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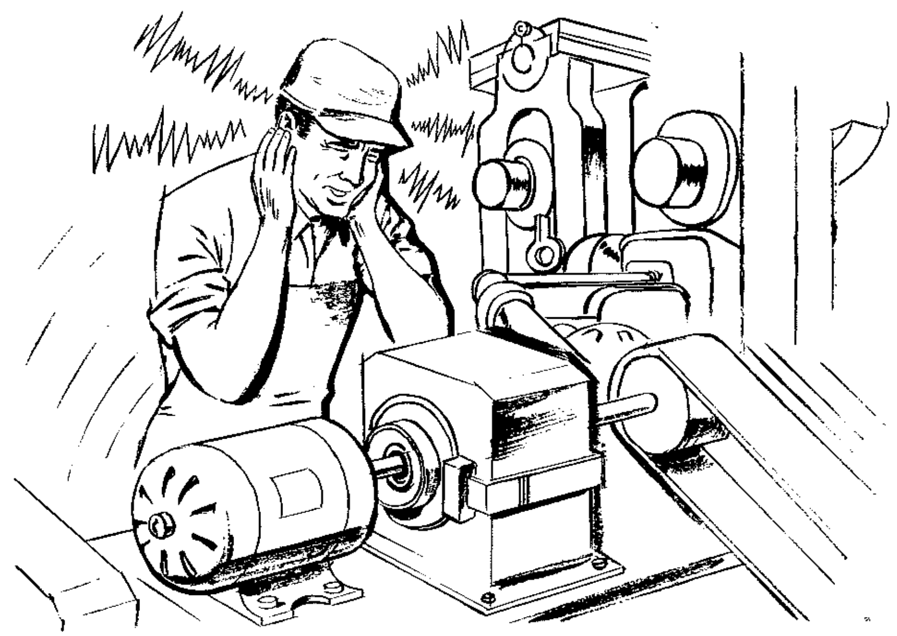
Albert E. Heustis, M.D., Commissioner

Noise — A Disquieting Problem



(It is not only prudent to consider the conservation of human resources as a worthy goal in itself, but also to realize the potential compensation costs which may be involved at a later date.)

Twelve years ago, the University of Michigan School of Public Health focused attention on the noise problem in a symposium entitled "The Acoustical Spectrum, Sound—Wanted and Unwanted."[1] Great interest in this subject was evidenced then by the 270 representatives of industrial, educational, and governmental organizations with responsibilities in industrial and community health programs.

With spectacular technical advances in most other areas, there would be the expectation that unique and clever methods would have been developed and instituted to solve the noise problems considered by this conference. This, however, has not been the case. Although some progress has been achieved in defining the problem in more precise terms, in the development of hearing damage risk criteria, and in the development of instrumentation to measure and analyze noise, industrial and community noise problems continue to plague our society.

"The damaging effects of industrial noise are a serious threat to human hearing and a potential socio-economic problem to the general community," writes Dr. Aram Glorig, Director of the Subcommittee on Noise Research Center.[2]

PROBLEM WIDESPREAD

His opinions and estimates of the potential compensation costs of a half-billion dollars for noise-induced hearing loss are considered conservative by some authorities in this field. The question is often raised whether the problem really is as serious as these statements indicate and, if so, does it involve all of industry and its employees or just a few "boiler factories" or "forge shops." Unfortunately, surveys conducted by this department confirm statements made by others that *few manufacturing plants are without a noise exposure problem of a serious nature.* With increased mechanization, automation, and speed of production, and with more power available for work, the noise problems continue to present a hearing loss hazard involving large industrial population groups.

Again using the information prepared by Dr. Glorig, the significance of the hearing loss problem is shown in Figures 1 and 2 which present composite audiograms of various population groups. Significant variations are seen in the hearing level of the non-exposed group as compared with the "typical industry" or with the "105 db over-all group." These figures reveal that for the group exposed to 105 decibel noise levels, the losses increase with years of exposure and occur more rapidly at 4000 cycles per second than at the 1000 cycle per second frequency. The rapid shift in hearing loss at 4000 cycles in the first few years of exposure is evident in these figures followed by a slower shift during the next 10 to 12 years when noise-induced hearing loss seems to be nearly complete at this frequency. Hearing loss in the 1000 cycle range shows a more gradual shift downward and continues at a moderate rate for an extended period of time. The rapid threshold shift in the 4000 cps band is an early indicator of damage due to noise exposure and has been used by many investigators as a screening technique to assist in the evaluation of industrial noise problems.

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The data presented in these figures show a substantial difference in hearing acuity at various ages between the industrially exposed population and the non-exposed population. As to the industrial noise exposure responsible for these variations, Table 1 gives examples of noise study data obtained from a number of different industries. Some of the noise levels measured are continuous noise exposures experienced throughout the entire workday and anticipated throughout the entire work life for the people involved. In other cases the noise levels are intermittent and involve exposures for only a portion of the workday.

It has been shown that exposure to noise levels of high intensity which continue over long periods of time present a more serious hazard than do noise levels of an intermittent character even though the over-all intensity may be essentially the same. Other variations in the character of the noise affect the way the ear responds to the noise exposure.

In making an evaluation of the noise problem it is necessary to obtain a complete description of the noise including the total intensity, the character of the noise in terms of its time and frequency distribution, and an indication as to the duration of exposure during the workday and anticipated work life for the exposed employees. This requires a careful study by persons familiar with the problem and with the techniques used to measure and evaluate noise exposures. The work can be handled by the plant engineering staff or by others who familiarize themselves with the procedures and equipment necessary for this type of investigation. While there are a number of specialized problems of a complex nature requiring the aid of specialists, it will be found that the majority of the industrial noise exposure problems can be evaluated by plant personnel with a sufficient degree of accuracy to allow for the development of an effective hearing conservation program.

Few Programs Started

In spite of the interest and attention given to the problem by various insur-

TABLE 1

TYPICAL SOUND PRESSURE LEVELS IN INDUSTRIAL PLANTS

Operation	*Overall Noise Level*	*Octave Band Levels, db* 20-75	75-150	300 150-	300-600	600-1200	1200-2400	2400-4800	4800-10,000	*Time Exposure In Percent of Work Day*
Specialized Manufacturing										
Abrasive Grit Crusher	114	103	108	105	105	108	106	104	100	Approx. 100%
Paper Mill Sheeter Machine	106	91	91	93	98	101	102	96	86	70%
Paper Mill Bagging Machine	99	84	86	89	91	92	91	89	81	80-90%
Cement Block Manufacturing Unit	110	100	102	106	102	103	102	100	94	60%
Small Pneumatic Grinding, With Mufflers	99	74	69	70	88	97	93	91	81	90%
Paper Corrugating Machine	109	86	88	94	105	100	99	99	94	70%
Hot Spray Metalizing	101	91	83	85	85	85	85	91	97	70%
Food Industries										
Food Packaging, Bottle Capping	102	91	93	92	94	94	91	90	80	Approx. 100%
Plastic Extrusion	96	90	91	88	88	88	82	78	72	90%
Bottle Forming	112	98	101	102	103	104	104	104	103	90%
Woodworking										
Planer	108	81	86	102	106	102	99	100	90	80%
Cross Cut Saw	104	82	79	86	88	86	91	103	90	80%
Jointer	98	87	86	94	91	91	91	86	81	80%
Automotive Manufacturing										
Engine Test Cell	101	79	100	92	90	90	85	82	80	20%
Vibrating Pan Feeder	98	86	87	88	89	90	91	90	82	90%
Pedestal Grinder	92	75	74	78	77	82	83	85	88	90%
Heat Treat Furnace	103	98	98	94	92	92	85	77	74	95%
Foundry										
Casting Shakeout	112	95	96	100	108	109	107	102	100	90%
Air Chisel Operation	114	90	96	98	100	96	102	111	108	50%
Jolt Squeeze Sand Molding	110	99	100	102	100	100	100	106	98	50-60%
Diaphram Sand Molding	109	91	91	97	100	100	104	103	100	50-60%
Shell Core Making	94	88	84	85	81	82	78	84	85	99%
Mining										
Mining, Pneumatic Drilling	120	106	110	113	114	112	113	112	109	10%
Underground Crusher	107	101	94	100	101	100	93	90	80	90%
Ball Mill	102	95	93	94	96	95	90	82	70	90%
Stamping Mill	102	101	98	92	90	89	89	89	88	90%

ance companies, industrial health and medical authorities, little in the way of significant progress has been achieved in Michigan industry in reducing noise or in studying the problem. There are a few notable exceptions, however. A large Michigan chemical plant began a noise control and hearing conservation program a number of years ago.[3] A large automotive company has recently undertaken a comprehensive program and although the task is acknowledged to be a large one, substantial benefits are foreseen from their efforts.

Other plants with the aid of insurance companies, private consultants, and engineers from this Division have initiated programs of noise control and hearing conservation, but by and large *the majority of the industrial plants in this state do not have a noise control or hearing conservation program in effect.* In essence, they "hide their heads in the sand" hoping the problem will disappear or go unrecognized. From the viewpoint of public health and the conservation of human resources, this situation cannot be considered satisfactory or tolerated. The knowledge and tools to minimize the problem are available. It is not necessary that industrial workmen lose hearing acuity. Only time, money, and determination are required to bring about a solution to this disturbing problem.

First, industrial management must recognize the facts and be willing to establish a hearing conservation program. They should understand that:

1. Many industrial noise exposures will cause permanent hearing loss and interfere with the ability to understand speech.

2. Noise-induced hearing loss may be permanent and is likely to become compensable resulting in substantial costs for industry.

3. Noise may reduce efficiency, cause a safety hazard, and affect operational costs, especially where communication between employees is required.

4. Noise must be considered in the selection of equipment and tools for industrial production. Not all equipment to do the same job produces the same amount of noise.

5. Noise-induced hearing loss can be prevented for most industrial employees and reduced to a large extent for all employees.

6. Noise can be reduced in many areas by applying fundamental engineering methods of control.

A careful evaluation in each industrial plant should be made to determine the significance or degree of the problem. As a general rule, one can anticipate that a noise problem exists:

1. If there is difficulty in communicating by speech while working in the area of noise,

2. If head noises or ringing in the ears occurs after workmen leave the area of noise, or

3. If there is a loss of hearing that has an effect of muffling speech after several hours of exposure to noise.

The absence of pain should not be used as a guide to suggest that the noise exposure is of no concern. Pain and annoyance are not reliable indicators of noise-induced hearing loss and they should not be used to indicate whether or not a hearing conservation program is needed.

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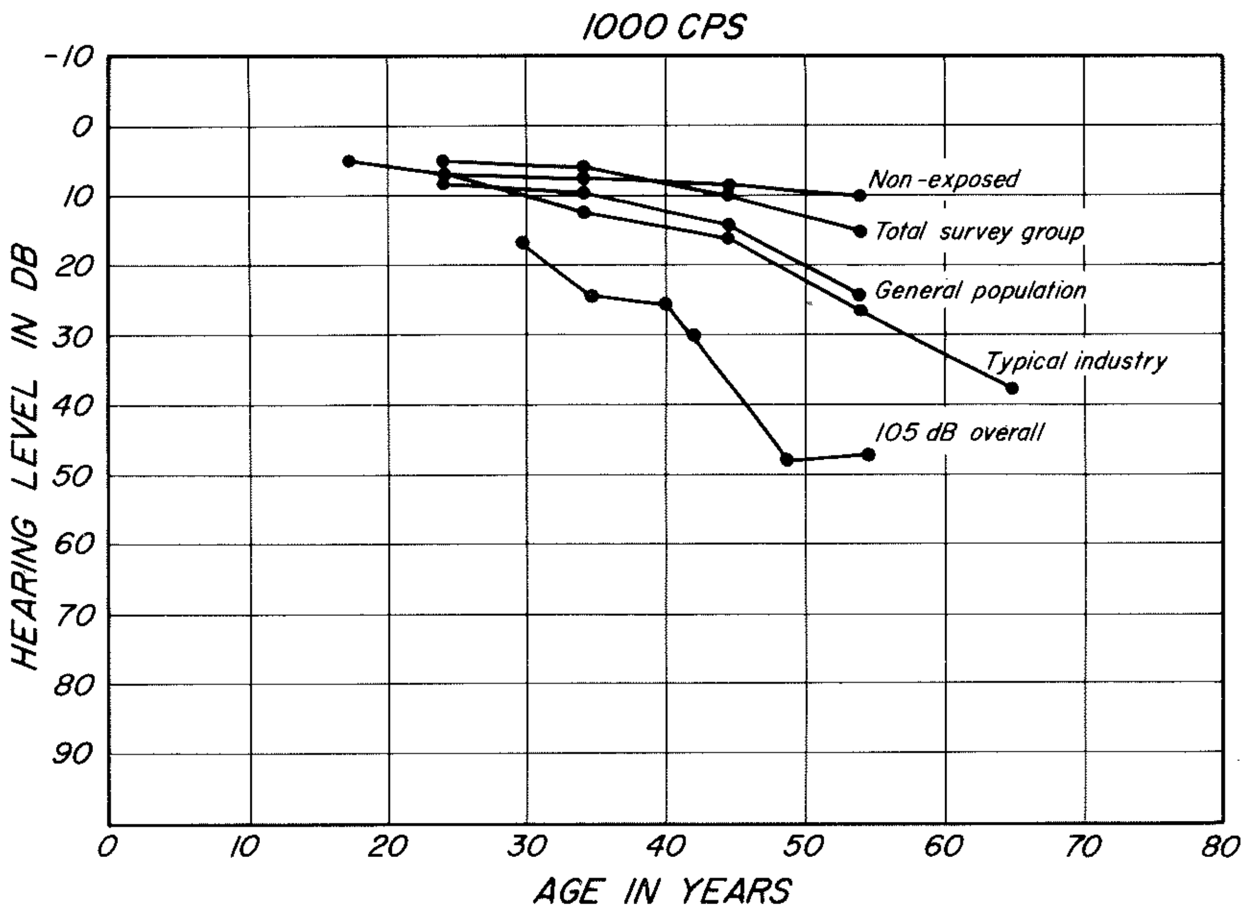


Figure 1. Composite audiograms at 1000 cps in various populations.

NOISE—Continued

The maintenance of the ability to understand speech is a minimum standard for any hearing conservation program. While it is desirable to maintain hearing acuity throughout the entire range of hearing, it is generally recognized that an industrial program to accomplish this is not entirely practical. No reasonable noise exposure limit can be suggested which will protect everyone because of individual susceptibility. A program, however, to limit hearing losses to less than 15 decibels at 500, 1000, and 2000 cycle per second, which are the frequencies most important to speech, is considered to be a reasonable and satisfactory guide. Damage risk criteria are usually based on this fundamental concept but they should be recognized only as guidelines to the prevention of significant noise induced hearing losses in the majority of exposed workers. An example of such a standard as proposed by the International Organization for Standardization in a form as modified by Dr. Glorig follows.

1. "When the exposure to broad band noise is habitual and the noise is continuous during the working day (5 or more hours) the average of the levels at frequencies of 300-600, 600-1200, and 1200-2400 cycles per second should not exceed 85 db. If this average exceeds 85 db, hearing conservation measures should be initiated. This standard applies to exposure to steady state noise only and does not apply to the impulsive type of noises.

Example:

Octave Band	300 600	600 1200	1200 2400
Sound Level	95	95	92

Average Level (3 Bands) $\frac{382}{3} = 92$

Note: Where octave band analyzers are used having frequency bands corresponding to the *ASA Standards S1.6-1960 Preferred Frequencies for Acoustical Measurement*, the measurements obtained in the 500, 1000, 2000 cps bands may be substituted for the 300-600, 600-1200, and 1200-2400 cps bands without significant error or need for modification of the criteria.

2. "When the exposure to broad band noise is habitual and

TABLE 2

Noise Exposure Limits

Average of 300-600 600-1200 1200-2400 cps (db)	*On-time per day (minutes)*
90	Less than 120
95	Less than 50
100	Less than 25
105	Less than 16
110	Less than 12
115	Less than 8
120	Less than 5

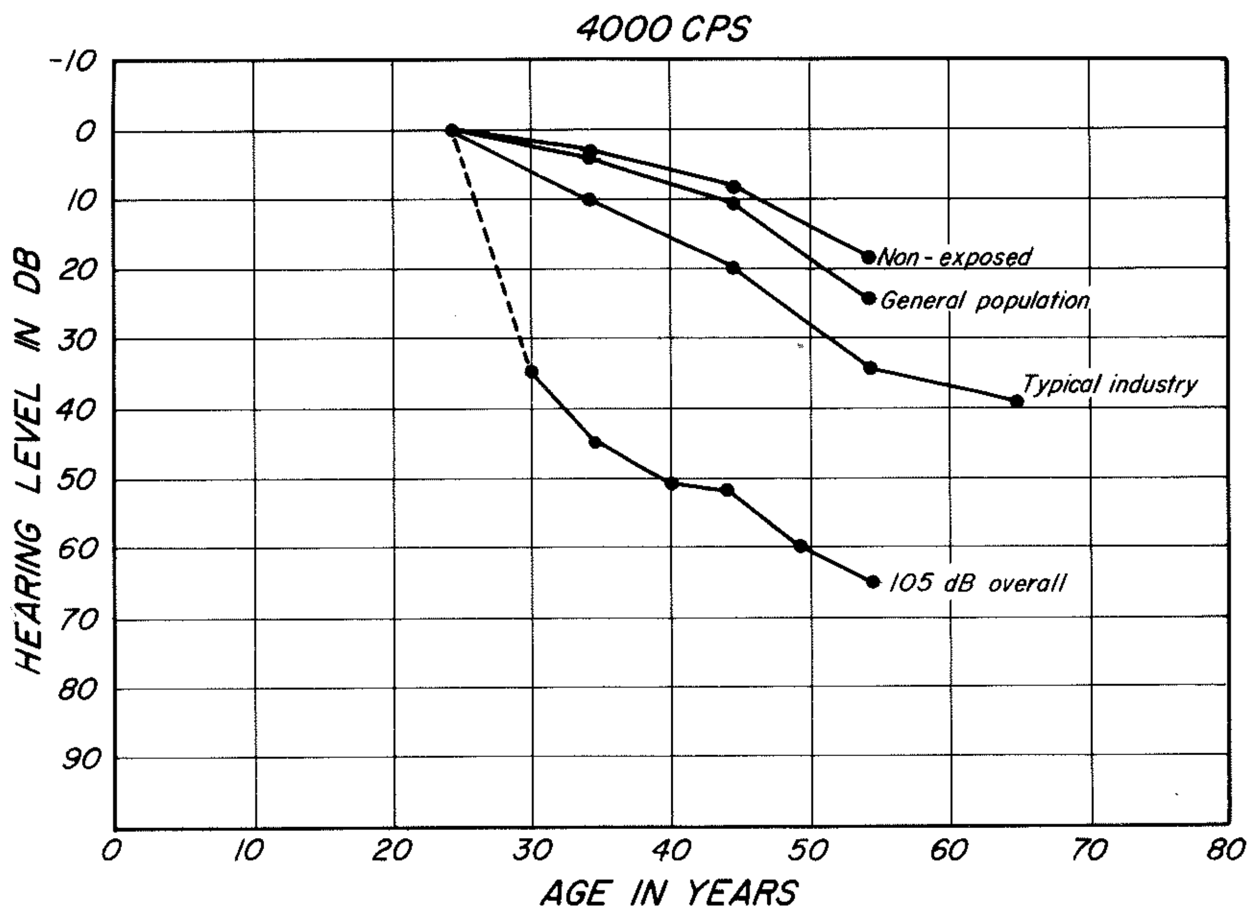
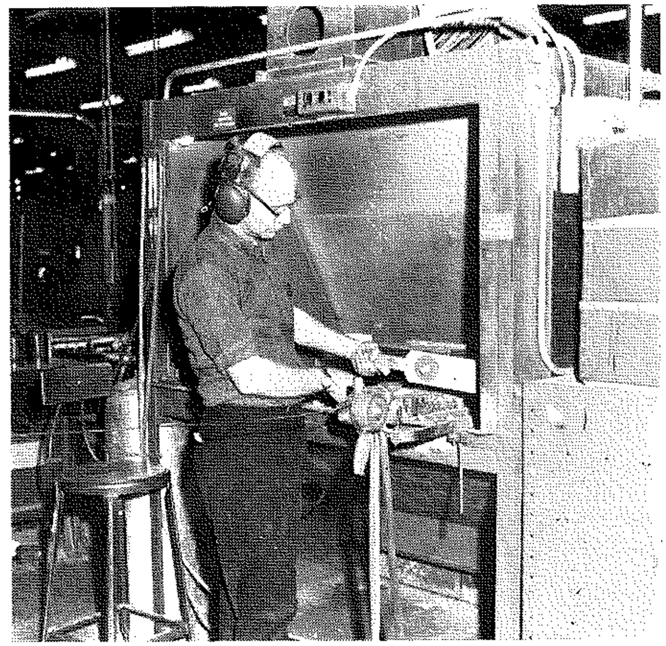


Figure 2. Composite audiograms at 4000 cps in various populations.

Roll Forming of Wheels – Measurement of Noise at Operator's Location

Overall Level	Octave Band Center Freq in CPS: 63	125	250	500	1000	2000	4000	8000	16000
	Noise Intensity in Decibels								
107	84	90	96	99	104	101	94	84	82



A Hot Spray Metallizing Operation

Overall Level	Octave Band Center Freq in CPS: 63	125	250	500	1000	2000	4000	8000	16000
	Noise Intensity in Decibels								
118	89	102	102	88	97	103	111	114	111

the noise is continuous for less than 5 hours per day, Table 2 should be consulted for recommended allowable exposures.

3. "When the exposure to broad band noise is intermittently 'on' during the workday, the recommended allowable exposure time may be determined by consulting Figure 3. This figure shows the relationship between the duration of the 'on-time' between the noise bursts (ordinate), and the allowable average level of the 300-600, 600-1200, and 1200-2400 cps bands. The broken contours show the number of permitted exposure cycles ('on-time' – 'off-time' combinations) per day, calculated for a working day of 480 minutes. Example: If the average of the level at 300-600, 600-1200, and 1200-2400 cps bands is 105 db and the noise is on ('on-time') for 10 minutes the ('off-time') between noise bursts is determined by noting the intersection of 10 minutes and the 105 db contour. In this case just under 40 minutes or approximately 10 exposure-cycles per day."

Similar recommendations for limiting noise exposures are contained in the United States Air Force Regulations

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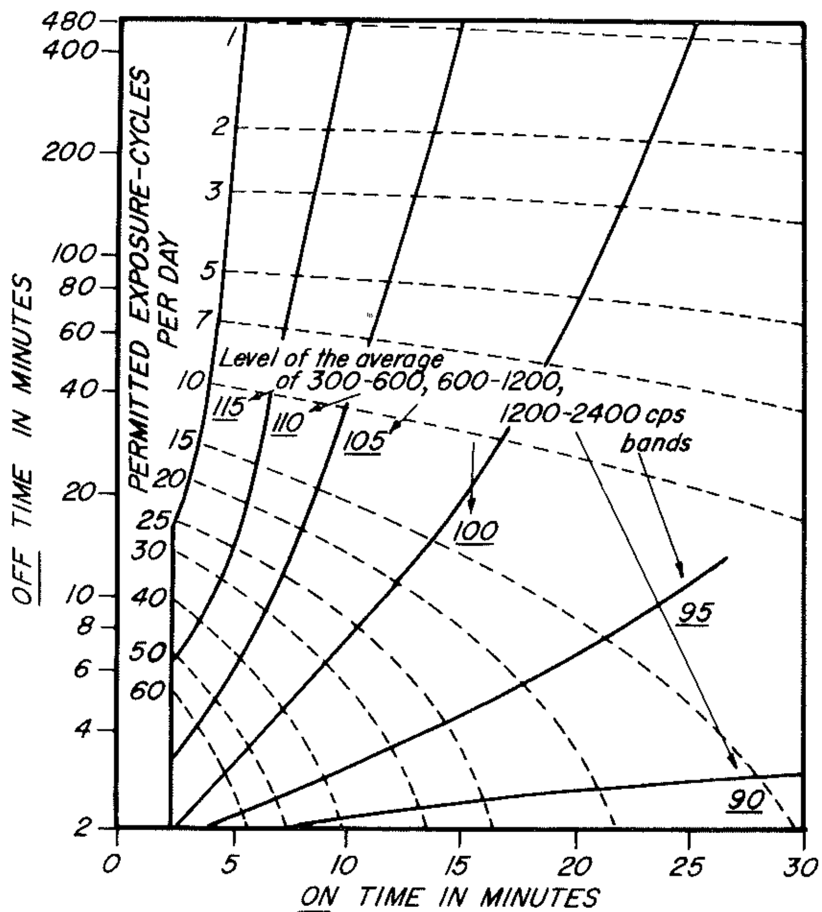
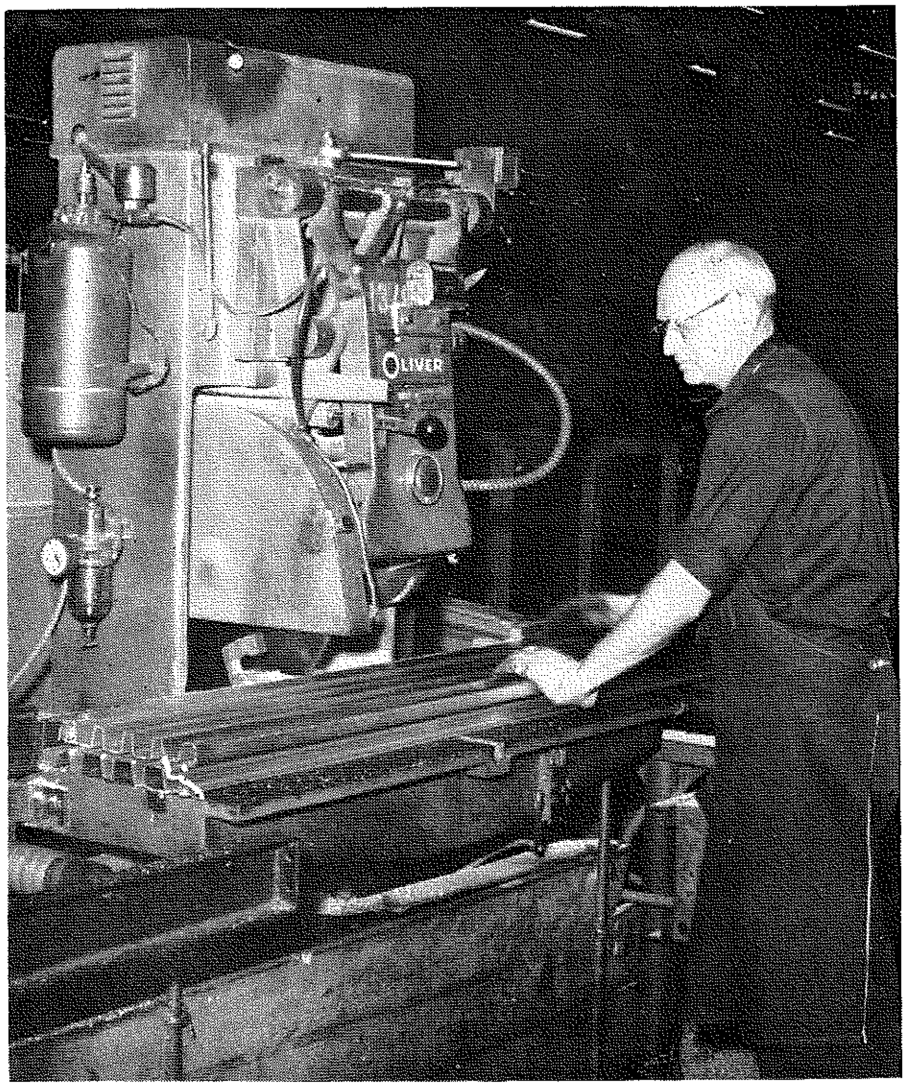


Figure 3. Recommended allowable exposure time for intermittent noise.

TABLE 3

ATTENUATION FOR EIGHT DIFFERENT EAR PROTECTORS
(in db re. zero of the audiometer)

Type	*125*	*250*	*500*	*1000*	*2000*	*3000*	*4000*	*6000*
	FREQUENCY							
Com-Fit Plug		21.9	25.0	25.9	33.4	38.8	41.2	33.0
V51-R Plug	15.0	15.9	16.2	21.3	28.8	33.7	33.7	32.9
Milkweed Plug	8.0	11.0	12.0	15.0	17.0	30.0	30.0	28.0
MSA Foam Ear Muff	8.0	23.0	30.0	32.0	33.0	40.0	39.0	39.0
MAS Grease Filled Ear Muff	19.0	30.0	38.0	38.0	42.0	44.0	45.0	40.0
Wilson 255 Ear Muff	7.0	13.0	23.0	31.0	34.0	34.0	42.0	40.0
Flents-Cotton Wax Impregnated Plug	8.0	16.0	16.0	19.0	23.0	29.0	27.0	34.0
Cotton	5.0	6.0	8.0	9.0	13.0	15.0	13.0	14.0



Aluminum Tubing Cut-Off Saw

	Octave Band Center Freq in CPS								
Overall	*63*	*125*	*250*	*500*	*1000*	*2000*	*4000*	*8000*	*16000*
Level	*Noise Intensity in Decibels*								
108	*77*	*85*	*92*	*98*	*98*	*104*	*106*	*104*	*102*

No. 160-3[4] and the U. S. Department of Labor, Bureau of Labor Standards "Guidelines for Control of Noise."[5] While there are some basic differences to be found in comparing the suggested noise limits, the variations are not great and the adoption of one of the proposals as a standard for an industrial noise control program is recommended as a beginning point.

ANALYSES OF NOISE

The next step in a hearing conservation program must be the analysis of noise. Noise exposures must be studied to determine the over-all intensity and frequency distribution of the noise, the duration and distribution during the typical workday, and the anticipated exposure during the work life. Effort should be made to analyze these factors as carefully as possible and complete records should be maintained of the data obtained for future reference and for comparison with damage risk criteria.

A part of any hearing conservation program must be the control of the noise exposure. This may be accomplished by environmental control which involves:

1. Reducing the noise at the source,

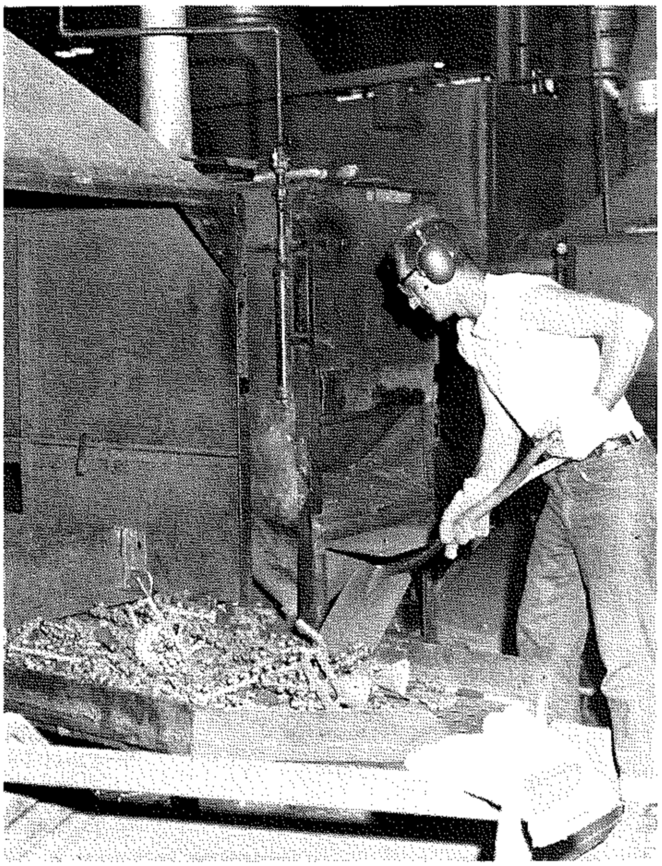
2. Reducing the amount of noise transmitted through the air or building structure to the ear of the affected person, or

3. Providing the affected person with personal protective equipment.

It is usually found that reducing the noise at the source requires considerable study and a certain time delay can be anticipated before noise control is achieved. Similar problems usually arise when one attempts to enclose an offending noise source in order to reduce the amount of noise transmitted through to the point where workers are exposed. While every effort should be made to reduce the noise at its source or to isolate the noise source, immediate attention should be given to the problem by providing the person affected with suitable ear protection so that the noise exposure can be controlled until such time as the environmental conditions are modified.

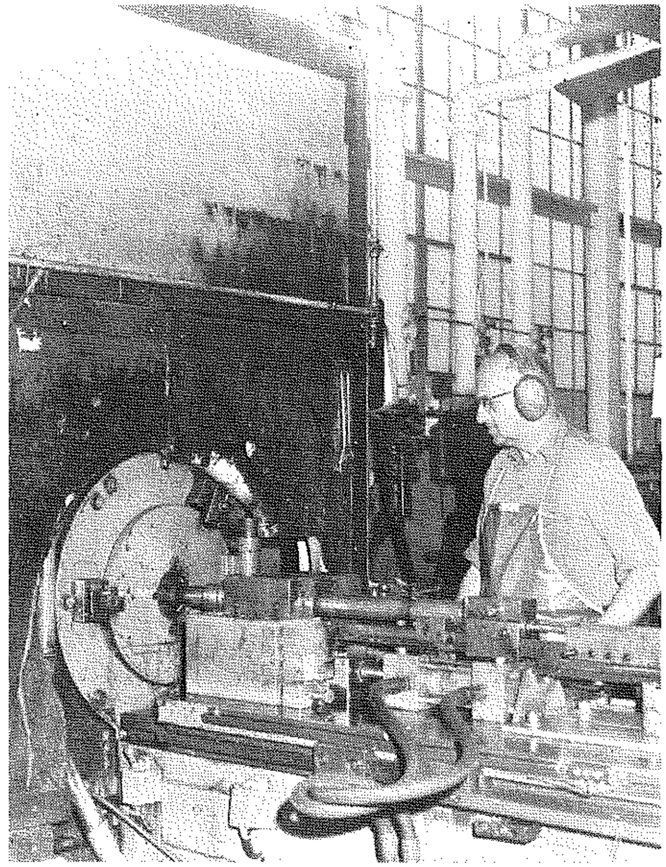
PLUGS AND MUFFS

The two types of ear protectors in current use include ear plugs of various



A Small Casting Shakeout

Overall Level	Octave Band Center Freq in CPS: 63	135	250	500	1000	2000	4000	8000	16000
	Noise Intensity in Decibels								
115	*92*	*107*	*100*	*101*	*107*	*110*	*110*	*109*	*108*



Swaging Operation with Machine Enclosure

Overall Level	Octave Band Center Freq in CPS: 63	125	250	500	1000	2000	4000	8000	16000
	Noise Intensity in Decibels								
108	*92*	*97*	*99*	*96*	*100*	*101*	*103*	*101*	*97*

designs and ear muffs. Ear plugs are designed to close the ear canal to reduce the transmission of noise to the inner ear and are normally made of natural rubber, neoprene, plastic, or cotton impregnated with wax. It has been found that dry cotton provides little or no protection even though this material has been popular with workmen for many years.

Ear muffs are designed to cover the entire ear and at frequencies above 1000 cps provide about the same protection as ear plugs. At frequencies below 1000 cps certain of the muffs provide somewhat better protection than the plugs. Table 3 illustrates the noise attenuation attainable with various types of ear protectors.

The determination as to whether to use ear plugs or muffs will depend largely on the individual preference, the work situation, and environmental conditions. Properly fitted ear plugs or muffs will provide satisfactory reduction of noise levels within the ear canal for nearly all industrial exposures. While there are advantages and disadvantages to the use of either the plugs or the muffs, the latter offer the advantage of being visible making it easy to see if the employee is wearing the protection.

An important part of any hearing conservation program includes the determination of hearing acuity for the employees. This should include a pre-employment or preplacement examination of all employees together with routine periodic follow-up tests. It is necessary that all hearing tests be done under the supervision of a physician who is knowledgeable in this area.

If the results are to have value for future reference, tests should be made in accordance with the American Standards Association standards.[6] Air conduction tests should be made for thresholds at 500, 1000, 2000, 4000, and 6000 cps. Audiometric testing should also be done prior to the employee's entering the noise exposure area in order to minimize or eliminate a temporary threshold shift in hearing acuity which may exist following a workday noise exposure. In the final analysis, the effectiveness of the noise control program is determined through audiometric testing.

Noise Control Committee

Because a hearing conservation program includes many functions involving analysis of the noise, control of the noise exposure, measurement of hearing, and a provision for personal protection, it is desirable to organize this activity using a representative committee. Such a committee would logically include people from the plant engineer's staff, from the personnel department, and the industrial physician responsible for the medical program within the

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plant. Such a group can effectively plan and carry out a hearing conservation program which will accomplish the goals set forth.

SUMMARY

Controlling noise in industry involves recognizing that noise problems exist in most industrial plants and cause permanent hearing loss among some employees. It involves understanding that noise can be controlled and that personal equipment can be provided which will minimize or eliminate the hearing loss hazard which exists. Finally it involves organizing of a group of people whose responsibility includes the evalaution of the noise associated with the work exposure within a given plant and the supervision of a hearing conservation program to meet the needs of the individual industry. Action is needed now and not in the future.

It is not only prudent to consider the conservation of human resources as a worthy goal in itself, but also to realize the potential compensation costs which may be involved at some future date.

REFERENCES:

[1]"The Acoustical Spectrum, Sound — Wanted and Unwanted," University of Michigan Press, Ann Arbor, Michigan, 1952.

[2]Glorig, Aram, M.D. "Hearing Conservation in Industry," Maico Audiological Library Series, Vol. 2.

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[4]*Air Force Regulation No. 160-3,* U.S. Government Printing Office, Washington, D. C.

[5]*Safety Standards,* Vol. XIII, No. 2, "Noise-Guidelines fòr Control," U.S. Government Printing Office, Washington, D. C.

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ERRATUM:

Please correct Vol. 9, No. 4, Summer 1964 issue of Michigan's Occupational Health to read in Figures 3 and 6, page "Iridium 192" rather than "Radium".

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