ACOUSTICS AND NOISE CONTROL IN CANADA

THE CANADIAN ACOUSTICAL ASSOCIATION

L'ACOUSTIQUE ET LA LUTTE ANTIBRUIT AU CANADA

L'ASSOCIATION CANADIENNE DE L'ACOUSTIQUE

Juillet 1976
VOL.4 N°3

July, 1976
VOL. 4, No.3

ACOUSTICS AND NOISE CONTROL IN CANADA

L'ACOUSTIQUE ET LA LUTTE ANTIBRUIT AU CANADA

CONTRIBUTIONS

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

SUBSCRIPTIONS

Acoustics and Noise Control in Canada is distributed free. To have your name put on the mailing list, please contact the Noise Control Division, Environmental Protection Service, Department of the Environment, Ottawa, Ontario K1A 0H3. Postal codes must be provided for all addresses in Canada..

This newsletter is published by the Canadian Acoustical Association. Printing and distribution are provided by the Department of the Environment. The contents of the newsletter and any opinions expressed are the responsibility of the authors and do not necessarily represent the views of the Canadian Acoustical Association or the Canadian Government, its departments or agencies.

(continued on inside back cover)

o o o o o o o o o

CONTRIBUTION

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

SOUSCRIPTION

L'acoustique et la lutte antibruit au Canada est distribué gratuitement. Veuillez communiquer avec la Division de la lutte antibruit, Service de la protection de l'environnement, Ministère de l'Environnement, Ottawa (Ontario), K1A 0H3, pour faire inscrire votre nom sur la liste d'envoi. Il est nécessaire que tous les résidants du Canada indiquent leur code postal.

Ce bulletin d'information est publié par l'Association canadienne de l'acoustique. Le Ministère de l'Environnement s'occupe de l'impression et de la distribution. Le contenu du bulletin ainsi que les avis exprimés ne représentent pas nécessairement l'opinion de l'Association canadienne de l'acoustique ou du gouvernement du Canada et des ministères et organismes fédéraux; ce sont les auteurs qui en assument la responsabilité.

(suite au recto de la couverture inférieure)

Contents/Table Des Matieres

NOTICE BOARD

INTER-NOISE 77

Inter-Noise 77, the sixth in a series of International Conferences on Noise Control Engineering, will be held on March 1-3, 1977 at the Swiss Federal Institute of Technology in Zurich. The main theme of the conference will be Noise Control: The Engineer's Responsibility. Contributed papers are welcome. Abstracts of about 500 words are requested and they should be informative rather than descriptive. Persons intending to participate in Inter-Noise 77 or requiring additional information should write to

Inter-Noise 77
ETH 8006
Zurich, Switzerland

C A A MEETING

Details of the annual meeting and symposium to be held in Vancouver on October 6, 7 and 8 will be sent to the membership by a separate mailing. It is planned to hold the business portion of the meeting on the evening of Wednesday, October 6. Items of business for that meeting should be forwarded to Bob Donato for inclusion in the agenda. The minutes of last year's meeting were reported in this newsletter in Volume 3, Number 4 (October, 1975).

Just a reminder to send your abstracts to Doug Whicker as soon as possible so that the program can be finalized and details sent to the membership. Doug's address is

Barron and Strachan
3284 Heather Street
Vancouver, B.C. V5Z 3K5

THE SPEED OF SOUND IN WATER

by C.D. Maunsell
Atlantic Oceanographic Laboratory
Bedford Institute of Oceanography
Dartmouth, N.S.

The introduction of the echo sounder into routine hydrographic surveying, replacing dependence on use of the lead line, produced a major change. It must be remembered that a sounder actually registers a time interval and that the speed of sound must be known to convert the time to depth. The International Hydrographic Bureau resolved that 1500 metres per second should be adopted as a standard velocity. Most Canadian waters are cold enough that this causes an overestimate and for calibration the value of 1463 metres per second (800 fathoms per second) is frequently used. Since fresh water has to have a temperature of 14.2°C before this speed is attained most soundings in deep lakes will be overestimated with this calibration.

The velocity of sound in water depends upon temperature, concentration of dissolved constituents (for which salinity is the conventional quantity in oceanography) and pressure. The actual value at a given location and time may be evaluated by use of one of the following procedures:

(1) A "bar check" by which the echo from a reflector lowered to a known depth is observed. This is conveniently carried out in shallow water with low currents, gives a mean velocity to the observed depth and simultaneously checks the calibration of the sounder. It is not too useful if the bottom soundings become very different from the check value because the average velocity is likely to change with depth.

(2) Direct measurement of the sound velocity as a function of depth. The appropriate mean velocity must then be calculated. This procedure can be time consuming in deep water and one must be satisfied that the velocimeter has been accurately calibrated.

(3) Reference to files of oceanographic or limnological station data observed in the same area at a similar time of year. The sound velocity is then found by reference to tables or use of an appropriate formula.

Early tables (up to 1939) were based on calculation from laboratory measurements of compressibility and additional thermodynamic data. Matthews' tables proved especially convenient since in addition to tables enabling calculation of in situ velocities he divided the oceans into oceanographically similar areas and published tables listing sounder corrections.

Following the introduction of digital computers formulas were fitted to the tabular data to permit large numbers of sound velocities to be routinely calculated.

By 1952 it had been shown that the near surface velocities given by Matthews and similar tables were about 3 m/s too low. In 1960 Wilson published the first measurements which included the variation with pressure to the values reached in the ocean depths. His formulas were widely adopted by oceanographers, replacing the earlier computation schemes. It is worth noting that in spite of the 3 m/s increase in near-surface velocity from earlier values the Wilson results agree with the tables for pressures corresponding to depths of 2000 metres.

Over the next decade there arose some questions about values from the Wilson equation. Part of this arose from the fact that the observations used by Wilson in developing his equation included combinations of temperature, salinity and pressure not found in nature. In addition it appeared that his atmospheric pressure values were high, perhaps as a result of inadequate abolition or correction of systematic errors. There was of course no guarantee that additional systematic errors were not introduced at high pressures.

A new program of determining sound velocities over range of temperature, salinity and pressure matching conditions throughout the oceans was engaged in by Del Grosso and Mader of the Naval Research Laboratory, Washington. Their results have been fitted to a new equation by Del Grosso which is also valid for fresh water. Recalculation of velocities for a meridional section of oceanographic stations in deep water gives velocities near the surface 0.2 m/s less than Wilson with the discrepancy at greater depths increasing, until the Del Grosso formula gives velocities 0.5 to 0.6 m/s less than the Wilson Formula. Recently Medwin has published a much simpler formula than Del Grosso's which for depths less than 1000 metres gives values in good agreement with those from the more complete formula.

An independent study of the dependence of sound velocity on temperature, salinity and pressure is being carried out by Kroebel and Mahrt of the University of Kiel. Their preliminary work, at atmospheric pressure, in both fresh and sea water agrees with that of Del Grosso within a few centimetres per second. They have not yet reported results on pressure dependence.

The effect of the changes in sound velocity formulas on echo sounding can be summarized as follows. In marine waters of Canadian interest Matthews gives corrections to raw depths read from a sounder calibrated for 1463 m/s. As percentages of the raw depth these are:

	approximate depth		
	200 m	3000 m	4800 m
Off Nova Scotia	1.5%	1.7%	--
Off Labrador	0.5%	1.6%	--
SE of Grand Banks	--	2.3%	3.2%
Arctic	-1.5%	0.5%	--
Near B.C. Coast	0.5%	1.5%	--
Pacific Offshore	--	1.7%	--

These are of sufficient magnitude to deserve consideration.

Going from Matthews' velocities to those of Wilson involves a further correction increasing depths by up to 0.2% of their value. It is probably not worth applying such a modification to values from the tables because the zone boundaries as published do not exactly describe the oceanographic conditions. The formula of Del Grosso predicts depths about 0.04% less than those given by use of Wilson's formula.

Use of the modern sound velocity formulas for correcting soundings in areas with adequate oceanographic coverage will give better estimates of true depth. Great care must be taken in combining old and new soundings to avoid contouring in imaginary features arising solely from the use of different depth corrections.

Because oblique propagation as is involved in side scan sonar is affected in a complicated manner by ray bending depending on the gradient of velocity with depth the effects of the different formulas cannot be easily summarized.

References

There is considerable literature on sound velocity in water. I have referred to work reported in a small number of papers. Examination of the recent papers will provide a comprehensive list.

D.J. Matthews, Tables of the Velocity of Sound in Pure Water and Sea Water for use in Echo Sounding and Sound Ranging, Second Edition, H.D. 282, Hydrographic Department, Admiralty, London, 1939.

W.D. Wilson, J. Acoust. Soc. Am., 32, 641-644, 1960; J. Acoust. Soc. Am., 32, 1357, 1960.

V.A. Del Grosso and C.W. Mader, J. Acoust. Soc. Am., 52, 961-974, 1972.

V.A. Del Grosso, J. Acoust. Soc. Am., 56, 1084-1091, 1974.

H. Medwin, J. Acoust. Soc. Am., 58, 1318-1319, 1975.

NOTE: Purists may cavil at the use of the word "velocity" to describe a scalar magnitude. However it is the conventional use in underwater acoustics.

The above paper was published in "Lighthouse" and is included here with the permission of the Canadian Hydrographics' Association.

A NEW ACOUSTIC TEST FACILITY IN WESTERN CANADA PART A

THE FACILITY AND ITS JUSTIFICATION

E.H. Bolstad
President, Bolstad Engineering Associates Ltd.
Box 5768, Station "L"
Edmonton, Alberta T6C 4G2

Critical to our work in corrective acoustics and the development of custom noise barriers, etc., is the need to know how well a proposed design will actually perform before large expenditures are made. In the earlier years of our practice we used the usual devices of borrowing space in a gymnasium, shop, or other available facility to conduct tests in conditions simulating the job site. The results of course had to be judged in the light of known deficiencies in the testing procedure.

It was also very apparent to us that there were a number of manufacturers of building materials, wall systems, machinery and equipment, etc. in Western Canada who were not able to provide adequate acoustical ratings on their products because the cost and inconvenience of testing at distant laboratories was prohibitive.

For these reasons, we decided, in 1972, to start construction of a full scale test laboratory. After considerable evaluation it was decided that the facility should consist of two reverberation chambers, one of 11,000 cubic feet, the other 8,000 cubic feet. They would have a test opening between them to allow testing of wall transmission and/or the isolation of components of mechanical systems.

From an economic point of view it was apparent that considerable cost could be saved by locating the laboratory in the country, thereby avoiding or at least postponing the cost of double shell construction, spring mountings, etc. We were successful in obtaining a pleasant country setting, within a short distance of the city, with an excellent view of the smog shrouded downtown core.

As shown in Figure 1, a fairly simple layout was developed, with the two chambers, essentially separate buildings, on separate foundations, located close to the service workshop, the instrument shop, the control room and the engineering office.

To accommodate large test panels and equipment, both chambers have double leaf doors, 6 feet wide. The large chamber has a 10 foot high door so that wall test specimens can be rolled into place.

To avoid the somewhat debatable duct or tunnel condition surrounding a test panel which is inserted in the space between two test rooms, it was decided to build the chambers close together and insert the test panels in the opening in one room in the manner of a plug. This of course required the development of a gantry, or lifting frame, which can handle the considerable weight of the panel. Test wall panels can be constructed in the removable steel frame or in the fixed wooden frame to suit the type of material or test procedure.

When the design of the chambers was first being considered, much thought went into the methods to be used for diffusion control and microphone sampling. From all the evidence available in many items of literature and in discussions with several authorities on the subject, it was decided to first of all adopt the dimension rations of $1:\sqrt[3]{2} : \sqrt[3]{4}$ for the overall shape and to use rotating vanes and a rotating microphone. This seemed to offer the principal advantage of simplicity of instrumentation and speed of sampling during a test.

After considerable experimentation, it was finally determined that the only satisfactory power source for driving the microphone system would be obtained if it was located outside the room. This had the obvious benefit of allowing us to develop a very powerful unit which could also operate the vane system. The power units, one for each room, are located in small penthouses on the roof.

On reconsidering the vane system, it occurred to us that the principal function of the vanes was to offer a constantly changing room geometry, and that while there was considerable experimental evidence to show that some vane systems could be superior to others, it was also evident that as long as the amount and size of the vanes was sufficiently large, the differences between one system and another would be of little consequence for our class of work.

With a little imagination, a very simple arrangement was worked out, using standard size sheets of plywood and a system of ropes, in a manner of ancient Indian Punkahs, to effect the necessary movement. The plywood sheets, curved to provide necessary stiffness, are shown hanging about the room in Figure 2. The microphone boom and cradle are also shown. This form of swivel cradle allows the microphone to be carried in a full circle, without twisting or having to use slip rings in the cable connection.

One distinct advantage of this system is that the vanes are essentially distributed about the perimeter and do not occupy valuable test space in the center of the room, as is the case with many rotating vane designs.

The simple crank arm and wrist pin arrangement which drives the microphone boom and pulls the ropes attached to the vanes is shown in Figure 3. The transmission shaft coming through the roof carries a V-belt drive which operates the rotating microphone boom and a crank arm with wrist pin which is grooved to hold the ropes securely.

Finally, the compliment of instrumentation used in the control room is shown in Figure 4. At the upper left is the noise generator and associated 1/3 octave filter set. Below that is the measuring amplifier and its associated 1/3 octave filter set which has a range of from 2 Hz to 200 K Hz. At the top of the equipment rack is a patch panel for interconnection of the various components in variable configurations. The broadcast quality recorder in the rack is used primarily for playback of tapes which are recorded in the field on our Nagra or Tandberg equipment. The small operator panel below the tape recorder contains remote functional switching, amplifier gain control, filter stepping, reverberation pulsing, etc. The strip chart recorder is located in a well in the operators' desk, providing convenient operation and a writing surface under the strip charts as they leave the recorder. Above the strip chart recorder is the X-Y plotter which is coupled to the strip chart recorder to provide immediate display of analysis curves on preprinted forms. Immediately above th- X-Y plotter is the 1/3 octave filter shaper. In the rack and on the shelf is a monitor amplifier and speaker, the statistical distribution analyzer, and power amplifier.

Complimenting this equipment is a mobile instrument van, mobile power unit, narrow band analyzer, beat frequency oscillator, portable sound level meters, noise dose meters, tape recorders, impact testers, audiometry equipment, and the usual test instruments associated with an electronic laboratory.

We are quite proud of the facility which we have constructed and to demonstrate in a more rigorous manner that the rooms meet the technical requirements of a laboratory meant to be used in producing credible test results, a series of evaluation tests were conducted by Mr. Don Olynyk and Dr. Gary Faulkner. A summary of the results of this testing follows.

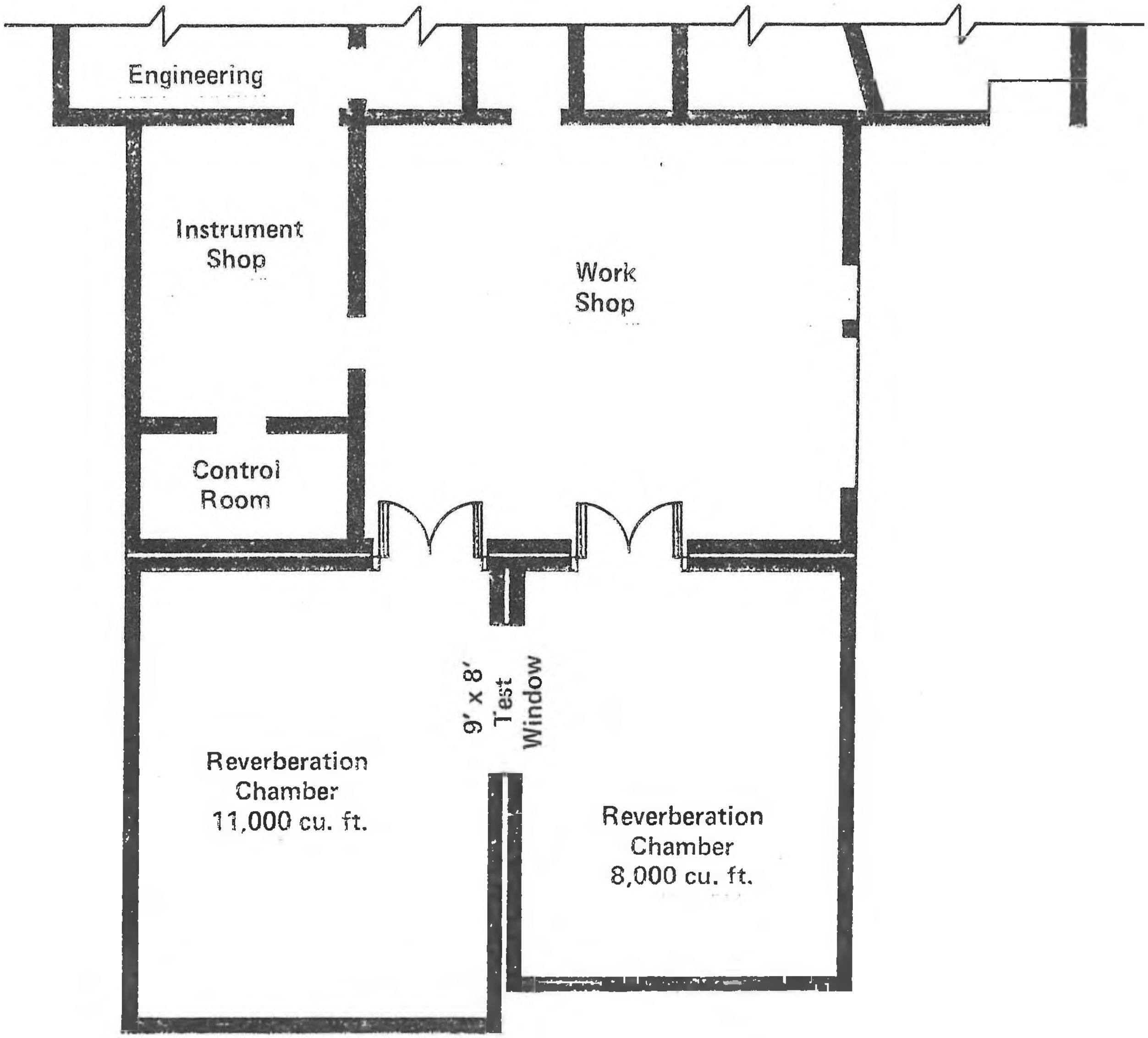

FIGURE 1 LABORATORY LAYOUT

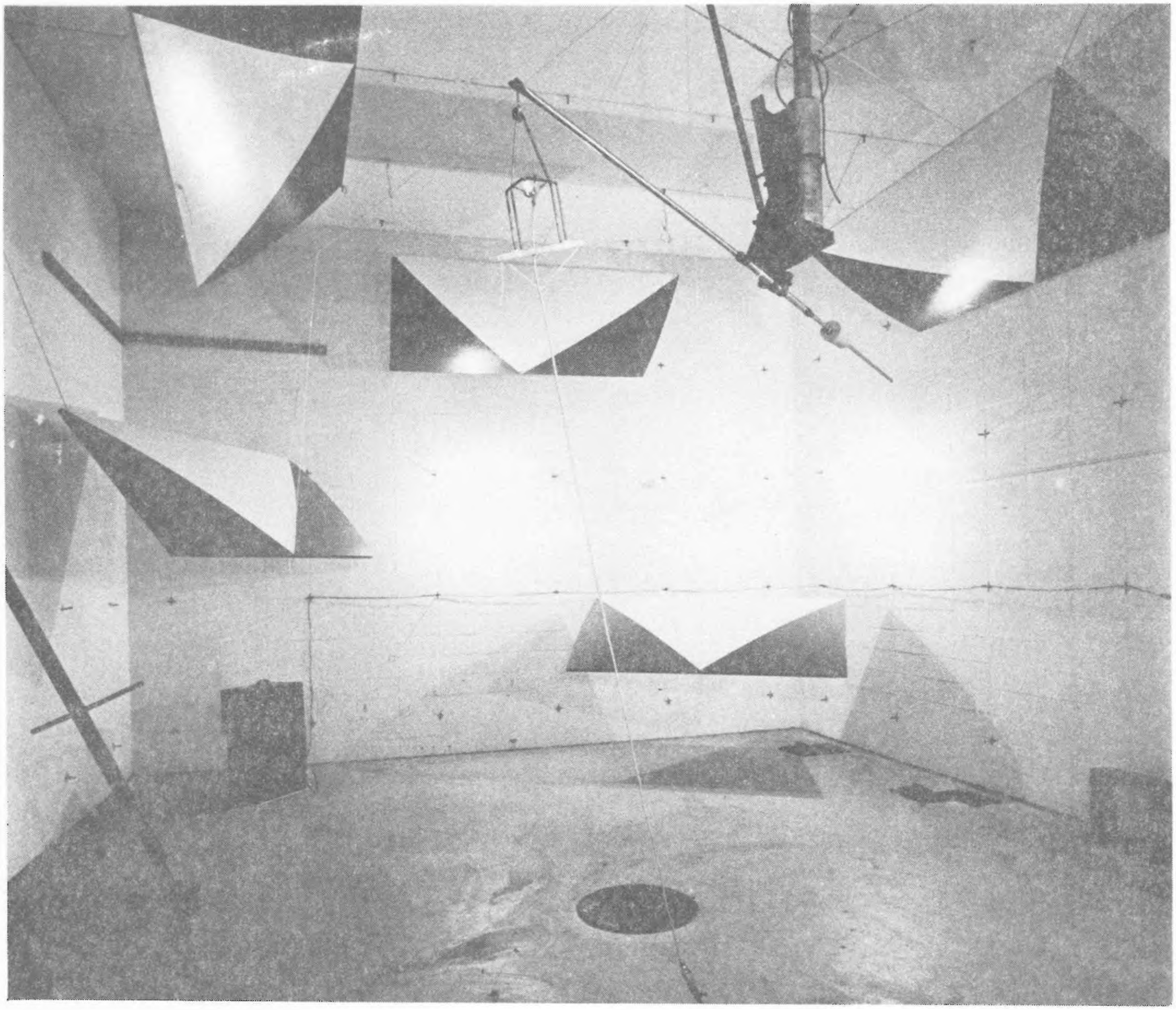

FIGURE 2

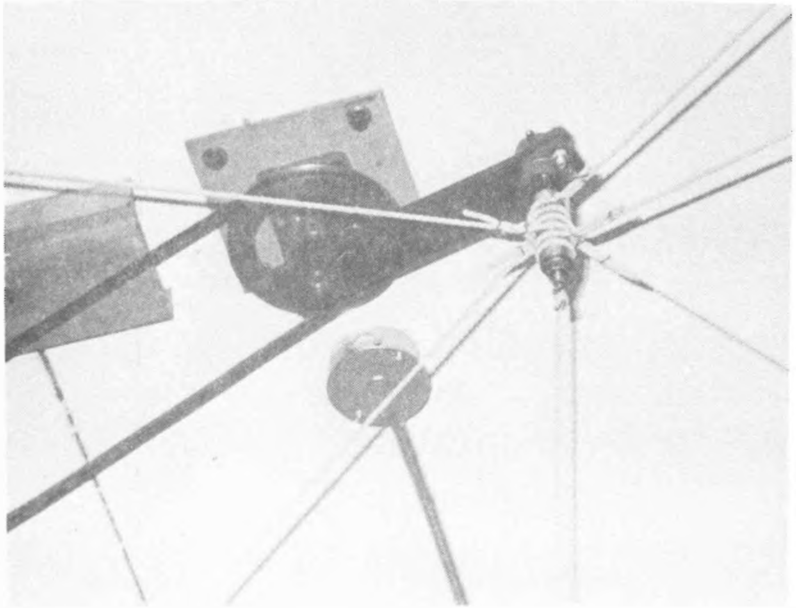

FIGURE 3

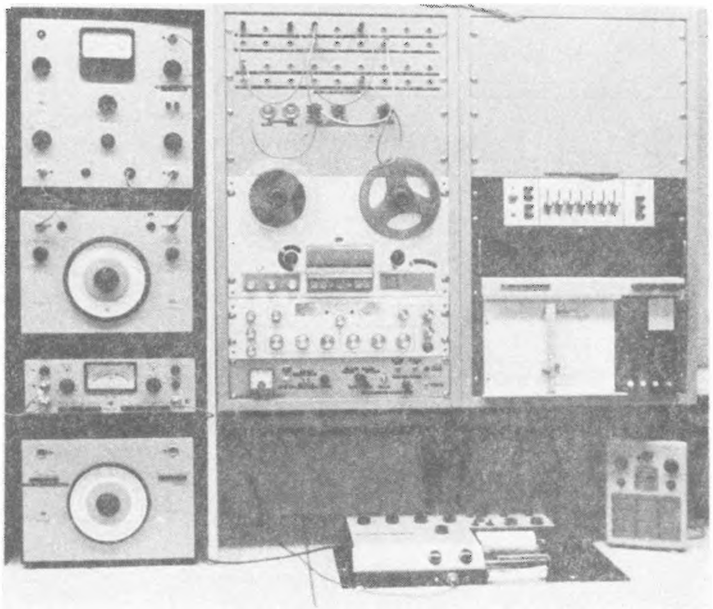

FIGURE 4

A NEW ACOUSTIC TEST FACILITY IN WESTERN CANADA PART B

TECHNICAL EVALUATION

M.G. Faulkner
Dept. of Mechanical Engineering
University of Alberta
Edmonton, Alberta

and

D. Olynyk
Acoustician
No. 22, 9740 - 62 Street
Edmonton, Alberta

1.0 Introduction

A new acoustic test facility has just been completed by Bolstad Engineering Associates Ltd. at 6720 - 30 St., Edmonton, Alberta. The facility, consisting essentially of a pair of reverberation rooms with associated electronic instrumentation, is the first full scale acoustical test facility in Western Canada.

The purpose of this article is to describe the evaluation of this facility for making laboratory measurements of sound absorption, sound transmission loss and sound power.

2.0 Description of Test Facility

The test facility which has been described in the preceeding article (see Figure 1) consists of two adjoining reverberation rooms, which can be linked through a common opening. The large reverberation room has interior floor dimensions of 28'4" x 22'4" with a height of 17'4" while the small rooms dimensions are 25'8" x 20'4" x 15'4". Suspended randomly throughout these rooms are diffusing devices consisting of slightly curved 4' x 8' x 3/8" thick plywood panels, the large room having eight while the smaller one has six. A 9'0" wide x 8'0" high test opening links the two rooms to accommodate walls for transmission loss measurements. When not in use the test opening is sealed with a filler plug wall.

Both reverberation rooms utilize a similar microphone system. By means of a rotating boom driven by the roof-mounted drive system the microphone is capable of traversing a circle 10 feet in diameter in a plane inclined at 5° with the horizontal.

The instrumentation used in conjunction with these rooms is shown schematically in Figure 1. Normally one loudspeaker assembly was used and it is placed on the floor near a trihedral corner.

3.0 Evaluation of Facility for Measurement of Sound Absorption

The most important standards for laboratory measurement of sound absorption have come from the International Organization for Standardization (ISO) and American Society for Testing and Materials (ASTM). Of interest are the following documents:

(1) ISO Recommendation R354 (1963) "Measurement of Absorption Coefficients in a Reverberation Room"

(2) ASTM C423-66 (Reapproved 1972) "Standard Method of Test for Sound Absorption of Acoustical Materials in Reverberation Rooms".

Measurement of sound absorption by this method is based on reverberation theory, the key hypothesis being that the sound field must be diffuse and the room surface be therefore exposed to an assembly of waves from all angles of incidence. To achieve good diffusion the standards agree quite closely that certain conditions must be met including liveness, size of rooms, shape, diffusing devices and precision of measurements.

To insure liveness, ISO recommends that the reverberation times of the empty room should exceed certain values, these values varying with room volume as given below:

125	250	500	1k	2k	4k	Hz
6.0	6.0	6.0	5.4	4.2	2.4	seconds for 310 cu.m. (10,963 ft^3)
5.4	5.4	5.4	4.9	3.8	2.2	seconds for 226 cu.m. (8,000 ft^3)

Measured reverberation times for the empty large and small reverberation rooms exceed ISO values at all frequencies. ASTM specifies this condition in another way by stating that the average absorption of the empty room surfaces shall be less than 0.06 at all measuring frequencies. In our case, the average absorption of empty room surfaces was found, after appropriate allowance for air absorption, to be 0.02 between 125 and 4000 Hz for both chambers.

For room size, ISO recommends a room volume larger than 180 m^3 (6357 ft^3) and further recommends, in the case of new construction, that the volume be as close to 200 m^3 (7,063 ft^3) as possible. (This criteria is met for both rooms). ASTM specifies that the smallest dimension of the room shall be more than one wavelength, λ, and preferably more than two wavelengths of the centre frequency of the lowest one third octave band at which measurements are to be made. The smallest dimension corresponds to one wavelength at 65 Hz and 73.5 Hz for the large and small reverberation rooms respectively. Corresponding frequencies where the smallest dimension is equivalent to two wavelengths are 130 and 147 Hz respectively.

Another factor that must be considered is room shape. ISO specifies that the shape of the room shall be such that $l_{max} < 1.9\ V^{1/3}$ where l_{max} is the length of the greatest straight line which can fit within the boundary of the room. Calculations show that this criterion is met for both chambers. ASTM specifies that the ratio of the largest to the smallest dimension shall be less than 2:1. The actual room dimension ratios in our case are within this range and are 1.63:1.29:1 for the large chamber and 1.67:1.32:1 for the small chamber. This is fairly close to the theoretical ratio of $1:\sqrt[3]{2}:\sqrt[3]{4}$ (1:1.26:1.59) commonly referred to in the literature.*

To insure a diffuse field ASTM recommends a number of sound-reflecting panels hung or distributed at random angles or kept moving presenting a room which continually changes in shape. ISO on the other hand mentions only static diffusing panels. ASTM essentially states that decay curves shall be independent of both microphone position, test specimen position and free of non-exponential irregularities. In general the decay curves became more exponential and smoother as the vanes and microphone were moving.

The number and precision of measurements is a factor worthy of consideration. ISO indicates that each evaluation of a decay rate for a given frequency band shall be based on at least 6 records, each under different variations in the sound field as far as loudspeaker position, microphone position, diffuser system configurations, etc.unless experience shows otherwise. ASTM recommends a group of measurements at each test frequency the size of the group chosen to yield an absorption coefficient to a precision of ± 0.04 at 125 and 4000 Hz and ± 0.02 at all intermediate frequencies with confidence limits of 90 percent. In addition, any decay curves with multiple slopes shall be excluded as both standards bring out. In tests made on an absorptive sample this precision was obtained by taking 8 to 10 decay curves for the empty room and a similar number with the sample in place.

4.0 Evaluation of Facility for Measurement of Sound Transmission Loss

The most important standard on this continent for laboratory measurement of sound transmission loss has come from ASTM and is entitled:

(1) ASTM E90-70, "Standard Recommended Practice for Laboratory Measurementsof Airborne Sound Transmission Loss of Building Partitions".

European practice is fairly similar to that of North American and is reflected in the following ISO standard:

(1) ISO Recommendation R-140-1960, "Field and Laboratory Measurements of Airborne and Impact Sound Transmission".

---

*Bolt (1947) "Normal Frequency Spacing Statistics", J. Acoust. Soc. Am. 19, 79.

The conditions for a diffuse field to be used for sound transmission testing are similar to those mentioned above for absorption measurements. The conditions for room size and shape as well as diffusing are met or exceeded by this facility. As well the absorption coefficient of the room walls are well below the specification of 0.06.

A further condition which must be met is that of flanking transmission. ASTM recommends that the sound power transmitted through the test structure be at least 10 dB greater than the power transmitted by all other paths. Flanking was investigated experimentally by a series of measurements on substantial walls in the test openings. Introduction of the available plug wall, normally used to seal the opening, yielded a value of the order of STC 56. A dip occurring in the vicinity of 2000 Hz is, presumably, the result of coincidence effects. A further test was carried out on a "better" wall consisting of a combination plug wall - batts - double leaf plasterboard wall; this resulted in the sound isolation being boosted up to STC 65. According to the measurements to date it is evident that the facility is capable of testing walls up to at least STC 55.

ASTM states that a sufficient number of measurements shall be taken to ensure that the mean value of the noise reduction is known to within ± 1 dB (90 percent confidence) except for the lowest band for which the limit shall be ± 2 dB. Similarly determination of the mean value of the receiving room absorption term (10 log A_2) must be made to the same precision. The data accumulated so far indicates that an averaging time or filter stepping time of at least 5 seconds should be used for one-third octave analysis. In this time interval the microphone completes one-half a revolution. The precision for the noise reduction was obtained by taking 9 to 10 sets of noise reduction measurements for one-third octaves from 125 Hz to 500 Hz. Above 500 Hz, 5 sets of measurements were sufficient to give the required precision. The precision of the receiving room absorption term was obtained with 4 to 5 decays for each one-third octave considered.

5.0 Evaluation of Facility for Measurement of Sound Power Level

A state-of-the-art standard for the measurement of sound power level is:

(1) American National Standard "Methods for the Determination of Sound Power Levels of Small Sources in Reverberation Rooms" S1.21-1972.

An attempt is made to achieve a uniform energy density within the room. Of the utmost importance is the volume of the room, its proportions and its absorption coefficient. Again the recommendations of ANSI are met or exceeded by these rooms.

A major factor affecting the qualification of a reverberation room for sound power determination is the uncertainty in the measurement of mean square sound pressure throughout the room. ANSI deals with these uncertainties by specifying the precision of measurements in terms of a maximum value for standard deviation for sound pressure. For broad band measurements these criteria are not difficult to meet.

In our case, a limited number of measurements were carried out for the purpose of assessing the test facility for sound power measurements. Room response to broad band excitation was determined by utilizing a loudspeaker as the sound source and exploring the sound field by stationary and rotating microphone. The maximum deviation was found to be of the order of 1 or 2 dB throughout most of the frequency range with somewhat higher scatter at the lower frequencies.

6.0 Conclusion

The new acoustic test facility by Bolstad Engineering Associates Ltd. has been designed with considerable thought. Introduction of novel moving diffusers and a rotating microphone system will contribute toward making efficient use of the facility for commercial sound laboratory testing and research purposes.

It is evident that the two reverberation rooms exceed minimum requirements for measurements of sound absorption according to ASTM and ISO standards. It would be desirable to make inter-laboratory comparisons on sound absorption coefficients of several materials. This would give a further opportunity to evaluate the effectiveness of the novel moving diffuser system.

In regard to measurement of sound transmission loss the pair of test chambers adequately meet minimum requirements given by ASTM. From the data obtained the facility is capable of measuring walls up to STC 55 and possibly higher.

Both reverberation rooms of the new test facility satisfy ANSI standards for measurement of sound power of broad band sources. Further testing is necessary to qualify the rooms for narrow band and discrete-frequency sources.

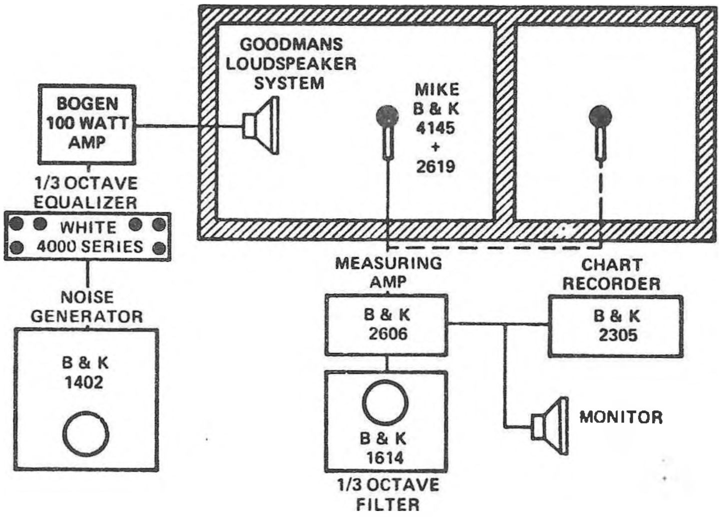

FIG. 1

EDITORIAL BOARD / REDACTION

Gary Faulkner
Mechanical Engineering Dept.
University of Alberta
Edmonton, Alberta T6G 2G8

D. N. May
Ontario Ministry Transport and
Communications
Research and Development Division
1201 Wilson Avenue
Downsview, Ontario M3M 1J8

REGIONAL CORRESPONDENTS / CORRESPONDANTS REGIONAUX

PACIFIC

J. H. Gilbert
Department of Pediatrics
University of British Columbia
715 West 12th Street
Vancouver , B.C. V5Z 1M9

Douglas Whicker
Barron and Strachan
3284 Heather Street
Vancouver, B.C. V5Z 3K5

WEST & NORTH

H. W. Jones
Department of Physics
University of Calgary
Calgary, Alberta T2N 1N4

E. H. Bolstad
Bolstad Engineering Acoustics Ltd.
P. O. Box 5768, Station L
Edmonton, Alberta T6C 4G2

M. Campbell
Department of Mines, Resources &
Environmental Management
1015 - 401 York Avenue
Winnipeg, Manitoba R3C 0P8

J. D. Welch
Faculty of Architecture
University of Manitoba
Winnipeg, Manitoba

ONTARIO

D. Benwell
Health and Welfare Canada
Health Protection Branch
Radiation Protection Bureau
Brookfield Road
Ottawa, Ontario K1A 1C1

Graham Jones
Ontario Ministry of Transport
1201 Wilson Avenue
Downsview, Ontario M3M 1J8

QUEBEC

A.C. Gervais
A.C. Gervais Associates
4003 Decarie Blvd.
Montreal, Quebec

MARITIMES

J. G. Tillotson
Department of Physics
Acadia University
Wolfville, Nova Scotia B0P 1X0

L. T. Russell
Atlantic Industrial Research Inst.
Department of Mechanical Engineering
P. O. Box 100, N.S. Technical College
Halifax, Nova Scotia

CORRESPONDING EDITOR FOR NOISE/NEWS / CORRESPONDANT DU NOISE/NEWS

T. E. Siddon
Department of Mechanical Engineering
University of British Columbia
Vancouver, B. C. V5Z 1M9