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# acoustics and noise control in canada

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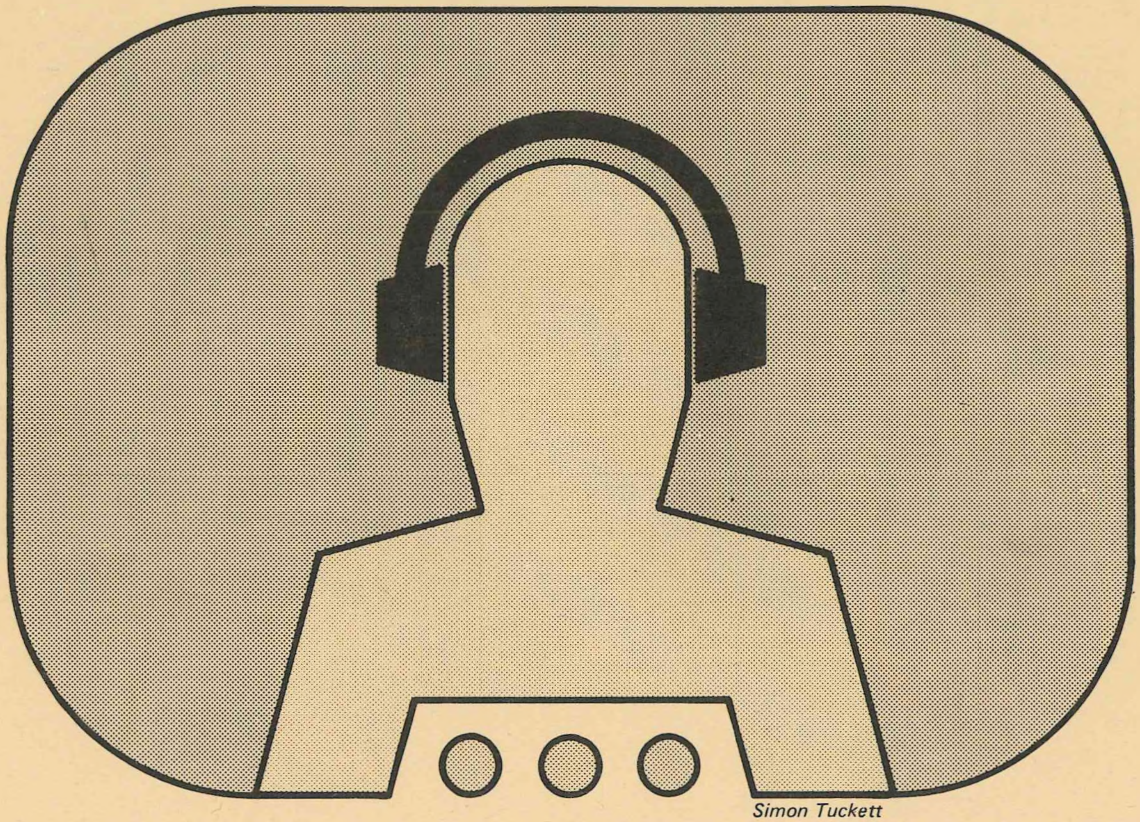
# l'acoustique et la lutte antibruit au canada





Simon Tuckett

**acoustics and noise control in canada**

The Canadian Acoustical Association
P.O. Box 3651, Station C
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l'acoustique et la lutte antibruit au canada

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## EDITORIAL

In this issue we have an article by Edgar Shaw on the acoustics facility in the division of Physics at National Research Council, Ottawa. This is the first in a series of articles on acoustics facilities in Canada. We hope in this way to inform our readers of the diverse pool of acoustics expertise in Canada and at the same time give some historical background. A forthcoming issue will carry an article on the noise and vibration facility in the division of Building Research at National Research Council.

In addition, your attention is drawn to the paper by Raymond Hetu entitled "Pourquoi effectuer des examens audiometriques en usines bruyantes" (Why conduct audiometric tests in noisy industries). The author particularly requests feed-back and comments on this paper (in French or English). We urge that all of you in the field that can read French oblige.

NOTE: We have a new address for subscriptions, see page 52.

## EDITORIAL

Dans ce numéro paraît un article par Edgar Shaw sur le Laboratoire de L'Acoustique, Division de physique, Conseil national de recherches, Ottawa. Cet article est le premier d'une série d'atticles sur des Laboratoires de L'acoustique au Canada. Nous espérons que cette serie nous permet de renseigner nous lecteurs sur les diverses activités en acoustique à travers le Canada et d'exposer quelques faits historiques sur ces laboratories. Prochainement, nous publierons un article sur le Laboratoire du Bruit et des Vibrations, Division du Batiment, Conseil national de recherches, Ottawa.

En plus, nous aimerions attirer votre attention à l'article entitulé "Pourquoi effectuer des examens audiométriques en usines bruyantes", par R. Hétu, publié dans ce numero. L'auteur est particulièrement interessé à recevoir des commentaires en anglais ou en français.

NOTE: Nous avons une nouvelle adresse pour L'abonnement, voir page 52.

## NEWS

### HAND-ARM VIBRATION SYMPOSIUM

The Third International Symposium on Hand-Arm Vibration is to be held in Ottawa from May 18-20, 1981, at the Chateau Laurier Hotel. The Symposium will be concurrent with the 101st meeting of the Acoustical Society of America. The Symposium will provide an international forum for the presentation and discussion of recent research on all aspects of hand-arm vibration, and will be the first on this subject in Canada. Its purpose is to clarify the risks associated with existing power tools, to assist the formulation of exposure limits and design goals for future tools, to improve measurement techniques and to stimulate further research. Approximately 50 papers on all aspects of Hand-Arm Vibration have been contributed.

Registration commences on Sunday, May 17, 1981, at 4:00 p.m. and Technical Sessions commence on Monday, May 18, 1981, at 9:00 a.m.

The registration fee is $75.00. To obtain a copy of the final programme please contact: - A.J. Brammer, Division of Physics, National Research Council, Montreal Road, Ottawa, Ontario, K1A 0R6. Telephone (613) 993-2840.

## INTERNATIONAL CONGRESS ON ACOUSTIC INTENSITY MEASUREMENT - CALL FOR PAPERS

C.E.T.I.M. (Centre Technique des Industries Mecaniques Senlis) has issued a Call for Papers for the "International Congress on Recent Developments in Acoustic Intensity Measurement", to be held in Senlis, France, September 30 to October 2, 1981. The Scope of the Congress is as follows: - "In all conventional measurement techniques energy flow is inferred from pressure (as to contrast with intensity) but the advent of new techniques now allows the direct measurement of energy flux. The principle of acoustic intensity measurement has been known since half a century but realization of practical instruments has taken place significantly only in the last decade because of recent innovation in electronics. The application of these techniques includes sound power calculation, source localization, transmission loss determination, etc. The aim of this congress is to stimulate the exchange of ideas among research workers as well as to give information to potential users." All correspondence should be directed to M. Bockhoff, C.E.T.I.M., B.P. 67, F60304, Senlis, France. Tel: (4) 453-32-66.

## CONGRES INTERNATIONAL DANS LA MESURE DE L'INTENSITE ACOUSTIQUE

C.E.T.I.M. (Centre Technique des Industries Mécaniques Senlis) a publié un Appel aux Communications pour le "Congrès International sur Les Progrès Récents dans la Mesure de L'Intensité Acoustique", Il se tiendra à Senlis, France, le 30 septembre au 2 octobre, 1981. L'objectif du Congres est le suivant: - "Dans les méthodes classiques de mesure l'énergie acoustique est généralement déduite de la pression acoustique (au lieu de l'intensité); l'apparition de nouvelles techniques permet maintenant d'accéder directement au flux d'énergie. Le principe de la mesure directe de l'intensité acoustique est déjà connu depuis un demi-siècle, mais les progrès dans la miniaturisation des composants électroniques ont permis, depuis environ 10 années seulement, de réaliser les premiers appareils opérationnels. Parmi les applications de ces techniques, on peut citer notamment : la détermination de puissance acoustique, la localisation de sources, la mesure de l'indice d'affaiblissement acoustique. Le but de ce congrès est double : donner aux spécialistes la possibilité d'échanger leurs connaissances et informer les utilisateurs potentiels de l'industries. Pour tous renseignements, s'addresser a : M. Bockhoff, C.E.T.I.M., B.P. 67, F60304, Senlis, France, Tel : (4) 453-32-66.

## NOISE POLLUTION PUBLICATIONS - ABSTRACTS

This monthly abstracting index to the World's English language literature on noise pollution, noise abatement and control, and noise pollution effects, is now being published (Vol. 1, no. 1, January 1981). It is available at a yearly subscription rate for 12 monthly issues of $100 (U.S.), from 12614 E. Park Street, Cerritos, California 90701, U.S.A. The editor is Richard L. King.

## NEW RESEARCH CONTRACTS

To Scannar Limited, Cornwall, Ont., $27,000 for "Development, design, fabrication and testing of a sonar transducer for gated doppler current meter to be used for oceanographic research". Awarded by the Department of Fisheries and Oceans.

NOISEXPO '81

Noisexpo '81, the National Noise and Vibration Control Conference and Exhibition will be held at the Hyatt Regency O'Hare, Chicago, Illinois, April 6-9, 1981. For further information phone (216) 835-0101.

M.I.T. SUMMER SESSIONS

The Massachusetts Institute of Technology is running 2 summer sessions on acoustics. One is "Fundamentals of Noise and Vibration Control", June 22-26, 1981, Tuition $900 (U.S.). The other is "Foundations of Engineering Acoustics", August 10-21, 1981, Tuition $1,250 (U.S.). For further information contact the M.I.T. Office of the Summer Session, Room E19-356, M.I.T., Cambridge, Mass. 02139, U.S.A. Telephone (617) 253-2101.

1981 IEEE ULTRASONICS SYMPOSIUM

The Sonics and Ultrasonics group of the Institute of Electrical and Electronic Engineers, Inc., has issued a Call for Papers for the 1981 IEEE Ultrasonics Symposium to be held at the McCormick Inn, Chicago, Illinois, October 14-16, 1981. The deadline for the receipt of Abstracts is June 15, 1981. For further information contact William D. O'Brien Jr., Bioacoustics Research Lab, University of Ullinois, Urbana, Illinois, 61801, U.S.A.

11th I.C.A. ANNOUNCEMENT/
L'ANNONCE DE L' 11ème C.I.A.

The 11th International Congress on Acoustics will take place in Paris, France, during the month of July 1983. The congress will cover all fields of acoustics and will be preceded and followed by Satellite Symposia, organized in various cities such as Lyon, Marseille, Toulouse./ Le 11ème Congrès International d'Acoustique se tiendra en France, à Paris, dans le courant du mois de juillet 1983 et il couvrira tous les domaines de l'Acoustique. Il sera précédé et suivi de Colloques Satellites qui seront organisés dans diverses grandes villes telles que Lyon, Marseille, Toulouse.

For more detailed information write to the following address: 11ème Congrès International d'Acoustique, Secrétariat du Groupement des Acousticiens de Langue Française (G.A.L.F.), C.N.E.T. - B.P. 40, 22301 Lannion cédex (France).

NOISE-CON 81

Applied noise control technology is the theme of Noise-Con 81, the fifth National Noise Conference sponsored by the Institute of Noise Control Engineering/USA and North Carolina State University. Noise-Con 81 will be held 8 through 10 June 1981 at the Jane S. McKimmon Center for Extension and Continuing Education on the campus of North Carolina State University, Raleigh, North Carolina. The technical program will emphasize the practical application of noise control in general industry and advances in noise control by traditional methods. An opening plenary session on the current status of noise control regulations and a session on community noise problems and solutions will also be included.

For further information write: Noise-Con 81, North Carolina State Unveristy, Division of Continuing Education, Post Office Box 5125, Raleigh, North Carolina 27650, Attn: Alice Strickland, Telephone: (919) 737-2261.

The Noise-Con Seminar, a special course on the fundamentals and applications of noise control technology, will be held prior to Noise-Con 81, from 4 through 6 June 1981, at the Mission Valley Inn and Conference Center in Raleigh, North Carolina. For further details write: Noise-Con Seminar, Institute of Noise Control Engineering, Post Office Box 3206, Arlington Branch, Poughkeepsie, New York 12603, Telephone: (914) 462-6719.

INTERNATIONAL INCE NEWS

Dr. Eric Rathe has resigned from the position of Secretary-General of I/INCE after 6 active years in the position. Professor H. Myncke has taken his place as Secretary-General. He will be assisted by Dr. A. Cops who has become editor of the I/INCE newsletter.

INTERNATIONAL STANDARDS WORKING GROUP MEETING TO BE HELD IN OTTAWA

Meetings of 4 International Standards Organization (ISO), and 1 International Electrotechnical Commission (IEC), Working Groups are scheduled to be held in Ottawa, May 25-29, 1981, following the spring meeting of the Acoustical Society of America. These meetings consist of small groups of technical experts from various countries who work together under the direction of a working group convenor to formulate draft international standards. These draft standards are then circulated for comment and voting by each international member country. The meetings are by invitation. A list of the titles of the groups' meeting and their Canadian participants follows:

ISO/TC43/SC1/WG1 - "Threshold of hearing", R.B. Johnston, Electromedical Instrument Co., Box 940, Oakville, Ont., L6J 5E8, Tel: (416) 845-8900.

ISO/TC43/SC1/WG3 - "Audiometry", R.B. Johnston, Electromedical Instrument Co., Box 940, Oakville, Ont., L6J 5E8, Tel: (416) 845-8900.

ISO/TC43/SC1/WG18 - "Environmental Noise", H.W. Jones, Engineering Physics Dept., Dalhousie Univ., Halifax, N.S., B3H 3J5, Tel: (902) 424-2344.

ISO/TC43/SC1/WG19 - "Occupational Noise", D.A. Benwell, Health and Welfare Canada, Rm. 233, E.H.C., Tunney's Pasture, Ottawa, Ont., K1A 0L2, Tel: (613) 995-9801.

IEC/SC29C/WG17 - "Mechanical Coupler for Calibrationof Bone Vibrators", No Canadian participant.

## JOBS WANTED

JERZY METELSKI is looking for a position in the field of acoustics and vibrations. He has a Ph.D. in mechanics from the Institute of Fundamental Technological Research (Warsaw) and a M.Sc. in electroacoustics from Warsaw Technical University. Experience in industrial noise and vibration analysis and control with particular emphasis on impulse and impact noise. Familiar with computer data processing. He has conducted and supervised many acoustical consulting projects in different branches of industry: metallurgy (foundry), automobile, chemical. Please contact applicant directly, c/o Mr. C. Zawitkowski, 511 The West Mall, #1411, Toronto, Ont., Tel: (416) 622-9628.

VLASTIMIL CHVOJKA is looking for a suitable position in acoustics. He has a degree in electrical engineering from the Czech Technical University of Prague and the equivalent of a Ph.D. in science education from Vuzork, an audio-visual research institute in Prague. The subject of his thesis was "Modelling of Traffic Noise Propagaton", and in the course of this work he designed and constructed a measuring laboratory for modelling traffic noise in the scale 1:40. For further information please contact Mr. Chovka directly, c/o B. Krivsky, Res. Trocadero, 10 sq. Poussin, Parly-2, 78150, Le Chesnay, France.

## POSITION AVAILABLE

SENIOR ELECTRICAL ENGINEER with ultrasonic transducer signal processing experience. The individual should be capable of high level analog system design for processing ultarsonic signals.

Apply to: -
Personnel
D.G. Instruments Ltd.
308 Leggett Drive
Kanata, Ontario, K2K 1Y6
Telephone: (613) 592-3141.

## C.A.A. - 1981 CONVENTION NEWS / NOUVELLES DE CONVENTION

### CALL FOR PAPERS

The Canadian Acoustical Association announces a call for papers for their annual symposium on October 8-9, 1981, at the Chateau Lacombe in Edmonton, Alberta.

The Symposium brings together individuals concerned with acoustics and related fields from across Canada and elsewhere. It provides an opportunity to discuss mutual concerns and present problem solutions.

Papers are invited on all aspects of acoustics and noise control including:

- Transportation Noise
- Industrial Noise & Vibration
- Speech Communication
- Audiology
- Architectural Acoustics
- Government Standards
- Current Research

Abstracts of about 100 words, suitable for publication in the program should be submitted immediately to Dr. G. Faulkner, Dept. of Mechanical Engineering, University of Alberta, Edmonton, Alberta. T6G 2G8. Telephone: (403) 432-3598.

### SOUMISSIONS DE RAPPORTS

"L'Association Canadienne de l'Acoustique" vous rappel de soumettre vos rapports pour le recueil annuel, qui aura lieu les 8 et 9 Octobre 1981, au Château Lacombe à Edmonton, en Alberta.

Le recueil annuel réuni les individus de partout au Canada et ailleurs qui sont intéressés dans les matières acoustique et aux domaines connexes. Cette rencontre donne la chance de discuter des problems mutuels et à en trouver des solutions.

Tous les rapports au sujet des aspects de l'acoustique et la lutte contre le bruit sont les bienvenus. Exemples:

- Bruit de Transport
- Bruits et Vibrations industriels
- Communication verbale
- Audiologie
- Architecture Acoustique
- Normes Gouvernementales
- Recherche Courante

Tous résumés (d'environ 100 mots) convenable pour publication dans le programme devraient être soumis immediatement au Dr. G. Faulkner, of Mechanical Engineering, University of Alberta, Edmonton, Alberta. T6G 2G8. Telephone: (403) 432-3598.

## CONVENTION NEWS

The CAA-81 convention will be held this year in Edmonton, Alberta, on October 8 and 9. Immediately preceding the convention on October 5, 6 and 7, two three-day courses on noise control are being planned, one for environmental noise and one for machinery noise.

The first is directed towards planners, developers, architects, engineers, and municipal authorities. The second is directed towards engineers and designers in industry.

On Wednesday, October 7, the noise and vibration committee of the Canadian Standards Association will hold their meeting at the same location.

The annual general meeting of the C.A.A. and a banquet will be held on Thursday evening, October 8.

All sessions will be held at the Chateau Lacombe Hotel in Edmonton. Convention room rates are in effect for all attendees at all sessions.

The convention committee is attempting to have special air fare packages available for those who book early.

For information, contact E. Bolstad, Box 5768, Station L, Edmonton, T6C 4G2. Telephone: (403) 465-5317.

## TOUR NEWS

The CAA-81 convention committee has made arrangements for a post-convention tour of the Jasper-Banff national park areas.

The tour will leave Edmonton Friday afternoon, October 9, stopping in Jasper overnight. Saturday will include visits to highlight points along the Jasper-Banff highway, such as Athabasca Falls, Columbia Icefields, Peyto Lake, etc. Overnight at a marvelous chalet in a mountain setting.

Sunday will be spent touring Lake Louise and Banff, ending in Calgary overnight.

Monday morning will include a tour of Calgary highlights, with the option to quit the tour here or return to Edmonton Monday afternoon.

It is imperative that interested persons should make reservations very early. For complete information package, contact E. Bolstad, Box 5768, Station L, Edmonton, T6C 4G2. Telephone: (403) 465-5317.

# REPORT ON ENVIRONMENTAL NOISE IN ONTARIO

# WITH REFERENCE TO HEALTH RELATED EFFECTS

The Noise Pollution Control Section, Ontario Ministry of the Environment, has received a new report on environmental noise in Ontario with reference to health related effects. This $65,000 study was funded in 1978 under the Provincial Lottery Trust Fund and the principal investigators were J. R. Hemingway/(416) 675-3983/and Dr. P. J. Dickinson/(801) 290-3465/. The project managers were SNC/GECO in Toronto. The major conclusions are:-

- Conclusive evidence regarding health effects of environmental noise is lacking. The main body of research has been concerned primarily with effects on human welfare rather than health.

- Because of confidentiality practices recently imposed by government agencies and medical practitioners in Ontario, direct correlation of health effects to noise could not be carried out as originally expected. As a result of this impasse, the study team was unable to determine whether or not environmental sound levels might have an effect on health.

- The audiometric survey did not produce sufficient evidence to indicate that environmental sound levels in the selected areas were a cause of hearing loss. Conversely, there was also no proof that these noise levels do not cause hearing loss.

- Regarding the rating of aircraft noise, no reasons could be found for rating this noise source differently to any other noise source.

- While Leq was found to be the most acceptable universal noise descriptor, it was found that Leq tends to under-emphasize continuous sounds from heavy traffic or steady industrial noise. The study indicated that a better solution lies in changing the trade-off relationship inherent in Leq. Instead of averaging energy or pressure squared, it was felt more appropriate to average simple pressure. This would correct the tendency to under-emphasize long duration sounds without any increase in complication over Leq itself.

- Analysis of the social survey responses indicated that environmental sound levels were perceived as resulting in increased drug purchases and to a lesser extent difficulty in hearing and sleep interference. Near continuous noise such as highway noise, in general, gave stronger indications of these responses than intermittent sounds such as train pass-by noise.

- The final conclusion was that a fixed difference between day and night sound levels (weighting) does not result in an equal response. Noise rating schemes such as Ldn are not wholly supported by this work.

Single free copies may be obtained from John Manuel, Supervisor, Noise Pollution Control Section, Ontario Ministry of Environment, Toronto, M4V 1P5.

J. Manuel

# THE ACOUSTICS SECTION: A PROFILE OF THE LABORATORY

by

Edgar A.G. Shaw
Division of Physics, National Research Council of Canada,
Ottawa K1A OR6

When Editor Deirdre Benwell invited me to open this series, my first inclination was to offer a simple account of our tasks and responsibilities. On reflection, however, it became apparent that a narrative which failed to bring out the philosophy and style of a scientific institution would miss the mark. That is why I have gone back to our roots and provided some context to frame the diverse activities in which we have engaged over the years.

The first Director of the Division of Applied Physics was Dr. Robert W. Boyle who was born in Newfoundland and educated at McGill University where he was the first recipient of a Ph.D. in physics from that illustrious institution. In 1929, when he gave up his position as Dean of Applied Science at the University of Alberta to join NRC, he brought with him a strong interest in ultrasonics thereby opening a line of research activity in acoustics which has continued unbroken ever since. One year later his young assistant Dr. George S. Field (later Chief Scientist of the Defence Research Board) was invited to form the Acoustics and Ultrasonics Section which developed slowly during its first decade and made important contributions to the war effort between 1940 and 1945 (See W.E.K. Middleton, Physics at the National Research Council of Canada 1929-1952, Wilfrid Laurier University Press, 1979). Dr. Thomas D. Northwood joined the Section in 1940 and later headed a new laboratory within the Division of Building Research devoted to building acoustics. This will be the subject of a later article.

It was Dr. George J. Thiessen, Section Head from 1950 to 1975, who rebuilt the AcousticsSection during the post-war years and charted the course we follow today. It is a course which has crossed many areas of acoustics over a thirty-year period including, for example ultrasonic absorption and hypersonic light scattering in liquids, radiation pressure, elastic waves in solids, sound-generating mechanisms in machinery especially suction rolls, blowers and compressors, the effects of sound on birds, hearing protector design, the acoustics of circumaural earphones, the design of acoustical instruments, hearing threshold measurements and physiological noise. Throughout this period the primary purpose has been to direct attention to scientific areas and specific problems in acoustics which are of substantial economic or social significance in Canada. In terms of the National Research Council mandate this means acoustics related to health, the environment, industrial technology and standards. The predominant style of research in the laboratory is strongly rooted in physics, interweaves experiment with theory, focusses on strategic scientific questions, searches for underlying mechanisms and emphasizes economy of method.

The major health effect of sound is, of course, noise-induced hearing loss. Unfortunately, the ability to detect the onset of this insidious occupational disease is severely limited by the accuracy of conventional audiometric measurements in the critical high frequency region. Our work on the ear was initially inspired by this problem but has proved equally relevant to the measurement of noise exposure, the spatial perception of sound and the design of hearing aids. The tasks undertaken during the past decade include the "decoding" of the external ear in terms of its normal modes, directionality, radiation impedance and diffuse-field response, the building of physical models of the ear, the simulation of eardrum impedance, the calibration of high fidelity earphones and the measurement of noise-exposure with an "in-ear" microphone. Our current work in this field is concerned with the role of the eardrum and the flow of energy through the middle ear. We are also hoping to start new work on hearing protection inspired by contemporary industrial needs.

Another important health effect, vibration-induced white finger, is an industrial disease associated with occupations requiring the use of hand-held vibrating tools such as chain saws and grinders. For several years our laboratory collected, sifted and analyzed scanty data from several countries in an attempt to establish a firm relationship between the sensation-weighted vibration level, the years of occupational exposure and the incidence of selected symptoms. This goal has now been reached clearing the way for an attack on the sources of vibration, the tools themselves. Some preliminary work on the behaviour of anti-vibration tool handles was in fact undertaken several years ago but a major effort is required if we are to bring the input of vibrational energy to the hands under adequate control. This field was reviewed last October in Montreal at a Seminar on Occupational Exposure to Noise and Vibration, jointly organized by the Division of Physics and the Radiation Protection Bureau of Health and Welfare Canada in Montreal, and is the subject of an International Symposium to be held in Ottawa in May 1981.

About fifteen years ago a steady stream of enquiries from municipalities and provinces across the country persuaded us to shift much of our effort towards the support of community noise control. Since motor vehicle noise was known to be predominant in most cities, we began to collect statistical information on source strength for the various classes of vehicle and to develop mathematical models for the "ideal" city. It soon became apparent that the steady-state noise levels which we observed at our homes in Ottawa could not always be reconciled with the source data, a finding which foreshadowed the need to reexamine almost every accepted tenet of sound propagation outdoors. At the outset, to account for the absorption of sound in air at frequencies below 2 kHz, which are predominant in urban noise, we found it necessary to include the effect of the vibrational relaxation in nitrogen. This change in long-accepted theory was recently embodied in a new ANSI Standard which is a key document in the interpretation of aircraft noise measurements. Managers of mission-oriented research may note that this important discovery was inspired by the insights gained from our earlier activities in a very different field, ultrasonic absorption in liquids.

Our decade of work on sound propagation outdoors has embraced such major themes as the theory and measurement of sound propagation over an impedance boundary, the effects of refraction due to wind and temperature, the effects of atmopheric turbulence and the diffraction of sound by simple barriers. These themes have been tightly interwoven with a steady stream of applications such as the effect of sloping terrain on sideline noise at Vancouver International Airport, the variability of motor vehicle test site measurements and the performance of highway barriers. Our current work in this field is concerned with a fundamental limitation in diffraction theory which only came to light last year and seems to be associated with wave-front curvature.

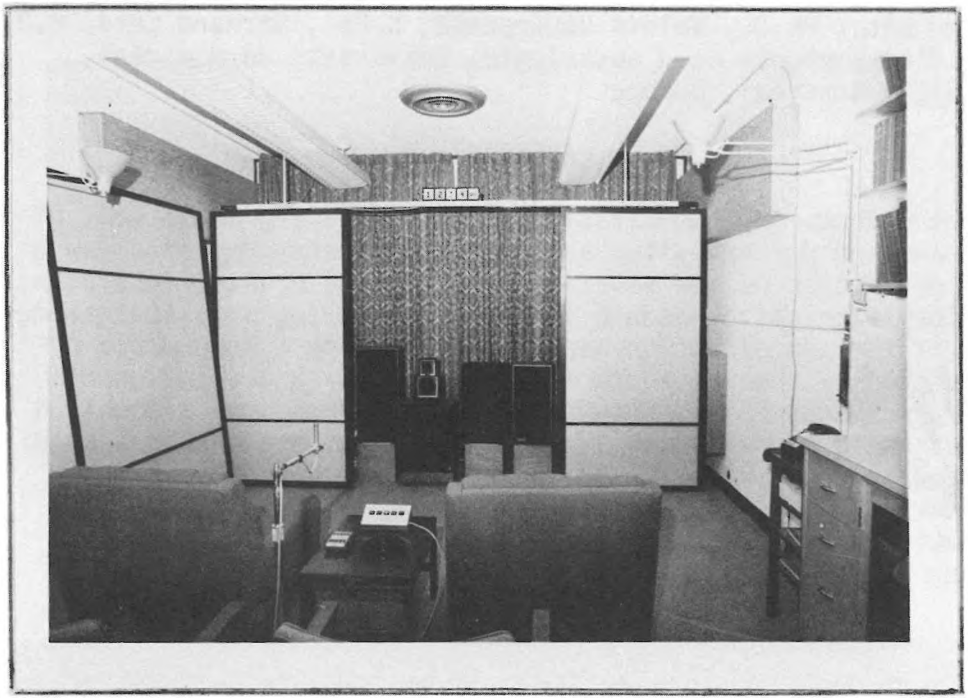
Fifteen years ago there was very little quantitative information about sleep disturbance which is generally recognized as one of the more important effects of urban noise. The sleep project was designed to fill this gap in a systematic way. Over a twelve year period (1968-1980) nearly 120 subjects participated in a series of experiments during which more than 1900 nights of sleep were measured in the laboratory. In all of these experiments the patterns of noise exposure were controlled and the sleep levels were monitored by means of electrical signals from the brain received by an electroencephalograph and recorded on magnetic tape. The results of this work are presented in a series of papers some which have already been published while others are in preparation.

During the late sixties the snowmobile, a spectacular new noise source with a strong attachment to Canada, appeared on the scene and soon achieved notoriety in environmental acoustics. In a few short weeks the laboratory took note of this problem, analyzed the noise-generating mechanisms in a typical machine, measured the levels from many others and issued a report outlining the measures needed to produce quieter vehicles. This document, which included a salutary appendix on noise-induced hearing loss, was clearly a landmark in the field.

It was by then apparent that machines powered by small internal combustion engines, such as motorcycles, lawnmowers and chain saws, accounted for a significant component of community noise in suburban areas. They were also more difficult to quieten than larger machines due to limitations in weight and size. In response to this problem, one of our current tasks is concerned with the fundamental mechanisms of exhaust noise generation and radiation in small single-cylinder engines of the types and sizesused in chain saws.

Ten years ago it would have been hard to find a Canadian-made high-fidelity loudspeaker system. Today more than half of the market is served by Canadian manufacturers. Whatever the reasons for this dramatic change, there can be no doubt that the industry is strongly supported by the studies of auditory processes, and physical factors related to the quality of reproduced sound, and the development of physical measurements, listening tests, interpretive methods and design techniques undertaken in the Acoustics Section during the past fifteen years. These activities also encompass the design of listening rooms, the reproduction of sound in centres for the performing arts, and the development of measurement techniques for earphones, phonograph pickups and turntables. In 1979, as a contribution to the work of the International Electrotechnical Commission, the laboratory assumed a major role in the development of draft standards on loudspeaker measurements and listening tests. The room shown in the photograph which accompanies this article is, in fact, the prototype international standard listening test room. Superficially, it resembles a conventional living room, but it is distinguished by exceptional control over the frequencies, pressure distributions and damping factors of the room modes without which consistent testing would be exceedingly difficult.

Increasingly statutes, regulations and international contracts require acoustical measurements which are traceable to the national laboratory. To meet such needs a highly accurate microphone comparison system has been built and a primary calibration system of exceptional quality is nearing completion in our laboratory. At the same time we are closely examining the performance of conventional sound level meters and various kinds of integrating instruments which are now coming into general use. It is now clear that factors such as the detector characteristics, (e.g. crest factor), the instrument time constants and the tolerances on the weighting networks and overall frequency response can cause errors which are much greater than those which would be inferred from the instrument specifications. To help solve these problems we are working closely with the IEC and ANSI Committees which are active in this field. More generally, we are finding it necessary to devote an increasing proportion of our effort to the scientific support of national and international standards activities which often provide the channels through which ideas and discoveries are translated into action. It should perhaps be added that the study of sound level measurement techniques has yielded several bonuses especially the development of a miniature sound level meter, now in production on a small scale, and a precision measuring amplifier with a remarkably large dynamic range.



NRC International Standard Listening-Test Room

Looking into the future, it is safe to predict that a higher proportion of our work will be associated with the needs of Canadian industry. These include the need to design quiet and vibration-free machinery meeting acceptable health and environmental goals and, incidentally, securing competitive positions in international markets, the need for innovative products and services related to fields such as speech communication, image formation, control systems, industrial processing and non-destructive testing, and the need for highly sophisticated measurement techniques commensurate with the wide variety of problems which can be anticipated during the nineteen eighties.

The Acoustics Section enters 1981 with a permanent staff of eight scientists (A.J. Brammer, R.J. Donato, T.F.W. Embleton, J.E. Piercy, E.A.G. Shaw, M.R. Stinson, F.E. Toole and G.S.K. Wong) and four technical officers (A. Hellard, A.C. Lapointe, R. St. Denis and M.M. Vaillancourt). Also, our effort is frequently augmented and the laboratory enriched by the presence of one or two visiting scientists, research fellows and students.

In addition to the listening room already mentioned, our special facilities include a sound-insulated anechoic chamber and a recently-completed measurement laboratory which features a clear space with principal dimensions exceeding 7 m. Measurements in this space will be made with advanced techniques such as time-domain spectrometry, impulse and correlation methods. With these techniques we expect to be able to make measurements which, in an earlier day, would have required a very costly and less convenient anechoic chamber.

# TOWARDS AN EPIDEMIOLOGICAL PROCEDURE FOR THE CLASSIFICATION OF RESULTS FROM SCREENING AUDIOMETRY AMONG NOISE EXPOSED WORKERS

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ABSTRACT

Current methods for the classification of hearing impairment of noise-exposed workers using screening audiometry do not allow a clear definition of the severity of the noise problem in a plant. An epidemiological procedure is proposed relying on a statistical index of the age effect on hearing sensitivity. An example of application of the procedure is presented for a population of foundry workers. It is shown that a worker has approximately 4 chances in 10 of suffering from a significant hearing loss when employed in this plant for 15 years. The reliability of the procedure is discussed in terms of the size of the target population and the influence of extra-occupational sources of hearing loss.

SOMMAIRE

Dans l'état actuel des pratiques, les méthodes de classification des résultats d'examens de dépistage de la surdité professionnelle ne permettent pas de définir clairement l'ampleur du problème du bruit d'une usine donnée. Une méthode épidémiologique fondée entre autres sur les effets de l'âge sur l'acuité auditive est proposée. Un exemple d'application de la procédure est présentée sous la forme d'un bilan collectif d'une population de travailleurs d'un complexe sidérurgique. Le bilan montre qu'en moyenne un travailleur a approximativement 4 chances sur 10 d'être atteint d'une perte auditive significative due au bruit de l'usine après 15 années de travail. La fiabilité de la procédure est discutée en fonction de l'effectif de la population cible et de l'influence des facteurs extra-professionnels de détérioration de l'audition.

## Introduction

It has been shown recently that the effectiveness of monitoring audiometry for secondary prevention of occupational hearing loss is seriously limited (1). This fact underlines the importance of a highly efficient use of the results of the very first hearing test performed on an industrial population. In this context, identification audiometry should actually aim at determining the severity of the noise problem or at verifying the effectiveness of a primary prevention program (noise control).

However, current methods for the classification of hearing impairment of noise-exposed workers, using screening audiometry, do not effectively serve such goals. Present classification relies on two sets of criteria: the first one relies on medico-legal definitions of hearing impairment (e.g., an average loss greater than

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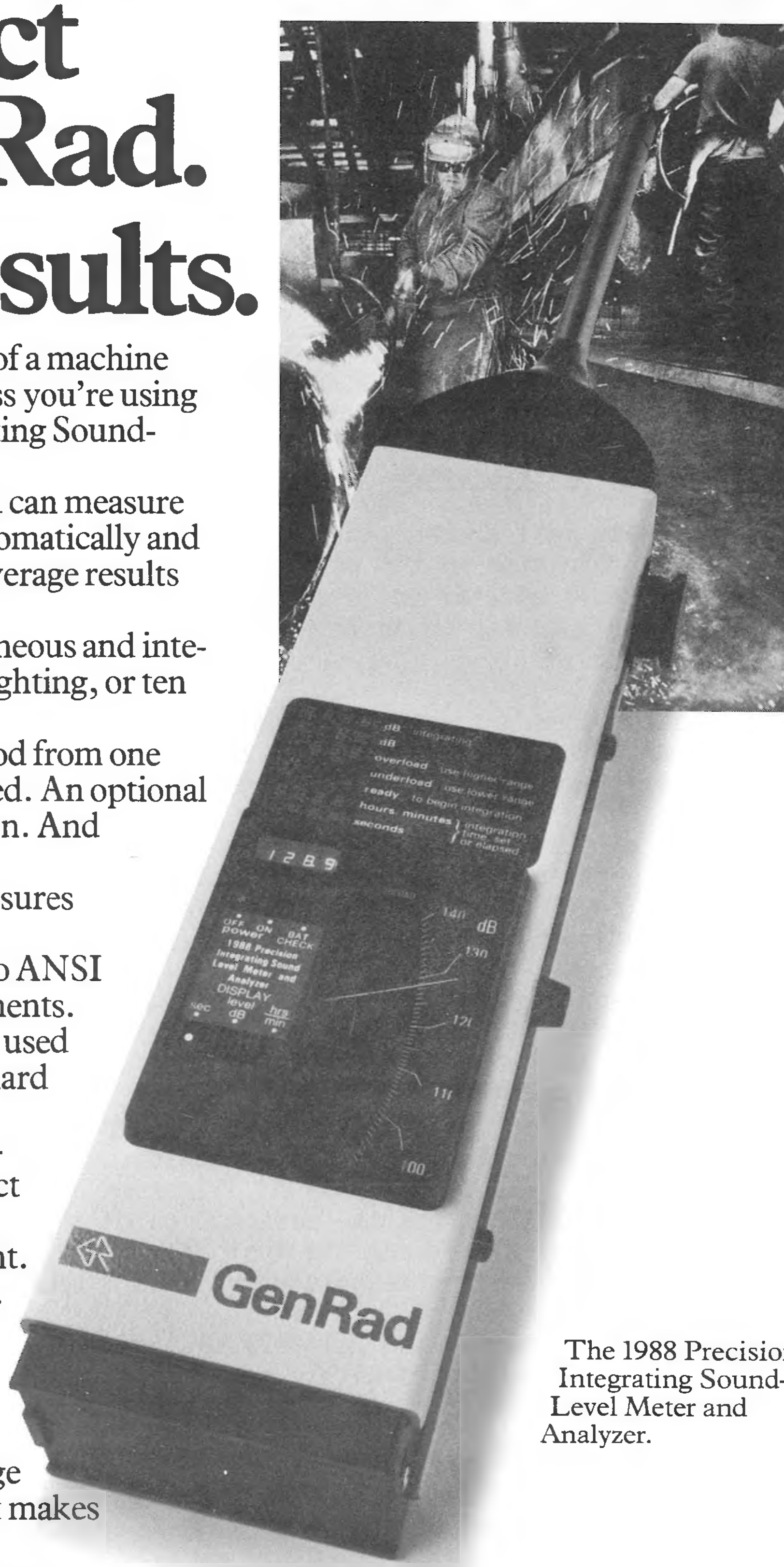


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25 dB at 500, 1000 and 2000 Hz); the second set of criteria is derived from a clinical evaluation of the audiogram configuration (2-5).

Then, when compiling the results of a screening program, one focuses on the number of referrals for clinical investigation. For various reasons, workers showing a notched audiogram in the range of 3000 to 6000 Hz usually are not referred. Moreover experience often shows that a majority of the referred cases involve other pathologies than occupational hearing losses. Consequently, the overall results of the identification audiometry program do not reflect at all the actual effect of the noise of a given industry on the hearing status of its population of workers.

This study is an attempt to develop an epidemiological procedure for the classification of the results of screening audiometry. It aims at estimating, with a high degree of credibility, the prevalence of hearing losses attributable to noise in populations of industrial workers.

<u>Outline of the Procedure</u>

1. Hearing test conditions

The objective of the procedure is to arrive at valid conclusions about the effects of industrial noise on the hearing status of a group of workers. The first step in this direction is to perform highly valid and reliable hearing threshold measurements.

It implies a painstaking control of the testing conditions and procedure:

- control of the background noise level in the testing environment, in accordance with the most recent standard at least for the testing frequencies between 500 and 6000 Hz (6)
- proper calibration and maintenance of the audiometer (7)
- adequate training and supervision of the examiner
- uniform instructions of all the workers tested
- proper adjustment of headband force and careful earphone placement
- for all workers tested, a minimum of 14 hours outside a noisy environment before undertaking the test (in order to prevent any contamination of the hearing threshold measurements by the presence of a noise induced temporary threshold shift).

2. Use of a questionnaire

Once the hearing status of the workers is adequately determined, the analysis must be supported by relevant information, such as (a) the history of noise exposure of the worker, (b) his history of illnesses and symptoms potentially associated with hearing deficits and (c) the description of the worker's condition at the time of the test (the interval between the test and the preceeding noise exposure, signs of infection of the upper respiratory tract, alcohol or drug consumption, etc.).

This information can reliably be gathered using a questionnaire in controlled conditions. Recent data on the sensitivity and the specificity of health questionnaires clearly show that they can be a valuable tool in this context (8).

3. Hearing impairment criteria

In any population study of occupational hearing loss, the most difficult step is to determine what should be considered as a hearing deficit due to noise. Ideally a selected control population should be recruited and compared to the noise exposed group. But it is a complex and expensive task that is rarely practicable.

A simple solution is to apply age-effect corrections from presbyacusis studies to the individual hearing threshold levels obtained. The approach adopted must however assure the smallest possible proportion of false-positives. In other words, a hearing loss can reliably be attributed to noise exposure only if it amounts to some significant value that would hardly be explainable strictly in terms of an age-effect, such a statement implies of course that other causes of hearing deficits are excluded.

In our procedure, a "significant hearing loss" (SHL) at a given frequency is defined as one greater than that attributable to age-effect in 90 per cent or more of the population. Generalized values of SHL can be found in Robinson and Sutton (9). Their computations are based on data from a number of presbycusis studies and the various assumptions underlying the estimation of age-effect are clearly discussed.

However, at the time we first applied the present procedure to screening audiometry data, these values were not available. We adopted provisional SHL criteria relying upon previously published generalized presbycusis values (10-11). These curves are based on results from 8 studies. Their use, at least in terms of median presbycusis corrections, is widespread among audiologists. Because of this, we have adopted SHL values that could be easily computed from the median presbycusis corrections already available.

Assuming a normal distribution of hearing threshold levels (HTL) for any age group under 69, dispersion data from Spoor and Passchier-Vermeer (11) show that the 90th centile values fall between 15 and 22 dB above the median hearing level at 3, 4 and 6 kHz for age groups between 20 and 69 years. For 0.5, 1 and 2 kHz, the difference between the 90th centile and the median extends from 8 dB at 20 years to 14 dB at 69 years of age. For reasons of simplicity, it was decided to adopt uniform dispersion criteria based on those for the more advanced ages. Hence it was estimated that adding 15 dB to the age-specific median presbycusis correction for 0.5 up to 3 kHz and adding 20 dB for 4 and 6 kHz would satisfy provisionally the above definition of a SHL.

This simplification implies that the criteria tend to be overly specific when applied to younger age groups and possibly overly sensitive with older groups, at least for a male population. This is confirmed by a comparison with the corresponding criteria derived from the generalized age-effect curves from Robinson and Sutton as shown in Table I. Thus, at the age of 25, our provisional criteria would correspond to the 99th centile. But, at the age of 55, they would approach the 85th centile at 3 kHz and above.

Table I. Comparison for two age groups of males of the criteria for the age-effects in dB (re: audiometric zero) associated with the 90th centile.

| | Present study | | Robinson & Sutton [9] | | Thiery et al. [12] | |
|---|---|---|---|---|---|---|
| Age groups (years) | 25-29 | 55-59 | 27.5 | 57.5 | 18-30 | 51-60 |
| Frequencies (kHz) | | | | | | |
| 0.5 | 15 | 21 | 9 | 17 | 12 | 18 |
| 1 | 15 | 21 | 9 | 18 | 13 | 22 |
| 2 | 15 | 26 | 10 | 27 | 17 | 26 |
| 3 | 15 | 32 | 12 | 39 | 13 | 35 |
| 4 | 20 | 43 | 13 | 51 | 15 | 37 |
| 6 | 20 | 47 | 15 | 57 | 25 | 50 |

Nevertheless, our criteria are valuable estimations of the limits that statistically define hearing impairments. This is supported by the comparison with the data from the most recently published age-effect study on an otologically screened population by Thiery et al (12). A close correspondance between the latter set of data and the present criteria can be observed (see Table I). It is therefore likely that our criteria represent valid indices of SHLs as defined above when applied to hearing losses due to industrial noise exposure.

4. Classification of individual data

The first step in classifying the audiograms is to identify (and refer for clinical investigation) those showing signs of pathological conditions other than occupational hearing loss. Those demonstrating SHLs due to noise exposure outside the industrial environment (for instance, during military service) should also be identified. The remaining cases will show either normal hearing or SHLs attribuable to occupational noise exposure.

The severity of the noise-induced hearing damage can be estimated according to the number of audiometric frequencies affected by a SHL. A tentative categorization was adopted:

- level I: A SHL at 1 or 2 frequencies; this corresponds to the first signs of hearing damage at 4 or 6 kHz.
- level II: SHLs at 3 frequencies; this represents the typical notched audiogram, in the range of 3 to 6 kHz.
- level III: SHLs at 4 frequencies or more; in this case the hearing loss extends to 2 kHz or below, without being eligible for compensation, according to the Quebec criteria given in the example in the Introduction.
- level IV: hearing losses that satisfy the currently accepted medico-legal definition of impairment in Quebec. The workers falling into this category are refered for clinical investigation.

5. Collective analysis

The object of the collective analysis is the severity of the noise problem in the industry under study. Compiling the data according to the above categories will first allow the division of the population of workers into two subsets:

- a group of workers suffering from hearing loss of extra-occupational origin (pathological condition or non-occupational noise exposures)
- a group of workers whose hearing status can be considered as representative of those exposed to occupational noise (those with normal hearing and those with SHLs due to industrial noise).

Since this latter group may include individuals exposed to noise in factories other than the one under study, it is desirable to identify those exposed only to the target environment. But, considering the high degree of mobility of the workers from one plant to another, the outcome of such a selection would generally result in very small final samples of workers. For this reason, the selection criterion adopted in the present procedure is based on the relative duration of exposure in the plant under study compared to other working environments. If exposure to other noisy industrial environments has been shorter than the time spent in the present environment, the hearing loss observed can be attributed in larger measure to the environment representing the longest exposure.

Thus, the severity of the noise problem in the plant studies can be estimated by computing the prevalence of occupational SHLs among the workers having spent the larger part of their working life in this plant. Accordingly, comparisons between different industries or between departments within a large industry can be performed if the average number of years of exposure inside and outside the industry is considered.

## An Example of Application of the Procedure

The procedure outlined above was applied to a population of 965 workers employed in a foundry. Over 35 percent of these workers were exposed daily to noise levels exceeding 90 dBA for 8 hours.

1. Hearing test conditions

All hearing tests were performed using fixed frequency Bekesy audiometry under the direct supervision of graduate students in audiology. The audiometers were calibrated according to the reference equivalent threshold sound pressure levels specified by ANSI (S3.6-1969) (7) standard. The background noise level in the testing room was below the permissibile level specified by ANSI (S3.1-1977) (6) standard at 250 Hz and above.

Hearing threshold levels of the workers were measured at 500, 1000, 2000, 3000, 4000 and 6000 Hz in both ears.

2. Classification of individual data

The classification of individual data is reported in Table II. It can be seen that one worker out of three suffered from a SHL attributable to industrial noise exposure, but only one out of 20 was possibly eligible for compensation (according to the low fence criterion in effect in Quebec, that is an average loss of 25 dB at 500, 1000 and 2000 Hz in one or both ears.

Table II. Collective treatment for a large plant (N=965)

Classification of individual data

(PERCENT OF TOTAL POPULATION)

| Normals | SHL occupational | SHL extra-occupational | Other pathologies |
|---|---|---|---|
| 53.3 | 33.7 | 8.9 | 4.0 |

Levels

| I | II | III | IV (eligible for compensation) |
|---|---|---|---|
| 18.9 | 6.8 | 3.1 | 4.9 |

A closer look at the distribution of the SHLs among the different levels allows one to make the following observations:

- a majority of the affected workers suffered from a noise induced hearing loss at one or two frequencies (level I), that is at 4 kHz and at 6 or 3 kHz;
- the proportion of affected workers decreases dramatically when 3 frequencies (level II) or 4 frequencies and more (level III) are considered;
- nevertheless, 29 of the 33 percent affected were not eligible for compensation and for this reason, would probably not have been identified as suffering from a hearing damage due to noise in the context of conventional classifications.

Such a result points out the advantage of the present procedure. As stated above, the proportion of cases refered for further clinical investigation and possibly for compensation is frequently considered as the index of the severity of the noise problem in the factory. The present finding of 33 percent affected workers is at variance with the usual 5 to 15 percent of refered cases. Moreover, this overall result is meaningful in itself if one considers the above definition of a SHL. The outcome of a hearing test program performed within a factory is sufficient in and of itself to define the severity of the noise problem in the plant.

3. Prevalence of SHL among the target population

A more reliable evaluation of the actual effect of the noise in the plant can be obtained when the prevalence of SHL is computed on the target population. Here, the workers suffering from a hearing loss from an extra-occupational origin as well as those exposed during a longer period of time to the noise of other plants are not considered.

Table III. Prevalence of SHL among the target population of the effect the noise of the plant under study (N=719).

Total prevalence of SHL: 38.8% (Standard error: 1.8%)

Average length of service: 14 years

Prevalence of SHL according to classes of length of service

| Length of service (years) | 0-4.9 | 5-9.9 | 10-14.9 | 15.19.9 | 20-24.9 | 25 |
|---|---|---|---|---|---|---|
| Prevalence of SHL (percent) | 20.8 | 31.8 | 34.9 | 48.7 | 57.6 | 54.5 |
| N | 221 | 110 | 63 | 76 | 118 | 123 |

It can be seen from Table III that, on an average, a worker has approximately 4 chances in 10 of suffering from a SHL when employed in this plant. This proportion is a function of the length of service in the industry. As reported by several authors the rate of growth of hearing loss in the range of 3 to 6 kHz is high during the first five years of exposure and decreases markedly thereafter (13-15). This phenomenon appears also to be true in terms of the proportion of workers affected by a SHL, as shown in Table III. But the increase in the prevalence of SHL, at least in the present case, approaches a ceiling after 15 to 20 years of exposure. At this time, approximately one worker out of two suffers from a SHL because of the noise in this plant.

A further analysis can possibly be performed in comparing the prevalence of SHLs across shops within the factory. But in the present case the relatively high degree of mobility among shops and the wide differences in average length of service from one shop to another would make such an analysis hardly meaningful.

## Discussion and Conclusions

If hearing conservation programs aim solely at preventing hearing losses, eligible for compensation, conventional classifications of audiograms are certainly adequate. But if one also intends to protect the physical integrity of the workers, one should rely more on an epidemiological than a clinical approach. Identification audiometry can serve as an effective prevention tool if it is truly oriented towards the noise problem and the whole population of the workers of a given industry.

The data from the one plant presented in this study is merely an example of the application of the general procedure outlined. The relationship of the data to the degree of risk of hearing loss due to occupational noise is not clear. For this the analysis needs to be performed with comparable data from several plants. This will be possible in the near future as the present procedure is applied over a number of different industrial populations.

The above results show that such an epidemiological approach is applicable to a large factory. It can also be valuable for small industries, as will be shown from the results of a study currently in progress. But in those cases, because of the small number of workers studies, the confidence intervals for the proportion of affected workers are considerably wider. Nevertheless, computing the prevalence of SHL attributable to the noise can serve as a valid index for the comparison of the severity of the noise problem from one factory to another or from one type of industrial production to another. This is especially true if the above procedure is applied in a uniform fashion in several plants.

There is no doubt that the present procedure could be improved, upon sharpening its ability to identify the influence of extra-occupational sources of SHL. This is particularily true (a) for after-effects of various diseases that affect hearing significantly and also (b) for non-occupational noise exposures that could be severe enough for being responsible for a SHL. Nevertheless, the present study represents a first step towards an effective use of identification audiometry for secondary prevention of occupational hearing loss.

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EXCERPTS FROM AN ADDRESS BY THE HONOURABLE WILLIAM G. DAVIS, PREMIER OF ONTARIO ON THE OCCASION OF THE 25th ANNIVERSARY OF THE METROPOLITAN TORONTO AND REGIONAL CONSERVATION AUTHORITY IN FEBRUARY, 1980

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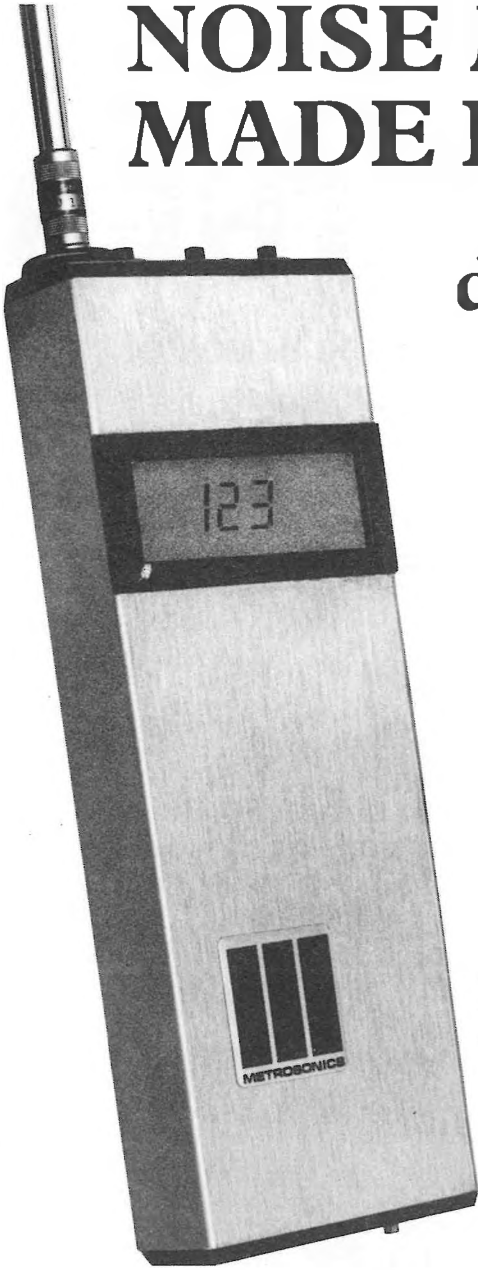


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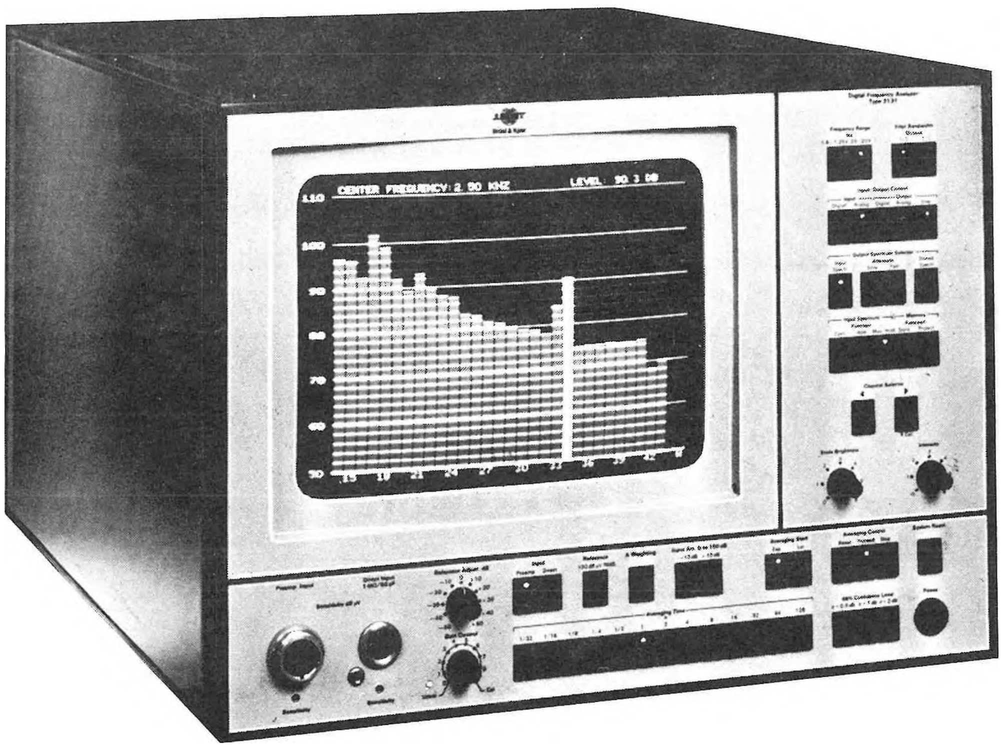

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MEETING OF THE ACOUSTICAL SOCIETY OF AMERICA

18 - 22 May 1981

The Acoustical Society of America will hold its 101st Meeting, Monday through Friday, 18-22 May 1981, at the Chateau Laurier Hotel, Confederation Square, Ottawa.

TECHNICAL SESSIONS

Plans have been made for the following 22 special sessions, which will usually include a series of invited papers featuring the best expertise available on this continent.

- Variable Room Acoustics in Auditoria
- Sound Isolation in Multifamily Dwellings
- Loudspeaker Materials
- Acoustics in Telecommunications (2 sessions)
- Middle Ear Engineering
- Sound Attenuation in Flow Ducts
- Operator Noise Measurements and Workplace Dosimetry
- Transformer Noise
- Outdoor Sound Propagation
- Ultrasonic Biophysics (2 sessions and bull session)
- Strings, Percussive and Bowed
- Music, Perception and Cognition
- Central Mechanisms in Sound Localization
- A Century of Auditory Fatigue
- Mobility and Ground Vibration
- Automobile Industry and Basic Structures (Shock and Vibration)
- Hand-Arm Vibration
- Models of Speech Perception
- Underwater Acoustics in the Arctic
- Topographical Effects on Ocean Propagation

There will be in addition 33 sessions of contributed papers in the areas of architectural acoustics, engineering acoustics, noise, physical acoustics, musical acoustics, psychological and physiological acoustics, shock and vibration, underwater acoustics and speech communication, just as they have arrived from both members and non-members, for a total of 55 sessions and 580 papers.

An idea of the subject material covered in the contributed sessions may be obtained in somewhat more detail from the session titles in the short advance version of the program which follows. For further information on the ASA meeting, please contact

Drs. T.F.W. Embleton or J.E. Piercy
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National Research Council
Ottawa, Ontario, Canada K1A 0R6
Telephone: (613) 993-2840 or 993-2300

THIRD INTERNATIONAL SYMPOSIUM ON HAND-ARM VIBRATION

This symposium, which will attract specialists from overseas, is being held in conjunction with the ASA meeting on Monday through Wednesday morning (May 17 to 20, 1981). It will include about 40 papers in the following areas:

- the Vibration Syndrome - physiological mechanisms and diagnosis;
- epidemiological studies of exposure to vibration;
- studies of the vibration of power tools and industrial processes involving vibration exposure;
- models of the hand-arm system and transmission of vibration into the hand;
- methods for reducing vibration levels of power tools; and
- relations between exposure to vibration and the development of symptoms, exposure limits and vibration standards.

For further information on the symposium please contact A.J. Brammer, Division of Physics, National Research Council, Ottawa, Ontario, Canada K1A 0R6 (Telephone (613) 993-2840).

TOURS AND VISITORS PROGRAM

Several half day technical tours are planned, and there is also a visitors program for accompanying persons.

REGISTRATION

Times of registration are shown in the program. There is no advance registration, and the registration fee is $30 (Canadian) for members and $50 for non ASA members for the ASA meeting. Registration for the Hand-Arm Symposium is separate, (except for ASA members) and the fee is $75.

ACCOMMODATION

A large block of hotel rooms has been reserved for the meeting at the Chateau Laurier ($55 - $77 single, $65 - $85 double; postal address - Box 474 Station A, Ottawa, Ontario K1N 8S7; telephone (613) 232-6411). Small blocks of additional accommodation have also been reserved at the Lord Elgin Hotel ($34 single, $38 double only; 100 Elgin St., Ottawa K1P 5K8; four blocks south; phone (613) 235-3333), at the Holiday Inn Market Square ($41 single, $43 double/twin; but $36 single, $38 double/twin Friday, Saturday and Sunday; 350 Dalhousie St., Ottawa K1N 7E9; five blocks east; phone (613) 236-0201), and at the Park Lane Hotel ($41 single, $49 double/twin, 111 Cooper St., Ottawa K2P 2E3; nine blocks south; phone (613) 238-1331.

For students with current international ID cards, low priced accommodation has been arranged in the residences of the University of Ottawa ($8-9/night single; Univ. Convention Bureau, 648 King Edward Ave., Ottawa K1N 6N5; 12 blocks south-east; phone (613) 231-7055). In case of last minute difficulties with accommodation please contact Dr. Krishnappa (telephone (613) 993-9325) from the local meeting committee.

# PROGRAM

## MONDAY MORNING, 18 MAY 1981

9:00 Symposium on Hand-Arm Vibration. Québec Suite.

## MONDAY AFTERNOON, 18 MAY 1981

2:00 Symposium on Hand-Arm Vibration.
4:00 Registration. Ballroom Lobby.

## TUESDAY MORNING, 19 MAY 1981

8:00 Registration. Ballroom Lobby.
8:30 A. Noise I: Noise Control, Radiation and Propagation.
8:35 B. Physical Acoustics I: Ultrasonic Propagation Properties of Biological Media.
8:45 C. Engineering Acoustics I and Underwater Acoustics I: Sonar Systems and Transducers.
9:00 D. Architectural Acoustics I: General.
9:00 E. Physiological Acoustics I and Psychological I: Central Mechanisms in Sound Localization.
9:00 F. Physiological Acoustics II: External and Middle Ear.
9:00 G. Speech Communication I: Acoustic Analysis.
9:00 Symposium on Hand-Arm Vibration.

## TUESDAY AFTERNOON, 19 MAY 1981

12:15 Committee on Education in Acoustics - Mini-session.
1:00 H. Underwater Acoustics II: Underwater Acoustics in the Arctic.
1:30 I. Psychological Acoustics II: Masking.
1:30 J. Shock and VibrationI: Mobility and Ground Vibration.
1:45 K. Physical Acoustics II: Biological Effects of Ultrasound.
2:00 L. Engineering Acoustics II: Loudspeaker Materials and Miscellaneous.
2:00 M. Noise II: Transformer Noise.
2:00 N. Speech Communication II: Models of Speech Perception.
2:00 Symposium on Hand-Arm Vibration.

## TUESDAY EVENING, 19 MAY 1981

5:00 Social Hour.
7:00 Bull Session on Ultrasonic Biophysics.

## WEDNESDAY MORNING, 20 MAY 1981

8:00 Registration.
8:00 O. Underwater Acoustics III: Propagation.
8:30 P. Architectural Acoustics II: Room Acoustics General.
8:30 Q. Musical Acoustics I: Musical Instruments: Timbre and Temperament.

WEDNESDAY MORNING, 20 MAY 1981 (cont'd)

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|---|---|---|
| 8:30 | R. | Noise III: Effects of Noise and Annoyance. |
| 8:30 | S. | Speech Communication III: Speech Recognition. |
| 8:45 | T. | Engineering Acoustics III and Physiological Acoustics III: Middle Ear Engineering. |
| 9:00 | U. | Physical Acoustics III: Relaxation Mechanisms: Techniques and Results. |
| 9:00 | | Symposium on Hand-Arm Vibration. |
| 11:00 | V. | Plenary Session. |

WEDNESDAY AFTERNOON, 20 MAY 1981

| | | |
|---|---|---|
| 12:15 | | Committee on Education in Acoustics - Mini-session. |
| 1:30 | W. | Architectural Acoustics III: Sound Isolation in Multi-Family Dwellings. |
| 1:30 | X. | Engineering Acoustics IV and Noise IV: Sound Attenuation in Flow Ducts. |
| 1:30 | Y. | Physiological Acoustics IV: Cochlea and Auditory Nerve. |
| 1:30 | Z. | Speech Communication IV: Speech Production I. |
| 1:30 | AA. | Underwater Acoustics IV: Topographical Effects on Ocean Propagation. |
| 2:00 | BB. | Physical Acoustics IV: Radiation and Scattering. |
| 2:00 | CC. | Psychological Acoustics III: Localization, Lateralization and other Topics. |
| 4:00 | | Underwater Acoustics: Panel discussion on Topographical Effects on Ocean Propagation. |

WEDNESDAY EVENING, 20 MAY 1981

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| 6:00 | Social Hour. |
| 7:00 | Banquet. |
| 8:45 | Entertainment. |

THURSDAY MORNING, 21 MAY 1981

| | | |
|---|---|---|
| 8:00 | | Registration. |
| 8:30 | DD. | Speech Communication V: Speech Production II. |
| 8:30 | EE. | Underwater Acoustics V: Propagation, Scattering and Signal Processing. |
| 8:45 | FF. | Psychological Acoustics IV: A Century of Auditory Fatigue. |
| 9:00 | GG. | Architectural Acoustics IV: Variable Room Acoustics in Auditoria. |
| 9:00 | HH. | Engineering Acoustics V: Acoustics in Telecommunications I. |
| 9:00 | II. | Noise V: Operator Noise Measurements and Workplace Dosimetry. |
| 9:00 | JJ. | Physical Acoustics V: Non-Linear Acoustics. |
| 10:45 | KK. | Speech Communication VI: Prosodies and Synthesis. |

THURSDAY AFTERNOON, 21 MAY 1981

| | | |
|---|---|---|
| 1:30 | LL. | Physiological Acoustics V: Evoked Response. |
| 1:30 | MM. | Shock and Vibration II: Automotive Industry and Basic Structures. |
| 2:00 | NN. | Musical Acoustics II: Strings, Percussive and Bowed. |
| 2:00 | OO. | Physical Acoustics VI: General. |
| 2:00 | PP. | Speech Communication VII: Perception I. |
| 2:00 | QQ. | Underwater Acoustics VI: Radiation, Scattering and Noise. |
| 3:30 | RR. | Psychological Acoustics V: Auditory Prosthesis. |

THURSDAY EVENING, 21 MAY 1981

5:00 Social Hour.
8:30 Engineering Acoustics Workshop.

FRIDAY MORNING, 22 MAY 1981

8:00 Registration.
8:25 SS. Physical Acoustics VII and Noise VI: Outdoor Sound Propagation.
8:30 TT. Musical Acoustics III and Psychological Acoustics VI: Perception and Cognition.
8:30 UU. Psychological Acoustics VII: Loudness, Temporal Factors and Related Topics.
8:30 VV. Shock and Vibration III: Structure and Machine Dynamics.
9:00 WW. Engineering Acoustics VI: Acoustics in Telecommunications II.
9:00 XX. Physiological Acoustics VI and Psychological Acoustics VIII.
9:00 YY. Speech Communication VIII: Perception II: Dichotic, Listening, Acoustic Cues.

FRIDAY AFTERNOON, 22 MAY 1981

1:30 ZZ. Noise VII: Jet and Flow Noise.
1:30 AAA. Psychological Acoustics IX: Pitch Perception and Musical Sounds.
1:30 BBB. Speech Communication IX: Perception III: Developmental, Language- and Hearing-Impaired and Vibrotactile.
1:30 CCC. Late papers.

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## PROPOSED REGULATION FOR NOISE IN ONTARIO

Report of the III Technical Meeting of the CAA Toronto Chapter, January 19, 1981

Our third meeting was devoted to a discussion of the Proposed Regulation for Noise and Related Code prepared by the Occupational Health and Safety Division of the Ontario Ministry of Labour. John Swallow presided over a panel of five experts from the Ministry of Labour, Industry, and Medicine. Each member of the panel spoke for about 20 minutes, addressing issues of particular concern to his sector.

Mr. John McEwen, representing the Ontario Ministry of Labour, stressed the need for devising a practical program for reducing noise exposure in industry. He discussed some of the more contentious problems, namely acceptable levels for noise, (85 or 90 dBA), provision of personal hearing protectors, warning signs on the job site, definition of impact noise, the rule for relating noise level and exposure time (i.e. whether to halve the duration for every 3 dB or 5 dB increment in level), and the locus of responsibility for assessment of hearing, whether government or industry.

Ms. Marilyn Pike, an audiologist working with the Ministry, described a working model for a hearing conservation program. She defined the goals for such a program as protection and identification. Major components of the program included measurement of noise, hearing tests, records of exposure, noise control and diagnosis. Thus, a wide range of expertise would be required from hygienists, safety engineers, industrial physicians and nurses, family physicians, otolaryngologists and audiologists. She proposed an occupational health committee to regulate the program from within the industry. The standards for each program component were detailed.

Mr. Greg Michel of Bruel and Kjaer Canada Limited discussed the instrumentation problems of noise measurement. These included difficulties in distinguishing impulse noise and impulsive from steady-state noise. He commented that these distinctions were often only possible using an oscilloscope on site and thus it might not be practicable to make the measurements in survey and/or monitoring situations. The problem of evaluating exposure was also discussed and the point stressed that personal dosimeters had originally been developed for steady-state levels. Mr. Michel also mentioned difficulties associated with using instruments in the cold Canadian North where batteries cease to operate and called for some standardization in the use of terminology for noise measurement.

Dr. Peter W. Alberti, Otolaryngologist-in-Chief at Mount Sinai Hospital reviewed in detail the recommendations of a Task Force on Occupational Hearing Loss to the Minister of Labour and Advisory Council on Occupational Health and Occupational Safety. The topic of the brief dated December 1979, was Occupational Hearing Loss: Prevention, Compensation and Rehabilitation. Among the problems discussed were the need to develop methods to reliably estimate noise dosage, the labelling of equipment for emission levels, lack of audiometric records in industry as well as methods for maintaining records and documentation of work histories. Recommendations included the mandatory use of personal hearing protection coupled with noise reduction at the source, and periodic assessment of standards.

The last panel speaker was Mr. Tony Taylor of Ontario Hydro. The focus of his address was the need to study the layout of equipment within the plant in order to assess the risk of noise exposure to the workers realistically. He described some of the current methods used at Ontario Hydro installations both to reduce noise at the source and to provide suitable enclosures and barriers to decrease the effective noise dosage. An evaluation was made of the costs and benefits associated with such programs.

The speakers were thanked by Mr. Alberto Behar, and a lively question and answer period ensued.

Sharon M. Abel

# AN ANALYTICAL MODEL FOR INPUT SPECTRAL DENSITIES FOR RESPONSE ESTIMATION

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## ABSTRACT

A mathematical approach is proposed to describe any arbitrarily varying power spectral density of a random process in order to obtain analytically the response of mechanical systems to such inputs. The proposed model optimally envelopes the input power spectral density with linear segments having rising and falling slopes as well as flat portions in dB scale and can be used to describe any power spectral density distribution to the required degree of accuracy. Response of a mechanical system to an arbitrary random loading is obtained by describing the input using this model and the result is compared against experimentally measured response for the system under same loading. The computed mean square response agreed well with the experimentally measured value, thereby validating the usefulness of the proposed model in evaluating the response of any general dynamic systems under random loading.

## RESUMÉ

Une nouvelle approche est proposée pour la description d'une densité spectrale arbitrairement variable d'un processus accidentel pour obtenir, d'une façon analytique, la réponse d'un système mécanique, pour cette entrée. Le modèle proposé enveloppe d'une façon optimale la densité spectrale d'entrée de la puissance avec des segments ayant des pentes montantes et descendantes et aussi des portions plates dans une échelle de dB. Ils peuvent être utilisés pour décrire n'importe quelle distribution de la densité spectrale avec le degré de précision requis. La réponse d'un système mécanique à une charge accidentelle arbitraire est obtenue par la description d'une entrée en utilisant ce modèle et le résultat est comparé avec la réponse obtenue expérimentallement pour le système avec une charge identique. La réponse moyenne carrée calculée se compare bien avec les résultats mesurés en confirmant l'utilité du modèle proposé pour l'évaluation de la réponse d'un système dynamique général sous une charge accidentelle.

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* Chairman
** Engineer, SPAR Aerospace Corporation
*** Research Assistant Professor

The spectral densities of many random processes, which excite structural systems, are often not amenable to an exact mathematical description. In order to design structures subjected to such random loadings, it is essential to describe these spectral densities of excitations analytically in a functional form. In some practical situations, it is sufficient to describe them approximately with simple mathematical functions, such as a white noise [1], a band limited white noise [2] or as a product of an algebraic and exponential function [3]. However, such models cannot describe any spectral densities in general, which may possess several peaks of varying magnitudes.

The present paper proposes a simple analytical model to describe any general spectral density of random processes, which may be used to estimate the responses of structural systems excited by such random processes. This model envelopes the spectral density curve with a number of linear segments having rising and falling slopes as well as flat portions in the decibel versus octave frequency scale. The mean square response of the structure subjected to that excitation can be evaluated for such individual segments analytically and the total response can be obtained by summing the responses to individual segments for a linear analysis. For illustration, a spectral density having three linear segments having a rising slope, a flat region and a falling slope in the decibel versus frequency scale is considered as shown in Figure 1. The mean square acceleration response of a typical dynamic system to this excitation is evaluated analytically. The mean square acceleration response is also measured experimentally on the same system by synthesizing a spectral density of loading comparable to that considered in the analytical study. A judicious comparison of the analytical and experimental mean square responses showed a good agreement thus validating the usefulness of the proposed model in estimating the random responses of structural systems.

## ANALYSIS OVERVIEW

Any shape of spectral density can be described approximately by enveloping the curve with lines of rising and falling slopes and flat segments in the decibel versus frequency scale. The relationship between the slope in the dB/octave, spectral density and frequency, along such linear segments is given by

$$S_x(f) = S_x(f_\ell)\ (f/f_\ell)^{N/3} \tag{1}$$

where

$N$ = slope of the line in dB/octave

$f$ = frequency at any point along the line

$S_x(f)$ = spectral density at frequency f

$f_\ell$ = lowest frequency on the line

$S_x(f_\ell)$ = spectral density at $f_\ell$

The response spectral density for a structure subjected to random excitations is given by the standard relation

$$S_y(f) = |H(f)|^2\ S_x(f) \tag{2}$$

where

$S_y(f)$ = output spectral density

$H(f)$ = complex frequency response relating the input to the output.

The mean square response in the frequency band covered by each segment can be obtained by the relation

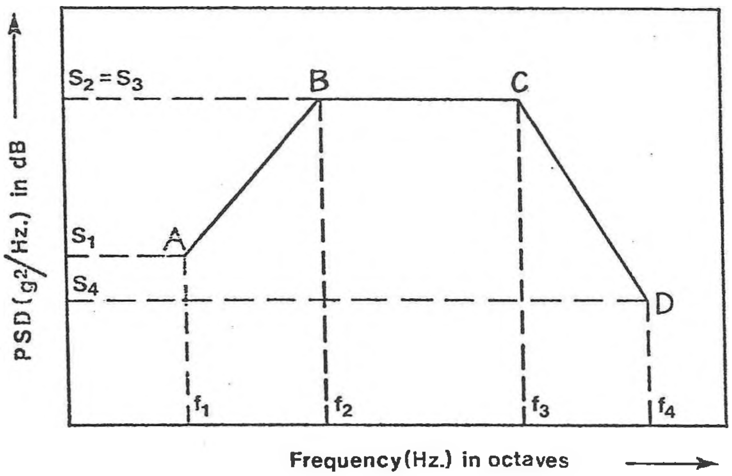


Fig. 1: Profile of a Power Spectral Density of Excitation

$$\sigma^2 = \int_{f_\ell}^{f_u} S_y(f)\, df \tag{3}$$

where

$\sigma^2$ = mean square value

$f_u$ = upper frequency limit on the line.

RESULTS

The above analysis is used to estimate the mean square acceleration response of a cantilever beam structure of length 30 cm and a cross section of 2.5 x 1.25 cm. Only the first two modes of the structure were considered in the analysis. The damping ratios of the structure corresponding to the first two normal modes were estimated from the frequency response of the structure under harmonic excitation, and were found to be 0.00625, respectively. An excitation signal having a spectral density profile as shown in Figure 1 was employed for the analytical estimation and for the experimental verification of the mean square response. The excitation signal was chosen in such a manner that the two regions with the non-zero slopes contained the first and second natural frequencies of the structure.

The root mean square acceleration estimated at the tip of the structure, when the root of the cantilever was subjected to excitation, was 61.3 g rms using the present approach. The experimentally measured root mean square acceleration was 62 g rms at the tip showing a good agreement with the analysis.

REFERENCES


1. Eringen, A.C. "Response of beams and plates to random loads", Journal of Applied Mechanics, Vol. 24, 1957, p. 46.

2. Roberts, J.B., "The response of a simple oscillator to band limited white noise", J. Sound & Vibration, Vol. 3, No. 2, 1966, p. 115.

3. Bhat, B.R., B.V.A. Rao and H. Wagner, "Structural response to random acoustic excitation", Earthquake Engineering and Structural Dynamics, Vol. 2, 1973, p. 117.

# POURQUOI EFFECTUER DES EXAMENS AUDIOMETRIQUES EN USINES BRUYANTES?

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SOMMAIRE

Un bilan partiel des programmes de préservation de l'audition dans les usines québécoises soulève la question de l'efficacité des programmes de surveillance audiométrique. Les faiblesses de tels programmes sont illustrées au moyen d'un exemple concret. Cette démarche conduit à une analyse critique de la logique-même de la préservation de l'audition dans le bruit et du rôle dévolu à la surveillance audiométrique dans ce contexte. Des propositions en vue de l'utilisation optimale des examens audiométriques en usines bruyantes sont présentées.

ABSTRACT

Evaluating the hearing status of populations of industrial workers in Québec raised the question of the effectiveness of ongoing hearing conservation programs at large and of monitoring audiometry in particular. The weaknesses of these testing programs are illustrated by means of a set data from a plant. This critical look is further supported by an analysis of the assumptions underlying hearing conservation in noise including the function of monitoring audiometry in this context. Guidelines for an optimal use of hearing tests in industry are presented.

## La problématique des examens audiométriques et son contexte

Dans un document qui a maintenant un caractère historique, "Guide for Conservation of Hearing in Noise" (AAOO, 1957), on retrouve les éléments et la logique des programmes de préservation de l'ouïe dans le bruit qui ont été implantés et qui sont présentement implantés dans les moyennes et grandes entreprises nord-américaines.

De façon schématique ces éléments se résument à trois temps:

1º l'évaluation de l'exposition au bruit

2º le contrôle de l'exposition
- contrôle du bruit
- contrôle administratif des doses de bruit
- protection personnelle

3º la surveillance audiométrique

Dans ce schéma, la surveillance audiométrique a pour objet explicite d'une part, l'évaluation de l'efficacité du programme de contrôle de l'exposition et d'autre part, l'identification des individus les plus sensibles aux effets auditifs du bruit.

Malheureusement, ces programmes de protection de l'ouïe se sont avérés un échec, du moins dans les industries québécoises. C'est ce que l'on peut déduire d'un certain nombre d'indices:

- malgré des dizaines de milliers d'examens périodiques effectués dans diverses entreprises, on dispose de très rares évaluations par entreprise de la population affectée d'une surdité professionnelle; on ne dipose par ailleurs d'aucune évaluation longitudinale bien que des examens périodiques aient été effectués

- chaque fois que l'on dresse un bilan rigoureux pour une population industrielle, on met en évidence une proportion importante de travailleurs affectés de déficits auditifs dus au bruit et ce, même dans des entreprises où un programme de protection de l'ouïe existait (voir Hétu et al., 1978)

- on assiste à un afflux de demandes d'indemnité pour surdité professionnelle provenant d'une variété de secteurs industriels

- les programmes de protection de l'ouïe se sont souvent limités aux examens audiométriques; on commence seulement à évaluer les doses de bruit par poste de travail dans plusieurs entreprises

- la technologie du contrôle du bruit industriel n'est en demande que depuis que des pressions syndicales ont suscité un tel besoin; les résultats de milliers d'examens n'ont pas suffi.

Mais pourquoi cet échec? On peut certainement invoquer un ensemble de facteurs et la liste ne sera jamais exhaustive:

- ce sont les coûts souvent élevés du contrôle du bruit
- le manque de ressources spécialisées en acoustique, en hygiène industrielle, en audiologie, en épidémiologie, etc.

- le manque de formation spécifique à la prévention des maladies professionnelles
- le manque d'éveil collectif aux problèmes de santé au travail et à la surdité professionnelle en particulier
- le caractère insidieux de la surdité professionnelle en même temps que la nature de ses conséquences; elles sont surtout ressenties en dehors du milieu de travail et ne causent généralement pas de perte de revenu d'emploi
- la faiblesse et l'incohérence du cadre législatif, tel que mises en évidence dans le livre blanc sur la santé au travail
- la faible efficacité des protecteurs individuels contre le bruit
- etc.

D'un point de vue plus étroitement médical, la cause la plus importante de cet échec est, à mon avis, l'utilisation inappropriée des examens audiométriques au détriment d'une action clairement orientée vers le contrôle du bruit.

Un tel biais s'explique par un certain contexte professionnel lié à la santé au travail:

- d'une part, la prévention de la surdité professionnelle est avant tout liée à une intervention technologique (c'est-à-dire le contrôle du bruit) indépendante des pratiques médicales

- d'autre part, la surdité professionnelle est une perturbation irréversible, qui ne peut être traitée médicalement.

Par conséquent, dans un contexte traditionnel, le seul champ d'action nettement ouvert à l'intervention médicale était l'évaluation de l'état de santé du point de vue auditif. Probablement copiée sur celle du cabinet privé, cette intervention était faite dans un contexte de cas par cas. C'est ce contexte que j'analyserai dans l'exposé qui suit.

<u>Analyse d'une situation concrète</u>

L'utilité des examens audiométriques en usine bruyante n'est généralement pas remise en question. Pourtant, s'ils ne sont pas accompagnés d'un programme de contrôle du bruit, ils deviennent, à la limite, un moyen d'observer l'évolution de la surdité dans une population. Un tel voyeurisme médical est évidemment inacceptable (voir par exemple: Royster et al., 1980, Fig. 1 à 5). Mais c'est en pratique ce qui se passe lorsqu'aucun bilan périodique des résultats d'examens n'est dressé; en effet on se limite généralement à une analyse cas par cas orientée vers les invidivus ayant une audition plus détériorée que la majorité (souvent à cause de pathologies autres que les seuls effets du bruit).

La conséquence de ce mode d'intervention est que l'audition de la population se dégrade de façon plus ou moins perceptible sans aucune intervention. Cette situation est illustrée par les données puisées d'une situation concrète et reproduites à la figure 1.

Il s'agit de l'évolution moyenne des seuils auditifs corrigés pour l'effet d'âge, à 5 fréquences audiométriques pour un échantillon de 25 travailleurs (sur un effectif de 125) d'une entreprise de moyenne envergure. Ils ont été examinés par la même infirmière d'entreprise à 5 reprises dans un intervalle de 14 ans. On trouve également au tableau 1 la variabilité moyenne des seuils auditifs entre le premier et le deuxième examen et entre le 4e et le 5e examen.

L'analyse de ces données met en évidence les effets de différentes sources d'erreurs de mesure audiométrique

- bruit de fond excessif: les seuils à 500 Hz sont anormalement élevés
- procédure d'examen déficiente: la variabilité élevée à toutes les fréquences démontre globalement la faiblesse de la procédure
- les effets d'entraînement des travailleurs à l'examen: ce facteur est probablement responsable de la légère amélioration des seuils entre les années 0 et 7.5 à toutes les fréquences. Sinon, il s'agit d'erreurs d'étalonnage.

Malgré toutes ces erreurs et probablement d'autres non-identifiables rétrospectivement, on observe une chute systématique (statistiquement significative) des seuils à la majorité des fréquences au cours des 14 années et en particulier entre l'année 7.5 et 13. Dans cet intervalle précis, on observe par exemple que 80% des cas montrent une chute égale ou supérieure à 15 dB à 6000 Hz.

On peut y soupçonner la manifestation d'une grossière erreur systématique d'étalonnage; dans ce cas, l'ensemble du programme d'examen était absolument inutile.

Dans le cas contraire, il y a de bonnes chances que la chute systématique des seuils témoigne d'une détérioration progressive mais importante de l'audition de cette population. Or, l'accumulation de ces données n'a donné lieu, sauf erreur, à aucune intervention en termes de contrôle du bruit;

- cependant, les examens ont donné la conviction à un grand nombre de travailleurs exposés au bruit que des experts s'occupaient de leur audition d'autant plus que certains d'entre eux ont été référés en clinique spécialisée

- le service de santé de l'entreprise a bénéficié non seulement de la satisfaction du travail accompli mais aussi de la faveur et de la considération des diverses parties impliquées

- on discute encore à ce jour, dans cette entreprise, du caractère potentiellement nocif du bruit qui y règne et on projette d'évaluer prochainement les doses de bruit à chaque poste de travail.

Cette situation, en apparence excessive et exceptionnelle, est malheureusement caractéristique d'une majorité des entreprises qui ont bénéficié depuis plusieurs années d'un service d'examens audiométriques. Elle montre que des examens, loin de servir à la promotion de la santé des travailleurs, ont été nuisibles parce que mal exécutés et utilisés dans une intervention cas par cas. Ils ont en quelque sorte masqué le problème en donnant l'impression que l'on s'en occupait.

La logique de la préservation de l'audition dans le bruit

Pourquoi donc exécuter un programme d'examen en usines bruyantes puisque les effets du bruit sur l'audition de populations de travailleurs sont relativement bien connus (Ward, 1980). Ne suffirait-il pas d'évaluer le facteur de risque pour mettre en oeuvre des correctifs appropriés?

La logique habituelle des programmes de préservation de l'audition dans le bruit ("Hearing conservation in noise") et des législations en vigueurs prévoit qu'il ne sera pas possible de contrôler le bruit dans un grand nombre de situations et par conséquent que l'efficacité des mesures palliatives (contrôle administratif et protecteurs individuels) sera confirmée par un programme d'examens périodiques.

Or, d'une part, on suppose que ces examens sont très sensibles à détecter les effets du bruit à court terme. Malheureusement, les conditions actuelles d'examens en usine comportent un nombre important de sources d'erreurs qui en limitent très sérieusement la sensibilité (voir Edwards et al., 1978). Même dans des conditions rigoureuses, l'examen comporte une marge d'erreur inévitable qui masque les effets du bruit d'autant plus que la population visée est déjà affectée de surdité due au bruit (Hétu, 1979).

D'autre part, on impose en quelque sorte le fardeau de la preuve de la nocivité du bruit aux oreilles des travailleurs sans effectivement prévoir un mécanisme rigoureux qui permette de constituer une telle preuve. En effet, on ne prévoit pas de conditions strictes d'examens leur assurant une sensibilité optimale, non plus que le dépôt de bilans appropriés d'après un calendrier spécifique.

Enfin, on ne prévoit pas de mécanisme explicite d'intervention pour les situations où les examens révèleraient que les moyens palliatifs de protection s'avéreraient insuffisants. Compte tenu de la variabilité des conditions d'exposition au bruit d'un poste de travail à un autre et de la variabilité inter-individuelle associée aux effets du bruit sur l'audition, il y a toutes les chances que les examens périodiques ne détectent à un moment donné des détériorations dues au bruit que sur quelques individus seulement. En situant ainsi le problème au niveau des individus, il y a toutes les chances pour que l'intervention porte sur les individus et non sur les conditions de travail: ou bien le travailleur porte mal ses protecteurs ou alors il est trop sensible aux effets du bruit. Dans le premier cas, on le rendra responsable de sa surdité tandis que dans le second cas, on cherchera à remplacer l'individu sensible par un autre éventuellement plus résistant. En d'autres termes, on est incité à faire en quelque sorte la "gérance" des oreilles des travailleurs à partir des résultats d'examens.

En tout état de cause, la logique des programmes de protection de l'ouïe contre le bruit s'appuie sur les examens audiométriques pour cautionner la faiblesse ou l'absence de correctifs au niveau de l'agresseur-même ainsi que le recours aux protecteurs individuels. Et cette caution peut être obtenue sans grandes difficultés.

La prévention primaire de la surdité professionnelle passe essentiellement par le contrôle du bruit. Si la dose de bruit excède un niveau admissible pour la santé d'une population, ce ne sont pas des examens pédiordiques qui rendront admissible cette dose. En d'autres termes, aussi longtemps que l'agresseur est présent et constitue une contrainte physiologique, il y aura des dommages à la santé; la surveillance de l'état de santé ne changera en rien la contrainte physiologique. Elle aura le plus souvent pour effet de la cautionner.

## Les conditions d'une utilisation optimale des examens audiométriques

En prenant une certaine distance par rapport à la logique décrite plus haut, comment concevoir les conditions de l'utilisation des examens audiométriques à des fins non-équivoques de prévention de la surdité professionnelle? En d'autres termes, dans quels contextes des programmes d'examens seraient-ils souhaitables?

Globalement, on peut identifier deux types de situations:

- d'un côté lorsqu'aucun correctif n'a encore été appliqué, des résultats d'examens peuvent contribuer à exercer une pression sur l'entreprise de façon à amorcer véritablement un programme de prévention de la surdité
- d'un autre côté, lorsque dans le cadre de l'implantation de correctifs, un doute persiste quant à la nocivité de l'ambiance sonore, une surveillance audiométrique peut effectivement contribuer à évaluer l'efficacité de ces correctifs.

Ce serait le cas (a) pour des ambiances dont les effets ont été peu étudiés (b) lorsqu'on soupçonne la présence d'agents potentialisant et (c) lorsque les conditions d'exposition sont hautement variables.

Mais ces deux contextes font appel à des démarches fort différentes:

- la première représente une analyse rétrospective des effets du bruit sur la population visée (étude de prévalence de pertes auditives dues au bruit);

- la deuxième est une analyse longitudinale ou prospective d'un groupe de travailleurs exposés à des conditions spécifiques.

Par conséquent, il est nécessaire de respecter les contraintes spécifiques à chacune des deux approches et de bien s'assurer que les programmes d'examens exécutés atteignent vraiment les buts visés.

Il serait trop long de développer ici la description des éléments méthodologiques qui distinguent les deux approches. Des protocoles spécifiques, élaborés par le Comité de Recherche en Audiologie Communautaire seront déposés incessamment au Service de la Santé au Travail du Ministère des Affaires sociales du Québec.

Qu'il suffise de mentionner les principales contraintes propres à chacune des procédures, de façon à mieux situer la nécessité de leur différentiation:

A) Etude de prévalence de pertes auditives dues au bruit (dépistage de masse de la surdité): il s'agit de déterminer de façon crédible la proportion d'individus affectés d'un déficit auditif imputable au bruit industriel

- cet objectif exige essentiellement de pouvoir distinguer les pertes dues au bruit de celles attribuables à d'autres facteurs (et ce, à l'échelle de toute une population) donc la collecte d'un bon nombre d'informations pertinentes

- une telle étude suppose aussi que l'ancienneté moyenne d'exposition au bruit soit relativement importante (plus de 5 ans) pour que les effets puissent se dégager des facteurs parasites

- il faut également qu'une proportion importante des individus ait été exposée plus longtemps au bruit de l'usine visée qu'à celui d'autres entreprises de façon à inférer le degré de risque spécifiquement à cette usine

- enfin, le degré de crédibilité d'une étude de prévalence dépend de l'effectif de la population étudiée. Une prévalence calculée sur une population de moins de 50 personnes est sujette à des erreurs d'autant plus importantes que l'effectif est restreint.

Toutes ces contraintes en sous-tendent une autre plus générale, soit celle d'examiner toute une population dans des conditions adéquates. Les coûts et les délais de réalisation d'un tel programme peuvent parfois retarder l'implantation de correctifs dans l'environnement. Dans de telles conditions, les examens ne seraient évidemment plus souhaitables.

B) étude longitudinale d'un groupe de travailleurs (surveillance audiométrique): il s'agit d'identifier le plus rapidement possible une détérioration de l'audition dans le temps. Toute erreur de mesure contribue à cautionner un risque éventuel pour l'audition des travailleurs. Pour garantir une sensibilité minimale aux examens de surveillance, il faut

- réunir des conditions d'examens hautement rigoureuses et stables dans le temps

- contrôler de la part des travailleurs l'effet d'entraînement à la tâche liée à l'examen, c'est-à-dire effectuer deux tests lors de l'examen de base (voir: Robinson et al., 1973, 1975)

- contrôler la marge d'erreur inévitable liée à l'examen de façon à définir un critère rigoureux de détérioration

- suivre un calendrier d'examens compatibles avec le degré de risque présumé

- prévoir un bilan périodique des examens de surveillance

- s'informer des changements des conditions d'exposition des individus concernés

- prévoir explicitement un mécanisme d'application de nouveaux correctifs si un bilan révélait des détériorations de l'audition.

Même en respectant toutes ces contraintes, il ne sera pas possible d'effectuer une surveillance adéquate si les travailleurs concernés souffrent déjà de déficits auditifs importants. En effet, malgré un degré élevé de nocivité du bruit, le processus de détérioration de l'ouïe est alors ralenti et masqué par les erreurs de mesure audiométrique inévitables (Hétu, 1979).

## Conclusion

En conclusion, même si les professionnels de la santé ont une propension à recourir aux examens, ceux-ci ne sont pas toujours souhaitables en usine là où l'agresseur est un agent physique permanent. Ils peuvent même être nuisibles à la prévention d'une maladie professionnelle. Et, lorsqu'ils semblent souhaitables, il est nécessaire de poser explicitement un certain nombre de questions avant d'entreprendre d'examiner des travailleurs:

- dans quel but implanter un programme d'examen? Sera-t-il vraiment utile à la prévention de la maladie?

- compte tenu des contraintes inhérentes aux objectifs visés, le programme est-il réalisable?

  - quelles sont les ressources disponibles?
  - quel seront les délais de réalisation?
  - comment seront utilisés les résultats des examens?

Lorsque les réponses à ces questions ne s'avèreront pas satisfaisantes, ce sera le signe que l'intervention du professionnel de la santé doit s' inscrire à d'autres niveaux du programme de prévention de la maladie professionnelle.

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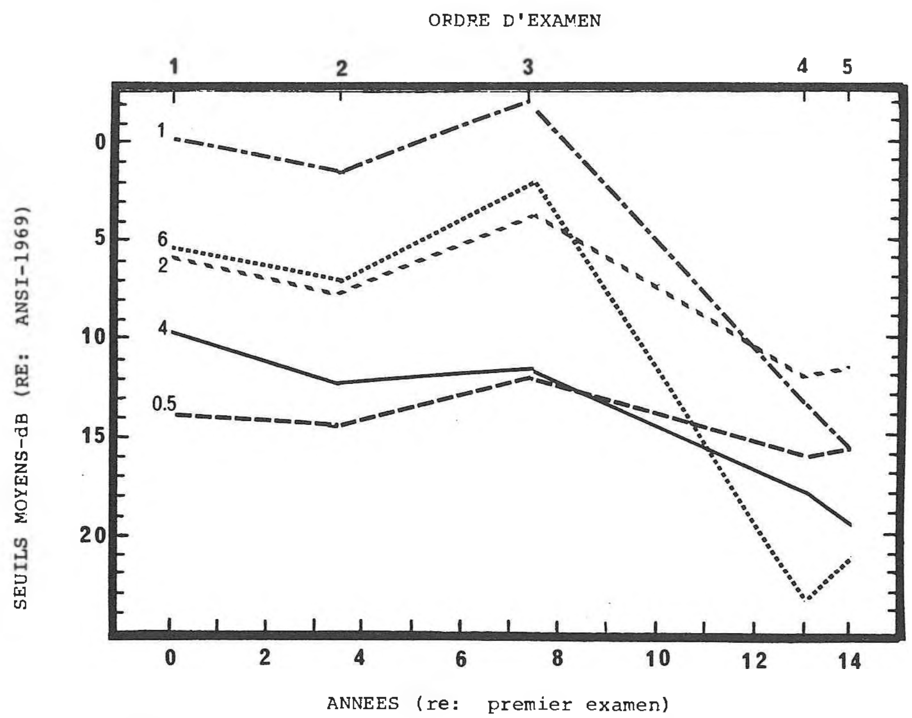


Figure 1. Evolution moyenne des seuils auditifs corrigés pour l'âge en fonction du temps écoulé depuis le premier examen (N = 25). En paramètre, les fréquences audiométriques en kHz.

Tableau 1. Erreurs-types de mesure ($S_e$)*, et intervalles de confiance à 95% (±1.96 $S_e$) des seuils d'audition de 25 travailleurs, tels qu'estimées d'après la variabilité des mesures du premier au deuxième et du quatrième au cinquième examen audiométrique de surveillance.

| Fréquence (Hz) | | 500 | 1000 | 2000 | 4000 | 6000 |
|---|---|---|---|---|---|---|
| 1er vs 2e examen | $S_e$ (dB) | 5.6 | 5.4 | 7.3 | 6.5 | 9.6 |
| | ±1.96 $S_e$ (dB) | ±11.0 | ±10.6 | ±14.3 | ±12.7 | ±18.8 |
| 4e vs 5e examen | $S_e$ (dB) | 4.2 | 7.1 | 4.0 | 4.1 | 7.0 |
| | ±1.96 $S_e$ (dB) | ±8.2 | ±13.9 | ±7.8 | ±8.0 | ±13.7 |

* $S_e = S_x \sqrt{1-r_{xx}}$ où $S_x$ est l'écart-type et $r_{xx}$, le coefficient de fiabilité des seuils d'audition

## THE INCORPORATION OF THE CANADIAN ACOUSTICAL ASSOCIATION/
## *CONSTITUTION JURIDIQUE DE L'ASSOCIATION CANADIENNE DE L'ACOUSTIQUE*

It is now nearly four years since our Board of Directors, after much thought, discussion and diligence, filed the appropriate documentation required to incorporate our Association under the above name. The documentation for this is in two main parts:

(i) The Letters Patent and its supporting application, and

(ii) The By-Laws of the Association.

Since these documents form an interesting and integral part of the history of our Association we will be publishing them in this and the following issue of "Acoustics and Noise Control in Canada".

*Il y a presque quatre ans déjà que les membres de notre bureau de direction, après avoir bien réfléchi, longuement discuté et travaillé avec diligence, ont présenté la documentation requise pour constituer juridiquement notre association, selon la désignation précitée. Deux documents principaux avaient été préparés, soit*

*(i) les lettres patentes et la demande à l'appui,*

*(ii) les règlements.*

*En raison de l'intérêt que présentent ces documents et parce qu'ils font partie intégrante de l'histoire de l'Association, nous avons pensé de les publier, l'un dans le présent numéro de "L'acoustique et la lutte antibruit au Canada". l'autre dans le prochain numéro.*

### PART (i): THE LETTERS PATENT AND ITS SUPPORTING APPLICATION./

### *PARTIE (i) - LES LETTRES PATENTES ET LA DEMANDE À L'APPUI.*

Consumer and Corporate Affairs — Consommation et Corporations

Canada Corporations Act — Loi canadienne sur les corporations

C A N A D A

LETTERS PATENT

WHEREAS an application has been filed to incorporate a corporation under the name

THE CANADIAN ACOUSTICAL ASSOCIATION -
L'ASSOCIATION CANADIENNE DE L'ACOUSTIQUE

THEREFORE the Minister of Consumer and Corporate Affairs, by virtue of the powers vested in him by the Canada Corporations Act, constitutes the applicants and such persons as may hereafter become members in the corporation hereby created, a body corporate and politic in accordance with the provisions of the said Act. A copy of the said application is attached hereto and forms part hereof.

Date of Letters Patent - April 22, 1977.

GIVEN under the seal of office of the Minister of Consumer and Corporate Affairs.

for the Minister of Consumer and Corporate Affairs.

RECORDED 14th June, 1977

Film 418 Document 266

Deputy Registrar General of Canada

APPLICATION FOR INCORPORATION OF A CORPORATION WITHOUT SHARE CAPITAL UNDER PART II OF THE CANADA CORPORATIONS ACT

To the Minister of Consumer and Corporate Affairs of Canada.

I

The undersigned hereby apply to the Minister of Consumer and Corporate Affairs for the grant of a charter by letters patent under the provisions of Part II of the Canada Corporations Act constituting the undersigned, and such others as may become members of the Corporation thereby created, a body corporate and politic under the name of

THE CANADIAN ACOUSTICAL ASSOCIATION

L'ASSOCIATION CANADIENNE DE L'ACOUSTIQUE

The undersigned have satisfied themselves and are assured that the proposed name under which incorporation is sought is not the same or similar to the name under which any other company, society, association or firm, in existence is carrying on business in Canada or is incorporated under the laws of Canada or any province thereof or so nearly resembles the same as to be calculated to deceive and that it is not a name which is otherwise on public grounds objectionable.

II

The applicants are individuals of the full age of twenty-one years with power under law to contract. The name, the place of residence and the calling of each of the applicants are as follows:

| | |
|---|---|
| EUGENE H. BOLSTAD | 5903 - 109B Avenue,<br>Edmonton, Alberta.<br>Consulting Engineer. |
| C. WILLIAM BRADLEY | 3550 Ridgewood Ave.,<br>Montreal, Quebec.<br>Consulting Engineer. |
| ROBERT J. DONATO | P. O. Box 893<br>157 Church Street,<br>Almonte, Ontario.<br>Senior Research Officer |

| | |
|---|---|
| GARY FAULKNER | 11615 - 36 Avenue,<br>Edmonton, Alberta.<br>University Professor. |
| HUGH W. JONES | 5300 Vicary Place,<br>Calgary, Alberta.<br>Physicist. |
| JOHN MANUEL | 44 Charles St. West,<br>Apt. 5007,<br>Toronto, Ontario.<br>Engineer. |
| CAMERON SHERRY | 445 Bellevue Ave.,<br>Dorion, Quebec.<br>Engineer. |
| DOUGLAS JAMES WHICKER | 302 - 2726 Spruce St.,<br>Vancouver, British Columbia.<br>Engineer. |

The said EUGENE H. BOLSTAD, C. WILLIAM BRADLEY, ROBERT J. DONATO, GARY FAULKNER, HUGH W. JONES, JOHN MANUEL, CAMERON SHERRY, DOUGLAS JAMES WHICKER will be the first directors of the Corporation.

III

The objects of the Corporation are:

(a) the fostering of a high standard of scientific, engineering and medical endeavour in all the branches of acoustics in Canada

(b) the encouraging of liaison between individuals, governments and other organisations engaged in activities relating to acoustics and

(c) the dissemination of knowledge relating to acoustics and its applications.

It is not the purpose of the Association to seek to establish the professional status of its members, believing this is the concern of other organisations.

It may, however, give special recognition or awards to individuals who, in the opinion of the board of directors of the Association, are particularly meritorious.

IV

The operations of the Corporation may be carried on throughout Canada and elsewhere.

V

The place within Canada where the head office of the Corporation is to be situated is: OTTAWA, ONTARIO.

VI

In accordance with Section 65 of the Canada Corporations Act, it is provided that, when authorized by by-law, duly passed by the directors and sanctioned by at least two-thirds of the votes cast at a special general meeting of the members duly called for considering the by-law, the directors of the Corporation may from time to time

(a) borrow money upon the credit of the Corporation;

(b) limit or increase the amount to be borrowed;

(c) issue debentures or other securities of the Corporation;

(d) pledge or sell such debentures or other securities for such sums and at such prices as may be deemed expedient; and,

(e) secure any such debentures, or other securities, or any other present or future borrowing or liability of the Corporation by mortgage, hypothec, charge or pledge of all or any currently owned or subsequently acquired real and personal, movable and immovable, property of the Corporation, and the undertaking and rights of the Corporation.

Any such by-law may provide for the delegation of such powers by the directors to such officers or directors of the Corporation to such extent and in such manner as may be set out in the by-law.

Nothing herein limits or restricts the borrowing of money by the Corporation on bills of exchange or promissory notes made, drawn, accepted or endorsed by or on behalf of the Corporation.

It is especially provided that upon the dissolution of the corporation any assets remaining after the payment and satisfaction of the debts and liabilities shall be transferred to an organization or organizations in Canada having cognate or similar objects.

VII

The by-laws of the Corporation shall be those filed with the application for letters patent until repealed, amended, altered or added to.

VIII

The Corporation is to carry on its operations without pecuniary gain to its members and any profits or other accretions to the Corporation are to be used in promoting its objects.

Dated at the City of Ottawa in the Province of Ontario, this FIRST DAY OF APRIL 1977

EUGENE H. BOLSTAD..............................

C. WILLIAM BRADLEY.. C. W. Bradley ..........

ROBERT J. DONATO...............................

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