ACOUSTICS AND NOISE CONTROL IN CANADA

THE CANADIAN ACOUSTICAL ASSOCIATION

L'ACOUSTIQUE ET LA LUTTE ANTIBRUIT AU CANADA

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CONTRIBUTIONS

Articles in English or French are welcome. They should be addressed to a regional correspondent or to a member of the editorial board.

SUBSCRIPTIONS

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CONTRIBUTION

Vous êtes invités à faire parvenir des articles en anglais ou en français. Prière de les adresser à un correspondant régional ou à un membre de la rédaction.

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(suite au recto de la couverture inférieure)

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Notice Board

Inter-Noise Seminar

An intensive short course on principles and applications of noise control will be presented on 4, 5 and 6 May 1978 at the Jack Tar Hotel in San Francisco, California, immediately preceeding INTER-NOISE 78, Seventh International Conference on Noise Control Engineering. The presentations on the first day will cover fundamentals of acoustics and noise control and will be given by Malcolm J. Crocker, Editor-in-Chief, NOISE CONTROL ENGINEERING and Professor, Purdue University and by William W. Lang, Program Manager, Acoustics Technology, IBM. The presentations on the next two days will be given by noise control specialists from industry, government and universities and will cover: in-plant noise control, design of facilities for noise control, noise measurements and data reduction, and acoustical standards used in noise measurements. The registration fee for the Seminar is $325. Further details may be obtained from the INTER-NOISE 78 Conference Secretariat, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603 or telephone 914/462-6719.

Inter-Noise 78

The seventh International Conference on Noise Control Engineering to be held at the Jack Tar Hotel, San Francisco, California, U.S.A. next May 8-10. Two special sessions on European progress in noise control will be featured at INTER-NOISE 78. For immediate release for further information, contact Mrs. Joyce B. Raymond, INTER-NOISE 78, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603, U.S.A.

1st Annual Noise Measurement and Control Course

The University of Maine at Orono (Bangor) announces that the 1st Annual Course in Noise Measurement and Control, directed by James L. Parsons will be held July 17 to 21, 1978.

The facilities of the University of Maine provide excellent accommodations for the participants.

Oriented to engineers, industrial hygienists, safety personnel and Federal and State inspectors, the course is presented to acquaint the participants with the methods for evaluating noise problems and working out solutions. The subjects of acoustics measurement, instrumentation, noise control, regulations, compliance programs, hearing damage and hearing conservation programs are treated and discussed thoroughly. Laboratories provide practice in the use of sound measuring systems. Ample opportunity is provided students to discuss individual problems with faculty members. Panel discussions with regulatory authorities and experts will be a special feature of the program. An excellent and renowned staff has been assembled to conduct this course. Tuition is $300.00 and Room and Board is $25.00 per day.

For descriptive brochure and application write or phone: NMC Coordinator, 1721 Pine St., Philadelphia, Pa. 19103 (215) 735-0205.

National Association of Acoustical Consultants

George Henderson of Valcoustics has been Canadian Correspondent to the National Council of Acoustical Consultants. He is interested in receiving from CAA members items which may be of interest to U.S. members of NCAC. His address is Valcoustics Canada Ltd., 30 Drewry Avenue, Suite 502, Willowdale, Ontario. M2M 4C4.

Bye Lines

Tony (A.G.) Taylor has joined Ontario Hydro Power Equipment Department, where he is working on critical speed and vibration analysis and on occupational noise in generating stations. Tony was formerly with the Noise section, Ontario Ministry of the Environment.

John R. Hemingway has joined SNC, Toronto as Senior Environmental Engineer. He has also recently become Chairman of the CSA Subcommittee on Noise Instrumentation. John was formerly with the Noise section, Ontario Ministry of the Environment.

Tim Kelsall has joined Hatch Associates Consulting Engineers, Toronto as a noise specialist - current responsibility includes the Iscott steel complex in Trinidad. Tim was also formerly with the Noise section, Ontario MOE.

John Coulter has joined Vibron Ltd., Toronto, in another move from Ontario MOE Noise section. John was equipment specialist at MOE.

Dick Worthington moved into wider environmental fields by joining a regional office of Ontario MOE at Sarnia. Dick was also formerly an inspector in the Noise section.

R.K. (Bob) Leong has joined Civil Aeronautics in Transport Canada, Ottawa working on the energy costs of aircraft noise abatement procedures. Bob was formerly with Transport Canada Road & Motor Vehicle Traffic Safety Branch.

Dr. Moustafa M. Osman is now with the Acoustics Office, Ontario Ministry of Transportation & Communications as Research Officer (Acoustics). Moustafa is a graduate of the University of Paris, his specialty being vehicle noise and vibration.

Alberto Behar has also joined the Acoustics Office, Ontario MTC as Research Engineer (Acoustics). Alberto was formerly in charge of Noise, Vibration, Building Acoustics and Electroacoustics at Instituto Nacional de Technologia Industrial in Argentina.

Further contributions to this column will be welcomed.

Book Announcements

Two books of Canadian parentage have just been published, and are commended to readers for their usefulness and international perspective as well as for the fact that their editors may be known to us.

"Architectural Acoustics" (editor, Tom Northwood) is the latest in the Benchmark Papers in Acoustics published by Dowden, Hutchinson and Ross, of Stroudsberg, Pennsylvania (428 pages, $30). Dr. Northwood has carefully selected 30 papers of outstanding significance in the development of architectural acoustics since the turn of the century. They are printed in facsimile, and are placed in perspective with the sort of discerning commentary one expects from the Head, Noise and Vibration Section of NRC's Division of Building Research. Dr. Northwood has also added a list of related references, and provided English of the summaries of the five papers which are in French or German.

The book is in two parts, one on Room Acoustics and one on Sound Insulation, and each is further divided into physical aspects (techniques and theories) and subjective aspects. "Architectural Acoustics" will be of interest to anyone with even a nodding knowledge of acoustics, and architects and most acousticians will enjoy the presentation of the subject in an historical framework through the words of its experts.

"Handbook of Noise Assessment" (editor, Daryl May) is also an international book, published by Van Nostrand Reinhold, New York (400 pages). It is authored partly by its editor (of Ontario Ministry of Transportation and Communications) and partly by other Canadian, American, British and Australian acousticians. It addresses the question largely neglected in other acoustical books of "How much noise is too much?" Thus it covers criteria and the principal limits established in the U.S. and other countries. Its subject is not noise control.

The handbook is in two parts, one on Physical Effects Assessment and the other on Psychological Effects Assessment. The physical effects are hearing damage, nonauditory effects of noise (including infrasound and ultrasound), sleep disturbance, and work disturbance. The psychological effects, annoyance and speech interference, are dealth with in a source-receiver framework - traffic noise to non-travellers, aircraft noise to non-travellers, recreational vehicle noise to non-users, transportation noise to travellers, plant noise to residents, and so on. Construction noise, domestic noise and noise in hospitals are subjects rarely covered in other books, and the chapters on these topics may be of special interest.

"Handbook of Noise Assessment" is intended first for "users" and only second for researchers, which should ensure a market among practising acousticians, engineers, consultants, environmentalists, lawyers and students. Researchers should also, however, find the book a handy reference. The question "How much noise is too much?" is a perpetual problem question to all those involved in acoustics, and the book is well-aimed.

1978 SYMPOSIUM AND CAA ANNUAL MEETING

PRELIMINARY ANNOUNCEMENT

The 1978 Symposium and Annual Meeting will be held in Halifax at the Chateau Halifax, on Thursday, November 3, and Friday, November 4, 1978. Plans for the meeting are progressing well and a final announcement and call for papers will be mailed to members in the near future.

Tentative plans for an "educational day" just prior to the meeting, on Wednesday, November 2, which may include a review of acoustics fundamentals and a session on acoustic standards, are being made. Any comments or suggestions from members regarding the usefulness of this "educational day" and the subjects to be considered would be most welcome.

Please forward any suggestions or comments (pro or con) to the convenor:

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Ultrasonics

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SB/SJE/ULT

31st January 1978

Dr. H.W. Jones,
Faculty of Arts and Science,
Department of Physics,
The University of Calgary,
Alberta,
Canada.

Dear Dr. Jones,

As you know one of the aims of our journal is to provide a balanced content, with regard to both subject matter and geographical location of the contributors. It would be most welcome, therefore, to receive more papers from your country and I wonder whether you will be in a position to send us any contributions from your colleagues shortly. It would be of great help, of course, if you were able to referee the papers before forwarding them to us.

Alternatively, if you can let me know of any workers who may have results suitable for publication in the journal, I should be pleased to write to them myself.

I look forward to hearing from you.

Yours sincerely,

Stephen Bailey

Stephen Bailey
Assistant Editor

A Comparison of the Annoyance Reduction Effects of Different Shielding Types

Susan Birnie
McMaster University
Hamilton, Ontario

Introduction

In view of the many expensive measures currently being taken to protect people from noise, the question which arises is whether the methods being used are as effective in reducing the impact of noise on people as they are in reducing the physical sound levels. This question is important since the methods used to date have assumed that physical measures of sound are reliable indicators of the effects of noise on people. The work done for this paper has provided an empirical test of that assumption, in the situation where some kind of barrier or shielding is installed between the highway and the residential area. This aspect is important to consider because transportation agencies are turning increasingly to the construction of barriers and buffers, as a method of reducing transportation noise.

It is not obvious what the effectiveness of a barrier is in reducing adverse impacts, as opposed to their acoustical effectiveness. It is possible that the acoustical effectiveness and the impact effectiveness are the same, so that the present assumption is correct, that acoustical measurements are good surrogates for noise impacts. However, two other possibilities are also evident. First the impact effectiveness may be less effective than the acoustical effectiveness, signifying that the residents living in an area where a barrier has been constructed may still be aware of the presence of the highway, and even the reduced noise levels may lead to more annoyance, complaints, and activity interference than one would expect from the sound level readings. On the other hand, impact effectiveness may be greater than acoustical effectiveness, such that the presence of the barrier has some kind of psychological effect, over and above its acoustical properties. For example, highway effects such as headlight glare, spray and dust may be mixed in with any response to road traffic noise, and therefore elimination of these will cause the adverse reaction to the noise to be less than would be expected from the sound levels. This question is important since the cost-effectiveness of shielding for noise must be expressed in terms of what it does for people, and not simply what it does for sound levels.

This paper investigates responses to road traffic noise in a number of residential areas which have some form of shielding between them and the highway. The impact effectiveness of the shielding is analyzed by comparing responses at each site with the responses to traffic noise at a second site, which experiences the same sound level at the dwelling, but which is either unshielded from the road, or is shielded by a different material.

Data Used

The data for such an analysis was collected throughout the summers of 1975 and 1976 under projects sponsored by the Ontario Ministry of the Environment. Data pertaining to attitudes to noise, activities interfered with by noise, perceived health effects of noise, and actions taken due to noise were collected in a number of residential neighbourhood sites. Each site consisted of a single row of housing parallel to the roadway in question, and was affected by no major noise sources other than the roadway. A twenty-four hour record of the noise levels was also taken, subsequent to the interviewing.

On the basis of this noise level information, all of the sites from the data collection efforts were considered to find pairs of sites with as similar as possible sound level readings at the residences, and with different kinds or degrees of shielding between the housing and the road. The acoustical effectiveness of the barrier is not under investigation here, since the sound levels at the housing units are the same in each pair, but not the noise generated by the road. For example, the first pair out of the five that were identified is illustrated in Figure I. It compares the responses of people in the second row of housing along a major highway which has a daily traffic volume of more than 90,000 vehicles, with the responses of people living adjacent to an arterial street which carries less than 30,000 vehicles daily. Clearly the noise at the road edge is much higher in the first instance than in the second. The point is that the sound levels at the residence are the same for each pair of sites, as shown by the monitor readings (Table 1). The day-evening-night equivalent level, L_{DEN}, was used as the principal identifier of similar sites, but day, evening and night-time Leq are also shown to permit more detailed comparison.

For each pair of sites, a large number of variables from the household interviews were investigated to see if there were any significant differences between the two sites in the responses (Table 2). Two variables deal with people's overall attitude toward the noise in their neighbourhood. The first is whether or not the respondent volunteered that noise was something they disliked about their neighbourhood, and the second was their rating of the overall neighbourhood noise on a 9-point bipolar scale ranging from extremely agreeable to extremely disturbing. The remaining variables deal with responses to specific noise sources, which for this analysis have been limited to the main road in general and trucks in particular. For each of these sources, there are sets of variables dealing with attitudes, activity interference, actions taken, and perceived health effects. The attitudes were measured in three ways: first; by whether or not the person volunteered that the specific source was a noise he or she noticed. Secondly, by a rating for each person mentioning the noise source, on the ordinal nine-point bipolar scale. Lastly, by a rating for each person disturbed by the noise source, on an interval level disturbance scale. Activity interruption is based on whether or not the respondent volunteered the information that any of the activities listed (Table 2) were interrupted by noise from each source. Information on actions taken was derived from a list read to the respondent (Table 2). Respondents were also asked if the specific noise source had any effect on their family's health, specifically those items shown (Table 2). Thus, in addition to the two variables on overall attitudes to noise, there are a total of 27 source-specific responses available for analysis.

Despite this large number of variables available for analysis, the method is quite straightforward. All we are examining is whether the response to the same noise level is different when different types of shielding or barriers are present. This comparison can be accomplished with several simple statistical tests: A chi-square test is used for the nominal variables, a Mann-Whitney test for the ordinal variables, and a T-test for the interval rating scale.

Results

The results of these tests proved to be quite informative (Table 3). In all five pairs of sites, there is a significant difference in attitude to the overall community noise. In two of the pairs, the difference is in the number volunteering noise as a problem; in the other three pairs the difference occurs on the rating of the community noise. Pair 1 indicates that a single row of housing is more effective in improving such attitudes than is a single row of trees providing a partial visual screen. Pair 2 indicates that several rows of housing are more effective subjectively than no shielding at all, while pair 3 suggests that no shielding at all is more effective than a solid concrete wall. The remaining 2 pairs suggest that a tree screen is more effective than no shielding at all. Consequently, if one is willing to postulate transitivity for such comparisons of effectiveness, the order of effectiveness of these types of shielding for improving attitudes toward the overall noise in a neighbourhood is as shown in Figure 2.

There is considerably less effect when one looks at variables referring directly to the main road traffic noise (Table 4). There is no significant difference in attitudes to the traffic noise in four of the five pairs, on any of the variables analyzed. Therefore, the figure shown previously refers only to the attitudes towards the overall community noise. When one considers the activities interfered with, there are significant differences at only two of the sites. Only one variable out of 8 action or 6 health effects shows up as significant, and this is only at a single site. By the general tendency of the sites, we may conclude that there is probably no meaningful difference in shielding types with respect to actions taken or the preceived health effects.

There are also no significant differences for any of the above variables in response to truck noise.

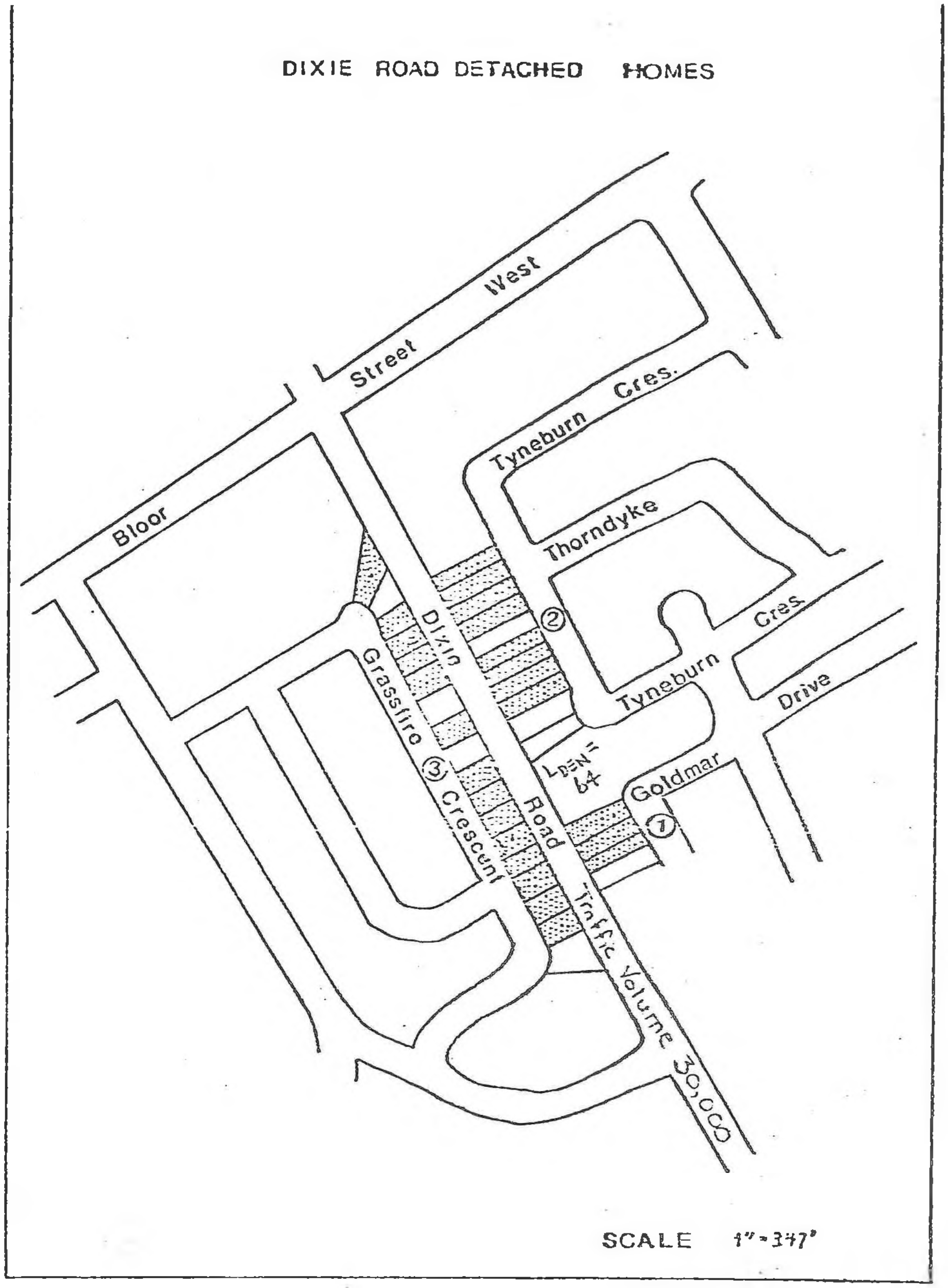
Conclusions

All forms of shielding investigated appear to be equally effective with respect to a large range of responses to road traffic noise. Therefore, the working assumption that sound level measurement is a reasonable surrogate for the measurement of road traffic noise impacts is supported. It may be assumed that any barrier which reduces sound levels will reduce impacts equally. However, this applies only to source-specific reactions. There does appear to be a significant difference in the effectiveness of different kinds of shielding with respect to the overall noise in their neighbourhoods.

One curiosity in the findings is that full visual shielding is on the one hand psychologically beneficial (in the case of a row of housing), and on the other hand psychologically detrimental (in the case of the concrete wall). We can only speculate about the reasons for this. It is generally accepted that noise causes adverse attitudinal reactions not simply as a result of its level, but also because of meanings associated with it. A concrete wall removes the sight of the road, but not all the characteristics associated with the traffic, of which one is reminded by the noise. A person living in such a situation is constantly reminded that they live next to a busy highway by that noise. A row of houses also constitutes an effective visual screen, but they also serve to put distance and other people between the resident and the highway. Therefore, the negative associations are more remote, and not necessarily a part of the neighbourhood in question.

Another question which is raised by this analysis is whether adding trees or other landscaping to an effective sound barrier improves attitudes in any way. A study directed to the effect of the appearance of barriers on attitude would seem useful, given the amount of money which has and will be spent on highway barriers. An acoustically effective barrier will clearly reduce the adverse effects of traffic noise. The question to be answered is whether an aesthetically pleasing barrier will improve general attitudes even more.

SITE PAIR 1


DIXIE ROAD DETACHED HOMES
Bloor Street West
Tyneburn Cres.
Thorndyke
Tyneburn Cres.
Drive
Goldmar
Dixie Road
Grassfire Crescent
DEN= 64
Traffic Volume 30,000
SCALE 1"=347'

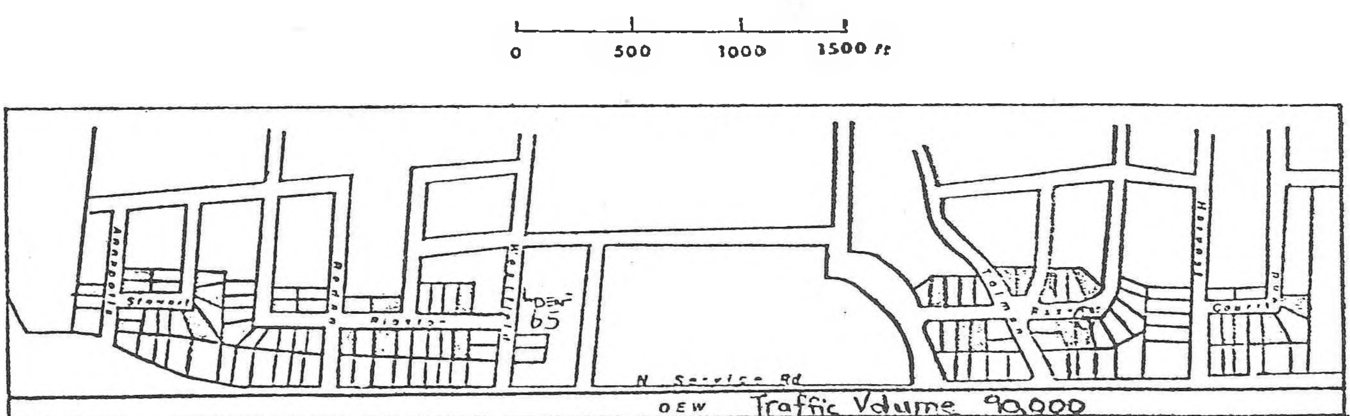

0
500
1000
1500 ft
Stewart
DEN= 65
N Service Rd
QEW
Traffic Volume 90,000

TABLE 1

Site Pairs for Analysis (Sound levels in dBA)

Pair	Location	Type of Shielding	L_{DEN}	Daytime Leq	Evening Leq	Nightime Leq
1	QEW row 2	1 row of housing	65	62	60	57
	Dixie Road	single row of trees	64	61	60	55
2	Stevenharris	several rows of housing	68	67	63	60
	Sterling St.	nothing	68	68	65	60
3	Horizon Village	concrete wall (3.7 m. high)	70	69	63	62
	Garth Street	nothing	69	67	65	61
4	Islington North	single row of trees	76	74	72	67
	Islington South	nothing	76	74	72	67
5	Islington North	single row of trees	76	74	72	67
	Upper James	nothing	77	73	71	70

TABLE 2

Variables Used in the Analysis

Source		Variables	Test
		Attitudes:	
Neighbourhood		1. mention/not mention noise	chi-square
		2. 9-point bipolar scale	Mann-Whitney
Main Road, Trucks	A.	Attitudes:	
		1. mention/not mention noise	chi-square
		2. 9-point bipolar scale	Mann-Whitney
		3. 10-point unipolar scale	T-test
	B.	Activity Interference:	
		mention/not mention:	chi-square
		sleeping	
		relaxing inside/outside	
		conversing inside/outside	
		working inside/outside	
		watching television	
		conversing on the telephone	
		eating	
	C.	Actions taken:	chi-square
		mention/not mention:	
		closing windows	
		using air conditioner	
		staying indoors	
		turning on/up television, radio, records	
		wearing ear plugs	
		waiting for noise to stop	
		individual complaint action	
		organized complaint action	
	D.	Perceived health effects:	
		mention/not mention:	chi-square
		nervousness	
		hearing loss	
		irritability	
		headaches	
		interruption of sleep	
		kept awake	

TABLE 3

Significance Levels for tests of Association

Pair	Shielding Comparison	Attitudes to Community Noise: 1. dislike noise (volunteered)	2. overall noise rating
1	a) one row of housing vs. b) tree screen	no difference	.05(a>b)
2	a) several rows of housing vs. b) nothing	no difference	.01(a>b)
3	a) 3.7 m concrete wall vs. b) nothing	no difference	.001(b>a)
4	a) trees vs. b) nothing	.05 (a>b)	no difference
5	a) trees vs. b) nothing	.01(a>b)	no difference

FIGURE 2

Comparative effectiveness of shielding types, for improving attitudes to overall community noise

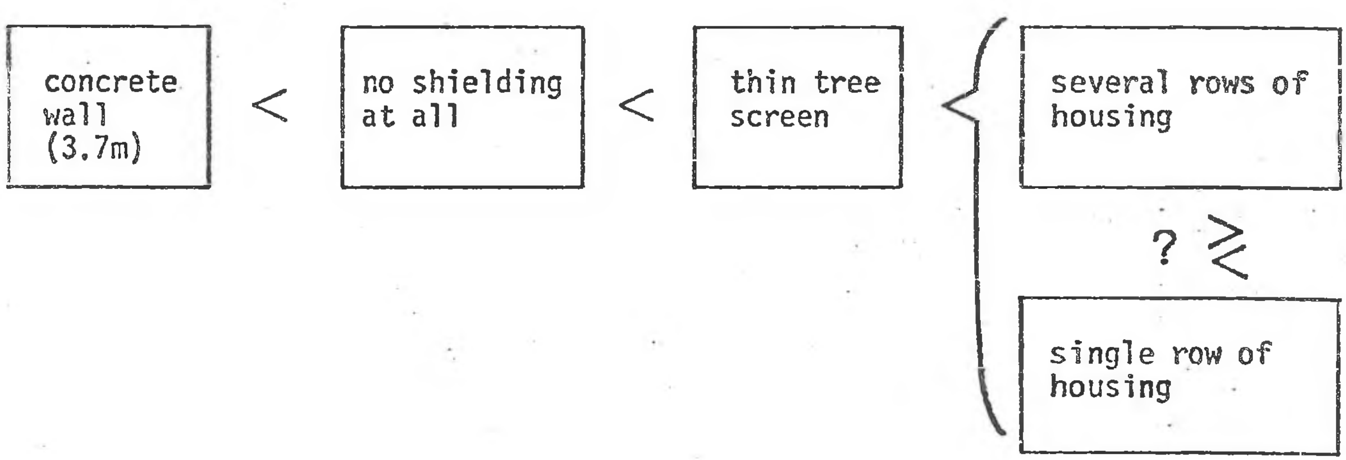


TABLE 4

Significant levels for tests of association

Pair Number	Shielding Comparison	Response to Noise from Main Road: Attitudes	Activity Interference	Actions Taken	Health Effects
1	a) one row of housing vs. b) tree screen	no difference	no difference	close window .05(a>b)	interrupt sleep .05(a>b)
2	a) several rows of housing vs. b) nothing	mention road .01(a>b)	no difference	no difference	no differenc
3	a) 3.7m concrete wall vs. b) nothing	no difference	no difference	no difference	no differenc
4	a) trees vs. b) nothing	no difference	relaxing outdoors .05(b>a)	no difference	no differenc
5	a) trees vs. b) nothing	no difference	working inside .05(a>b)	no difference	no differenc

An Overview of Noise Related Health Effects

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X-rays and Radiation Devices Division
Radiation Protection Bureau
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Health & Welfare Canada
Ottawa, Ontario. K1A 1C1

This paper attempts to summarize those aspects of noise related to health. In a field in which technology is advancing rapidly and where research into noise-induced bioeffects is unable to keep pace with these advances, no attempt has been made to provide details. Instead, an outline of current knowledge in each of the areas concerned and the direction of further research required will be presented. It is planned to publish a document on this background information and to follow it with specific criteria on each of the various health effects of noise.

Much of the impetus for Health and Welfare's involvement comes from the fact that health criteria for noise are largely lacking in Canada, and so noise control has proceeded in a largely uncoordinated fashion, resulting in regulations and bylaws that not only differ across Canada but in some cases are drafted in technically meaningless terms. With more and more reports on the effects of noise becoming available and also workers compensation benefits to employees suffering noise-induced hearing loss increasing rapidly, there is a great need for coordination in noise control. Producing health criteria on noise is one activity towards achieving this goal.

Noise can affect the ability to communicate and/or understand speech and other audio-messages. This may be due to previous impairment of the hearing mechanism or as a result of sufficiently high background noise that speech cannot be understood by the listener. In addition to the direct effect of noise on the auditory mechanism, there are at least three other neural systems that may be affected. These non-auditory effects are not well understood at the present time, but should not be neglected.

Hearing Loss

We will begin by looking at the effects of noise on hearing. Hearing loss may be defined as any reduction in the ability to hear from that of a normal person. There are two general categories of hearing loss: (1) temporary hearing loss (temporary threshold shift or TTS), and (2) permanent hearing loss (which may occur as a result of the aging process, disease, injury, or exposure to loud noises over a long period of time). When from the latter cause, it is generally referred to as noise-induced hearing loss or Noise-Induced Permanent Threshold Shift (NIPTS).

Some factors which create difficulty in assessing the amount of hearing loss caused by noise exposure are: (1) individual susceptibility, (2) presbycusis and (3) sociocusis.

Hearing impairment is a term developed by the American Academy of Ophthalmology and Otolaryngology (AAOO). In 1959 they devised the following formula (see next slide) for assessing a person's impairment of hearing which is still widely used. This formula assumed: (1) the frequencies 0.5, 1, and 2 KHz cover the range of primary importance for hearing and understanding speech; (2) they are given equal weight, and it is the average threshold shift at these three frequencies that is used to measure a person's ability to understand everyday speech; (3) "Impairment" begins after a person has lost an average of 25 dB at the speech frequencies; (4) each decibel loss above 25 dB constitutes 1.5% impairment, so that a loss of 92 dB at the speech frequencies constitutes total impairment.

The problem with this definition is that under very noisy conditions the three and four KHz frequencies become very important and these are not covered by the AAOO formula. This problem is widely recognized. Also this type of definition is really more concerned with hearing as applied to speech communication in optimal conditions, and does not look at the quality of hearing required to enjoy a good orchestra, for instance.

Relation of Hearing Loss to Noise Exposure

Baughn conducted a study in the United States in 1973 that gives strong statistical evidence in favour of an 85 dBA noise limit. A survey of 14 million people in selected industries in the States showed that at that time 1.7 million (12%) would suffer hearing impairment after 40 years of work. If a 90 dBA standard was rigorously enforced, the number would drop slightly to 1 million (7%) whilst an 85 dBA standard would reduce the number that would suffer hearing impairment after 40 years to 200,000 (1-1/2%). The maximum noise limit that would completely eliminate hearing impairment at 4 KHz (the frequency at which the ear is the most sensitive), for the median of the population, is considerably less than 85 dBA. Figure 1 shows this "no effect" level as determined by a number of recent studies.

Thiessen in his report "effects of noise on man" has carefully analyzed data relating hearing loss to noise exposure. His data are mainly based on the EPA Report on the health hazards of noise, which includes results obtained world-wide, and whose general validity and consistency were examined and weighted accordingly. Thiessen's calculation of maximum Noise-Induced Permanent Shift (NIPTS) over 40 year exposure in dB is given in Figure 2. Dr. Thiessen does not make specific recommendations in his report for an occupational noise limit, but he does strongly recommend a 3 dBA higher level for each factor of 2 reduction in exposure time (as opposed to the presently used 5 dBA).

There is at least as much evidence for 3 dBA as 5 dBA. Further the 3 dBA level represent a factor of 2 change in energy. This is supported by recommendations made by the Health and Safety Executive for British Legislation. Some assessment is made of the effect of impulse (very short duration) noise by Dr. Thiessen but, as he says, the areas of ignorance are still great.

Bruel reports in his article "Do we measure damaging noise correctly?" that in the iron and steel industry there are significant peaks of short duration noise containing a significant amount of energy in the 4-6 kHz frequency range. He suggests that since these frequencies are amplified by the outer and middle ear, this explains why hearing loss always starts in this frequency range. The impulse noises found in this industry and similar noise producing environments such as railway shops, may account for the higher risk of hearing loss than that given by the total noise exposure criterion now used.

This view is supported by the World Health Organization who recommends further research in this area.

The premise that occupational noise limits should ensure protection from any measurable degradation of hearing acuity if they are to adequately protect public health and welfare, appears a valid one.

There has been a great deal of controversy over the appropriate limits to be set, particularly in the United States. This is primarily because both the adequacy and interpretation of the scientific data have been disputed.

There is nevertheless enough evidence supporting lower occupational noise limits to make it appear worthwhile revising regulations now. More data is required to assess both the effects of impulse noise and also if there is a better way than the present noise dose criterion to protect hearing.

<u>Audiometric (hearing) testing</u> is conducted for five main reasons:

1. The identification of hearing impairment.

2. As need to the diagnosis of the problem.

3. As a guide to the management of the patient once the problem is found to exist.

4. Monitoring the hearing status of the individual.

5. Indicator of the efficacy of the hearing conservation program.

An audiometer is a frequency-compensated, audio-signal generator. It produces pure tones at various frequencies and intensities for use in measuring hearing sensitivities. It enables the measurement of the minimum audible field for each ear at certain prescribed frequencies. A typical audiogram is shown in Figure 3. The main purposes of such hearing tests are to identify existing or developing hearing impediments and to monitor the effectiveness of hearing conservation programs. The former is referred to as diagnostic audiometric testing and the latter as industrial audiometric testing.

A number of variables exist which can affect the accuracy of audiometric measurements. These are summarized in Figure 4. Not only must care be taken in the type and calibration of the equipment, but also in the test location and procedures. In particular, the instructions to the person taking the test must be carefully given. There are, however, physiological and psychological variables that cannot be controlled and which contribute to the variation in response.

Careful control of audiometric testing is necessary to provide the necessary precision by which hearing loss may be assessed. Whilst over the years this has become better understood and carefully controlled by better equipment, operator training and procedures, improvements in measurement precision are still required.

Personal hearing-protective devices are acoustical barriers that reduce the amount of sound energy transmitted to receptors in the inner ear. The sound attenuation capability of the hearing protective device at threshold may be measured by the difference (in decibels), between the threshold of audibility for an observer with hearing protectors in place (test threshold), and the measured hearing threshold when his ears are open and uncovered (reference threshold).

Hearing protective devices used today are generally inserted into the ears or ear muff types. The insert-type protector attenuates noise by plugging the external ear canal, whereas the ear muff type protector closes the auricle of the ear to provide as acoustical seal. Their effectiveness depends on several factors that are related to the way in which the sound energy is transmitted through or around the device.

In selecting a personal hearing-protective device, several design factors should be considered including the performance, comfort, communications requirements, and appearance.

There are Canadian and other standards for the measurement of the effectiveness of hearing protectors. At the moment, however, none of them adequately account for the importance of the hearing protectors fit to the ear, a subject for further studies. There is also a need for a long term study to assess the effectiveness of the use of hearing protectors in conjunction with careful audiometric testing.

Speech Interference

Speech interference is one aspect of the phenomenon of masking. Masking is an interaction of two acoustics stimuli where one of them:

1. Changes the quality of the other.

2. Shifts its apparent location or loudness.

3. Makes it completely inaudible.

Speech intelligibility and articulation index are two measures of speech interference. They provide a measure of the amount of conversation an alert listener is likely to comprehend at a certain distance. The problem with measures such as these, however is that they do not fully account for the fact that speech consists of a complicated sequence of sounds of varying intensity and frequency distribution. Since speech is not uniform, some sounds will be masked by certain sources but not others. This varies with time, as speech varies in intensity and frequency content with time even in a steady sound field.

Speech interference can be a danger - (when masking warning or emergency signals), or it can be a useful tool, such as masking systems in offices that cover up disturbing noises. It can also be a form of annoyance.

Effect of Noise on Sleep

The effect of noise on sleep is a highly important health effect. We are fortunate in that the acoustics section at National Research Council is amongst the foremost in this field. The following information is based on Thiessen's report on the "Effect of noise on man".

It is known that sleep may be disturbed by noise and that some groups (such as the old, middle-aged and sick) are particularly sensitive to these effects. Sleep is thought to be a restorative process during which the organs of the body renew their supply of energy and nutritive elements. Survey data also indicate that sleep disturbance is often the principal reason given for noise annoyance. Sleep interference thus constitutes a common health hazard.

The interference of sleep is viewed with concern by the individual and health authorities alike. The individual is aware of mainly two effects - a noise induced delay in falling asleep when first retiring, and being awakened by noise during the night.

Medical authorities know that there are different stages of sleep - usually labelled stages 1, 2, 3, 4 and 1 (REM), and that appropriate amounts of sleep are necessary. Noise may cause a shift from a deep level of sleep to a shallower one, thus disturbing the normal apportionment of each stage. Furthermore, sleep progresses during the night in a cyclical pattern consisting of about 3 to 7 cycles, depending on the individuals. Noise may disrupt the cyclical pattern of sleep. Some believe that interferring with this cyclical pattern is in itself deleterious.

In order to monitor sleep in detail, sleep laboratories, such as that at the National Research Council, use the electroencephalograph to monitor sleep. Two or more electrodes are attached to appropriate parts of head and the electrical signal from these are recorded on a chart recorder or on magnetic tape, and these signals may be analyzed by eye or computer. In this way the aforementioned effects of noise on sleep continue to be quantified by laboratories in greater detail.

Non-Auditory Physiological Responses

There is a substantial body of data indicating that noise may have non-auditory physiological effects. The major effect of noise in this area is as a general biological stressor. Significant adverse health consequences are produced by cardiovascular and endocrine effects. Major cardiovascular diseases account for over half of all deaths in North America and noise-induced stress is a contributing factor. A retrospective study carried out in the United States by NIOSH (1973), of medical records of workers for a 5 year period 1966-1970 (Figure 5) indicate a substantial increase in diseases for workers in a high noise environment compared to workers in a low noise environment. There is however, at present, a lack of conclusive evidence for these effects at noise levels of less than those which will cause hearing loss. Further research is required in this area to establish the impact on society.

Annoyance and Other Psychological Effects

Although a highly important area of the effects of noise, this subject is beyond the scope of this paper, which is restricted to more direct effect of noise on health.

Summary

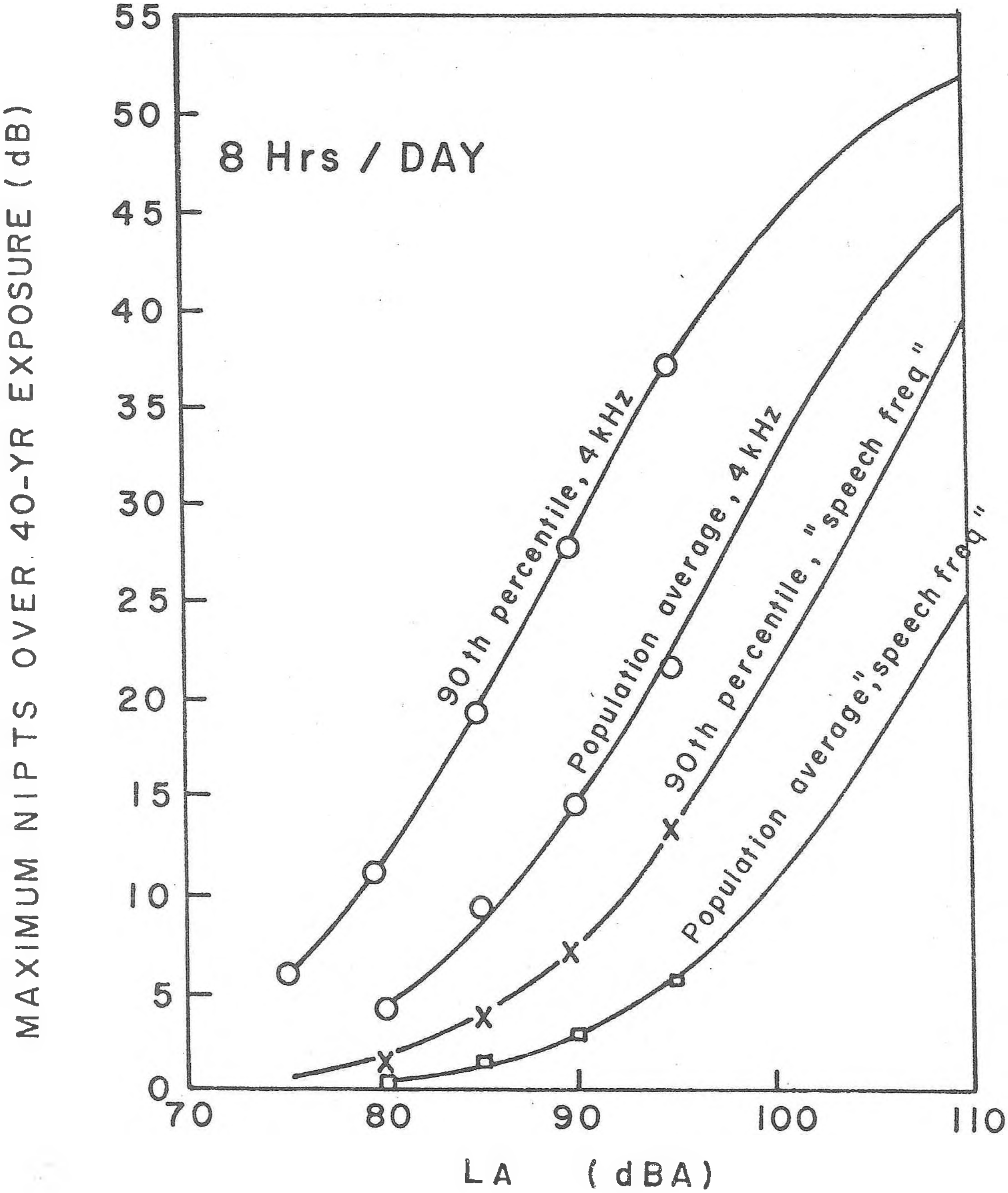
This paper has attempted to summarize the major health effects of noise. It is proposed that there is a great need for health criteria, coordination of Federal noise control programs, revision of present legislation and suggesting areas in which new legislation should be presented. It would seem appropriate that the Department of National Health and Welfare should provide basic health criteria in both occupational and environmental noise. Since noise legislation is enacted primarily to reduce adverse health effects, this would assist in providing coordination in Canadian noise control programs.

"NO EFFECT" LEVEL OF NOISE

(AT 4 KHz FOR THE MEDIAN OF THE POPULATION)

W. BURNS AND D.W. ROBINSON	78 dBA
W.L. BAUGHN	78 dBA
PASSCHIER - VERMEER	76 dBA
D. WARD ET AL	81.5 dBA
G. THIESSEN	72 dBA

Figure 1



8 Hrs / DAY
MAXIMUM NIPTS OVER 40-YR EXPOSURE (dB)
0
5
10
15
20
25
30
35
40
45
50
55
70
80
90
100
110
LA (dBA)
90th percentile, 4 kHz
Population average, 4 kHz
90th percentile, "speech freq"
Population average, "speech freq"

Figure 2

AUDIOGRAMS

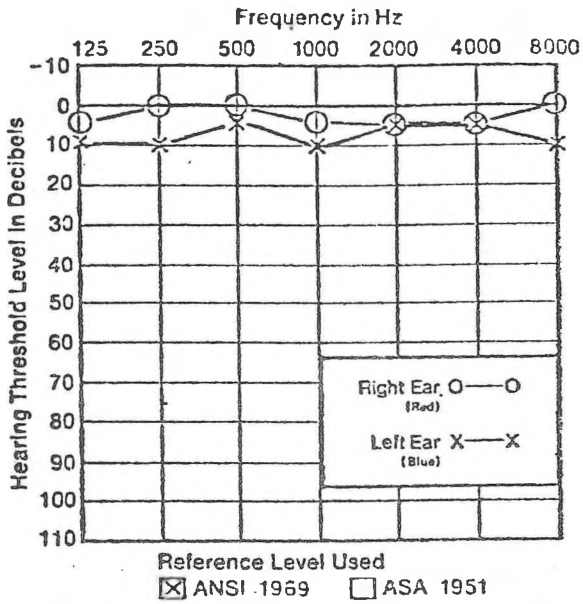


FIG. 25–1.—A typical manual audiogram showing hearing thresholds within the normal range.

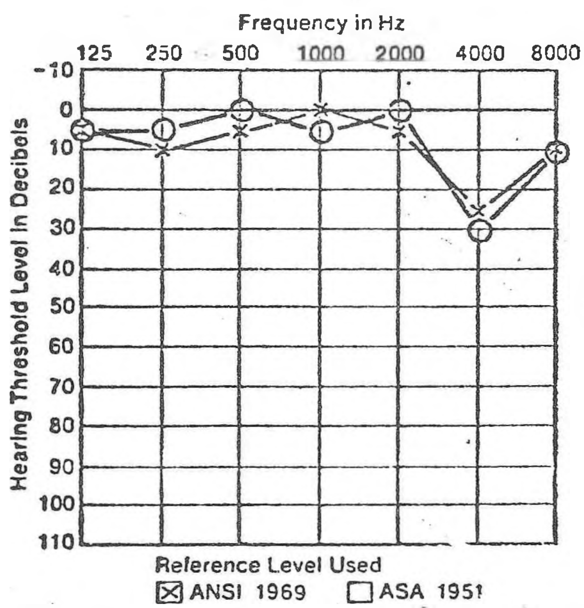


FIG. 25–2.—A typical manual audiogram that was taken immediately after the employee was exposed to excessive noise. Compare the hearing threshold levels shown here with those plotted on the audiogram shown in Figure 25–1. Note the sharp drop at 4000 Hz.

Figure 3

Causes Of Audiometric Changes

Physical Variables

Improper placement of earphones
Ambient noise levels in test room
Equipment variables, such as accuracy of attenuator steps, type of earphone cushions, hum, noise, etc.

Physiological Variables

Age and sex
Pathology of the auditory organs
General health of subject
Temporary threshold shift
Tinnitus and other head noises

Psychological Variables

Motivation of subject
Momentary fluctuations of attention
Attitude toward the test situation
Personality attributes
Intellectual factors
  Comprehension of instructions
  Experience in test taking of any sort
Response conditions
  Type of response required of subject, i.e., button pressing, finger raising, verbal response, etc.

Methodological Variables

Testing technique used
Time interval between successive tests
Instructions to subjects
Order of presentation of frequencies

Figure 4

NUMBERS OF DIAGNOSED DISORDER BY MEDICAL CATEGORY
FOR WORKERS IN HIGH AND LOW NOISE GROUPS FOR
5 YEAR PERIOD 1966-70

CATEGORY OF DIAGNOSED DISORDER	NUMBER AFFLICTED		NUMBER OF OCCURRENCES	
	HIGH NOISE	LOW NOISE	HIGH NOISE	LOW NOISE
RESPIRATORY	331	146	2152	590
ALLERGENIC	196	86	358	118
MUSCULO/SKELETAL	75	31	104	47
CARDIOVASCULAR	64	37	114	70
DIGESTIVE	50	21	66	30
GLANDULAR	39	10	48	14
NEUROLOGICAL	34	11	49	29
UROLOGICAL	29	14	40	15

Figure 5