station. This chart was produced by an area at which the cumulative noise exposure was 110% for an 8-hour day. From the plot it can be readily determined that 13% of the exposure occured between 10:33 and 10:35 (2 minutes of greater-than-110-dB(A) noise divided by 15 minutes allowed). As a result, a reduction of that peak to less than 90 dB(A) will make the total daily exposure 97% (within the legally acceptable limit).

mote microphone, or you can enclose it in a tamper-proof security case. On the plant floor, the instrument can operate with the neon-display turned off until you're ready to record the final result.

These inconspicuous instruments can patiently and meticulously perform a 100% observation, automatically keeping their own records if you wish, for only a few dollars a day. And, they will require only 5 to 10 minutes per day of a plant safety officer's valuable time. Small and easily moved to the problem areas in your plant, they can be set up and working in a new location in a matter of minutes.

In addition, they can be set to study either impact or continuous types of noise. The 1934 will detect and hold an indication that impact noise has exceeded 140 dB at any time, or that the steady level has exceeded 115 dB (A).

An important consideration in noise-exposure measurements, especially where they can become part of a legal record, is a simple and convenient means of periodically checking proper operation of the measuring instrument. The GR 1562 Sound-Level Calibrator provides a rapid check of the validity of the data being gathered, justifying its use at the start and end of each day's measurements.

A Special Case:

Impact Noise – Short-Duration, High-Level

Under the regulations, the maximum permissible level of any single impact noise is 140 dB peak sound-pressure level.

The commonly accepted method for impact-noise measurements is to use an impact-noise analyzer, with a sound-level meter, to collect and store data from a rapidly occurring noise for later study*. It is both an inexpensive and completely portable system. The photograph shows such a measuring setup.

The bottom instrument, a GR 1556-B Impact-Noise Analyzer, is an amplifier-voltmeter system designed to measure the peak value of an impact noise. By means of electrical storage circuitry, the instrument will "hold" this peak level of the impact for subsequent reading. The analyzer is capable of peak sound-level measurements up to 150 dB, when used with a GR 1565 Sound-Level Meter.

Some Notes About Duration

All noises that measure below 90 dB(A) are assigned "zero" ratio; in other words, whatever their duration may be they do not contribute to the computed total effect used in the regulation.

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*Tests indicate that levels up to about 160 dB peak sound-pressure level can be tolerated for extremely short durations. Any readings made on a standard sound-level meter for such short-duration sounds will be much lower. As the duration of the sound increases, the meter reading gets closer to the actual level of the noise until, at about a 1-second duration, the impact noise ceases to become a specialized measurement. Because of this sound-level meter characteristic, the Department of Labor will accept the following procedure in lieu of a bona fide impact-noise measurement (based on the recommendations of the Intersociety Committee in Guidelines for Noise Exposure Control).

Impact noises of greater than 5-millisecond duration may be measured on a standard sound-level meter set on its 130-dB range and on "C_F" weighting. If the reading is 125 dB or less, the impact noise may be considered to be lower than the 140-dB peak-sound-pressure level stated in the regulation.

It is important to note that impact noises having durations longer than 50 milliseconds and having peak levels *less* than 140 dB will give readings *higher* than the 125 dB stated in the alternative method. Thus, in some cases users of this technique can find themselves in situations where the sound-level meter reading will be higher than those allowed by this alternative method. In actuality, the peak level may be *somewhat below* the 140-dB figure written into the Federal regulation. For improved accuracy, an impact-noise analyzer is to be preferred.

GR 1565 Sound-Level Meter with GR 1556-B Impact-Noise Analyzer.

Noise that measures above 115 dB(A) is automatically "too high" for any length of exposure over about 1 second.

All noises between 90 dB (A) and 115 dB (A) should be recorded and combined to obtain equivalent continuous levels. Notice, however, that the tolerance for high-level noise is for much shorter periods than for low-level noise.

Noise-Exposure Monitor

The sound-level meter is an indispensible tool for any noise-control specialist. Its small size and battery power make it ideally suited to surveys of an industrial plant, for quick identification of areas of potentially harmful noise. In areas where the noise remains constant for substantial periods of time, the SLM can also be used to compute the amount of exposure, as shown in earlier examples.

When the noise level fluctuates significantly and often during the workday, the manual computation technique becomes difficult and time consuming to perform reliably and accurately. Use of an instrument that *automatically* measures and computes the total exposure, in accordance with Table G-16, is a more economical method.

Continuous Noise

If the noise remains at the same level all day, it is considered to be "continuous." As long as the noise does *not exceed* 90 dB(A), it is within the permissible limits. Usually, the noise level fluctuates widely during the course of the work day and more complex procedures are necessary.

Noise Interrupted — 1 Second or Less

If any noise is interrupted for 1 second or less, it is considered to be continuous.

Example 1

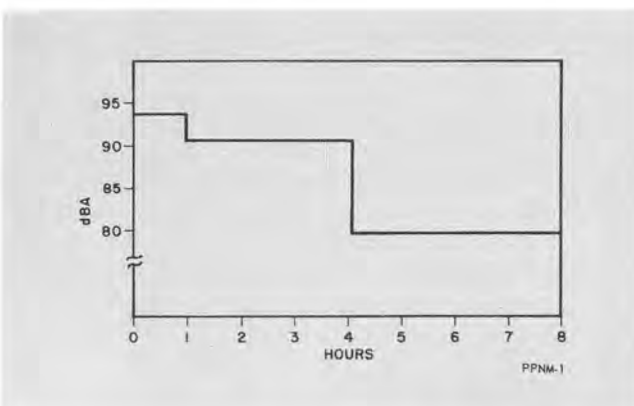
A drill runs for 15 seconds and is off for 1/2 second between operations through the day. This noise is rated at its "on" level for the whole 8-hour day and would be "safe" only if that level were 90 dB(A) or less.

Noise Interrupted — More than 1 Second

When the total exposure consists of various noise levels for various durations, each level and duration must be measured and added to the others to obtain the daily exposure. This is a two-step process:
(1) Find the permissible durations from Table G-16 (p4) for each noise and (2) add the *ratios* of the actual noise durations and those permitted by the regulations. An answer *greater than one* (i.e., greater than 100%) is unacceptable.

Example 2

In a work area, the noise levels are read as 94 dB(A) for 1 hour a day, 91 dB(A) for 3 hours a day, and 80 dB(A) for the remaining 4 hours a day.



1. Find the permissible durations in Table G-16 for each noise level:

92-95 dB(A) = 4 hours
90-92 dB(A) = 6 hours
80 dB(A) = no limit

2. Add the ratios –

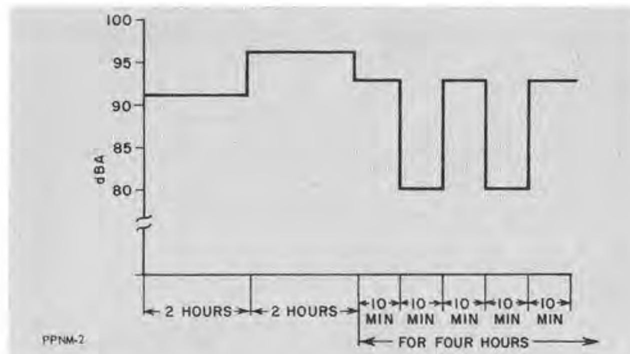
hours	94 dB(A)	91 dB(A)	80 dB(A)
measured	1	3	4
permissible	4	6	no limit

1/4 + 3/6 + 0 = 1/4 + 1/2 = 3/4 = 0.75 = 75% of limit.

Noise exposure is *within limits* (i.e., less than 100%).

Example 3

Noise in an area measures 91 dB(A) for 2 hours a day, 96 dB(A) for 2 hours a day, and for the remaining 4 hours, there are alternate noise levels of 93 dB(A) for 10 minutes and of 80 dB(A) for 10 minutes.



1. The equivalent steady value of the 93-dB noise is 10 minutes x 3 (the number of times per hour that the noise is "on") x 4 hours = 2 hours at 93 dB(A).

2. Add the ratios –

hours	91 dB(A)	96 dB(A)	93 dB(A)
measured	2	2	2
permissible	6	3	4

2/6 + 2/3 + 2/4 = 1 1/2 = 1.50 = 150% of limit.

This *exceeds the permissible limit* of 100%.

The Survey Record

The sample form shown outlines the information needed for a noise survey. The date, time of day, operator, and location identify the measurement conditions. Recommendations for action should also appear on the same form to ensure that they are never separated from the noise-measurement records for the location. Finally, the noise levels measured on the sound-level meter should be recorded carefully and in the same format by all operators. The sound-level meter "procedure checklist" is a reminder for the operator, much like a pilot's takeoff checklist.

Using the Sound-Level Meter

You'll find very little "witchcraft" in noise measurement. A sound-level meter and a bit of common sense are all you need to make very effective plant-noise surveys.

A measurement with the sound-level meter is a simple five-step procedure. Select A weighting, slow meter response, adjust the range switch, read the meter, add the reading to the range setting, and you have the sound level in dB(A).

In most areas you will be concerned primarily with noise levels near the normal position of the worker's ear (without the worker present, of course). You may wish to measure the noise at other points in the working space as well, depending on the area.

A sound-level meter, like any precision instrument, should be checked regularly. You can perform these checks yourself with a simple, inexpensive calibrator (GR 1562), or, if it is a GR sound-level meter, our nearest office will perform the checks for you.

For more information about General Radio sound-level meters, see the *Primer of Noise Measurement*, available free of charge.

Duration of Noise

The maximum level allowed in the noise regulation is 90 dB(A) for continuous noise exposure (8 hours a day). Higher noise levels are allowed, but for shorter durations. When noise is not at the same level continuously, the duration of the noise must also be measured, in order to assess hearing damage risk.

Plant-Noise Survey Form

DATE: 1/2/69
METER #: 6547

LOCATION: Building 1, Second Floor, Cable Braiding Area

NUMBER OF PERSONNEL EXPOSED: 1

WEARING EAR PROTECTION? ☑ yes ☐ no

OPERATOR: J. R. LaConner

SIGNED: P. G. Alan

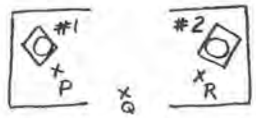
1565 PROCEDURE CHECK LIST

1. REMOVE WHITE CAP.
2. SELECT A WEIGHTING, SLOW METER RESPONSE (OR C WEIGHTING, FAST RESPONSE FOR IMPACT NOISE).
3. TURN ATTENUATOR KNOB TO GET SCALE READING (OR TO 140 dB FULL SCALE FOR IMPACT NOISE).
4. ADD READING TO KNOB SETTING TO GET TOTAL dB.

DIAGRAM: (Show measuring location with an X.)

dB(A)

Location	P	Q	R
#1 on	99	95	91.5
# 2 on	89.5	92	96.5
Both on	99.5	97	98



Mike 5' 2" off floor

NOTES:
— Operator goes back and forth between machines
— Set-up time: ~4 min.; Initial run: ~1 min
— 5 minutes at Q, alternate runs
— 25 cables/day-average. Worst case used.
— Both machines not always on during initial part of run

MAXIMUM LEVELS AS MEASURED ON THE SCALE OF THE SOUND-LEVEL METER SET AT A WEIGHTING, SLOW METER RESPONSE. IF THE READING IS BETWEEN LEVELS SPECIFIED, USE THE HIGHER LEVEL.

dB(A) MAX LEVEL	EXPOSURE TIME (If necessary, note time of day)	D: TOTAL DURATION IN HOURS PER DAY	P: PERMISSIBLE HOURS PER DAY	D/P
OVER 115			NONE	
115			¼	
110			½	
105			1	
102			1½	
100	25 times at 1 minute each	.42	2	.21
97	13 times at 5 minutes each	1.08	3	.36
95			4	
92	13 times at 4 minutes each	.87	6	.15
90	12 times at 4 minutes each	.80	8	.10
UNDER 90	coffee break, lunch, cable layout — 4:50 total	4.83	ANY	0

IMPACT CHECK (MUST BE UNDER 140 dB PEAK SOUND-PRESSURE LEVEL AS MEASURED WITH AN IMPACT NOISE ANALYZER, OR BE UNDER 125 dB AS MEASURED WITH A SOUND-LEVEL METER ON C WEIGHTING, FAST RESPONSE, 140 dB FULL SCALE RANGE.)

Max — 101 dB(C)

TOTAL: .82
To comply with regulations, total cannot be more than 1.

RECOMMENDATIONS: Continue use of ear protection

GENERAL RADIO CONCORD, MASSACHUSETTS 01781 Form No. 3227-A

Actual plant-noise survey conducted on two cable-braiding machines.

Complimentary copies of this Plant-Noise Survey Form (No. 3227-A) are available on request.

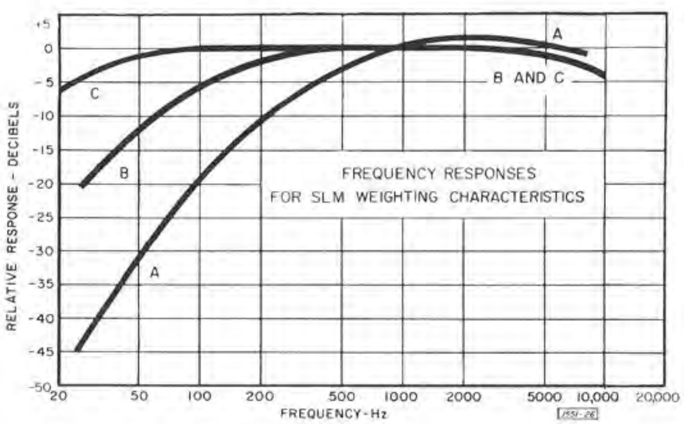
Frequency

Frequency (or pitch) is another important, yet subtle, part of noise and hearing. Our ears discriminate naturally against low-frequency sounds. Therefore, we can tolerate more low-frequency noise than high-frequency noise. When we begin to lose our hearing, our ears usually become less sensitive at first to the higher frequencies, such as the consonant sounds (f, s, t, etc) in normal speech.

Weighting Networks

Because our reasons for measuring noise usually involve people, we are ultimately more interested in the human reaction to sound than in sound as a purely physical phenomenon. Sound-pressure level, for instance, can't be taken at face value as an indication of loudness, because the frequency (in hertz) of a sound has quite a bit to do with how loud it sounds. For this and other reasons, it often helps to know something about the frequency of the noise you're measuring. This is where weighting networks come in.

They are the sound-level meter's means of responding more to some frequencies than to others, with a prejudice something like that of the human ear. The writers of the acoustical standards have established 3 weighting characteristics, designated A, B, and C. The chief difference among them is that very low frequencies are discriminated against quite severely by the A network, moderately by the B network, and hardly at all by the C network. Therefore, if the measured sound-level of a noise is much higher on C weighting than on A weighting, much of the noise is probably at low frequencies.



Curves for the A, B and C weighting networks.

It is important to note that the Federal regulations, except that for impact noise, require use of the A network, hence the symbol "dB(A)" for sound-level decibels on the A scale.

Since most sound-level meters offer a choice of fast or slow meter indications on each weighting network, the regulation opts for the "slow" setting, which averages the rapid fluctuations of sound level and makes meter reading easier.

Measuring Noise

The procedure for measuring noise, and then relating the numbers from a sound-level meter to hearing-damage risk, can be learned in a matter of minutes.

As is true of any systematic study, a plant-noise survey should conform to the requirements of the standards. To begin, your sound-level meter should meet the requirements listed in ANSI* Standard S1.4-1971, "Sound-Level Meters."

Although this booklet is written around a specific sound-level meter, General Radio's compact and inexpensive 1565, most of the material applies to the use of any sound-level meter meeting current U.S. and international standards.

*American National Standards Institute.

A plant-noise measurement made with the GR 1565 Sound-Level Meter.

Noise Monitor

Installation of an automatic noise-exposure monitor is a simple and reliable, yet inexpensive, method of establishing the degree of hazard in each suspected area.

Hearing Measurements

Another key part of the program is a properly set-up and conducted employee hearing-testing facility, particularly for workers in noise-hazardous jobs.

Such a facility should include a recording-type audiometer, preferably in a sound-isolated environment, and personnel capable of conducting the tests, certifying the results, and referring those with possible hearing problems to hearing specialists.

Reducing Noise

Noise reduction through engineering controls is a subject that cannot be adequately covered in this booklet. Basic principles are covered in the literature.* Seminars on topics such as plant-noise control and techniques for product noise reduction, etc, are offered regularly by a number of firms. Acoustic consultants and manufacturers of noise-control materials are sources of advice in solving specific problems.

Personnel Protection

If engineering noise-control techniques do not eliminate hearing hazards, then use of personal protection, such as ear muffs or ear plugs, is called for. Government agencies concerned with enforcement of the noise provisions of the Occupational Safety and Health Act are quite specific in stating that use of such personal protection is a *last resort*, to be utilized only after it has been demonstrated that application of all engineering controls, within economical and technological bounds, has not reduced the noise to safe levels. However, most companies provide employees with some form of hearing protection, such as ear plugs, while they are investigating methods of reducing the noise at the source.

*L.L. Beranek, ed., *Noise Reduction*, McGraw-Hill, New York, 1960.

C.M. Harris, ed., *Handbook of Noise Control*, McGraw-Hill, New York, 1957.

PART III
Measuring Plant Noise

Noise Factors

Before we can rate the possible effects of noise on hearing, we must know three things about it: level, frequencies present, and duration (when the noise is *not* continuous).

Even though noise is a complex phenomenon, the pertinent noise measurements are relatively simple to make. The basic noise-measuring instrument, the sound-level meter (SLM), is little more than an "electronic ear;" it changes noise into an electrical signal and displays it on an indicator. Thus, the sound-level meter reads the noise level directly, and it does it in terms of the decibel.

Level

The decibel (dB) is used to express the sound level associated with noise measurements. The weakest sound that can be heard by a person with very good hearing, in an extremely quiet location, is assigned the value of 0 dB. At 140 dB, the threshold of pain is reached. In between is the noise level in a large office, usually between 50 and 60 dB. Among the very loud (but still tolerable) sounds are those produced by *nearby* power lawn mowers and riveting machines, which are near 100 dB. These typical values should give a feeling for this term decibel as applied to sound level.

detail by the regulations. Since there are no U.S. standards, per se, regarding the *use* of instrumentation in the measurement of occupational noise, we must rely on widely accepted good practice for such measurements.

The Noise Problem – What Must Be Done?

The regulation states (in part)

"(a) Protection against the effects of noise exposure shall be provided when the sound levels exceed those shown in Table G-16 of this section when measured on the A scale of a standard sound level meter at slow response.

"(b)(1) When employees are subjected to sound (*levels*) exceeding those listed in Table G-16, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels within the levels of the table, personal protective equipment shall be provided and used to reduce sound levels within the levels of the table.

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

"(3) In all cases where the sound levels exceed the values shown herein, a continuing, effective hearing conservation program shall be administered.

"Exposure to impulsive or impact noise shall not exceed 140 dB peak sound-pressure level."

The following sections of this primer discuss the techniques that can be applied to comply with this regulation.

TABLE G-16
Permissible Noise Exposures

Duration per day, hours	Sound level dB(A) Slow-Response
8	90
6	92
4	95
3	97
2	100
1 ½	102
1	105
½	110
¼ or less	115

PART II
Hearing-Conservation Program

Elements

A complete industrial hearing-conservation program contains the following elements:

1. A means of identifying areas of possible noise hazard.
2. A reliable means of monitoring employee exposure, in accordance with official criteria.
3. A generally recognized means of measuring employee hearing acuity.
4. Engineering effort to eliminate or isolate hazardous noise sources.
5. Use of protective equipment to safeguard employee hearing, where the noise hazard can't otherwise be controlled.

Hazard Identification Survey

A plant-wide survey with a portable sound-level meter, made in each of the various work areas, for both continuous and impulse noise types, can quickly sort out work stations most likely to constitute a hazard.

Areas where noise can be expected to exceed the 90 dB(A) level, for any substantial period of a work shift, should be designated for continuous monitoring. Periodic plant-wide surveys will uncover areas that have shifted into the potentially hazardous category because of deterioration of equipment. When new equipment, materials, or methods are introduced, the appropriate areas should, of course, be resurveyed.

Foreword

Life in a technologically advanced society presents a paradox. Almost every advance we realize in our material living standard can only be accomplished with some diminution in the overall quality of life. What we gain from the impressive output of our arsenal of machines and processes may cause serious physical impairment for those on the production line. Where, for instance, is the advantage in having an abundance of superb hi-fi equipment, if those who make it are deafened in the process?

While industrial hearing impairment is nothing new, our Government has recently acted to set standards to protect the hearing of nearly everyone exposed to industrial noise hazards. In so doing, it created a new problem for industry, that of controlling noise to conserve hearing.

This slim volume presents a single-source solution to the measurement aspects of that problem. It gives a capsule analysis of the new standards and, in summary form, describes the instrumentation package needed to comply with them. It is prepared by a firm with a long history of meeting industrial needs in noise measurement.

PART I
Noise and Hearing

As we grow older our ears gradually become less sensitive to sound. Most scientists believe that a certain amount of hearing loss with age is normal. Prolonged exposure to excessive noise also can cause gradual hearing loss.

Of course, an extremely loud noise can cause immediate loss of hearing, but such catastrophic noises are usually predictable (rocket blasts, gunfire, etc), and we can prepare for them.

Loud noise, even if not so extreme that it hurts, can be dangerous, because it is more common and more likely to last for long periods. The noise we "get used to" and endure for many years is more likely to cost us our hearing than is the high-level noise we instinctively avoid.

Standards

On May 17, 1969, occupational noise-exposure regulations of the U.S. Department of Labor went into effect for the first time. Under Section 50-204.10 of the Walsh-Healey Public Contracts Act – Safety and Health Standards*, any business wishing to sell (to the Federal Government) goods valued in excess of $10,000, or services valued over $2500, must take steps to protect employees' hearing.

The Occupational Safety and Health Act of 1970 (84 Stat. 1590) extends the regulation to cover some 55 million workers in *all business engaged in interstate commerce*. Enforcement, resting with the Department of Labor, calls for more specific penalties for violations.

Except as otherwise noted, the noise limits in this booklet are taken from Part 1910 of Title 29 of the regulations, as published on page 10518 of the *Federal Register*, Volume 36, No. 105, dated Saturday, May 29, 1971†. The procedures and equipment we recommend meet all appropriate U.S. regulations and standards.

The Federal noise regulations, like any legal requirements, are subject to interpretation. The instrumentation and the method of evaluating the data are spelled out in

*41 USC 351, et seq.

†See also *Guidelines To The Department of Labor's Occupational Noise Standards* (Bulletin 334, Revised 1971), copies available from U.S. Department of Labor, Occupational Safety and Health Administration, Washington, D.C. 20210; American Conference of Governmental Industrial Hygienists "Threshold Limit Values of Physical Agents."

Primer of Plant-Noise Measurement and Hearing Testing

The information in this booklet is consistent with Federal Regulations effective August 27, 1971, and the recommendations of the Combined Intersociety Committee on Guidelines for Noise Exposure Control.

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