canadian acoustics
acoustique canadienne

JUNE 1995 JUIN 1995

Volume 23 — Number 2 Volume 23 — Numéro 2

EDITORIAL 1

TECHNICAL ARTICLES AND NOTES / ARTICLES ET NOTES TECHNIQUES

Noise reduction in a factory workplace using ray tracing method: a complete study from prediction to experimental validation
Jean-Luc Wojtowicki and Jean Nicolas **3**

Working party report: Technical assessment of upper noise limits in the workplace **11**

OTHER FEATURES / AUTRES RUBRIQUES

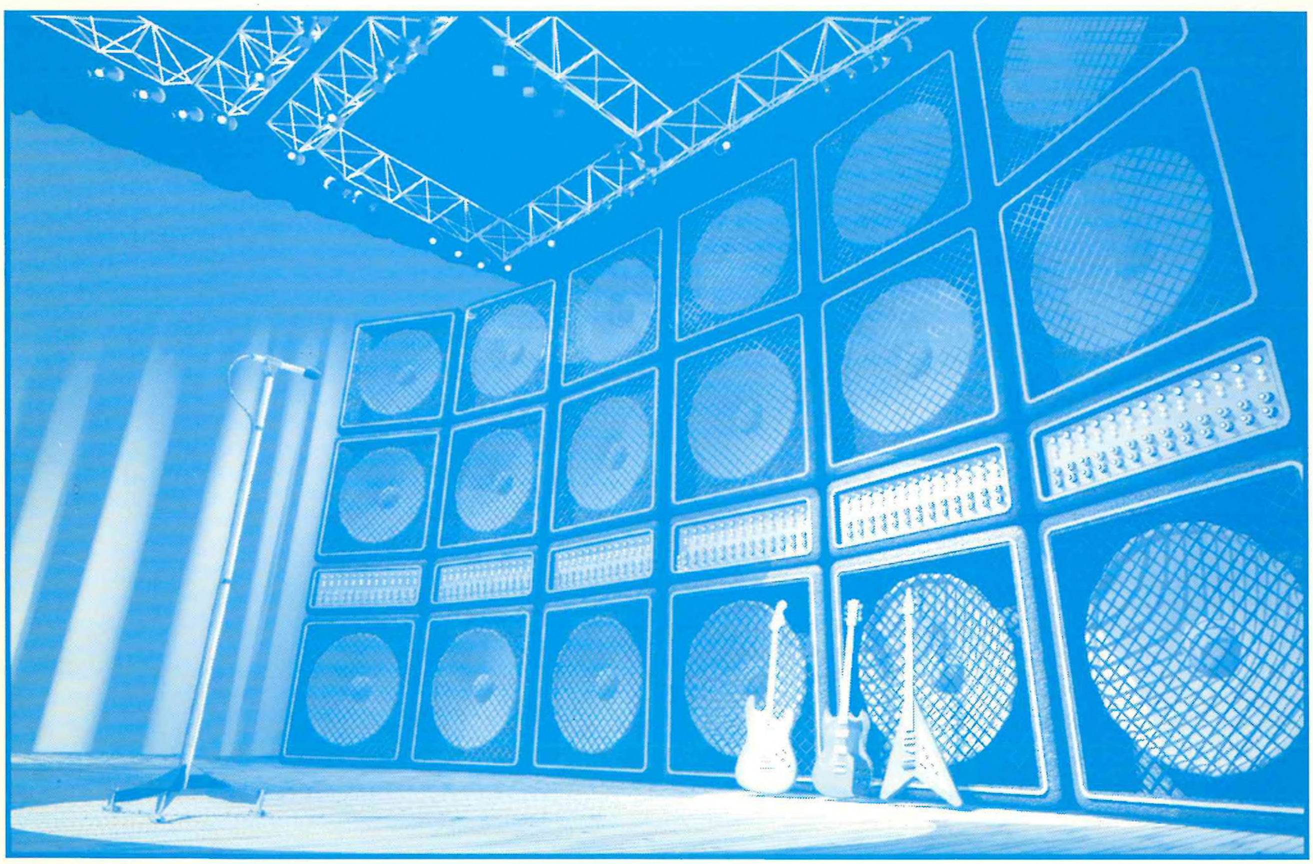
Letters to the Editor / Courrier des lecteurs **21**

Book reviews / Revues de livre **25**

Semaine canadienne d'acoustique 1995 / Acoustics Week in Canada 1995 **28**

Minutes of the CAA Board of Directors meeting / Compte rendu de la réunion des directeurs de l'ACA **33**

News / Informations **35**



canadian acoustics

acoustique canadienne

**THE CANADIAN ACOUSTICAL ASSOCIATION
P.O. BOX 1351, STATION "F"
TORONTO, ONTARIO M4Y 2V9**

**L'ASSOCIATION CANADIENNE D'ACOUSTIQUE
C.P. 1351, SUCCURSALE "F"
TORONTO, ONTARIO M4Y 2V9**

CANADIAN ACOUSTICS publishes refereed articles and news items on all aspects of acoustics and vibration. Articles reporting new research or applications, as well as review or tutorial papers and shorter technical notes are welcomed, in English or in French. Submissions should be sent directly to the Editor-in-Chief. Complete instructions to authors concerning the required camera-ready copy are presented at the end of this issue.

CANADIAN ACOUSTICS is published four times a year - in March, June, September and December. The deadline for submission of material is the first day of the month preceeding the issue month. Copyright on articles is held by the author(s), who should be contacted regarding reproduction. Annual subscription: $10 (student); $35 (individual, corporation); $150 (sustaining - see back cover). Back issues (when available) may be obtained from the CAA Secretary - price $10 including postage. Advertisement prices: $350 (centre spread); $175 (full page); $100 (half page); $70 (quarter page). Contact the Associate Editor (advertising) to place advertisements.

ACOUSTIQUE CANADIENNE publie des articles arbitrés et des informations sur tous les domaines de l'acoustique et des vibrations. On invite les auteurs à soumettre des manuscrits, rédigés en français ou en anglais, concernant des travaux inédits, des états de question ou des notes techniques. Les soumissions doivent être envoyées au rédacteur en chef. Les instructions pour la présentation des textes sont exposées à la fin de cette publication.

ACOUSTIQUE CANADIENNE est publiée quatre fois par année - en mars, juin, septembre et décembre. La date de tombée pour la soumission de matériel est fixée au premier jour du mois précédant la publication d'un numéro donné. Les droits d'auteur d'un article appartiennent à (aux) auteur(s). Toute demande de reproduction doit leur être acheminée. Abonnement annuel: $10 (étudiant); $35 (individuel, société); $150 (soutien - voir la couverture arrière). D'anciens numéros (non-épuisés) peuvent être obtenus du Secrétaire de l'ACA - prix: $10 (affranchissement inclus). Prix d'annonces publicitaires: $350 (page double); $175 (page pleine); $100 (demi page); $70 (quart de page). Contacter le rédacteur associé (publicité) afin de placer des annonces.

EDITORIAL

Ce numéro porte sur le bruit industriel. Nous publions un rapport sur la réduction du bruit dans un local industriel, incluant l'application de modèles prédictifs. Par ailleurs, nous reproduisons, du Noise/News International, le rapport du groupe de travail I-INCE sur les limites supérieures de niveaux de bruit admissibles dans les milieux de travail. Deux membres de l'ACA, Tony Embleton et Edgar Shaw, font partie de ce groupe de travail. Le comité de direction de l'ACA - représentant l'ACA, un des membres de I-INCE - a été appelé à voter sur la question de la contribution de ce rapport au développement du champ de l'ingéniere spécifique au contrôle du bruit, au niveau mondial. Le rapport est reproduit dans ce numéro pour information et discussion.

On nous a demandé de rappeler aux membres que l'*Acoustique Canadienne* accepte des soumissions de plusieurs types - pas seulement des articles scientifiques. Les rapports techniques - par exemple, émanant du milieu de la consultation - et les revues de littérature, ainsi que les rapports sur les activités de votre laboratoire ou de votre groupe professionnel, sont les bienvenus.

Ceux d'entre vous qui ont suivi la discussion portant sur l'article de Raymond Hétu trouveront, dans ce numéro, d'autres (peut-être les derniers?) lettres au rédacteur à ce sujet.

La Semaine Canadienne d'Acoustique, qui se tiendra à Québec, approche à grands pas. Les détails des sessions techniques sont publiés dans ce numéro, tout comme le formulaire d'inscription pour les présentations étudiantes - omis par erreur dans le dernier numéro. Ceux qui présentent des communications doivent noter que le 14 juillet est la date limite pour soumettre leur résumé de 2 pages qui paraîtra dans le numéro de septembre de l'*Acoustique Canadienne*.

The theme of this issue is industrial noise. Published are a report on work done to reduce noise in an industrial workroom, including the application of prediction models. We also reprint, from *Noise/News International*, the report of the I-INCE Working Party on Upper Limits for Noise Levels in the Workplace. This working party included CAA members Tony Embleton and Edgar Shaw. The CAA Board of Directors - representing the CAA, which is an I-INCE Member Society - has been asked to vote on whether or not the report makes a contribution to the world-wide development of the field of noise-control engineering. The report is reprinted here for information and discussion.

I have been asked to remind members that *Canadian Acoustics* welcomes the submission for publication of all types of material - not only research articles. Technical reports - for example, from the consulting world - and literature reviews, as well as reports on your laboratory's or group's professional activities are welcome.

Those of you following the discussion of Raymond Hétu's article will find further (and the last?) Letters to the Editor on the subject in this issue.

Acoustics Week in Canada 1995, to be held in Quebec City, is approaching quickly. Details of the technical sessions are presented here, as is the application form for the student presentations - inadvertently omitted for the last issue. For those of you presenting papers, note that July 14 is the deadline date for the submission of two-page summaries to appear in the September proceedings issue of *Canadian Acoustics*.

NOISE REDUCTION IN A FACTORY WORK PLACE USING RAY TRACING METHOD: A COMPLETE STUDY FROM PREDICTION TO EXPERIMENTAL VALIDATION

Jean-Luc Wojtowicki and Jean Nicolas
Department of mechanical engineering,
Acoustic and vibration group
University of Sherbrooke (Québec)

SUMMARY

The aim of this study is to test the efficiency and the accuracy of the ray tracing method applied to factory noise prediction. The originality of the work lies in the complete validation of the method on a real factory workplace instead of a well controlled laboratory case. The main finding of this study is that the ray tracing method is able to accurately predict noise reduction provided by a set of acoustical treatments in a practical case. Finally, this study shows that the method is an useful tool for a industrial company to choose among several acoustical treatments and to optimize the gain/cost ratio.

SOMMAIRE

Cette étude a pour but de tester l'efficacité et la précision de la méthode des rayons appliquées à l'acoustique prévisionnelle dans les locaux industriels. L'originalité de ce travail consiste en une validation complète de la méthode sur un cas concret et non sur un cas de laboratoire. Le principal résultat est la bonne précision de la méthode des rayons pour prédire des réductions du bruit réalistes par un ensemble déterminé de traitements acoustiques dans un véritable bâtiment industriel, même si le modèle n'inclut pas les effets de diffraction des ondes acoustiques. Enfin, on a montré que la méthode est un outil fort utile pour un industriel afin de choisir une solution de traitement acoustique et d'optimiser le rapport réduction/coût.

1. INTRODUCTION

Several methods are available to predict noise levels in industrial buildings. The method most often used is certainly the diffuse-field theory (Sabine and Eyring theories), but it has restrictive applications [1]. In order to simulate the acoustic response of rooms with more details, geometrical methods have been developed, namely the method of images and the ray tracing method [2].

This paper presents the results of a noise control study using RAYSCAD+ software based on the ray tracing method which has been developed by INRS [2]. Hodgson [3] has clearly proven the usefulness and flexibility of the ray tracing method to model fitted rooms with a high accuracy. However, the prediction of noise abatement due to a room acoustical treatment has been rarely verified experimentally after setting up the acoustical treatment, see for instance reference [4].

This study has been made in a new factory hall following an exhaustive method: preliminary sound pressure level measurements before treatment, modeling of the room with the objective to reduce the noise levels, simulation of noise reduction provided by possible treatments (acoustic screens, absorbing walls, suspended absorption, ...), factory installation of the most promising solutions and validation measurements.

2. DESCRIPTION OF FACTORY HALL

The company studied is specialized in house appliances and mainly manufactures heat exchangers. With the aim to enlarge the work area, a new factory hall (see figure 1) has been built. This new factory hall (60 m length, 29 m width and 6 m height) is divided in two sections: the fabrication area (punching machines, cutting presses,...) and the assembly-lines area. The flooring is made of concrete, the walls of concrete blocks and corrugated steel and the roof of metal sheets. Since the relocation in the new factory, workers of the assembly lines are exposed to the noise emitted from the fabrication area machines.

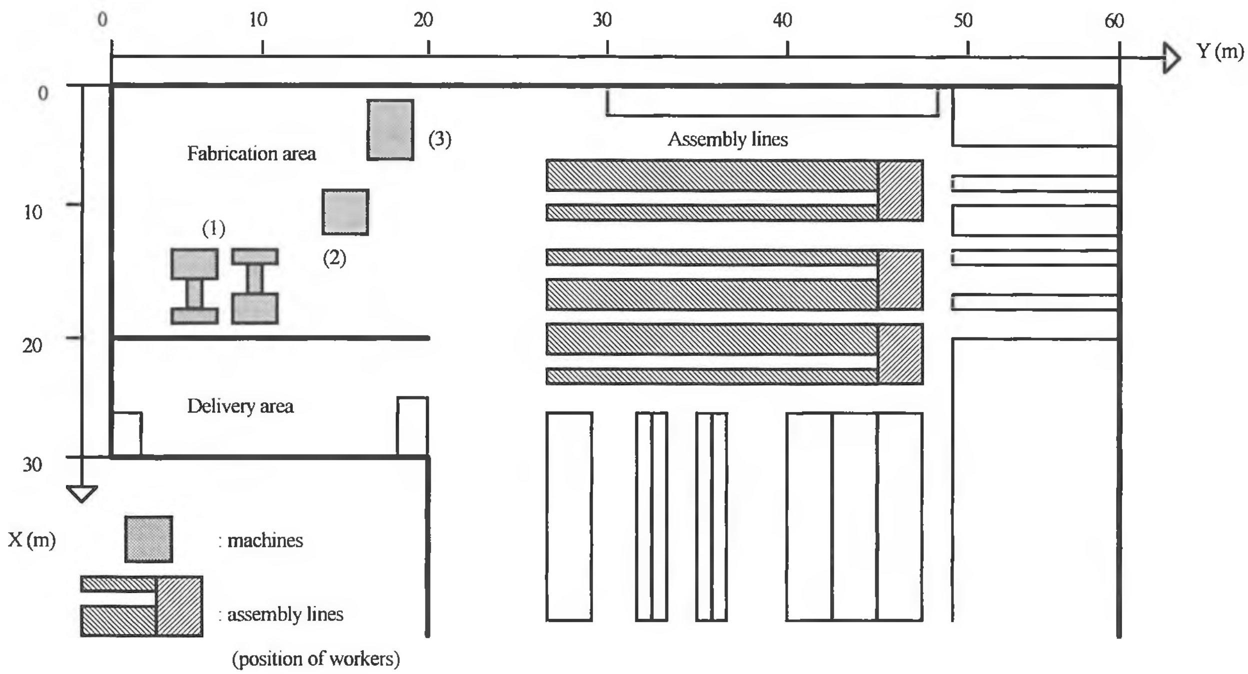


Figure 1. General overview of the factory hall

Table 1: Maximum sound pressure levels measured at one meter of the machines during one impact (dB(A))

	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Punching machine (1)	81	93	95	94	90
Punching machine 60 tons (2)	75	84	87	89	87
Cutting press (3)	77	86	90	90	92

Noise sources are power presses which produce a broadband noise each time an impact cycle occurs. The predominant source is a pair of punching machines (numbered (1) in figure 1) located on the other side of the wall which separate the fabrication area and the delivery area. The secondary sources are a cutting press and two punching machines (numbered (2) and (3) respectively in figure 1). Sound pressure levels measured individually at one meter from those noise sources are reported in table 1.

The sound pressure levels measured at the assembly-line worker stations can vary strongly depending on whether the machines are operating simultaneously or not. Measurements conducted in the assembly-line area vary from 75 dB(A) up to 85 dB(A). Those noise levels are not excessive, but the workers of the assembly lines are disturbed by the presence of the fabrication area noise since this noise problem did not exist in the old factory hall.

As the workers are far away from the noise sources (from 10 to 40 meters), it was assumed that the directivity of the machines did not have much importance at those distances. Moreover, the use of a well controlled sound source was preferred rather than the actual noise sources because of the strong variability of the impact noise emitted by punching machines. No control could be exercised on the gage of the punched steel sheets, the diameter of punching tools and the machine activity since these factors depended upon production schedules.

The main goal of this study was to protect the workers on the assembly lines from the fabrication area noise, as well as the operators in the delivery area to obtain a less "noisy and resonant" working environment.

3. PRELIMINARY MEASUREMENTS

A first set of measurements has been made in the room using the controlled noise source. This source is a sphere composed of twelve loudspeakers. Those loudspeakers are driven by a 500 W Yamaha amplifier with white noise generated by a Brüel & Kjaer analyzer type 2133. The sound pressure level has been measured with a Brüel & Kjaer sound level meter type 2218 and recorded for further investigations on a Sony PCM-2000 digital audio tape recorder.

Table 2: Absorption coefficient at 1 kHz

	Present study	Hodgson study [1]
Air absorption coefficient	0.001 Np/m	0.001 Np/m
Empty room surface absorption coefficient	0.10	0.08
Fitted room surface absorption coefficient	0.142	0.140

The sound power level of the machines has been evaluated using the inverse square law applied to the average sound pressure levels measured at one meter from its center. It has been verified through RAYSCAD+ that the reflections contribution was negligible (< 1 dB) in the factory hall at one meter. As to the sound source, it had been calibrated in a semi anechoïc chamber.

Sound pressure level measurements have been made in the fabrication area corridors, along the assembly lines and in the delivery area. These measurements were used to characterize the noise distribution in the factory hall.

A second set of measurements has been made on a straight line starting from the noise source. Each measurement point was separated by 5 meters. These experimental measurements were used to evaluate the sound propagation decay (Lp(at x meters from the source) - Lw(source)) in the factory hall from the source to the receiver position.

The entire study was concentrated in the octave band frequencies between 250 Hz and 4 kHz. Representative results presented in the remainder of this paper will be limited to the 1 kHz octave band for brevity and because the 1 kHz octave band was the dominant octave band in measured spectra in the factory hall.

4. MODELLING THE FACTORY HALL

The factory hall is modelled as close as possible to reality. Dimensions of the factory have been measured; walls, ceiling and floor materials have been identified. The data computed in the 1 kHz octave-band are given in table 2.

The absorption coefficient values computed are typical for an industrial hall, they are very close to those determined by Hodgson [3] for another room in another building. Indeed Hodgson [3] has calculated absorption coefficient values using reverberant time determination whereas in this paper, an average absorption coefficient has been calculated from the individual absorption coefficients and surfaces of each room surface (walls, ceiling, ...). These results confirm the fact that empty room surface absorption coefficient can be estimated with the values given by Hodgson [3]. The "fitted room" surface absorption parameters are quite similar to those obtained by Hodgson [3]. Because these parameters are the most difficult to evaluate, it is more convenient to use the ones given by Hodgson as starting values for modelling purposes.

The geometry of the hall has been modelled with 11 planes with corresponding absorption coefficients representing each surface of the room. Three encumbered zones have been defined, the first two correspond to the 0 to 2 meters height and the 2 meters to the roof zones in the studied area of interest (fabrication area + delivery area + assembly lines) and the third zone corresponds to the rest of the factory. The fitting parameters (absorption and density) have been estimated with typical data given in the RAYSCAD+ software data bank. The values chosen have been confirmed according to A.M. Ondet [6] who has extensively validated the data bank values.

The sound pressure levels are calculated using a 29×59 grid of 1711 reception cells equally distributed in the factory hall model. Each cell has a volume of one cubic meter ($1 \times 1 \times 1$ meter), the center height of these cells is 1.5 meters and the distance between two cells is 1 meter as shown in figure 6.

5. BEFORE TREATMENT: COMPARISON OF EXPERIMENTAL AND PREDICTION RESULTS

5.1 Sound propagation decay

The sound propagation decay has been calculated for both experimental and calculated results. The sound propagation curves are presented in figure 2.

The comparison between the two curves demonstrates a very good agreement between calculated and experimental results. The difference is less than 2 dB at any measurement point. This difference can be attributed to the measurement deviation as well as the estimated calculation parameters. As the sound propagation decay curves do not present significant differences for any octave-band, the parameters computed in the model have been taken as satisfactory.

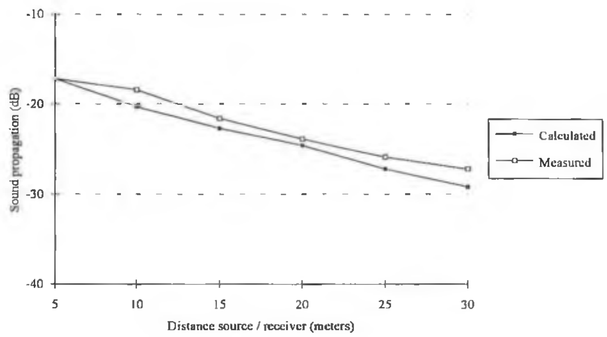


Figure 2. Sound propagation decay at 1 kHz before treatment

5.2 Sound Pressure Levels

As the sound pressure levels could not be measured at 1711 points, the comparisons between experimental and calculated results are limited due to actual accessibility to 29 measurement points. Table 3 presents the differences that can be observed in the factory hall before acoustical treatment installation. The discrepancies range between 0 to 3 dB, and mostly around 1 dB.

It can be observed that maximum error points are located in a specific area on a line from 24 to 44 meters on the X axis and 21 meters on the Y axis. This line is located between two storage racks which produce a local sound absorption increase. The encumbrance is not equally distributed in the room as it is assumed in the RAYSCAD+ software calculation hypothesis. Moreover, measurements were made on point locations when calculations are averaged on one cubic meter volumes. Local differences may be observed for all these reasons.

Overall, a good agreement is observed with an average error over the whole room of 1.1 dB.

6. DESCRIPTION OF THE STUDIED TREATMENTS

6.1 Acoustical treatment for noise reduction in the delivery area

The noise in the delivery area was high enough to render impossible any conversation including phone calls. The delivery area is located beside a 3.6 meter high partial wall (see fig. 3) separating this zone from the fabrication area (see fig. 1).

The obvious solution in this case is to raise the wall. Simulations have shown that it is preferable to raise the wall up to the roof in order to decrease the noise level down to the level of background noise. Since RAYSCAD+ does not

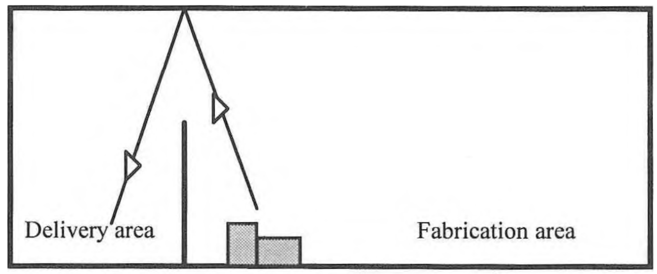


Figure 3. Separation wall between fabrication and delivery areas

include transmission loss effects, verifications have been made to insure that the transmission loss of the wall was at least 30 dB within the octave bands between 500 Hz and 2 kHz. The actual wall is made of double wall corrugated steel sheets separated by an air gap partially fulfilled with thermo-acoustic material.

6.2 Acoustical treatment for punching machines noise reduction

As mentioned earlier, the punching presses are the most important noise sources in the fabrication area. Since no economical and practical noise control solutions at the source were available, it has been decided to protect workers by adding acoustical screens around the pair of punching presses. The company did not want to install a full enclosure for various production reasons. Figure 4 describes the partial enclosure made with 3 m high screens with an inner surface covered of absorbing material (a = 0.9 at 1 kHz) and protected by a perforated metal sheet. The screen frame is made of 0.012 m plywood. Some important remarks must be made at this stage. Firstly, even though it was not possible to install a full enclosure equipped with a roof, the installation of absorbing baffles above this area will help to improve the efficiency of the partial enclosure. This has been confirmed by simulations and by the actual reduction measured (see section 7). Secondly, transmission loss of the wall is well above 15 dB, therefore insuring the transmitted field to be negligible. Thirdly, as RAYSCAD+ did not predict the diffraction effects, uncertainties will undoubtedly affect the predictions.

6.3 Acoustical treatment for noise reduction in the assembly-line area

Since the noise sources (production area) are far away from the assembly line (see figure 1), the most suitable way of decreasing noise is to act on the sound propagation. For this specific goal, RAYSCAD+ has proven to be quite powerful in the sense that it has permitted to evaluate the acoustic efficiency of various scenarios. These efficiencies can then be compared versus cost and the relative advantages and

Table 3. Relative error between calculation and experiment at 1 kHz before treatment

X (m) \ Y (m)	5	10	15	20	24	29	34	39	44	49
3					0.8	0.9	2.4	2	2.5	0.1
4	0.9	0.4	1.2	-0.1						
12					2.3	-0.1	0.7	-0.5	0.2	0
14	-0.8	-0.9	0.3	1.1						
21					1.1	2.3	1.7	2.2	3	
23	0.8	0.4	0.3	2						

(positive value: calculated SPL lower than measured SPL)

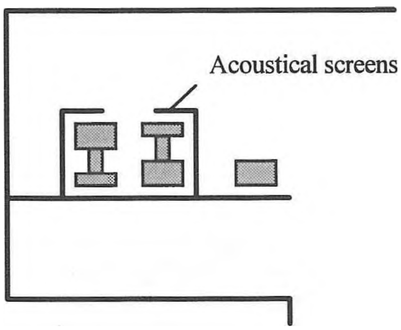


Figure 4. Acoustical screens around the pair of punching machines

constraints from the company's production point of view. Therefore, informed decisions can be exercised by company executives and engineers. It would be too long to describe the numerous scenarios but some of them deserve to be mentioned.

Partial screens from the roof towards ground or vice versa installed in the corridor between the production and the assembly line had proven to be efficient. The installation of baffles above the production line was predicted to be insufficient. The same can be said about installing baffles just above the assembly line. On the contrary, the installation of baffles all over the roof surface was predicted to be too efficient, so that an intermediate solution was chosen to limit costs. Baffles would be installed over the production area and above half the assembly area (see figure 5). Various baffle configurations have been simulated in accordance with the selected solution. For a good parametric study of baffle's effects, we refer the reader to recent work done by Hodgson et al. [5].

The chosen installation was such that each baffle is 2.4 meter long and 0.6 meter high and demonstrated an absorption of 0.9 at 1 kHz. The entire acoustical treatment of the roof consists of 280 baffles in a square arrangement (see figure 7). Those baffles are modelled with only 27 planes crossing every 2.4 meters. However, in practice, all these baffles could not be installed because of the presence of a suspended electric pulley tracks. The actual baffles were made of a sandwich consisting of two 2.5 mm acoustic tiles separated by 0.05 m air gap. This sandwich was supported by a steel frame.

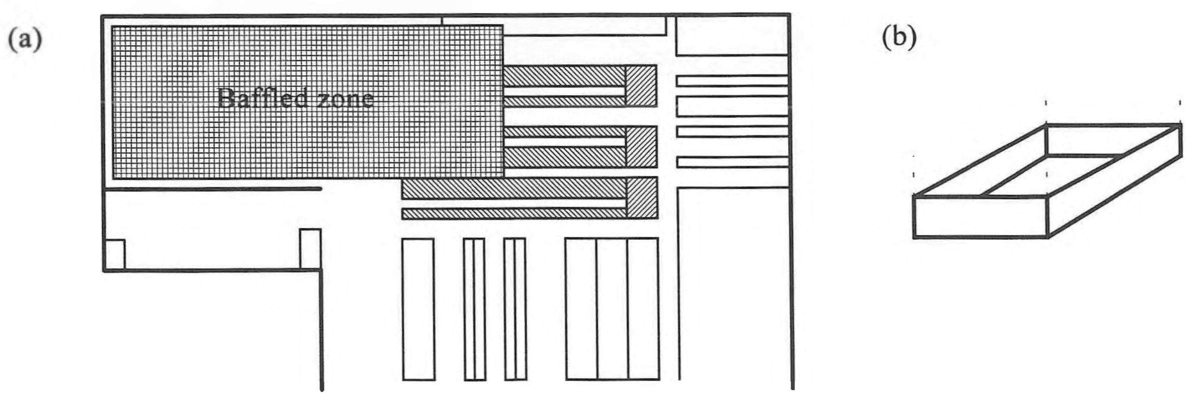


Figure 5. Acoustical baffles over the fabrication area. (a): location of the treatment, (b): four baffles disposed in square

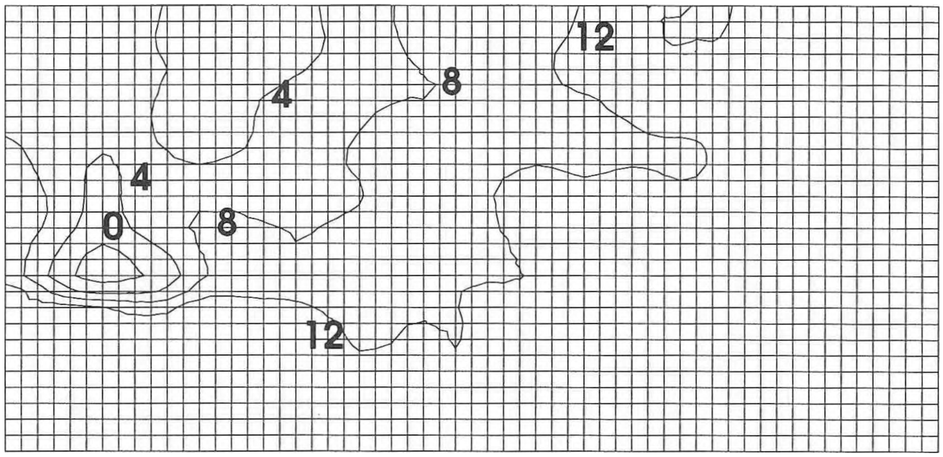


Figure 6: Predicted noise reduction at 1 kHz

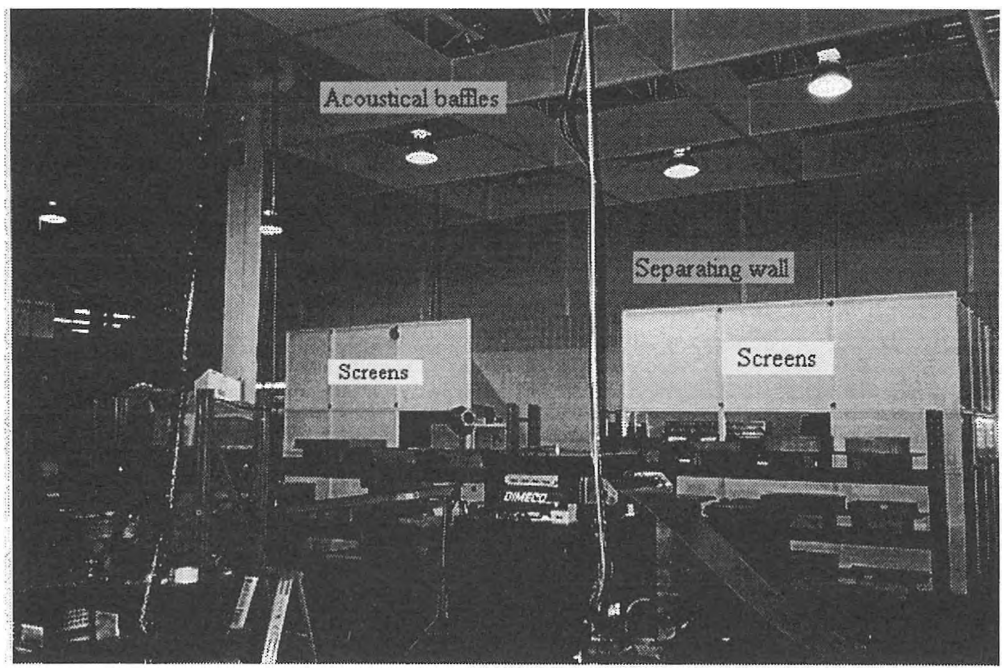


Figure 7: Photograph of the Venmar factory hall after treatment

7. AFTER TREATMENT: COMPARISON BETWEEN PREDICTED AND MEASURED RESULTS

Following the acoustical treatment installation, noise levels were measured in the fabrication area corridors, along the assembly lines and in the delivery area in the same manner used in the preliminary measurements.

7.1 Sound propagation decay

The new sound propagation decay has been measured on a straight line starting from the sound source, in the middle of the fabrication area, towards the assembly area. The measured and the predicted results are presented in figure 8. The agreement is quite good. Further away from the source, at 20 to 30 m, one may notice a small overestimation. This

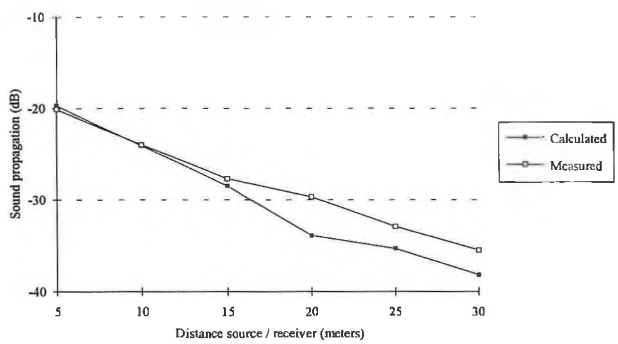


Figure 8. Sound propagation decay at 1 kHz after treatment

Table 4. Reverberation time before and after ceiling treatment

Frequencies	500	1 kHz	2 kHz	4 kHz
T.R. before(s)	1.6	2.2	1.8	1.6
T.R. after (s)	0.8	1.2	1	0.9

may be due to several reasons: (i) the fact that diffracted waves are not taken into account in RAYSCAD+; (ii) because the installation of baffles in the area of pulley tracks was not possible resulting in the use of less than 280 baffles; (iii) a small overestimation of the baffle absorption coefficient. Nevertheless the agreement is quite satisfactory and the gains obtained (figure 9) readily observable. To complete this aspect, reverberation time before and after treatment, under the treated zone have been measured. The results are given in Table 4. This explains also which the acoustic confort have been persued as greatly improved by the workers.

7.2 Sound pressure levels

The sound source is now located into the partial enclosure. Before presenting any results, it must be noted that the background noise inside the factory is about 54 dB. In order to compare actual levels with the predicted ones at each point, the predicted levels have been calculated by adding the background noise which was far from being negligible especially in the assembly and delivery areas.

In the first comparison (before treatment), no background noise correction had to be done. The main reason is that with no treatment, noise levels measured far from the sound source were still higher than the background noise.

Table 5 gives the comparison for several points distributed all over the three areas of interest. In general, and considering the complexity of the problem, the results are quite satisfactory. The precision is around or less than 2 dB for most of the points. However, in a central area,

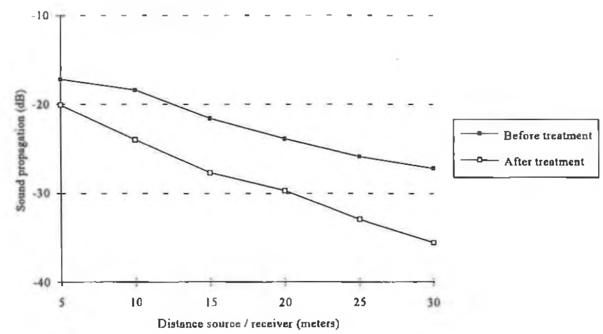


Figure 9. Sound propagation decay before and after treatment, experimental results

discrepancies up to 6 dB may be found. It is interesting to keep in mind that these discrepancies are given in the most severe case, that is to say for precise position. If we compare average levels on a given area (delivery, fabrication, assembly), discrepancies go down to about 2 dB. One may note that levels are well predicted in front of the opening of the partial enclosure. On the sides, however, reductions are overestimated and this is mainly due to the fact that diffracted waves (directly diffracted or diffracted and reflected) are not taken in account by RAYSCAD+.

8. EFFICIENCY OF THE PROPOSED NOISE TREATMENTS

The predicted and measured reductions have been calculated with sound sources located at the punch presses and cutting press positions. No attempt has been made to, after the fact, change some parameters to obtain a better fit. Data shown here are raw data (see figure 6).

- **<u>Noise reduction in the delivery area</u>:**

The predicted noise reduction was 12 dB (including the background noise) and the measured reduction, in this area shows an average of 13.5 dB. Not only is the prediction good but the objective of being able to sustain a conversation in this area is now achieved.

- **<u>Noise reduction in the production area</u>:**

Inside the partial enclosure the level is almost the same, as expected. The worker is essentially exposed to the direct field. By adding absorption on the inside walls of the partial screens we have made negligible the contribution of the supplementary reflected waves created by these new proximity walls. In this area, the predicted and measured noise reductions are 6 dB and 5.5 dB respectively. One may note here that this gain is partly due to the screens, partly due to the baffles.

Table 5. Relative error between calculation and experiment at 1 kHz after treatment, considering background noise

X (m) \ Y (m)	2	5	10	15	20	23	28	33	38	43
4						5	4	4	4	3
5	0	-1	1	5	4					
10	0	0	2	6	4	5	4	1	1	1
13	2	-1	6	4	5					
18						2	2	0	1	
23	3	2	2	2	4					

(positive value: calculated SPL lower than measured SPL)

- <u>Noise reduction in the assembly line area</u>:

The predicted noise reductions in this area varies from 8 to 12 dB, and the measured ones vary from 7 to 10 dB. The reasons for this overestimation have been explained previously. In the factory, during a normal workshift, this difference is clearly audible and results in the achievement of the main objective of the study.

9. CONCLUSION

In this study, the ray tracing method has been confronted not only to academical laboratory well controlled conditions but also to a real industrial one in all its complexity. The case chosen here included several degrees of complexity and the solutions tested involved all major situations such as: adding walls, adding partial enclosures, adding baffles.

Thanks to systematic measurements before and after treatment, it has been shown that RAYSCAD+ is undoubtedly a good and efficient tool. The predictions are generally reliable with a clear restriction stemming from its weakness of not including the diffracted waves. This effect of including the diffraction for a barrier was studied by L'Espérance [7], who in recent simulations [8], confirms that ignoring this effect may cause a 1 to 3 dB underestimation of the insertion loss of a barrier. The main advantage lies in the possibility for a given industry to choose rationally between various scenarios and to optimize the ratio gain/cost. Although the software is not complicate to use, knowledge in room acoustics is necessary to adequately adjust the model and to optimize the various solutions.

10 ACKNOWLEDGMENTS

The authors would like to thank the Venmar Company for its financial and technical support during this study.

11 REFERENCES

[1] M. Hodgson, «When is diffuse field theory accurate», Proc. Sabine Centenial session, 127th A.S.A. Meeting, Cambridge, 157-160 (1994).

[2] A.M. Ondet and J.L. Barbry, «Modeling of sound propagation in fitted workshops using ray tracing», *J. Acoust. Soc. Am.* **82**(2), 787-796 (1989).

[3] M. Hodgson, «Case history: Factory prediction using ray tracing - Experimental validation and the effectiveness of noise control measures», *Noise Control Engineering Journal,* **33**(3), 97- 104 (1989).

[4] M. Hodgson, N.D. Lewis., «Practical application of ray tracing to the modelling of factory sound fields», Proc. IOA, Vol.15, Pt. 3, 471-479 (1993).

[5] M. Hodgson et al., «Evaluation of the performance of suspended baffle arrays in typical industrial sound fields. Part I. 1:8 scale-model experiments», *J. Acoust. Soc. Am.* **97**(1), 339-348 (1995).

[6] A.M. Ondet, Private communication (April 1994).

[7] A. L'Espérance et al., «Barrier efficiency inside industrial halls via the image approach», Inter-Noise, Munich, 491-494 (1985).

[8] A. L'Espérance, A. Boudreau, «Évaluation de l'efficacité d'un traitement acoustique d'une centrale», Rapport technique ALCAN (1994).

TECHNICAL ASSESSMENT OF UPPER NOISE LIMITS IN THE WORKPLACE

Reprinted with permission from *Noise /News International* 2(4) 227-237 (1994). This document is a draft circulated for approval and comment; it is subject to revision.

Abstract

It is becoming widely recognized that the economic and social costs of high noise levels in the workplace require significant action to reduce the noise exposure of workers. Such costs include not only the financial compensation or damages that must be paid, and the reduced enjoyment of everyday life for those with a hearing loss, but also less quantifiable factors such as reduced productivity, increased stress and risk of accidents for a much larger number of workers. This technical assessment is presented in the form of a report which briefly reviews the extensive scientific and epidemiological evidence relating noise exposure to risk of hearing damage, and discusses the factors that are relevant to legislation. The basic features of existing legislation from many jurisdictions are tabulated. The report makes specific recommendations for legislation in the areas of 8-hour daily noise exposure level, acceptable level changes for longer or shorter daily exposure periods, limitation of peak sound levels for short-duration (impulsive) noises, audiometric testing on schedules that depend on exposure level, sound absorption treatment in working areas, and the inclusion of noise performance in purchase specifications for new production machinery.

Sommaire

Il est de plus en plus reconnu que les coûts économiques et sociaux associés aux niveaux de bruit élevés dans les milieux de travail rendent nécessaires des actions significatives pour réduire l'exposition au bruit des travailleurs. Ces coûts incluent non seulement les compensations financières ou les dommages qui doivent être payés ainsi que la perte de jouissance de la vie pour les individus atteints de surdité, mais aussi des facteurs moins faciles à quantifier tels la baisse de productivité, l'augmentation du stress et les risques d'accident touchant un plus grand nombre de travailleurs. Cette évaluation technique est présentée sous la forme d'un rapport qui fait une brève revue des nombreuses évidences scientifiques et épidémiologiques concernant le lien entre l'exposition au bruit et le risque d'atteinte à l'audition, et discute des facteurs de nature législative. Les éléments de base de la législation en vigueur, émanant de plusieurs juridictions, sont présentés. Le rapport fait des recommandations spécifiques à l'égard de la législation dans le domaine du niveau d'exposition au bruit pour une période de 8 heures, des changements acceptables de niveaux pour des expositions de plus longue ou de plus courte durées quotidiennes, de l'échéancier des tests audiométriques qui dépendent du niveau d'exposition, du traitement acoustique des locaux de travail, et de l'ajout de spécifications d'achat concernant les performances acoustiques de nouvelles machines.

Preface

The International INCE General Assembly on 1992-07-22 approved an initiative to review current knowledge and practice concerning *Upper Noise Limits in the Workplace.* The background and concept for this initiative are described beginning on the facing page. Each member of the Working Party that prepared this report represents a different Member Society that supports the International Institute of Noise Control Engineering; in addition there was a Special Advisor and a Convenor. Countries and members of the Working Party were as follows:

Convenor: Tony F. W. Embleton

Australia: Bruce Gibson-Wilde
Brazil: Jules G. Slama
Canada: Edgar A. G. Shaw
France: René Gamba
Germany: Hans Lazarus
Hungary: Peregrin Lazlo Timar
New Zealand: George Bellhouse
USA: (ASA): W. Dixon Ward
USA: (INCE-USA): Stephen I. Roth
Special Advisor: Alice H. Suter

Background

This initiative of International INCE deals with the effects of upper noise limits on individuals in their working environments. It concerns the potential of prolonged exposure to high noise levels to induce hearing loss in those exposed to the noise. This initiative is not concerned with sound levels at the workplace which are so low that the chances of causing noise-induced temporary or permanent hearing threshold shift are insignificant.

Many countries have introduced regulations which set upper limits on noise levels at the workplace. There is little, if any, coordination internationally in the setting of the upper noise limits. Regionally, the European Community (EC) has taken steps to coordinate the setting of upper limits, and several Member States have already adopted these uniform limits. There is general agreement in Europe, as well as within scientific communities elsewhere, that the methods defined in International Standard ISO 1999:1990, "Acoustics - Determination of occupational noise exposure and estimation of noise-induced hearing impairment," are valid and should be used by regulatory bodies for guidance in setting upper limits. Nonetheless, this International Standard contains a disclaimer which states: "The selection of maximum tolerable or maximum permissible noise exposures... require(s) consideration of ethical, social, economic and political factors not amenable to standardization. Individual countries differ in their interpretation of these factors and these factors are therefore considered outside the scope of this International Standard."

Since workplace noise regulations were first introduced more than 30 years ago, there have been many proposals that the upper limits should be significantly lowered. But this has generally not happened as the factors mentioned in the ISO disclaimer above have come into play.

Few people question the need for workplace noise limits, but the cost to comply is frequently cited as the reason for non-compliance. For this and other reasons, it is important to present the technical basis for the establishment of upper noise limits in a manner as independent as possible of the non-technical factors that influence the selection. In this area, I-INCE has identified a lack of objective evidence to support the selection of upper limits.

Concept

I-INCE has decided to undertake a study of the technical basis for the selection of upper noise limits at the workplace by regulatory authorities. This study will disregard the non-technical factors that influence the selection of upper noise limits and will be undertaken as follows:

1. Identify the development of regulations specifying upper limits on noise at the workplace during the past four decades.

2. Concentrate on the two most widely specified limits (L_{eq} = 85 dB and L_{eq} = 90 dB for eight-hour exposures) and the "fence" with the greatest degree of acceptance in the scientific community, and answer the question: what percentage of workers would suffer noise-induced threshold shifts due to long-time exposure at these levels?

3. Examine the scientific basis for the two trading relationships (equivalent continuous A-weighted sound pressure level versus time) most commonly used, 3 dB and 5 dB, and recommend the one that is more appropriate for regulatory purposes.

4. Develop a model regulation which includes an upper limit, a "fence" (hearing threshold level above which degrees of hearing disability exist), a trading relationship, and a noise measurement methodology.

The International INCE General Assembly approved the formation of a Working Party on Upper Noise Limits in the Workplace to carry out this work. Nine Member Societies volunteered to participate and contribute information. Their position papers covered existing legislation, compensation practices, typical industrial noise levels, programs to enforce regulations and their effectiveness, and future plans and expectations in the countries of the participants. This information was compiled into an initial draft report that was reviewed during a meeting of the Working Party in Leuven, 1993-08-23, and reported during INTER-NOISE 93. After several further drafts, a major revision was presented during INTER-NOISE 94 in Yokohama, and with minor changes is now being published in *Noise/News International* for wider discussion and vote by Member Societies.

Report by the International Institute of Noise Control Engineering Working Party on "Upper Limits on Noise in the Workplace"

Tony F.W. Embleton, Convenor of the Working Party

P.O. Box 786 Nobleton, Ontario,
Canada L0G 1N0

1. Introduction

The primary goal of this report is to contribute to the reduction of risk and magnitude of long-term hearing damage, towards a practical minimum for those people habitually exposed to noise in the workplace. A secondary result of reducing noise in the workplace is likely to be some increase in worker safety due to enhanced ability to hear warning signals, and reduced stress on the job. The regulations, and terms of financial compensation for loss of hearing in several industrialized countries are summarized as examples of current practice. It is hoped that this summary and resulting recommendations may eventually promote international uniformity, and encourage jurisdictions currently without control of noise levels in the workplace to enact regulations, by showing what is considered by legislators to be socially desirable and economically feasible in other countries.

Over the past 30 years, many countries have introduced regulations that set upper limits on noise levels in the workplace. In the past there has been little coordination internationally in the setting of such upper noise limits. Regionally, the European Community has taken steps to coordinate the setting of upper noise limits, and several Member States have already adopted these uniform limits. There is general agreement in Europe, in some non-European countries, and in most scientific communities, that the methods defined in International Standard ISO 1999:1990, "Acoustics - Determination of occupational noise exposure and estimation of noise-induced hearing impairment", are valid[1] and should be used by regulatory bodies for guidance in setting upper limits. This standard contains a disclaimer that states: "The selection of maximum tolerable or maximum permissible noise exposures ... requires consideration of ethical, social, economic and political factors not amenable to international standardization. Individual countries differ in their interpretation of these factors and these factors are therefore considered outside the scope of this International Standard." In most industrially advanced countries there are few people who question the need for workplace noise limits, but the commercial and financial costs to comply are often cited as reasons for non-compliance. The administrative difficulties and costs of effective and uniform enforcement of regulations are also a deterrent to those who might otherwise wish to reduce noise levels. These are valid concerns, and so it has become important to present the technical basis for the establishment of upper noise limits in a manner as independent as possible of non-technical factors that influence the selection. Review of the regulations does however illustrate what legislators consider to be suitable national goals, given each country's particular mix of "ethical, social, economic and political factors".

There are overall similarities in factors that are regulated in each country, but differences in the noise limits set, and in the methods of compensation for hearing damage (see Table 1). For example, most countries have an exposure limit of 85 dB (A-weighted, equivalent sound level for 8 hours), though the Netherlands has a limit of 80 dB, and the USA has a time-weighted-average limit of 90 dB, A-weighted. The allowed increase in sound level for a halving of exposure time, often called the exchange rate, is generally 3 dB, though Brazil, Israel and USA allow a 5-dB increase. The maximum sound level permitted for exposure, regardless of duration, is expressed in different ways in different countries but is generally in the range of 115 dB (A-weighted, fast) to 140 dB (linear, peak). Exposure to impulsive noise or blast is treated separately from 8-hour exposure levels in most jurisdictions, with limits being set for the peak sound level of a single event. Most countries require certain engineering and administrative controls to be implemented when exposure levels exceed a certain limit. These controls take several forms but include such requirements as specifications for the noise performance of new machinery, mandatory audiometric testing programs, adjustment of work schedules to reduce exposure time, or the use of ear protection. There are major differences in the financial aspects of compensation for hearing damage (see Table 2); in some countries there is a lump-sum payment, in others the payment is related to some fraction of the minimum salary and paid as a supplement. In most jurisdictions the practice is to allow partial compensation for partial loss of hearing, although in some cases compensation is only paid if there is an actual loss of earning power as a result of the hearing loss that has been suffered.

2. Scientific Basis

Two reviews, both with extensive bibliographies, of great relevance to this report are "Occupational Noise Exposure and Noise-Induced Hearing Loss: Scientific Issues,

Table 1. Some features of legislation tabulated for different countries*

Country (Juristiction)	L_{Aeq} 8-hour exposure rate	Exchange rate	Limit for engineering or administrative controls	Limit for monitoring hearing	Upper limit for sound level
Australia (varies by state)	85 dB	3 dB	85 dBA	85 dBA	140 dB lin, peak
Brazil	85 dB	5 dB	90 dBA. No exposure >115 dBA if no protection	85 dBA	130 dB peak
Canada (Federal) (ON, PQ, NB) (Alta, NS, NF) (BC)	87 dB 90 dB 85 dB 90 dB	3 dB 5 dB 5 dB 3 dB	87 dB 90 dBA 85 dBA 90 dBA	84 dBA 85 dBA (a)	140 dB peak
China	70–90 dB	3 dB			115 dBA
Finland	85 dB	3 dB	85 dB		
France (b)	85 dB	3 dB	90 dBA or 140 dB peak	85 dBA	135 dB peak
Germany (b) (c)	85 dB	3 dB	90 dBA	85 dBA	140 dB peak
Hungary	85 dB	3 dB	90 dBA		125 dBA or 140 dB peak
Israel	85 dB	5 dB			115 dBA or 140 dB peak
Italy	85 dB	3 dB	90 dB	85 dB	140 dB peak
Netherlands	80 dB	3 dB	85 dB		140 dB peak
New Zealand	85 dB	3 dB	85 dBA + 3 dB exchange rate		115 dBA slow or 140 dB peak
Norway	85 dB	3 dB		80 dBA	110 dBA
Spain	85 dB	3 dB	90 dbA	80 dBA	140 dB peak
Sweden	85 dB	3 dB	90 dBA	80 dBA	115 dBA, 140 dBC
United Kingdom	85 dB	3 dB	90 dBA	85 dBA	140 dB peak
USA (d) USA (Army and Air Force)	90 dB (TWA) 84 dB	5 dB 3 dB	90 dBA but no exposure >115 dBA	85 dBA 85 dBA	140 dB peak or 115 dBA 140 dB peak
This Report Recommends	**85 dB**	**3 dB**	**use quietest machines and room absorption in workplaces**	**on hiring and at intervals thereafter**	**140 dB peak**

* Information for countries not represented by Member Societies participating in the Working Party is taken from Ref. 15.

(a) A more complex situation is simplified to fit this tabulation.

(b) These countries require the noise declaration of machinery, the use of the quietest machinery where reasonably possible, and reduced reflection of noise in the building, regardless of sound or exposure levels.

(c) The noise exposure consists of L_{Aeq} and adjustments for tonal character and impulsiveness.

(d) TWA is Time Weighted Average. The regulations in the US are unusually complex because different thresholds are used to compute levels to initiate hearing programs (85 dBA), noise exposure monitoring (80 dBA), and noise reduction measures (90 dB), each using a 5–dB exchange rate.

Table 2. Some features of compensation tabulated by participating countries

Country	Compensation basis
Australia	Generally lump-sum compensation; provisions vary between States and Territories.
Brazil	10% to 40% minimum salary (extra pay as compensation for higher level of exposure).
Canada	Varies by Province; total loss of both ears is in the range of 20% to 25% of total disability. Paid only when earning power lost.
France	Averages FFR 600 000 per admitted claim paid by company (amount depends on wage and degree of disability).
Germany	Paid if loss of earning capacity greater than 20%. In 1987/1988, average pension was DM 6150 (whole term about DM 130 000).
Hungary	Damages are paid as a supplement of earnings. Supplement increases progressively from 8% when degree of hearing impairment is between 16% and 25%, to 30% for impairment of 50% or greater. Paid for only 2 years if impairment is less than 26%, otherwise continuously.
New Zealand	Fine on employer. Maximum compensation is 80% of pay if unable to work plus allowance of up to NZD 40 per week depending on the amount of injury.
USA	Varies by State. Total loss in both ears: from USD 125 000 (Iowa), USD 132 500 (Pennsylvania), to USD 12 000 (Colorado and North Dakota). Some states pay only for loss due to trauma, not for NIPTS.

Technical Arguments and Practical Recommendations," by Edgar A. G. Shaw[2], and "The relationship of the exchange rate to noise-induced hearing loss" by Alice H. Suter[3]. The review by Suter has been reprinted, and for many, may be more accessible, in *Noise/News International*[4].

The body of scientific knowledge on noise-induced hearing loss is extensive, and has been built up over a period of at least 40 years through the contributions of many researchers worldwide. The amount of hearing loss produced by exposure to noise is a function of many factors that interact in a complicated way that precludes any simple set of rules relating noise exposure to hearing loss. These factors include the nature of the sound itself (its sound level and spectral content), and whether it is steady or variable, impulsive, continuous, or intermittent. In this latter situation it is important how long the quiet periods last, and how much quieter they are compared with the noise, in determining the extent to which they may help to reduce the hearing loss caused by the exposure.

The goal of regulation is to reduce the permanent loss of hearing due to habitual exposure to excessive noise, as occurs on a daily basis over many months or years in the workplace. This is commonly known as Noise-Induced Permanent Threshold Shift (NIPTS). Whilst protection against NIPTS is the goal of regulation, it is the form of hearing loss least amenable to direct and controlled scientific investigation, because of the risk of permanent damage to the subjects. The most relevant alternative is to conduct epidemiological studies of NIPTS, but these are becoming more difficult to design and evaluate because the increased use of hearing protection, administrative controls, or quieter machines in recent years leads to small sample sizes and subjects having exposure to noise that has changed with time. In some studies from earlier years, before the time of widespread preventative measures, the sample sizes may have been adequately large, but the measurement of sound levels to which the subjects were exposed may have been made with instruments lacking the impulse and dynamic-range capabilities of modern instruments.

For these reasons many investigations have employed secondary measures, such as Temporary Threshold Shift Two (TTS2), or Asymptotic Threshold Shift (ATS). The use of either TTS2 or ATS rests on the assumption that there is a close relationship between these temporary effects and permanent hearing loss, NIPTS. In neither case has this assumption been adequately validated, and evidence indicates that the relationship varies considerably between individuals. Suter concludes that temporary threshold shift (TTS) should not be relied upon for predicting the long-term adverse effects of noise exposure. Another experimental approach that avoids assumptions about the relationship between temporary and permanent threshold shifts is the use of animal subjects. Much valuable information has been obtained concerning damage to hair cells in the inner ear and its relationship to NIPTS. But there are again major assumptions; that the ears of such animals respond in the same way as the human ear to all types of noises, and that the laboratory conditions under which these measurements are made are analogous to real-world human exposures.

Hence the relevance of much of the existing scientific knowledge to long-term noise exposure of humans in the workplace, and the consequent permanent threshold shift that they may suffer, rests on various assumptions that have not been adequately validated. One's ability to obtain a clear understanding of the relationships involved is also made more difficult by the fact that some evidence comes from epidemiological studies of NIPTS and some from controlled studies of TTS. The ISO Standard 1999:1990[1] is based on evidence from epidemiological studies, hence its relationships between noise exposure and NIPTS are clearly reliable but apply statistically to groups of people and do not apply to individuals.

A central issue in both scientific work and in legislation is the relation between two or more noises that produce the same amount of NIPTS when these noises differ in intensity, in duration, and in temporal pattern. This has come to be known as the "exchange rate." It is expressed as the number of decibels by which the sound level may be increased for a halving of the exposure time. Suter's review suggests (a) that laboratory studies on both humans and animals generally support a value for the exchange rate of 3 dB rather than 5 dB, (b) that data from a number of field studies also generally support the 3 dB, i.e. equal energy, rule, (c) some field data from outdoor occupations having intermittent noise exposures, such as forestry and mining, show less hearing loss than expected when compared with continuous noise exposure, and (d) the ameliorative effect of intermittence does not support the use of a 5-dB exchange rate although it might allow the use of an upward adjustment to the maximum permissible exposure limit (8-hour equivalent sound exposure) for certain occupations.

Shaw[2, p. 32] has analyzed many of the same scientific and epidemiological studies and reaches conclusions similar to those of Suter. In his words: "It is concluded (a) that for steady, intermittent and varying noise, there is adequate scientific support for the acceptance of the equivalent continuous A-weighted sound pressure level or, in the terminology of ISO/R1999-1984, the 'time integral of the squared, A-weighted sound pressure,' with an appropriate integration period, as the best available measure of sound exposure, (b) that there is at present no scientifically acceptable means of refining this approximate measure, and (c) that there is at present no scientifically acceptable alternative measure of sound exposure. In other words, the 3 dB exchange rate should be accepted and the 5 dB exchange rate firmly rejected."

Individuals almost certainly differ in their susceptibility to noise-induced hearing loss. Thus no single descriptor of the sound exposure can closely predict the likely NIPTS for an individual, even if all the known complexities associated with the varying nature of the noise, such as its spectral content, sound level and time variations, can be correctly taken into account. Thus a factor that may lead to some confusion, and which should be recognized explicitly in legislation, understood during the process of developing regulations, and in the interpretation of scientific studies, is whether one is dealing with a sound level that presents no risk to anybody (or no more than a given degree of hearing loss in everybody), or a median sound level that produces a zero or negligible loss of hearing (or a given degree of hearing loss) in the average, or median individual. Obviously the exposure level to protect everybody is lower than the level to protect the average person.

Another factor that may lead to some confusion arises from the use of terms such as the percent risk of incurring a noise-induced hearing loss. This means the excess risk of exceeding a certain "fence" or threshold value of loss of hearing due to noise exposure, after subtracting the percentage of people that would exceed the fence due to the effects of aging alone (presbycusis). The actual percent risk from a given noise exposure is highly dependent upon a number of factors apart from the level and duration of the exposure itself: these include the audiometric frequencies used to define and measure the hearing loss; the hearing threshold level ("fence") beyond which a hearing loss is defined to have occurred; the hearing threshold levels of the non-noise exposed population used to estimate the effects of presbycusis, and especially the degree to which this population has been screened for occupational and even non-occupational noise exposure[1, Annex A and Annex B]. Initially, in the United States, audiometric frequencies of 500, 1000 and 2000 Hz were used and a fence of 25 dB. Later, NIOSH (U.S. National Institute of Occupational Safety and Health) started to use frequencies of 1000, 2000 and 3000 Hz with a fence of 25 dB, whilst the EPA (U.S. Environmental Protection Agency) used audiometric frequencies of 1000, 2000 and 4000 Hz. The Standard ISO 1999:1990[1] tabulates values of hearing threshold levels at six audiometric frequencies, viz. 500, 1000, 2000, 3000, 4000 and 6000 Hz, but does not specify any preferred frequency combinations or weighted combinations to be used for the evaluation of hearing handicap, nor does it specify a hearing threshold level ("fence") which must be exceeded for a hearing handicap to exist. Selection of these parameters is explicitly left to the user. The use of higher frequencies or lower fences makes the risk appear to be higher, and conversely the use of lower frequencies or higher fences makes the risk appear to be lower.

The status of an individual's hearing is the result of the combination of occupational noise exposure, exposure to the noises of everyday life, the aging process, and disease processes - occupational NIPTS, sociacusis, presbycusis and nosoacusis respectively. The report is primarily concerned with occupational noise exposure. However, reliable separation of the contributions of occupational and non-occupational noise exposure to any measured hearing loss is difficult. Non-occupational noise exposure occurs in all human populations due to such factors as transportation, communications, mechanical or powered tools, and many other sources, and is probably increasing with time in all societies. Thus any meaningful screening of subjects for non-occupational exposure (sociacusis), whether to determine the effects of aging alone (presbycusis) or to determine the effects of occupational NIPTS, is likely to leave a population that is too small, possibly even zero, for reliable study in most mechanized societies.

It has been recommended in Sweden that exposure levels should not exceed 75 dB (A-weighted, 8-hour equivalent sound level)[5, p. 22 and 6, p. 203] in the workplace if all risk of NIPTS is to be avoided **for all persons**. If such exposure is associated with 16 hours spent in much quieter surroundings, then this is equivalent to a 24-hour exposure level of 70 dB. To quote from Reference 6, page 203: "The Commission of the European Community has established L_{eq} = 75 dBA as the noise level at which the risks of sustaining hearing damage can be considered negligible (Proposal for a Council Directive, Com/92/560). This level is based on the findings of a number of medical studies. In the proposal, 75 dBA is defined as a threshold level. The proposal gives some room for flexibility by defining action levels in the range between 75 and 90 dBA and by declaring 90 dBA the upper limit." It must be pointed out that there is not general agreement that levels as low as L_{Aeq} = 75 dB are necessary to avoid all risk of long-term hearing loss; Ward[7, p. 97, Fig. 4.5] shows that the estimated industrial noise-induced permanent threshold shift at 4 kHz, for the average person, decreases to zero at a sound level of about 80 dBA.

Published knowledge of the effects of impulsive noise, as generally encountered in industry, is not as extensive as for the other factors mentioned above. However, based on the available information, Shaw reaches the conclusion[2, p. 36]: "... that, in the measurement and specification of sound exposure, no distinction should be made between impulsive noise and other types of noise. Steady, intermittent, varying and impulsive noise should all be included in a comprehensive measurement of 'the time integral of the squared A-weighted sound pressure,' in accordance with ISO/1999-1984." The published text of ISO 1999:1990 makes it clear that the definition of noise exposure given in the standard is comprehensive in that it "applies to all types of audio frequency (less than 10 kHz) noise including "noise which is impulsive in character." While no explicit peak level is given, it is stated that the "Use of this International Standard for instantaneous sound pressures exceeding 200 Pa (140 dB relative to 20 mPa) and for higher sound pressures should be recognized as extrapolation." This does not set 140 dB as a noise limit, but does suggest that the principle of energy equivalence may not be valid at higher sound pressures.

Exposure even for very brief periods to very intense noise, or to single impulses such as blast or gunshots, can cause permanent damage to hearing for the most susceptible individuals. This type of traumatic damage risk exists also with noise containing intense impulses, and may be higher than that caused by continuous noise.

3. Factors Relevant to Regulation

A recent survey by the public health authorities in Hungary[8] is typical and concludes that "In the middle of the 1980s we have estimated that the number of workers working in higher noise immission than (8-hour L_{Aeq} = 85 dB) is about 500 000. This is about 30% of the industrial workers, 10% of the earners and 5% of the whole population." Authorities in Germany[9] estimate that 15% of the earners or working population is exposed to more than 85 dBA. If it is decided that the workplace should be without risk of noise-induced hearing loss for anybody due to long-term exposure then "noise levels around L_{eq} = 85 dBA are not satisfactory for the working environment .... exposure levels of L_{eq} < 70 - 75 dBA should be the goal for production facilities."[6, p. 203] It is clear from existing legislation that governments have so far set levels of noise in their regulations that allow some chance of hearing damage for some fraction of the population, but which reduce the amount of damage to a low value, deemed acceptable, for most of the noise-exposed population.

3.1 Basic Level of Exposure

Most legislation sets a limit of 85 or 90 dB (L_{Aeq} for 8 hours) for permissible noise exposure in the workplace. Such a limit implicitly accepts that some fraction of workers will suffer a hearing handicap sufficient to affect adversely some of the communication activities of daily life, as the result of habitual exposure. Obviously a level of 85 dB, compared with a limit of 90 dB, reduces the fraction suffering NIPTS as well as the magnitude of the hearing loss in those that are affected. These greater social benefits are often associated, sometimes erroneously, with greater financial costs to achieve lower sound levels, at least in terms of initial capital investment. The choice between 85 and 90 dB is therefore based, for each jurisdiction, on its particular choice of "ethical, social, economic and political factors not amenable to standardization" - the proviso in ISO 1999:1990. It is clear that the balance between these non-technical, sociological factors can often change over a period of time, and hence that there is adequate justification to change the noise exposures and other requirements in legislation as society's expectations evolve. Several

European countries base their national legislation on the EC Directives (the statutory regulations of the European Community). For example, in Germany[10] Workshop Ordinance (A. bStättV), Section 15 states that the rating level (L_{Aeq} plus adjustments for impulses and tones) should not exceed 55 dB for mental activities, recreation or sanitary rooms etc; 70 dB for simple or mainly mechanized office work; or 85 dB for all other activities.

3.2 Exchange Rate

Scientifically, no exchange rate is applicable in all possible situations. Even if all scientific details of this complicated matter were better established than they currently are, much simplification is needed for purposes of legislation. This has been achieved by setting a single number, either 3 or 5 dB in most jurisdictions. However, there are several possible choices:

1. The simplest, and almost certainly the best choice, is to leave the exchange rate undefined, at least in explicit terms. This can only be done provided that the legislation very clearly defines the value set for L_{Aeq}, as the *exposure level* for the worker, and not as the sound level which exists at the workplace. The allowed value then limits the total 8-hour exposure for the individual worker, regardless of whether this is acquired at a lower sound level over 8 hours or at a higher sound level for a shorter period. The technical definition of equivalent A-weighted sound level, L_{Aeq}, is based on the time-averaging of sound energy and hence implicitly defines the use of a 3-dB exchange rate. As noted above, Ref. 2 concludes that there is adequate scientific support for the use of the 3-dB exchange rate and, at present, no scientifically acceptable means of refining it even though in some cases it is an approximate measure;

2. Most jurisdictions have regulations that set limits on allowable *sound levels* in the workplace, and hence these regulations must also set a value for the exchange rate in order to control the period of exposure for the individual worker. The exchange rate used by most jurisdictions is 3 dB, see Table 1. This value is equivalent to the choice noted in 1. above. An increase in sound level of 3 dB represents a doubling of the sound energy. Thus a 3-dB exchange rate has the simple connotation of an *equal energy rule* wherein exposure of the ear to equal amounts of energy is assumed to produce equal amounts of NIPTS regardless of the time pattern of the exposure. The scientific evidence is that 3 dB is probably the most reasonable exchange rate for daily noise exposure. Statistically it is also a good approximation for the results of many epidemiological studies relating to intermittent exposures[2], even though these show considerable spread about any mean curve. If the exposure is broken by quieter periods spread throughout the day that happen to be beneficial, any deviation of the "true" exchange rate for any specific situation, from the legislated 3-dB rate, affords extra protection to the worker;

3. The exchange rate used in the United States (civilian), Israel and Brazil is 5 dB. This assumes that the sound level may be allowed to increase by more than 3 dB per halving of exposure time because of the beneficial effects of intermittence. Even if this supposition is valid, the 5 dB exchange rate is not limited to appropriate situations by regulation, and so it is often applied to many situations where it is clearly not appropriate. For example, in many industrial situations the only "intermittence" involved is the lunch break. Where this happens there is a risk of over-exposure of the worker, even when regulations based on the 5-dB exchange rate are being properly followed;

4. In some industrial situations, notably in forestry and mining operations, the periods of exposure to intense sound may be brief and be followed by many minutes of very little sound. In these cases, the noise-induced TTS may recover completely and an increase in allowed noise exposure could be justified. It has been suggested in Ref. 4 that in these very few industrial situations an exchange rate of 3 dB should still be used, but that there should be a special allowance of several decibels to account for the long quiet periods that allow recovery of the ear. The amount of the special allowance should be set at a value that depends on the value set for the maximum allowable daily exposure, $L_{Aeq(8\ hours)}$; a larger allowance could be justified provided L_{Aeq} is lower.

3.3 Maximum Upper Limit

For a very small fraction of the most susceptible individuals, even a single burst of intense noise can produce a permanent loss of hearing. Most legislation, see Table 1, explicitly limits the peak sound level of a single burst of intense noise, or an impulse, independently of its contribution to the daily 8-hour noise exposure, to a value of about 140 dB (linear, peak). This upper limit is often stated in different terms such as 125 dB (linear, fast) or 115 dB (A-weighted, slow). These stated limits vary by about 10 dB between different jurisdictions, and also vary depending on the spectral content of the noise. The use of specifications involving A-weighting with fast or slow response time allows the sound to be monitored, albeit less precisely, using simpler instruments.

4. Recommendations

It is likely that the spread of data obtained from different epidemiological studies results from non-acoustical factors that are not controlled, and are not statistically separable in small sets of data. From a scientific and practical point of view the best course of action would be to provide and adhere to a set of internationally-recognized procedures, so that all future data would in effect contribute to a single large epidemiological study known to have been made according to the guidelines.

The primary goal of this report, and its recommendations, is to reduce the risk of long-term hearing damage in exposed people to a practical minimum. This report therefore makes the following recommendations based on current practice, drawn from various different jurisdictions. Each feature recommended has been considered to be practicable by at least one national jurisdiction and there may be some experience of its usefulness. Much current legislation was enacted several years ago, before the more recent scientific evidence was available, and before it was integrated into current understanding of this complex scientific topic. Even some of the recent standards and technical reviews, including Refs. 1 to 4, rely heavily on studies that were conducted some years ago. Socio-economic factors in a society often change with time, so there is adequate technical and social justification to modify existing regulations if there is the political will to do so.

This report deals only with noise exposure in the workplace. However, for its recommendations to be valid it is important that noise exposures outside the workplace, i.e. due to leisure time activities, should not contribute significantly to hearing loss and should remain low. The Standard ISO 1999:1990[1] states "Only if this non-occupational exposure is negligible compared with the occupational exposure does this International Standard allow prediction of the occurrence of hearing impairment due to occupational noise exposure. Otherwise, it should be used to calculate the hearing impairment to be expected from the combined (occupational plus non-occupational) total daily noise exposure."

4.1 Exposure Levels

Allowed exposure levels in most jurisdictions are in the range of L_{Aeq} for 8 hours equal to 85 to 90 dB. This accepts that some small fraction of the exposed population will suffer some degree of permanent hearing loss over a period of many years that is in excess of that due to aging. A level no greater than about L_{Aeq} = 75 dB is desirable if work-related risk of hearing loss is clearly to be avoided for all exposed individuals, and this should be considered to be the ideal goal. However, the economic costs, and resulting disruptive social consequences, are probably too great for 75 dB, or even 80 dB, to be achieved in the near future. **It is therefore recommended that all jurisdictions with currently higher levels should set a basic exposure level of 8-hour L_{Aeq} = 85 dB as soon as possible.** For those working longer shifts, or in unusual environments, there is no evidence that the principle of equal energy does not apply; but it may be preferable to state the same exposure limit in equivalent but different terms, such as L_{Aeq} for 12 hours = 83 dB or L_{Aeq} for 24 hours = 80 dB.

4.2 Exposure to Impulsive Noises

The basic exposure level of the previous paragraph should include any contribution from short-term, high-intensity noises or blasts. Such noises are traditionally also limited in legislation to a maximum sound level - this additional limitation may not be strictly necessary given the present state of scientific evidence, but is certainly prudent.

Instruments having "impulse" or "peak sound level" capability should be used for measurement, and it is recommended that regulations should set a limit for impulses of 140 dB linear, peak.

4.3 Exchange Rate

Stating the exposure level in terms of equivalent sound level, L_{Aeq}, already implies that **an exchange rate of 3 dB per halving or doubling of exposure time** is to be used. This is indeed the recommendation for all exposures **regardless of the degree of intermittence or time-varying characteristics of the noise.** A value of 3 dB may not always be correct, but in those situations where it deviates from the "true" value it is likely to afford extra protection for the worker. Furthermore it is conceptually the easiest to understand, and is the easiest to implement simply in the design of a measuring instrument.

4.4 Engineering Controls

Efforts should be made to reduce sound levels in the workplace to the lowest reasonable values, even when there is no risk of long-term damage to hearing.

It is essential that workers be able to hear alarm signals clearly and verbal warnings intelligibly. To prevent noise-induced health hazards and performance decreases, target values differentiated for different activities are recommended in Refs. 10 and 13.

Two administrative approaches should be required at the design stage of any new installation, or as a required retrofit when existing installations are being upgraded or new machinery purchased. Both are able to provide long-term reduction of sound levels, and in many cases can be done at little or no cost.

1. **The acoustical design of the building should provide for sound and vibration isolation between noisier and quieter areas of activity.** Machinery and equipment that is relatively noisy, especially if it does not require the presence of an operator but only infrequent maintenance, should be separated from the main production areas and offices. Rooms normally occupied by people should have a significant amount of acoustic absorption; even in production areas this can usually be located on the upper surfaces of walls and on baffles suspended from the ceiling. **A minimum average absorption coefficient of 0.3 should be required for each occupied room.** (These matters are discussed further in Refs. 6 and 11 and the procedure has been used in Ref. 12.);

2. The purchase specifications for all new and replacement production machinery should contain clauses specifying the maximum emission sound power level or emission sound pressure levels allowable when the machinery is operating. The specifications should consider what is said in Ref. 13: "A-weighted immission sound pressure levels at the work stations of a machine can be about 5 to 15 dB higher than the noise emission values declared, due to noise from similar neighboring machines, workroom reverberation and operating conditions different from those for which the noise declaration was made." When the manufacturer cannot fulfil these specifications, there should be a noise declaration as specified in regulations or standards[11] so that the purchaser can consider additional noise control measures.

4.5 Audiometric Programs

EEC Directives on noise control in the workplace[14] require certain actions to be taken when noise exposure limits of 85 or 90 dB are exceeded. These include audiometric testing and the wearing of ear protection.

Some prudent employers, for their own protection, require pre-placement audiometric testing at the time of hiring a new worker. This action serves two purposes, a) it provides a baseline record of hearing levels against which future audiograms can be compared, to provide an earlier warning of possible hearing damage, and b) it is likely to provide some legal protection for the employer against later claims of hearing loss, possibly incurred before hiring, when the workplace is in fact safe. **It is recommend that all employers conduct audiometric testing at intervals that depend on exposure levels and past history of the individual worker.** For example, in Germany[10], testing is conducted every 60 months if the exposure level is about 85 to 90 dB, and every 30 months at exposure levels of 90 dB or greater. In Hungary[8], testing is conducted every 48 months for exposure levels of 85 to 95 dB, every 24 months for exposure levels of 95 to 105 dB, every 12 months for exposure levels of 105 to 115 dB, and every 6 months for levels above 115 dB.

References

1. ISO 1999:1990, Acoustics - Determination of occupational noise exposure and estimation of noise-induced hearing impairment, International Standard ISO 1999:1990 (1990).
2. E.A.G. Shaw, "Occupational Noise Exposure and Noise-Induced Hearing Loss: Scientific Issues, Technical Arguments and Practical Recommendations," for the Special Advisory Committee on the Ontario Noise Regulation, NRC Report No. APS 707 (1985 October).
3. A.H. Suter, "The Relationship of the Exchange Rate to Noise-Induced Hearing Loss," for the U.S. Department of Health and Human Services, NTIS No. PB-93 118610 (1992 September).
4. A.H. Suter, "The Relationship of the Exchange Rate to Noise Induced Hearing Loss," reprint of Reference 3, *Noise/News International*, Vol. 1, No. 3, pp. 131-151 (1993 September).
5. T. Kihlman, "National Action Plan against Noise," (Summary in English, 33 pages; Report in Swedish, 345 pages + 17 appendices), for Ministry of the Environment and Natural Resources, Report No. SOU 1993:65 (1993 July).
6. T. Kihlman, " Sweden's Action Plan Against Noise," summary of Reference 5, *Noise/News International*, Vol. 1, No. 4, pp. 194-208 (1993 December).
7. W.D. Ward, "Noise-induced Hearing Loss," in Noise and Society, (Chapman and Jones).
8. P.L. Timar, "The situation of noise control at workplaces in Hungary," Private communication as a member of this Working Party (1993 February).
9. B.H. Pfeiffer, "Hearing Conservation in the European Community - Practice and demands," Proc. 6th International FASE Congress, p. 121 (1992).
10. Parthey, H. Lazarus, and G.A. Serndt, "Noise Limits for Workplaces in Germany," Private communication from H. Lazarus as a member of this Working Party (1993 August).
11. H. Lazarus and G.A. Sehrndt, "European standards for occupational and machinery noise control," *Safety Science*, **15**, 375-386 (1992).
12. Private communication from W. Atkinson, about 1980. This procedure was successful in limiting A-weighted sound levels to 85 dB throughout a reconstructed and expanded automo tive construction plant. The purchaser provided some noise control assistance when necessary to small machinery suppliers.
13. ISO/DIS 11690-1:1993, Acoustics - Recommended practice for the design of low-noise workplaces containing machin ery - Part 1: Noise control strategies.
14. Council Directive of 12 May 1986 on the protection of workers from the risks related to exposure to noise at work (86/188/EEC). OJ No L 137, 24.5.86, p. 28.
15. A.H. Suter, "Current Standards for Occupational Exposure to Noise," 5th International Symposium on Effects of Noise on Hearing, Gothenburg, Sweden (1994 May).

Response to R. Hétu's Reply to Comments on "The Hearing Conservation Paradigm and the Experienced Effects of Occupational Noise Exposure", *Canadian Acoustics* 23(1) 11-13 (1995)

Larry H. Royster, Ph.D

and

Julia Doswell Royster, Ph.D

In Raymond Hétu's response, he failed to address the fundamental issue that was the dominant reason that we responded to his article in the first place.

That is, his article consistently misquoted or misinterpreted the contents in our papers that he referenced. It was this seemingly deliberate misinterpretation which we considered unethical, not the questioning or honest criticism of some general Hearing Conservation paradigm.

It would be impossible for any scientist to read our various papers and come to the conclusion that our Hearing Conservation Program black box is driven by a concern for the risk of compensation for noise induced hearing loss. As our papers have shown and by our comments, our belief backed up by our published data is that in general USA industry, the risk of compensation for noise induced hearing loss is insignificant. Indeed, our data indicates that the percentage of the population potentially compensable is from 5-7 percent and the percentage that is sufficiently above the low fence to possibly support proceeding with a claim is most likely 2-3 percent.

Reply to further comments by L.H. Royster and J.D. Royster on "The Hearing Conservation Paradigm and the Experienced Effects of Occupational Noise Exposure", Canadian Acoustics 22(1) 3-19 (1994).

Raymond Hétu, Ph.D, Groupe d'acoustique de l'université de Montréal

In section 2.3 of the paper, it is stated that the presuppositions of the Hearing Conservation paradigm were explicitly drawn from the Guide for Hearing Conservation in Noise published by the AAOO in 1969. Hence, postulate A is based on an exact quotation from this document. It states that occupational noise exposure poses a health problem as long as it is proved to cause 'compensable hearing losses'. This is not presented as a quotation from a paper written by Larry and Julia Royster. That containment of compensation cost is nevertheless a preoccupation of these authors is indicated by their published analysis of industrial workers' audiometric data for the explicit purpose of estimating such cost within the AAOO framework [1]. Furthermore, if "the percentage of the population potentially compensable is from 5-7 percent" in general USA industry [2], this might be interpreted as evidence for hearing conservation achieving its original goal of compensation cost containment. This being said, evidence of prevention of any degree of occupational hearing loss by means of current hearing conservation practices is still lacking as I reiterated in my reply [3] to comments on my paper.

References

1. Royster, L.H., Thomas, W.G., Royster, J.D., Liley, D.T., "Potential hearing compensation cost by race and sex", *Journal of Occupational Medicine* **20**, 801-806 (1978).

2. Royster, L.H., Royster J.D. "Response to R. Hétu's Reply to Comments on 'The Hearing Conservation Paradigm and the Experienced Effects of Occupational Noise Exposure'", *Canadian Acoustics* **23**(1) 11-13 (1995).

3. Hétu, R., "Reply to Comments on: R. Hétu, 'The Hearing Conservation Paradigm and the Experienced Effects of Occupational Noise Exposure'", *Canadian Acoustics* **22**(1) 3-19 (1994).

HOLD THE SOUND OF THE WORLD IN THE PALM OF YOUR HAND

Bruel & Kjaer has introduced
a sound level analyzer
which is the most advanced
in the world and yet is so compact
that it can be held
in the palm of your hand

The Type 2260

- **REAL TIME ANALYSIS**
- **2 channel capability with 80 dB dynamic range**
- **Fully programmable due to DSP design**
- **Uses New Type 4189 microphone**
- **PCMCIA Technology**
- **Spectral statistics**
- **Back-Lit LCD display**
- **Multi-Language**
- **1.3 Kg weight**

B K

BRÜEL & KJAER CANADA LTD
90 Leacock Road, Pointe Claire, Quebec H9R 1H1
Tel.: (514) 695-8225 Fax: (514) 695-4808

Blachford

"The ABC's of noise control"

H.L. Blachford's Comprehensive Material Choices

Noise treatments can be categorized into three basic elements: Vibration Damping, Sound Absorption and Sound Barriers.

Vibration Damping

It is well known that noise is emitted from vibrating structures or substrates. The amount of noise can be drastically reduced by the application of a layer of a vibration damping compound to the surface. The damping compound causes the vibrational energy to be converted into heat energy. Blachford's superior damping material is called ANTIVIBE and is available either in a liquid or a sheet form.

ANTIVIBE DL is a liquid damping material that can be applied with conventional spray equipment or troweled for smaller/thicker application.

It is water-based, non-toxic and provides economical and highly effective noise reduction from vibration.

ANTIVIBE DS is an effective form of damping material provided in sheet form for direct application to your product.

Sound Barriers

Sound Barriers are uniquely designed for insulating and blocking airborne noise. The reduction in the transmission of sound (transmission loss or "TL") is accomplished by the use of a material possessing such characteristics as high mass, limpness, and impermeability to air flow. Sound barriers can be a very effective and economical method of noise reduction.

Blachford Sound Barrier materials:

BARYMAT

Limp, high specific gravity, plastic sheets or die cut parts. Can be layered with other materials such as acoustical foam, protective and decorative facings to achieve the desired TL for individual applications.

Sound Absorption

Blachford's CONASORB materials provide a maximum reduction of airborne noise through absorption in the frequency ranges associated with most products that produce objectionable noise. Examples: Engine compartments, computer and printer casings, construction equipment, cabs,...etc.

Available with a wide variety of surface treatments for protection or esthetics. Material is available in sheets, rolls and die-cut parts – designed to meet your specific application.

Suggest Specific Material or Design

Working with data supplied by you, H.L. Blachford will make recommendations or treatment methods which may include specific material proposals, design ideas, or modifications to components.

A Quality Supplier

The complete integration of:

- Experience
- Quality-oriented manufacturing technology
- Research and development
- Problem solving approach to noise control

Our Mississauga Plant is ISO-9001 CERTIFIED

Result in:

Comprehensive Noise Control Solutions

MISSISSAUGA (905) 823-3200
MONTREAL (514) 938-9775
VANCOUVER (604) 263-1561

COMPUTATIONAL OCEAN ACOUSTICS, 1994

by Finn B. Jensen, William A. Kuperman, Michael B. Porter, and Henrik Schmidt

The field of computational acoustics - especially as applied to oceanographic applications - has expanded rapidly along with the capabilities of the computer hardware available for the task. By computational acoustics, we mean the numerical modelling of acoustics problems on a computer, often involving complicated acoustic environments and boundary conditions. In the simplest case, we specify a steady source of known frequency and location and then model the acoustic field that propagates from that source to a receiver at a specified location, as governed by the acoustic wave equation. More complicated problems may include arrays of sources or receivers, distributed sources (such as the noisy ocean surface), or may even invert the problem, attempting to probe the acoustic environment by matching the modelled field with experimental data. This book is the first comprehensive treatment of the theoretical underpinnings of the principal ocean acoustic propagation models in use today.

The authors are all members of the Acoustical Society of America and have all "done time" or in one case is a "lifer" at NATO's SACLANTCEN Undersea Research Centre in La Spezia, Italy, an internationally-recognized centre of ocean acoustics research, including modelling. Consequently, the book has a uniform look and feel throughout. Several ocean acoustic models in common use originated at SACLANTCEN or were developed further there: SNAP and KRAKEN (normal modes), SAFARI (wavenumber integration), and PAREQ (parabolic equation). Although the authors could be commended for not taking advantage of the opportunity to promote their own models (the model names don't even appear in the index), perhaps they are being too modest. For the newcomer, it might have been useful to have an appendix indicating the capabilities of the various codes and where they can be acquired.

An introductory chapter on the fundamentals of ocean acoustics is a concise overview of the major physical processes governing propagation, attenuation, scattering, bottom loss, and ambient noise. There is nothing at all on reverberation, although one could argue that could be the subject of a separate work for which this book would be a necessary introduction. The following chapter is an exposition of the theory of acoustic wave propagation, with particular emphasis on horizontally layered media, which the ocean and its seabed are (almost!).

The following chapters present the details of several numerical techniques for computing acoustic propagation: ray-tracing, wavenumber integration (including FFT-based algorithms), normal modes, the parabolic equation (PE), finite differences, and finite elements. There are special chapters on broadband modelling (all of the previous chapters assumed a CW frequency), ambient noise modelling, and beamforming (including a wee bit on matched field methods).

This book is theoretical but it is not abstract, having many practical suggestions and tips; the examples are meaningful and the illustrations are effective. At the same time the authors have been careful not to get bogged down in the details of operation of particular computer codes based on these techniques. However, several "recipes" are offered to aid those interested in designing their own code, and there are many references to work in the research literature covering specialized topics.

As someone in the field who is likely to use this book, I would guess that it is destined to become a classic reference that any serious practitioner of ocean acoustics cannot afford to ignore. As far as the price is concerned, it is a bargain, doubly so for AIP members, who are entitled to a discount (ASA members and AGU members are AIP members).

This is one of the books (the first?) in the AIP Series in Modern Acoustics and Signal Processing (the series Editor-in-Chief is Robert T. Beyer.) intended for scientists and graduate students involved in research, teaching, and studies. A companion volume is Oceanography and Acoustics: Prediction and Propagation Models, edited by Allan R. Robinson and Ding Lee, to be reviewed elsewhere in *Canadian Acoustics.*

[This book, (ISBN 1-56396-209-8) is available from the American Institute of Physics at the price of US$85 (US$68 for AIP members)].

Reviewed by: David M. F. Chapman, Defence Research Establishment Atlantic

OCEANOGRAPHY AND ACOUSTICS: PREDICTION AND PROPAGATION MODELS

edited by Allan R. Robinson and Ding Lee

The stated purpose of this book is to provide an overview of research progress in the coupling of ocean dynamical prediction models and ocean acoustic propagation models. Rapid recent advances in each of these fields, and the natural union of two research areas which are often treated in isolation make this a timely and interesting work. Hence, the book will appeal to ocean acousticians and acoustical oceanographers (not necessarily the same thing), as well as to dynamical oceanographers and numerical modellers.

This is the second book in the American Institute of Physics (AIP) series in Modern Acoustics and Signal Processing to deal with the topic of ocean acoustics, the first being Computational Ocean Acoustics by Jensen, Kuperman, Porter and Schmidt. Unlike Computational Ocean Acoustics, which is written as an advanced textbook, Oceanography and Acoustics is a collection of papers each written by a different author or authors. This has the advantage that a variety of topics can each be treated by an established authority in the field. The disadvantage is that the material, approach and writing styles can seem somewhat disjointed from chapter to chapter, and basic material is often repeated a number of times. The style of some chapters resembles a textbook, with sufficient background and explanation to be relatively self-contained, while other chapters follow the terse, reference-heavy format of a research paper. Although the book is uniformly strong throughout from a scientific point of view, some chapters are certainly more readable than others. Also, it would appear that the authors set their own figures, since some chapters have clear, well labelled figures or colour plates, while other chapters have figures that have been reduced to such an extent that contour lines are indistinguishable and labels difficult to read.

Chapter 1, by the editors, presents a good introduction to ocean variability, acoustic propagation and coupled modelling. Chapter 2 considers the effects of ocean environmental variability on acoustic propagation forecasting. An overview of numerical propagation modelling is presented, and examples are given of propagation through variable ocean structure on different spatial scales including internal waves (sub-mesoscale) and thermohaline steps (microstructure scale). Chapter 3 considers acoustic propagation through the ocean near-surface mixed layer, which can act like an acoustic duct or half-waveguide. This chapter also gives an overview of propagation modelling, then considers measurements and model results of surface-layer mixing due to wind stress and the effects on propagation in the surface duct. This material is presented particularly well.

Chapters 4-8 consider a variety of aspects of ocean dynamical modelling and acoustic propagation modelling for mesoscale ocean structure associated with the Gulf Stream (e.g., eddies, rings and current meanders). The majority of the oceanographic modelling in these chapters is carried out using the Harvard Open Ocean Model. Acoustic modelling is carried out using parabolic equation, adiabatic normal-mode, and coupled-mode propagation models. Two-dimensional (2-D, range and depth), N x 2-D (N 2-D slices with no azimuthal coupling) and state-of-the-art fully 3-D propagation models are considered. I found Chapter 7 on acoustic propagation, noise and array processing in a 3-D Gulf-Stream environment to be particularly interesting.

The final chapter, Chapter 9, considers 3-D propagation modelling using ray acoustics. This chapter is thorough and nicely self-contained. It presents a concise tutorial on current ray-theory techniques. Applications include global-scale ray modelling for the Heard Island ocean-warming study and current estimation in a Gulf-Stream tomography experiment.

Overall the book is good, and will be useful to scientists or students interested in ocean dynamical modelling, acoustic propagation modelling, and particularly to those interested in the union of these fields (which is likely to be become increasingly important). I do have one complaint. A number of chapters compare the results of numerical ocean-dynamical models to field measurements to validate the model performance. However, the book does not contain a single example of acoustic field measurements to validate the numerical propagation models. Although this is admittedly not the focus of the text (and has been dealt with in numerous research papers), the book's results seem somehow unsubstantiated when the 'ground-truth' is always taken to be a numerical result.

[This book (ISBN 1-56396-203-9) is available from the American Institute of Physics at the price of US$65.]

Reviewed by: Stan Dosso, Defence Research Establishment Pacific

Acoustics Week in Canada 1995

SYMPOSIUM, October 25 - 26

Presentations covering all areas of acoustics and vibration are solicited. A number of special technical sessions on particulars themes have already been created. A session organizer has been assigned to each of these sessions, which will also include invited communications. The list of the special sessions and the corresponding organizers is as follows :

• Noise control :	D[r] F. Laville	(514) 289-8800, ext. 7662
• Speech- Hearing:	D[r] D.G. Jamieson	(519) 661-3901
• Numerical methods in acoustics :	D[r] K. Fyfe	(403) 492-7031
• Experimental methods in acoustics :	D[r] Y. Champoux	(819) 821-7146
• Architectural acoustics :	D[r] J.S. Bradley	(613) 993-9747
• Psycho-physio acoustics :	D[r] Ch. Laroche	(613) 564-2933
• Vibration :	D[r] L. Cheng	(418) 656-7920
• Active control of noise and vibration :	D[r] A. Berry	(819) 821-7148

Submitted communications will be incorporated into the program by assigning them to the existing sessions or creating new sessions when necessary.

Summary of dates :

May, 19 :	Deadline for receipt of abstracts.
June, 1 :	Notification of acceptance.
July, 14 :	Deadline for receipt of summary paper, registration form and registration fee.
October, 25-26 :	Symposium.

The two-page summary paper, prepared in accordance with the enclosed instructions, will be sent to the technical program chairman ***before July 14, 1995***. This deadline will be strictly enforced. The summary papers will be published in the proceedings issue of ***Canadian Acoustics***.

Address the summary papers to :

D[r] Alain Berry, technical program chairman
Département de génie mécanique
Faculté des sciences appliquées
Université de Sherbrooke
2500, boul. Université
Sherbrooke (Québec) J1K 2R1
Phone number : (819) 821-7148, Fax : (819) 821-7163

Student competition : student participation to the Symposium is strongly encouraged. Monetary awards will be given to the three best communications. Students must signify their intention to compete by submitting the ***"Annual Student Presentation Award"*** form in this issue, to be enclosed with the summary paper.

Semaine canadienne d'acoustique 1995

Symposium, 25 - 26 octobre

Des présentations sont sollicitées sur tous les domaines de l'acoustique et des vibrations. Un certain nombre de sessions techniques portant sur des thèmes ciblés sont déjà planifiées. Ces sessions seront prises en charge par un organisateur désigné et incluront des communications invitées. En voici la liste avec les organisateurs correspondants :

• Contrôle du bruit :	Dr F. Laville	(514) 289-8800, poste 7662
• Parole-Audition :	Dr D.G. Jamieson	(519) 661-3901
• Méthodes numériques en acoustique :	Dr K. Fyfe	(403) 492-7031
• Méthodes expérimentales en acoustique :	Dr Y. Champoux	(819) 821-7146
• Acoustique architecturale :	Dr J.S. Bradley	(613) 993-9747
• Psycho-physio acoustique :	Dr Ch. Laroche	(613) 564-2933
• Vibrations :	Dr L. Cheng	(418) 656-7920
• Contrôle actif du bruit et des vibrations :	Dr A. Berry	(819) 821-7148

Les présentations soumises seront réparties dans les sessions précédentes ou dans d'autres sessions si besoin est.

Résumé des dates importantes :

19 mai :	Date limite de réception des résumés.
1er juin :	Notification d'acceptation.
14 juillet :	Date limite de réception du sommaire, du formulaire d'inscription et des frais d'inscription.
25-26 octobre :	Symposium.

Le sommaire de deux pages, préparé suivant les instructions incluses dans ce numéro d'***Acoustique canadienne***, devra être envoyé au responsable technique ***avant le 14 juillet 1995***. Cette échéance devra être scrupuleusement respectée. Les sommaires seront publiés dans les actes du Symposium.

Veuillez faire parvenir les sommaires à :

Dr Alain Berry, responsable du programme technique
Département de génie mécanique
Faculté des sciences appliquées
Université de Sherbrooke
2500, boul. Université
Sherbrooke (Québec) J1K 2R1
Téléphone : (819) 821-7148, Télécopieur : (819) 821-7163

Concours étudiants : la participation des étudiants au Symposium est fortement encouragée. Des prix en argent seront décernés pour les trois meilleures communications. Les étudiants doivent indiquer leur intention de participer en complétant le formulaire ***"Prix annuels relatifs aux communications étudiantes"*** qui figure dans le présent numéro et en le joignant au sommaire.

ANNUAL STUDENT PRESENTATION AWARDS

The Canadian Acoustical Association makes awards to students whose papers are presented at the CAA Annual Symposium. Students contemplating presenting papers at the Symposium should apply for these awards with the submission of their abstract.

RULES

1. These awards are presented annually to authors of outstanding student papers that are presented during the technical sessions at Acoustics Week in Canada.
2. In total, three awards of $500.00 are presented.
3. Presentations are judged on the following merits:
   i) The way the subject is presented;
   ii) The explanation of the relevance of the subject;
   iii) The explanation of the methodology/theory;
   iv) The presentation and analysis of results;
   v) The consistency of the conclusions with theory and results.
4. Each presentation is judged independently by at least three judges.
5. The applicant must be:
   i) a full-time graduate student at the time of application;
   ii) the first author of the paper;
   iii) a member of the CAA;
   iv) registered at the meeting.
6. To apply for the award, the student must send this application simultaneously with the abstract. Multiple authors are permitted, but only the first author may receive an award.

PRIX ANNUELS RELATIFS AUX COMMUNICATIONS ETUDIANTES

L'Association Canadienne d'Acoustique décerne des prix aux étudiant(e)s qui présenteront une communication au congrès annuel de l'ACA. Les étudiant(e)s qui considèrent présenter un papier doivent s'inscrire à ce concours au moment où ils (elles) soummettent leur résumé.

REGLEMENTS

1. Ces prix sont décernés annuellement aux auteurs de communications exceptionelles presentées par des étudiants lors des sessions techniques de la Semaine Canadienne d'Acoustique.
2. Au total, trois prix de 500$ sont remis.
3. Les présentations sont jugées selon les critères suivants:
   i) La façon dont le sujet est présenté;
   ii) Les explications relatives à l'importance du sujet;
   iii) L'explication de la méthodologie;
   iv) La présentation et l'analyse des résultats;
   v) La consistence des conclusions avec la théorie et les résultats.
4. Chaque présentation est evaluée séparément par au moins trois juges.
5. Le candidat doit être:
   i) un étudiant à temps plein de niveau gradué au moment de l'inscription;
   ii) le premier auteur du papier;
   iii) un membre de l'ACA;
   iv) un participant au congrès.
6. Afin de s'inscrire au concours, l'étudiant doit envoyer ce formulaire d'inscription en même temps que son résumé. Plusieurs auteurs sont permis, mais seul le premier auteur peut recevoir le prix.

APPLICATION FOR STUDENT PRESENTATION AWARD AT ACOUSTICS WEEK IN CANADA

FORMULAIRE D'INSCRIPTION POUR LES PRIX DECERNES AUX ETUDIANTS LORS DE LA SEMAINE CANADIENNE D'ACOUSTIQUE

NAME OF THE STUDENT:____________________NOM DE L'ETUDIANT

SOCIAL INSURANCE NUMBER:____________________NUMERO D'ASSURANCE SOCIALE

TITLE OF PAPER:____________________TITRE DU PAPIER

UNIVERSITY/COLLEGE:____________________UNIVERSITE/COLLEGE

NAME, TITLE OF SUPERVISOR:____________________NOM ET TITRE DU SUPERVISEUR

STATEMENT BY THE SUPERVISOR: The undersigned affirms that the above-named student is a full-time student and the paper to be presented is the student's original work.

Signature:____________________

DECLARATION DU SUPERVISEUR: Le sous-signé affirme que l'étudiant(e) mentionné(e) ci-haut est inscrit(e) à temps plein et que la communication qu'il (elle) présentera est le fruit de son propre travail.

Date:____________________

APPLICATION FOR STUDENT TRAVEL SUBSIDY TO ACOUSTICS WEEK IN CANADA

Travel subsidies (minimum $150) are available to students presenting papers at Acoustics Week in Canada if they live at least 150 km from the conference venue, if the subsidy is needed, and if they publish a two-page summary of their paper in the proceedings issue of *Canadian Acoustics*.

I wish to apply for a CAA Travel Subsidy: _____yes _____no.

STATEMENT BY THE SUPERVISOR: The undersigned affirms that the CAA Travel Subsidy, combined with other travel funds that the above-named student may receive to attend the meeting will not exceed his/her travel costs.

Signature:____________________

FORMULAIRE DE DEMANDE DE REMBOURSEMENT POUR FRAIS DE DEPLACEMENT A LA SEMAINE CANADIENNE D'ACOUSTIQUE

Un remboursement de frais de déplacement (minimum de $150) est offert aux étudiants qui présentent une communication lors de la Semaine Canadienne d'Acoustique, s'ils demeurent à plus de 150 km du site du congrès, si le remboursement est nécessaire, et s'ils publient un résumé de 2 pages dans les Actes du Congrès.

Je désire demander un remboursement: _______oui _______non.

DECLARATION DU SUPERVISEUR: Le sous-signé affirme que le remboursement, jumelé à d'autres fonds que l'étudiant(e) ci-haut mentionné(e) peut recevoir ne dépasseront pas ses coûts réels de voyage.

Date:____________________

ACOUSTICS WEEK IN CANADA
SEMAINE CANADIENNE DE L'ACOUSTIQUE

REGISTRATION FORM/FORMULAIRE D'INSCRIPTION

October 25-26 Octobre, 1995
Loews Le Concorde
1225, Place Montcalm
Québec (Québec)
CANADA G1R 4W6

Surname/Nom : ____

First Name/Prénom : ____

Institution :____

Address/Adresse : ____

____

Postal Code/Code Postal : __________ Tel/Tél.: _____________________

Accompanying person/Personne qui accompagne : ____________________________

Symposium/Congrès
October 25-26 Octobre 1995

	REGULAR/RÉGULIER	STUDENTS/ETUDIANTS
REGISTRATION/INSCRIPTION		
Member/Membre	$130	$40
Non-Member/Non-Membre	$165	$50

TOTAL : $______

HOTEL RESERVATION - Loews Le Concorde ($105, single or double/occupation simple ou double)

Date of Arrival/Date d'arrivée : ________________________________

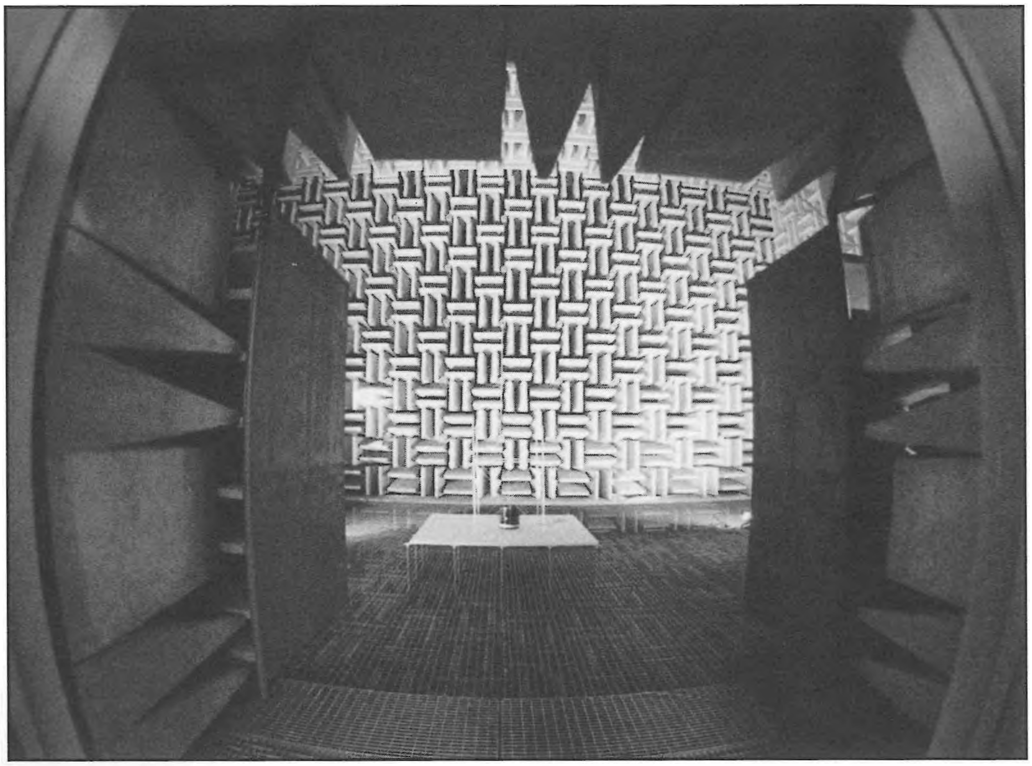
Date of Departure/Date de départ : ______________________________

Name(s)/Nom(s) : ____

Please make cheques payable to Congrès ACA 1995 and mail to :

S.V.P. faites votre chèque à l'ordre de Congrès ACA 1995 et postez à :

Jeanne C. Fortin
ACA 1995
Hydro-Québec
75, boul. René-Lévesque ouest
16ième étage
Montréal (Québec)
H2Z 1A4



GRANDE SALLE ANÉCHOÏDE

DU BUREAU DE LA RADIOPROTECTION DE SANTÉ CANADA DISPONIBLE CONTRE PAIEMENT À L'ACTE

Cette installation est dotée d'un vaste espace, calme, anéchoïde et souple permettant de produire et de caractériser des champs sonores. Sans être conçue pour remplacer les salles anéchoïdes commerciales, elle convient à une vaste gamme d'applications pertinentes en génie et en recherche et développement, qui pourraient intéresser le secteur privé, les universités, de même que les ministères et organismes gouvernementaux.

La disponibilité de la salle anéchoïde sera établie selon les exigences du programme de protection contre le bruit du Bureau.

Nous vous invitons à nous communiquer vos besoins en vous adressant à :

Stephen Bly, Santé Canada
Pièce 228A, 775 chemin Brookfield
Ottawa (Ontario) K1A 1C1
Tél. : (613) 954-03080
Téléc. : (613) 941-1734
c. élec. : sbly@hpb.hwc.ca

Il nous fera plaisir de vous communiquer plus de détails, y compris l'estimation des coûts, le calendrier et la disponibilité de l'équipement.

Caractéristiques :

- 12,7 x 8,7 x 7,8 m (l x l x h) d'une pointe de coin à l'autre
- anéchoïde de 50 à 20 000 Hz
- bruit de fond inaudible

Options :

- robot de positionnement des microphones
- milieu hémi-anéchoïde pour charges réparties jusqu'à 1200 kg/m^2

Quelques applications :

- systèmes actifs de réduction du bruit
- moyens techniques de réduction du bruit
- systèmes de divertissement audio
- psychoacoustique

Canadian Acoustical Association
Association Canadienne d'Acoustique

MINUTES OF THE BOARD OF DIRECTOR'S MEETING

June 17, 1995
University of Montreal, Montreal

Present:	B. Gosselin	R. Hetu	M. Hodgson	D. Jamieson	F. Laville
	T. Nightingale	D. Quirt	C. Sherry	E. Slawinsky	
	R. Ramakrishnan				
Regrets:	D. Chapman	S. Dosso	J. Hemingway	M. Roland-Mieszkowski	

The meeting was called to order at 10:30 am.

The minutes of the BoD meeting October 20th. 1994 were accepted as written.

President's Report

The matter of CAA's vote on the I-INCE document "Technical assessment of upper limits on noise in the workplace" was tabled. The board will vote on the document and will announce the result of the vote at the Newport Beach Conference. A.C.C. Warnock shall act as the CAA representative at the I-INCE meeting in New Port Beach. The Board agreed to endorse the 4th. International Conference on Spoken Language Processing.

Executive Secretary's Report

Paid memberships (member, and student) were only slightly down from 1994. Subscriptions (corporate and sustaining) were unchanged. It was noted that there is a large turn-over in the member and student categories.

Treasurer's Report

R. Hetu read a prepared report from J. Hemingway. The motion, "That G.E. Arlen, C.A. of 295 Southgate Drive, Ste 5, Guelph, Ontario, N1G 3M5 be appointed as auditor to the Canadian Acoustical Association, effective immediately provided that the cost does not exceed the allotted $1500 as set in the minutes of the 1994 October BoD meeting" was proposed by C. Sherry, seconded by M. Hodgson, and carried.

Editor's Report

Journal submissions are low. Printing costs are rising due in part to the large proceeding issues which constitutes nearly half the annual Editorial budget. An account of the Journal revenues and expenses was requested. The Journal seeks a person to write the "News/Information."

Membership/Recruitment

It was suggested to change the name and fee structure of the "Corporate subscription" and replace it by "Institutional subscription" at a slightly increased rate with a small advertising perk. The idea of a "Fellow of the Association" was also introduced. D. Jamieson was requested to prepare a proposal for change to the membership structure including the definition of 'Fellow' and a mechanism for selection.

Awards

Directors':	5 applications received;
Bell:	3 applications received and judged;
Fessenden:	No applications received;
Eckel:	3 applications received and judged;
Shaw:	3 applications received and judged;
Science Fair:	G. Bolstad reports this is proceeding well;
Student Presentation:	R. Ramakrishnan to select judges in advance of the Conference;

S. Abel reports of the difficulty in administering the Shaw Post Doctoral Prize and requested a change to its term. R. Hetu proposed the motion, "For the year 1996 and subsequent years the Shaw Post Doctoral Prize will be $3000 for a single one year non-renewable term". Motion seconded by R. Ramakrishnan and carried. It was also agreed that for the recipient of the 1995 award only, the possibility of renewal shall be maintained.

Acoustics Week Reports

Ottawa 1994: T. Nightingale reported that there were 108 paid registrations, 90 presentations, 79 extended summary papers published, and 35 new members gained at registration. A surplus of $280.85 was realized after obligations external to CAA were met. After honouring CAA memberships offered at the Conference ($950) the Conference lost $669.15. It was suggested to integrate the applications for student presentation awards and travel subsidy. M. Hodgson agreed to take on this task.
R. Ramakrishnan moved that, "The Ottawa conference was a success and the BoD should accept the report of the Conference Chair", seconded by D. Jamieson and carried.

Quebec City 1995: B. Gosselin reported details of the Quebec conference.

Calgary 1996: E. Slawinski reported plans for the Calgary conference. Questions were raised about the appropriateness of inviting a non-Canadian to give a key-note address. The BoD also expressed its concern with recent and proposed conferences falling mid-week. This may discourage delegates from attending as they will have to stay additional nights to obtain the less expensive apex air fare.

Windsor 1997: To be confirmed.

Nomination Committee

The terms of F. Laville and M. Roland-Mieszkowski end this October.

Other Business

C. Sherry reported that the Canadian Standards Association (CSA) wishes to drop committee Z107 which is responsible standards work in the area of acoustics. The Z107 main committee would like another Canadian organization, like CAA, to take responsibility for administering Canadian standards relating to acoustics. The BoD indicated a willingness to consider this, and requested C. Sherry to prepare a formal proposal for the CAA to adopt CSA Z107 standards work and the associated costs.

Meeting adjourned at 3:52.

NEWS/INFORMATIONS

CONFERENCES

International Conference on Computational Acoustics: April 5-7, 1995, Environmental Applications, Southampton, UK. Contact: J. Evans, Conference Secretariat, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton S04 2AA, UK. Telephone: +44 703 293223, Fax: +44 703 292853.

Vibration and Noise '95: April 25-27, 1995, Venice, Italy. Contact: M.J. Goodwin, School of Engineering, Staffordshire University, P.O. Box 333, Beaconside, Stafford ST18 0DF, England. Telephone: +44 785 275212, Fax: +44 785 227741.

ACOUSTICS '95 - Environmental Noise and Vibration: May 9-11, 1995, Spring Conference of the IOA, Liverpool, United Kingdom. Contact: Institute of Acoustics, Agriculture House, 5 Holywell Hill, St. Albans, Herts, ALI IEU, United Kingdom. Telephone: +44 727 848195; Fax: +44 727 850553.

129th Meeting of the Acoustical Society of America: May 31-June 4, 1995, Washington, DC, USA. Contact: Elaine Moran, Acoustical Society of America, 500 Sunnyside Blvd., Woodbury, NY II797, USA. Telephone: +1 (516) 576-2360, Fax: +1 (516) 349-7669.

2nd International Conference on Acoustics and Musical Research: 3rd week, May 1995, Ferrara, ITALY. Contact: Conference Secretariat, CIARM95, National Research Council of Italy, Cemoter Acoustics Department, Via Canal Bianco, 28-44044 Ferrara. Tel. +39 532 731571-Fax +39 532 732250. E-mail CIARM95@CNRFE4.FE.CNR.IT.

International Symposium in Music and Concert Hall Acoustics (MCHA95): May 15 to 18, 1995, Kirishima, Kagoshima-Prefecture, JAPAN. Contact: The Kirishima International Concert Hall, Kagoshima, Japan for further details.

SAE Noise and Vibration Conference: May 15-18, 1995, Travorse City, Michigan, USA. Contact: Mone Asensio, SAE International, 3001 West Big Beaver Road, Troy, Michigan, USA. Telephone: 313 649-0420.

Noise Control '95 - 10th International Conference on Noise and Vibration Control: June 20-22, 1995, Warsawa, Poland. Contact: D. Koracecka, Central Institute for Labor Protection, ul. Czerniakowska 16, 00-701 Warszawa, Poland. Telephone: +482 623 4601; Fax: +482 623 3695.

8th International Conference on Low Frequency Noise and Vibration: June 21-23, 1995, Trondheim, Norway. Contact: B. Hughes, Multi-Science Publishing Company Ltd., 107 High Street, Brentwood, Essex CM14 4RX, England. Fax: +44 277 223453.

15th International Congress on Acoustics: June 26-30, 1995, Trondheim, NORWAY. Contact: ICA'95, SEVU, Congress Department, N-7034 Trondheim, Norway. Telephone +47 7359 5251/7359 5254, Fax +47 7359 5150, Electronic Post ica95@sevu.unit.no.

CONFÉRENCES

Conférence internationale sur l'acoustique du calcul (applications environnementales): Southampton, Royaume-Uni, du 5 au 7 avril 1995. Renseignements: J. Evans, Conference Secretariat, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton S04 2AA, Royaume-Uni. Téléphone: 44 703 293223; télécopieur: 44 703 292853.

Vibration and Noise 95: Venise, Italie, du 25 au 27 avril 1995. Renseignements: M.J. Goodwin, School of Engineering, Staffordshire University, P.O. Box 333, Beaconside, Stafford ST18 0DF, Angleterre. Téléphone: 44 785 275212; télécopieur: 44 785 227741.

ACOUSTICS 95 - Conférence de l'IOA sur le bruit et les vibrations d'environnement: Liverpool, Royaume-Uni, du 9 au 11 mai 1995. Renseignements: Institute of Acoustics, Agriculture House, 5 Holywell Hill, St. Albans, Herts, AL1 1EU, Royaume-Uni. Téléphone: 44 727 848195; télécopieur 44 727 850553.

129e rencontre de l'Acoustical Society of America: du 31 mai au 4 juin 1995, Washington, DC. Renseignements: Elaine Moran, Acoustical Society of America, 500 Synnyside Blvd., Woodbury, NY 11797, États-Unis. Téléphone: (516) 576-2360; télécopieur: (516) 349-7669.

2e conférence internationale sur la recherche en acoustique et en musique: Ferrara, Italie, 3e semaine de mai 1995. Renseignements: Conference Secretariat, CIARM95, National Research Council of Italy, Cemoter Acoustics Department, Via Canal Bianco, 28-44044 Ferrara, Italie. Téléphone: 39 532 731571; télécopieur: 39 532 732250; courrier électronique: CIARM95@CNRFE4.FE.CNR.IT.

MCHA 95 - Symposium international d'acoustique musicale et de salles de concert : Kirishima, Kagoshima-Prefecture, Japon, du 15 au 18 mai 1995. Renseignements: The Kirishima International Concert Hall, Kagoshima, Japon.

Conférence SAE sur le bruit et les vibrations:Travorse City, Michigan, du 15 au 18 mai 1995. Renseignements: Mone Asensio, SAE International, 3001 West Big Beaver Road, Troy, Michigan, États-Unis. Téléphone: (313) 649-0420.

Noise Control 95 - 10^{e} conférence internationale sur la maîtrise du bruit et des vibrations: Varsovie, Pologne, du 20 au 22 juin 1995. Renseignements: D. Koracecka, Central Institute for Labor Protection, ul. Czerniakowska 16, 00-701 Warszawa, Pologne. Téléphone: 482 623 4601; télécopieur 482 623 3695.

8e conférence internationale sur le bruit et les vibrations à basse fréquence: Trondheim, Norvège, du 21 au 23 juin 1995. Renseignements: B. Hughes, Multi-Science Publishing Company Ltd., 107 High Street, Brentwood, Essex CM14 4RX, Angleterre. Télécopieur: 44 277 223453.

15e congrès international d'acoustique: Trondheim, Norvège, du 26 au 30 juin 1995. Renseignements: ICA 95, SEVU, Congress Department, N-7034 Trondheim, Norvège. Téléphone: 47 7359 5251/5254; télécopieur: 47 7359 5150; courrier électronique: ica95@sevu.unit.no.

ACTIVE 95 - Conférence internationale sur la maîtrise active du bruit et des vibrations: Newport Beach, Californie, du 6 au 8 juillet 1995. Renseignements: Symposium Secretariat, ACTIVE 95 - 1995 International Symposium on Active Control of Sound and Vibration: July 6-8, 1995, Newport Beach, California, USA. Symposium Secretariat: Noise Control Foundation, P.O. Box 2469 Arlington Branch, Poughkeepsi, NY 12603, USA. Telephone: +1 914 462 4006, Fax: +1 914 463 0201.

INTER-NOISE 95: July 10-12, 1995, Newport Beach, California, USA. Contact: Institute for Noise Control Engineering, P.O. Box 3206, Arlington Branch, Poughkeepsi, NY 12603, USA. Tel. (914)462-4006, Fax. (914)473-9325.

17th Boundary Element International Conference: July 17-19, 1995, Wisconsin, USA. Contact: Lis Johnstone, Conference Secretariat, BEM 17, Wessex Institute of Technology, Ashurst Lodge, Ashurst Southampton, SO4 7AA. Tel 44(0) 703 293223, Fax 44 (0) 703 292853, EMail CMI@uk.ac.rl.ib, Inti EMail CMI@ib.rl.acc.uk.

Second International Conference on Theoretical & Computational Acoustics, August 21-25, 1995, Hawaii, USA. Contact: Dr. Ding Lee (Code 3122), Naval Undersea Warfare Center, Detachment New London, New London CT 06320 USA. Tel 203-440-4438 Fax 203-4406228.

1995 World Congress on Ultrasonics: September 3 to 7, 1995, BERLIN. Contact: WCU'95 Secretariat, Prof. Dr. J.Herbertz, Gerhard-Mercator-Universitat, D-47048 Duisburg, Germany. Tel +49(203)379-3243, Fax +49(203)37 35 34.

22nd International Symposium on Acoustical Imaging: September 4-6, 1995, Firenze, Italy. Chairman: Professor Piero Tortoli, President of the International Advisory Board - Professor Leonardo Masotti, University of Florence.

BETECH 95: September 13-15 1995, Liege, BELGIUM Contact: Liz Johnstone, Conference Secretariat - BETECH 95, Ashurst Lodge, Ashurst, SO40 7AA UK. Tel +44 703 293223, Fax +44 703 292853, EMail CMI@uk.ac.rl.ib., Intl EMail CMI@ib.rl.ac.uk.

130th Meeting of the Acoustical Society of America: November 27-December 1, 1995, St. Louis, Missouri, USA. Contact: Elaine Moran, Acoustical Society of America, 500 Sunnyside Blvd., Woodbury, NY 11797, USA. Telephone: +1 (516) 576-2360, Fax: +1(516)349-7669.

Forum Acusticum 1996: April 1-4, 1996, Convention Secretariat, Technological Institute K VIV, Christine Mortelmans and Diane Voet, Desguinlei 214, B-2018 Antwerpen, Belgium. Telephone: +32-(0)3-216.09.96, Fax: +32-(0)3-216.06.89.

COURSES

The Canadian Centre for Occupational Health and Safety (CCOHS), Hamilton, Ontario, is offering a one-day course in "Controlling Noise in the Workplace". This course is designed for joint health and safety committee members, line managers, plant engineers, safety officers, occupational health nurses, and personnel responsible for workplace health and safety. The dates are as follows: March 13, 1995 and June 12, 1995. For more information, contact Lyne Paquin at (905) 572-4489 or Customer Service at 1-800-668-4284, 250 Main Street, East, Hamilton, Ontario, Canada, L8N 1H6.

Noise Control Foundation, P.O. Box 2469, Arlington Branch, Poughkeepsi, NY 12603, États-Unis. Téléphone: (914) 462-4006; télécopieur (914) 463-0201.

Inter-Noise 95: Newport Beach, Californie, du 10 au 12 juillet 1995. Renseignements: Institute of Noise Control Engineering, P.O. Box 3206, Arlington Branch, Poughkeepsie, NY 12603, USA. Téléphone: (914) 462-4006; télécopieur: (914) 473-9325.

17e conférence internationale sur les éléments de frontière: Winconsin, États-Unis, du 17 au 19 juillet 1995. Renseignements: Lis Johnstone, Conference Secretariat, BEM 17, Wessex Institute of Technology, Ashurst Lodge, Ashurst Southampton, SO40 7AA. Téléphone: 44 703 293223; télécopieur: 44 703 292853; courrier électronique: CMI@uk.ac.rl.ib; courrier électronique international: CMI@ib.rl.ac.uk.

2e conférence internationale sur l'acoustique théorique de calcul: Hawaï, du 21 au 25 août. Renseignements: Dr. Ding Lee (code 3122), Naval Undersea Warfare Center, Detachment New London, New London CT 06320, États-Unis. Téléphone: (203) 440-4438; télécopieur: (203) 440-6228.

Congrès mondial de 1995 sur les ultrasons: Berlin, Allemagne, du 3 au 7 septembre 1995. Renseignements: WCU 95 Secretariat, Prof. Dr. J. Herbertz, Gerhard-Mercator-Universitat, D-47048 Duisburg, Allemagne. Téléphone: 49 (203) 379 3243; télécopieur: 49 (203) 37 3534.

22e symposium international sur l'imagerie acoustique: Florence, Italie, du 4 au 6 septembre 1995. Renseignements: président du symposium, professeur Piero Tortoli, président de l'International Advisory Board, professeur Leonardo Masotti, université de Florence.

BETECH 95: Liège, Belgique, du 13 au 15 septembre 1995. Renseignements: Liz Johnstone, Conference Secretariat, BETECH 95, Ashurst Lodge, Ashurst, SO40 7AA, Royaume-Uni. Téléphone: 44 703 293223; télécopieur: 44 703 292853; courrier électronique: CMI@uk.ac.rl.ib; courrier électronique international: CMI@ib.rl.ac.uk.

130e rencontre de l'Acoustical Society of America: St. Louis, Missouri, du 27 novembre au 1er décembre 1995. Renseignements: Elaine Moran, Acoustical Society of America, 500 Sunnyside Blvd., Woodbury, NY 11797, États-Unis. Téléphone: (516) 576-2360; télécopieur: (516) 349-7669.

Forum Acusticum 1996: du 1er au 4 avril 1996. Renseignements: Convention Secretariat, Technological Institute K VIV, Christine Mortelmans et Diane Voet, Desguinici 214, B-2018 Antwerpen, Belgique. Téléphone: 32 (0)3216 0996; télécopieur: 32 (0)3 216 0689.

COURS

Le Centre canadien d'hygiène et de sécurité au travail (CCHST), situé à Hamilton (Ontario), offre un cours d'une journée intitulé Controlling Noise in the Workplace. Ce cours s'adresse tout particulièrement aux membres de comités de santé et de sécurité, aux superviseurs, aux ingénieurs d'usine, aux infirmières en santé au travail et à tous les responsables de la santé et de la sécurité au travail. Il sera offert le 13 mars et le 12 juin 1995. Pour inscription et renseignements, appelez Lyne Paquin au (905) 572-4489, ou le service à la clientèle au 1-800-668-4284. Le centre est situé au 250, rue Main est, Hamilton (Ontario) L8N 1H6.

Comprehensive Industrial Hygiene Review Course: May 27-31 and August 14-18, 1995, St. Paul, Minnesota. Sponsored by: Midwest Center for Occupational Health and Safety. Call Jim Viskocil, CIH or Chris Western at the Midwest Center for Occupational Health and Safety, (612) 221-3992.

NEW PRODUCTS

The NOISE LEVELS database, an excellent source of measured noise levels from a broad spectrum of industrial settings, is now available on diskette from The Canadian Centre for Occupational Health and Safety.

Data for NOISE LEVELS is gathered from both published and unpublished sources. Each record provides explicit information on the noise source (for example, piece of machinery or equipment), the industry, operation associated with the noise production, and the occupational categories. Several fields provide additional information such as type of noise, exposure duration per day, the presence of engineering controls, and the use of ear protection. Measurement data consists of one or more of the following: Sound Pressure Level (SPL) in dB(A), Time Weighted Average (TWA), Equivalent Continuous Noise Level (ECNL), and the octave band analysis. Bibliographic citations of data source are also provided.

Industrial hygienists, noise control engineers, researchers, health and safety committee members, and government agency personnel will find NOISE LEVELS invaluable. For more information call CCOHS Customer Service 1-800- 668-4284 or 905-570-8094.

Comprehensive Industrial Hygiene Review Course - Ce cours sera offert par le Midwest Center for Occupational Health and Safety du 27 au 31 mai ainsi que du 14 au 18 août 1995 à St. Paul, Minnesota. Pour inscription et renseignements, contactez Jim Viskocil, au CIH; ou Chris Western, au Midwest Center, (612) 221- 3992.

NOUVEAUX PRODUITS

La base de données NOISE LEVELS, produite par le Centre canadien d'hygiène et de sécurité au travail (CCHST) et disponible sur disquette, est une excellente source de niveaux de bruits industriels mesurés.

Chaque fichier contient des renseignements détaillés sur la source du bruit (type de machine ou d'équipement, par exemple), l'industrie, l'activité et les catégories d'occupations. D'autres champs fournissent des renseignements sur le type de bruit, la durée d'exposition quotidienne, la présence de dispositifs limiteurs de bruit et le port de protecteurs auditifs. Les niveaux de bruit sont mesurés à partir des méthodes suivantes: niveau de pression acoustique (SPL) en dB(A), moyenne pondérée dans le temps (TWA), niveau de bruit continu équivalent (ECNL) et analyse par bande d'octave. Des renvois bibliographiques sont également fournis.

NOISE LEVELS sera d'une aide précieuse aux hygiénistes industriels, aux ingénieurs acousticiens, aux chercheurs, aux membres de comités de santé et de sécurité et au personnel des organismes gouvernementaux. Pour de plus amples renseignements, contactez le CCHST au 1-800-668-4284 ou (905) 570-8094.

ECKEL

Noise Control Products & Systems

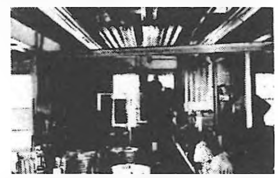
for the protection of personnel...
for the proper acoustic environment...

engineered to meet the requirements of Government regulations

---

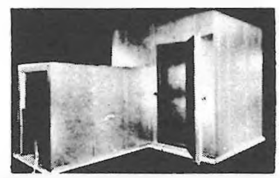
Eckoustic® Functional Panels

Durable, attractive panels having outstanding sound absorption properties. Easy to install. Require little maintenance. EFPs reduce background noise, reverberation, and speech interference; increase efficiency, production, and comfort. Effective sound control in factories, machine shops, computer rooms, laboratories, and wherever people gather to work, play, or relax.



Eckoustic® Enclosures

Modular panels are used to meet numerous acoustic requirements. Typical uses include: machinery enclosures, in-plant offices, partial acoustic enclosures, sound laboratories, production testing areas, environmental test rooms. Eckoustic panels with solid facings on both sides are suitable for constructing reverberation rooms for testing of sound power levels.



Eckoustic® Noise Barrier

- **Noise Reduction Curtain Enclosures**
- **Machinery & Equipment Noise Dampening**

The Eckoustic Noise Barrier provides a unique, efficient method for controlling occupational noise. This Eckoustic sound absorbing-sound attenuating material combination provides excellent noise reduction. The material can be readily mounted on any fixed or movable framework of metal or wood, and used as either a stationary or mobile noise control curtain.

Acoustic Materials & Products for dampening and reducing equipment noise

---

Multi-Purpose Rooms

Rugged, soundproof enclosures that can be conveniently moved by fork-lift to any area in an industrial or commercial facility. Factory assembled with ventilation and lighting systems. Ideal where a quiet "haven" is desired in a noisy environment: foreman and supervisory offices, Q.C. and product test area, control rooms, construction offices, guard and gate houses, etc.

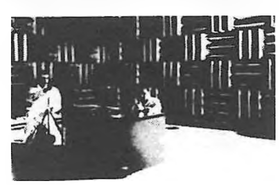
Audiometric Rooms: Survey Booths & Diagnostic Rooms

Eckoustic Audiometric Survey Booths provide proper environment for on-the-spot basic hearing testing. Economical. Portable, with unitized construction.

Diagnostic Rooms offer effective noise reduction for all areas of testing. Designed to meet, within ±3 dB, the requirements of MIL Spec C-81016 (Weps). Nine standard models. Also custom designed facilities.

An-Eck-Oic® Chambers

Echo-free enclosures for acoustic testing and research. Dependable, economical, high performance operation. Both full-size rooms and portable models. Cutoff frequencies up to 300 Hz. Uses include: sound testing of mechanical and electrical machinery, communications equipment, aircraft and automotive equipment, and business machines; noise studies of small electronic equipment, etc.



For more information, contact

ECKEL INDUSTRIES OF CANADA, LTD., Allison Ave., Morrisburg, Ontario • 613-543-2967

The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

PRIZE ANNOUNCEMENT

A number of prizes, whose general objectives are described below, are offered by the Canadian Acoustical Association. As to the first four prizes, applicants must submit an application form and supporting documentation to the prize coordinator before the end of February of the year the award is to be made. Applications are reviewed by subcommittees named by the President and Board of Directors of the Association. Decisions are final and cannot be appealed. The Association reserves the right not to make the awards in any given year. Applicants must be members of the Canadian Acoustical Association. Preference will be given to citizens and permanent residents of Canada. Potential applicants can obtain full details, eligibility conditions and application forms from the appropriate prize coordinator.

Edgar and Millicent Shaw Postdoctoral Prize in Acoustics

This prize is made to a highly qualified candidate holding a Ph.D. degree or the equivalent, who has completed all formal academic and research training and who wishes to acquire up to two years supervised research training in an established setting. The proposed research must be related to some area of acoustics, psychoacoustics, speech communication or noise. The research must be carried out in a setting other than the one in which the Ph.D. degree was earned. The prize is for $3000 for full-time research for twelve months, and may be renewed for a second year. Coordinator: Sharon Abel, Mount Sinai Hospital, 600 University Avenue, Toronto, ON M5G 1X6. Past recipients are:

1990	*Li Cheng*	*Université de Sherbrooke*
1993	*Roland Woodcock*	*University of British Columbia*
1994	*John Osler*	*Defense Research Establishment Atlantic*

Alexander Graham Bell Graduate Student Prize In Speech Communication and Behavioural Acoustics

The prize is made to a graduate student enrolled at a Canadian academic institution and conducting research in the field of speech communication or behavioural acoustics. It consists of an $800 cash prize to be awarded annually. Coordinator: Don Jamieson, Department of Communicative Disorders, University of Western Ontario, London, ON N6G 1H1. Past recipients are:

1990	*Bradley Frankland*	*Dalhousie University*
1991	*Steven D. Turnbull*	*University of New Brunswick*
	Fangxin Chen	*University of Alberta*
	Leonard E. Cornelisse	*University of Western Ontario*
1993	*Aloknath De*	*McGill University*
1994	*Michael Lantz*	*Queen's University*

Fessenden Student Prize in Underwater Acoustics

The prize is made to a graduate student enrolled at a Canadian university and conducting research in underwater acoustics or in a branch of science closely connected to underwater acoustics. It consists of $500 cash prize to be awarded annually. Coordinator: David Chapman, DREA, PO Box 1012, Dartmouth, NS B2Y 3Z7.

1992	*Daniela Dilorio*	*University of Victoria*
1993	*Douglas J. Wilson*	*Memorial University*
1994	*Craig L. McNeil*	*University of Victoria*

Eckel Student Prize in Noise Control

The prize is made to a graduate student enrolled at a Canadian academic institution pursuing studies in any discipline of acoustics and conducting research related to the advancement of the practice of noise control. It consists of a $500 cash prize to be awarded annually. The prize was inaugurated in 1991. Coordinator: Murray Hodgson, Occupational Hygiene Programme, University of British Columbia, 2206 East Mall, Vancouver, BC V6T 1Z3.

1994	*Todd Busch*	*University of British Columbia*

Directors' Awards

Three awards are made annually to the authors of the best papers published in *Canadian Acoustics*. All papers reporting new results as well as review and tutorial papers are eligible; technical notes are not. The first award, for $500, is made to a graduate student author. The second and third awards, each for $250, are made to professional authors under 30 years of age and 30 years of age or older, respectively. Coordinator: Blaise Gosselin, Hydro Québec, 16e étage, 75 boul. René Lévesque ouest, Montréal, QC H2Z 1A4.

Student Presentation Awards

Three awards of $500 each are made annually to the undergraduate or graduate students making the best presentations during the technical sessions of Acoustics Week in Canada. Application must be made at the time of submission of the abstract. Coordinator: Alberto Behar, 45 Meadowcliffe Drive, Scarborough, ON M1M 2X8.

The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

ANNONCE DE PRIX

Plusieurs prix, dont les objectifs généraux sont décrits ci-dessous, sont décernés par l'Association Canadienne d'Acoustique. Pour les quatre premiers prix, les candidats doivent soumettre un formulaire de demande ainsi que la documentation associée au coordonnateur de prix avant le dernier jour de février de l'année durant laquelle le prix sera décerné. Toutes les demandes seront analysées par des sous-comités nommés par le président et la chambre des directeurs de l'Association. Les décisions seront finales et sans appel. L'Association se réserve le droit de ne pas décerner les prix une année donnée. Les candidats doivent être membres de l'Association. La préférence sera donnée aux citoyens et aux résidents permanents du Canada. Les candidats potentiels peuvent se procurer de plus amples détails sur les prix, leurs conditions d'éligibilité, ainsi que des formulaires de demande auprès du coordonnateur de prix.

Prix Post-Doctoral Edgar et Millicent Shaw en Acoustique

Ce prix est attribué à un(e) candidat(e) hautement qualifié(e) et détenteur(rice) d'un doctorat ou l'équivalent, qui a complété(e) ses études et sa formation de chercheur, et qui désire acquérir jusqu'à deux années de formation supervisée de recherche dans un établissement reconnu. Le thème de recherche proposée doit être relié à un domaine de l'acoustique, de la psycho-acoustique, de la communication verbale ou du bruit. La recherche doit être menée dans un autre milieu que celui où le candidat a obtenu son doctorat. Le prix est de $3000 pour une recherche plein temps de 12 mois avec possibilité de renouvellement pour une deuxième année. Coordonnatrice: Sharon Abel, Mount Sinai Hospital, 600 University Avenue, Toronto, ON M5G 1X6. Les récipiendaires antérieur(e)s sont:

1990	*Li Cheng*	*Université de Sherbrooke*
1993	*Roland Woodcock*	*University of British Columbia*
1994	*John Osler*	*Defense Research Establishment Atlantic*

Prix Étudiant Alexander Graham Bell en Communication Verbale et Acoustique Comportementale

Ce prix sera décerné à un(e) étudiant(e) inscrit(e) dans une institution académique canadienne et menant un projet de recherche en communication verbale ou acoustique comportementale. Il consiste en un montant en argent de $800 qui sera décerné annuellement. Coordonnateur: Don Jamieson, Department of Communicative Disorders, University of Western Ontario, London, ON N6G 1H1. Les récipiendaires antérieur(e)s sont:

1990	*Bradley Frankland*	*Dalhousie University*
1991	*Steven D. Turnbull*	*University of New Brunswick*
	Fangxin Chen	*University of Alberta*
	Leonard E. Cornelisse	*University of Western Ontario*
1993	*Aloknath De*	*McGill University*
1994	*Michael Lantz*	*Queen's University*

Prix Étudiant Fessenden en Acoustique Sous-marine

Ce prix sera décerné à un(e) étudiant(e) inscrit(e) dans une institution académique canadienne et menant un projet de recherche en acoustique sous-marine ou dans une discipline scientifique reliée à l'acoustique sous-marine. Il consiste en un montant en argent de $500 qui sera décerné annuellement. Coordonnateur: David Chapman, DREA, PO Box 1012, Dartmouth, NS B2Y 3Z7.

1992	*Daniela DiIorio*	*University of Victoria*
1993	*Douglas J. Wilson*	*Memorial University*
1994	*Craig L. McNeil*	*University of Victoria*

Prix Étudiant Eckel en Controle du Bruit

Ce prix sera décerné à un(e) étudiant(e) inscrit(e) dans une institution académique canadienne dans n'importe quelle discipline de l'acoustique et menant un projet de recherche relié à l'avancement de la pratique en contrôle du bruit. Il consiste en un montant en argent de $500 qui sera décerné annuellement. Ce prix a été inauguré en 1991. Coordonnateur: Murray Hodgson, Occupational Hygiene Programme, University of British Columbia, 2206 East Mall, Vancouver, BC V6T 1Z3.

1994	*Todd Busch*	*University of British Columbia*

Prix des Directeurs

Trois prix sont décernés, à tous les ans, aux auteurs des trois meilleurs articles publiés dans l'*Acoustique Canadienne*. Tout manuscrit rapportant des résultats originaux ou faisant le point sur l'état des connaissances dans un domaine particulier sont éligibles; les notes techniques ne le sont pas. Le premier prix, de $500, est décerné à un(e) étudiant(e) gradué(e). Le deuxième et le troisième prix, de $250 chacun, sont décernés à des auteurs professionnels âgés de moins de 30 ans et de 30 ans et plus, respectivement. Coordonnateur: Blaise Gosselin, Hydro Québec, 16^{e} étage, 75 boul. René Lévesque ouest, Montréal, QC H2Z 1A4.

Prix de Presentation Étudiant

Trois prix, de $500 chacun, sont décernés annuellement aux étudiant(e)s sous-gradué(e)s ou gradué(e)s présentant les meilleures communications lors de la Semaine de l'Acoustique Canadienne. La demande doit se faire lors de la soumission du résumé. Coordonnateur: Alberto Behar, 45 Meadowcliffe Drive, Scarborough, ON M1M 2X8.

INSTRUCTIONS TO AUTHORS PREPARATION OF MANUSCRIPT

Submissions: The original manuscript and two copies should be sent to the Editor-in-Chief.

General Presentation: Papers should be submitted in camera-ready format. Paper size 8.5" x 11". If you have access to a word processor, copy as closely as possible the format of the articles in Canadian Acoustics 18(4) 1990. All text in Times-Roman 10 pt font, with single (12 pt) spacing. Main body of text in two columns separated by 0.25". One line space between paragraphs.

Margins: Top - title page: 1.25"; other pages, 0.75"; bottom, 1" minimum; sides, 0.75".

Title: Bold, 14 pt with 14 pt spacing, upper case, centered.

Authors/addresses: Names and full mailing addresses, 10 pt with single (12 pt) spacing, upper and lower case, centered. Names in bold text.

Abstracts: English and French versions. Headings, 12 pt bold, upper case, centered. Indent text 0.5" on both sides.

Headings: Headings to be in 12 pt bold, Times-Roman font. Number at the left margin and indent text 0.5". Main headings, numbered as 1, 2, 3, ... to be in upper case. Sub-headings numbered as 1.1, 1.2, 1.3, ... in upper and lower case. Sub-sub-headings not numbered, in upper and lower case, underlined.

Equations: Minimize. Place in text if short. Numbered.

Figures/Tables: Keep small. Insert in text at top or bottom of page. Name as "Figure 1, 2, ..." Caption in 9 pt with single (12 pt) spacing. Leave 0.5" between text.

Photographs: Submit original glossy, black and white photograph.

References: Cite in text and list at end in any consistent format, 9 pt with single (12 pt) spacing.

Page numbers: In light pencil at the bottom of each page.

Reprints: Can be ordered at time of acceptance of paper.

DIRECTIVES A L'INTENTION DES AUTEURS PREPARATION DES MANUSCRITS

Soumissions: Le manuscrit original ainsi que deux copies doivent être soumis au rédacteur-en-chef.

Présentation générale: Le manuscript doit comprendre le collage. Dimensions des pages, 8.5" x 11". Si vous avez accès à un système de traitement de texte, dans la mesure du possible, suivre le format des articles dans l'Acoustique Canadienne 18(4) 1990. Tout le texte doit être en caractères Times-Roman, 10 pt et à simple (12 pt) interligne. Le texte principal doit être en deux colonnes séparées d'un espace de 0.25". Les paragraphes sont séparés d'un espace d'une ligne.

Marges: Dans le haut - page titre, 1.25"; autres pages, 0.75"; dans le bas, 1" minimum; latérales, 0.75".

Titre du manuscrit: 14 pt à 14 pt interligne, lettres majuscules, caractères gras. Centré.

Auteurs/adresses: Noms et adresses postales. Lettres majuscules et minuscules, 10 pt à simple (12 pt) interligne. Centré. Les noms doivent être en caractères gras.

Sommaire: En versions anglaise et française. Titre en 12 pt, lettres majuscules, caractères gras, centré. Paragraphe 0.5" en alinéa de la marge, des 2 cotés.

Titres des sections: Tous en caractères gras, 12 pt, Times-Roman. Premiers titres: numéroter 1, 2, 3, ..., en lettres majuscules; sous-titres: numéroter 1.1, 1.2, 1.3, ..., en lettres majuscules et minuscules; sous-sous-titres: ne pas numéroter, en lettres majuscules et minuscules et soulignés.

Equations: Les minimiser. Les insérer dans le texte si elles sont courtes. Les numéroter.

Figures/Tableaux: De petites tailles. Les insérer dans le texte dans le haut ou dans le bas de la page. Les nommer "Figure 1, 2, 3,..." Légende en 9 pt à simple (12 pt) interligne. Laisser un espace de 0.5" entre le texte.

Photographies: Soumettre la photographie originale sur papier glacé, noir et blanc.

Références: Les citer dans le texte et en faire la liste à la fin du document, en format uniforme, 9 pt à simple (12 pt) interligne.

Pagination: Au crayon pâle, au bas de chaque page.

Tirés-à-part: Ils peuvent être commandés au moment de l'acceptation du manuscrit.

WHAT'S NEW ??

Promotions	Retirements
Deaths	Degrees awarded
New jobs	Distinctions
Moves	Other news

Do you have any news that you would like to share with *Canadian Acoustics* readers? If so, fill in and send this form to:

QUOI DE NEUF ??

Promotions	Retraites
Décès	Obtention de diplômes
Offre d'emploi	Distinctions
Déménagements	Autres nouvelles

Avez-vous des nouvelles que vous aimeriez partager avec les lecteurs de l'*Acoustique Canadienne*? Si oui, écrivez-les et envoyer le formulaire à:

Jim Desormeaux, Ontario Hydro, 1549 Victoria Street East, Whitby, Ontario L1N 9E3

The Canadian Acoustical Association — l'Association Canadienne d'Acoustique

SUBSCRIPTION INVOICE

Subscription for the current calendar year is due January 31. New subscriptions received before July 1 will be applied to the current year and include that year's back issues of *Canadian Acoustics*, if available. Subscriptions received from July 1 will be applied to the next year.

Check ONE Item Only:

CAA Membership	$35
CAA Student membership	$10
Corporate Subscription	$35
Sustaining Subscription	$150

Total Remitted $_________

INFORMATION FOR MEMBERSHIP DIRECTORY

Check areas of interest (max 3):

1. Architectural Acoustics _____
2. Engineering Acoustics / Noise Control _____
3. Physical Acoustics / Ultrasound _____
4. Musical Acoustics / Electroacoustics _____
5. Psychological / Physiological Acoustics _____
6. Shock and Vibration _____
7. Hearing Sciences _____
8. Speech Sciences _____
9. Underwater Acoustics _____
10. Signal Processing / Numerical Methods _____
11. Other _____

FACTURE D'ABONNEMENT

L'abonnement pour la présente année est dû le 31 janvier. Les nouveaux abonnements reçus avant le 1 juillet s'appliquent à l'année courante et incluent les anciens numéros (non-épuisés) de *l'Acoustique Canadienne* de cette année. Les abonnements reçus après le 1 juillet s'appliquent à l'année suivante.

Cocher la case appropriée :

Membre individuel
Membre étudiant(e)
Membre de société
Abonnement de soutien

Versement total

RENSEIGNEMENT POUR L'ANNUAIRE DES MEMBRES

Cocher vos champs d'intérêt (max. 3):

Acoustique architecturale
Génie acoustique / Contrôle du bruit
Acoustique physique / Ultrasons
Acoustique musicale / Electroacoustique
Physio/psycho-acoustique
Chocs et vibrations
Audition
Parole
Acoustique sous-marine
Traitement des signaux / Méthodes numériques
Autre

Business telephone number (_____) _______________ Numéro de téléphone au bureau
Business facsimile number (_____) _______________ Numéro de télécopieur au bureau
Business E-Mail number ___________________________________ Numéro de courier électronique au bureau

PLEASE TYPE NAME AND ADDRESS BELOW:

VEUILLEZ ECRIRE VOTRE NOM ET VOTRE ADRESSE CI-DESSOUS:

Faites parvenir ce formulaire à l'adresse suivante en prenant soin d'y joindre un chèque fait au nom de L'ASSOCIATION CANADIENNE D'ACOUSTIQUE:

Make cheques payable to THE CANADIAN ACOUSTICAL ASSOCIATION. Mail this form with payment to:

Trevor R. T. Nightingale
Secretary, Canadian Acoustical Association
P. O. Box 74068
Ottawa, Ontario K1M 2H9

The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

PRESIDENT **PRÉSIDENT**	**Raymond Hétu** Groupe d'acoustique de l'Université de Montréal C.P. 6128, succ. centre-ville Montréal, Québec H3C 3J7	(514) 343-7559
PAST PRESIDENT **PRÉSIDENT SORTANT**	**David Chapman** Defence Research Establishment Atlantic P.O. Box 1012 Dartmouth, Nova Scotia B2Y 3Z7	(902) 426-3100
SECRETARY **SECRÉTAIRE**	**Trevor Nightingale** P. O. Box 74068 Ottawa, Ontario K1M 2H9	(613) 993-0102
TREASURER **TRÉSORIER**	**John Hemingway** 2410 Old Pheasant Road Mississauga, Ontario L5A 2S1	(905) 949-2164
MEMBERSHIP **RECRUTEMENT**	**Don Jamieson** Hearing Health Care Res. Unit Elborn College University of Western Ontario London, Ontario N6G 1H1	(519) 661-3901
EDITOR-IN-CHIEF **RÉDACTEUR EN CHEF**	**Murray Hodgson** Occupational Hygiene Programme University of British Columbia 2206 East Mall Vancouver, British Columbia V6T 1Z3	(604) 822-3073
DIRECTORS **DIRECTEURS**	**Stan Dosso** **Blaise Gosselin** **Frédéric Laville** **David Quirt**	**Ramani Ramakrishnan** **Marek Roland-Mieszkowski** **Cameron Sherry** **Elzbieta Slawinski**

SUSTAINING SUBSCRIBERS / ABONNES DE SOUTIEN

The Canadian Acoustical Association gratefully acknowledges the financial assistance of the Sustaining Subscribers listed below. Annual donations (of $150.00 or more) enable the journal to be distributed to all at a reasonable cost. Sustaining Subscribers receive the journal free of charge. Please address donation (made payable to the Canadian Acoustical Association) to the Secretary of the Association.

L'Association Canadienne d'Acoustique tient à témoigner sa reconnaissance à l'égard de ses Abonnés de Soutien en publiant ci-dessous leur nom et leur adresse. En amortissant les coûts de publication et de distribution, les dons annuels (de $150.00 et plus) rendent le journal accessible à tous nos membres. Les Abonnés de Soutien reçoivent le journal gratuitement. Pour devenir un Abonné de Soutien, faites parvenir vos dons (chèque ou mandat-poste fait au nom de l'Association Canadienne d'Acoustique) au secrétaire de l'Association.

Acoustec Inc.
935 rue Newton, suite 103
Québec, Québec G1P 4M2
Tél: (418) 877-6351

Atlantic Acoustical Associates
P. O. Box 96, Station M
Halifax, NS B3J 2L4

H.L. Blachford Ltd.
Noise Control Products
Engineering / Manufacturing
Mississauga: Tel.: (905) 823-3200
Montreal: Tel: (514) 938-9775
Vancouver: Tel: (604) 263-1561

Bolstad Engineering Associates Ltd.
5110 - 97A Street
Edmonton, Alberta T6B 2R9
Tel: (403) 434-9386

Canadian Home Acoustics Inc.
PO Box 388
9 Doble Street
Sunderland, Ontario L0C 1H0
Tel: (905) 357-3303

J.E. Coulter Associates Engineering
Suite 507, 1200 Sheppard Avenue East
Willowdale, Ontario M2K 2S5
Tel: (416) 502-8598

Daiimar Instruments Inc.
193, Joseph Carrier
Vaudreuil-Dorion, Québec J7V 5V5
Tél: (514) 453-0033

Eckel Industries of Canada Ltd.
Noise Control Products, Audiometric
Rooms - Anechoic Chambers
P.O. Box 776
Morrisburg, Ontario K0C 1X0
Tel: (613) 543-2967

Environmental Acoustics inc.
Unit 22, 5359 Timberiea Blvd.
Mississauga, Ontario L4W 4N5
Tel: (905) 238-1077

Hatch Associates Ltd.
Attn.: Tim Kelsall
2800 Speakman Drive
Mississauga, Ontario L5K 2R7
Tel: (905) 855-7600

Hugh W. Jones & Assoc. Ltd.
374 Viewmount Drive
Allen Heights
Tantallon, Nova Scotia B0J 3J0
Tel: (902) 826-7922

Industrial Metal Fabricators (Chatham) Ltd.
Environmental Noise Control
288 Inshes Avenue
Chatham, Ontario N7M 5L1
Tel: (519) 354-4270

Integral DX Engineering Inc.
907 Admiral Avenue
Ottawa, Ontario K1Z 6L6
Tel: (613) 761-1565

Lalonde, Girouard, Letendre & Assoc.
2271 boul. Fernand-Lafontaine
Longueuil, Québec J4G 2R7
Tél: (514) 651-6710

Mechanical Engineering Acoustics and Noise Unit
University of Alberta
6720 - 30th St.
Edmonton, Alberta T6P 1J6
Tel: (403) 466-6465

MJM Conseillers en Acoustique Inc.
M.J.M. Acoustical Consultants Inc.
Bureau 440, 6555 Côte des Neiges
Montréal, Québec H3S 2A6
Tél: (514) 737-9811

Nelson Industries Inc.
Corporate Research Department
P.O. Box 600
Stoughton, Wisconsin, USA 53589-0600
Tel: (608) 873-4373

OZA Inspections Ltd.
PO Box 271
Grimsby, Ontario L3M 4G5
Tel: (905) 945-5471

Peutz & Associés
103 Bd. Magenta
F-75010 Paris, France
Tél: (33) 42-85-84-85

Scantek Inc.
Sound and Vibration Instrumentation
916 Gist Avenue
Silver Spring, Maryland, USA 20910
Tel: (301) 495-7738

SNC/Lavalin Environment Inc.
2 Felix Martin Place
Montreal, QC H2Z 1Z3
Tel: (514) 393-1000

Spaarg Engineering Limited
Noise and Vibration Analysis
822 Lounsborough Street
Windsor, Ontario N9G 1G3
Tel: (519) 972-0677

Tacet Engineering Limited
Consultants in Vibration & Acoustical Design
111 Ava Road
Toronto, Ontario M6C 1W2
Tel: (416) 782-0298

Valcoustics Canada Ltd.
30 Wertheim Court, Unit 25
Richmond Hill, Ontario L4B 1B9
Tel: (905) 764-5223

Wilrep Ltd.
Unit C10 - 1515 Matheson Blvd. E.
Mississauga, Ontario L4W 2P5
Tel: (905) 625-8944