ACOUSTICS AND NOISE CONTROL IN CANADA

THE CANADIAN ACOUSTICAL ASSOCIATION

L'ACOUSTIQUE ET LA LUTTE ANTIBRUIT AU CANADA

L'ASSOCIATION CANADIENNE DE L'ACOUSTIQUE

Octobre 1977
Vol. 5, N° 4

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ACOUSTICS AND NOISE CONTROL IN CANADA

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CONTRIBUTIONS

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

SUBSCRIPTIONS

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 0C8. Postal codes must be provided for all addresses in Canada.

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(continued on inside back cover)

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CONTRIBUTION

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

SOUSCRIPTION

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(suite au recto de la couverture inférieure)

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Notice Board

ICA Meeting Madrid, July 4-8, 1977

Shown above is Edgar Shaw the President of International Committee on Acoustics during the opening ceremonies of the 9th ICA Conference in Madrid, Spain. The meeting which took place in the Palacio de Congressos was officially greeted by King Juan Carlos who is shown seated to the left of Edgar.

International Phonetic Sciences Congress IPS-77

An International Phonetic Sciences Congress will be held December 17-19, at the Carillon Hotel, Miami Beach, Florida immediately following the Fall convention of the Acoustical Society of America (Dec. 13-16, 1977) and concurrently with the annual (1977) meetings of the American Association of Phonetic Sciences (AAPS) and the Academy for the Forensic Application of the Communication Sciences (AFACS). AAPS and AFACS are sponsors of the congress, as are the International Society of Phonetic Sciences and Institute for Advanced Study of the Communication Processes, University of Florida. A full program is planned: plenary lectures, special interest programs, scientific sections, general sections and exhibits on all facets of Phonetics, Phonetic Sciences, Speech Science, Phonology, the Communication Sciences and related areas. The official languages for IPS-77 are English, Spanish, French and German; simultaneous translations are planned for the plenary sessions. Up to two contributed papers will be considered for inclusion in the IPS-77 program. Abstracts must be no more than 250 words in length and must be submitted for consideration by the program committee prior to September 1, 1977. Awards will be given for outstanding papers (in several categories). The Congress fees are $25.00 for full participation ($20.00 for prepayment; i.e. prior to September 1, 1977); $7.50 for accompanying persons and $7.50 for students ($5.00 for prepayment). Rates at the Congress hotel (the Carillon) are $20-24 for a single and $22-26 for a double. For circulars, forms and further information, contact the IPS-77 Secretariat: Prof. H. Hollien, IASCP: ASB-50, University of Florida, Gainesville, FL., 32611, USA.

Postdoctoral Fellowship/Research Assistantship in Environmental Noise

The Sound and Vibration Laboratory of the Faculty of Engineering Science has an opening for a postdoctoral fellowship or research assistantship.

The position entails assisting in the supervision of a project for the Canadian Electrical Association: instrumentation development and calibration; long-term field measurement of audible noise from high-voltage transmission lines and of other environmental data; statistical analysis of data (including computer programming); laboratory preparation for, and testing of, attitudinal response of people to transmission line noise; correlation of subjective data with field data.

The Laboratory works closely with the Department of Psychology in connection with subjective reactions to noise. A full-time technician will be available on the project. The Laboratory is fully equipped and also operates a mobile acoustical laboratory for field studies.

Salary would be at the postdoctoral level ($10,000/annum minimum) or would be negotiable on the basis of qualifications and experience. An appointment would entail the usual fringe benefits available to employees of the University. The appointment would be for approximately two years, and could start anytime in the immediate future.

Enquiries should be addressed to:

John E.K. Foreman, P.Eng.
Professor and Head
Sound Vibration Laboratory
Faculty of Engineering Science
The University of Western Ontario
London, Ontario, Canada. N6A 5B9

Telephone: (519) 679-3301

Positions Wanted

A Ph.D. in Physics specializing in ultrasonics wishes a position in this field. Qualifications include a Ph.D. from Helsinki University an M.Sc. in Physics (electronics) from Punjab University as well as 3 years experience in ultrasonic surface waves. For more information please contact Khalid Mafeez, c/o M.J. Khan, #204 - 1315 - 6 St. S.W., Calgary, Alberta. T2R 0Z6

A mechanical engineer specialized in noise and vibration is looking for a permanent job. Qualifications include an M.Sc. in transportation noise (University of Windsor, Ontario), A. B.A.Sc. in mechanical engineering and extensive experience in the field of noise and vibration analysis. Please contact: Arthur Steevensz, 3017 Austen Drive, Windsor, Ontario. N8T 1Z4 Tel: (519) 948-0545

The Canadian Acoustical Association
l'Association Canadienne de l'Acoustique

MINUTES OF CANADIAN ACOUSTICAL ASSOCIATION MEETING HELD IN THE TERRITORIES ROOM AT THE INN OF THE PROVINCES, OTTAWA, ONTARIO - 26 OCTOBER 1977

1. A brief summary of the minutes of the October 1976 meeting previously published in the October, 1976, Vol. 4, No. 4 edition of "Acoustics and Noise Control in Canada" was read by the secretary.

2. It was moved by E. Bolstad and seconded by S. Abel that the minutes of the October 1976 meeting be accepted as distributed. There being no discussion, the president called for the question and the motion carried unanimously.

3. It was moved by E. Bolstad and seconded by J. Manuel that the treasurer's report be accepted is read. (A copy of attached as an appendix to the minutes.) After a short discussion, the president called for the question and the motion carried unanimously.

4. The editor, G. Faulkner, reported that he was no longer using regional correspondents. He noted that D. May was the associate editor and that they both were requesting a steady flow of material for our publication. A vote of thanks to the editor was endorsed by all present.

5. G. Faulkner moved and E. Bolstad seconded that the membership fee for 1978 be $0 levied equally on all members. During the discussion, it was pointed out that fees may have to be charged sometime in the future. if we have to cover the costs of producing our own publication, sufficient funds are presently being generated for our needs from our meeting charges. The motion carried unanimously.

6. In an article published in the July, 1977, Vol. 5, No. 3 edition of "Acoustics and Noise Control in Canada", J. Manuel outlined some reasons why we should join International/INCE. J. Manuel, therefore, moved and H. Jones seconded that the Canadian Acoustical Association should join International/INCE. T. Embleton noted that there would be strong pressure for us to host an international meeting some time in the future. Several members, D. Benwell and D. May, questioned the benefits we might receive by joining. It was noted that the people who attend the meeting of International/ INCE will be doing so at their own expense. If a drastic change of the fee structure occurred (300 Swiss Francs presently) then we could opt out. Upon asking the question, it was found that seven were against and the majority were in favour.

7. The motion on sending someone from C.A.A to San Francisco was ruled out of order as we are not paying their way. It was agreed that the directors would appoint someone to represent C.A.A. at the meetings of I/INCE if one or more persons were intending to attend.

8. It was noted that the consultants directory of C.A.A was being formed as information arrived. (At the time of writing these minutes, about ten one page or less statements had been received.) The directory will only be sent to those who request it. We are not now in the position of printing out such a directory in our publication as the government does not allow advertising.

9. J. Manuel reported that the joint CPR and CNR symposium on marshalling yard noise was a success. Further action is now being considered by the Federal Government and a review is being made of the jurisdiction of the noise control laws which effect marshalling yards.

10. It was reported by H. Jones that the directors have agreed to present an award to the best author, who is 30 or under, of a paper published in our publication. Joint authorship with a senior acoustician is acceptable but questions will be asked about the junior author's contribution. The award will be paid for by the dirctors and will likely be a suitably inscribed chunk of metal. (Further details will appear in one of our future publications.)

11. D. Whicker moved and T. Taylor seconded that the memerbhip list of over 1000 names not be available for sale to anyone for commercial purposes. Uses such as the mailing of community by-laws is quite acceptable (see attached note). It was moved by B. Dunn that the motion be tabled until the next meeting. The vote was 29-2 in favour of tabling until the next meeting.

12. J. Manuel reported that there are funds available in Ontario for research into the effects of the environment on health Any proposal will be considered but cannot be more than two or three years in duration. Further information can be obtained by contacting J. Manuel.

13. The following directors were proposed by H. Jones and seconded by E. Bolstad.

C.W. Bradley	J. Piercy
G. Faulkner	C.W. Sherry
D. Whicker	E. Bolstad
J. Manuel	

It was moved by E. Bolstad and seconded by J. Manuel that H. Jones also be a director. it was further moved by K. Novack and seconded by H. Forester that J. Hemingway also be a director. After a short discussion, J. Hemingway declined the nomination. The president, C.W. Bradley, after asking twice for further nominations, declared that the eight directors were accepted as nominated.

14. The following officers were proposed by H. Jones and seconded by E. Bolstad.

President	C.W. Bradley
Executive Secretary	C.W. Sherry
Editor	G. Faulkner
Treasurer	L.T. Russell.

The president, C.W. Bradley, after asking for further nominations and receiving none declared the officers were accepted as nominated.

(As a note of explanation by the executive secretary to those who are completely,or at least partially, baffled by the election procedures, the officers of CAA for 1978 wil be as follows:

President	C.W. Bradley	(2)
Executive Secretary	C.W. Sherry	(1)
Editor	G. Faulkner	(1)
Treasurer	L.T. Russell	(3)

Past President	H. Jones	non-elected officers
Convenor last annual meeting	T. Embleton	non-elected officers
Convenor next annual meeting	L.T. Russell	non-elected officers

It has been a tradition of CAA to have the elected officers serve for three years before they are replaced. Elections must be held annually, however, so any officer (and any director by the way) can be replaced at a general meeting by a majority vote. The number in brackets after an officer's name indicates the number of years until his traditional term of office would be complete. This means, for instance, that new faces should occupy the offices of executive secretary and editor after next year's general meeting.)

15. A motion of thanks was moved thanking E. Bolstad for acting as the treasurer of C.A.A over the past three years.

16. The president accepted the kind offer of L. Russell to convene the 1978 annual meeting of C.A.A. in Halifax next October.

17. The meeting was adjourned by the president at 6:30 PM.

Cameron W. Sherry

C.W. Sherry - Secretary

The Canadian Acoustical Association
l'Association Canadienne de l'Acoustique

ANNUAL MEETING - OCTOBER 26, 1977

TREASURER'S REPORT

Mr. President:

As the accompanying financial statement will indicate, the Association is gradually developing a cash reserve to meet the inevitable requirements for funding of operating expenses which to date have been negligible but which must sooner or later fall to our account.

It might be interesting to note the progress achieved since the first attempt was made to collect funds at the 1974 annual meeting in Edmonton:

Operating Surplus	October 9, 1975	$ 36.25
Operating Surplus	October 8, 1976	$254.29
Operating Surplus	August 31, 1977	$938.79

This surplus has been realized from the diligence of the conveners of the annual meetings who have succeeded in showing a profit each time. It is also of course attributable to the fact that we are still receiving many gratuitous services from such agencies as Environment Canada and the National Research Council as well as executive members.

It should be noted here that the terms of our incorporation require the appointment of an auditor to verify the accounts of the Association. Since the operating profit for the last year was $684.50 it seems somewhat out of scale to spend $100.00 on an audit (the minimum offered by a professional auditor to date). With the anticipated concurrence of this meeting, I have taken the liberty of simply asking another member of the board to scrutinize the accounts and certify his agreement.

.... continued

Since this appears to by my last effort as treasurer, let me say thanks to the members of the Association who have made my task simple by their careful scrutiny and accounting for income and expenses.

I will leave the task of considering when and how a budget should be prepared for this organization to the incoming treasurer.

Yours very truly,

E. H. Bolstad
Treasurer

CANADIAN ACOUSTICAL ASSOCIATION
FINANCIAL STATEMENT FOR YEAR ENDING AUGUST 31, 1977
COVERING PERIOD FROM OCTOBER 9, 1976

CASH FLOW SUMMARY

	Debit	Credit
Cash on hand, Oct. 9, 1976		254.29
Operating profit from 1976 Annual Mtg.		895.62
Term deposit receipt (T.D.R.)	1,000.00	
Printing and stationery	35.35	
Incorporation fees	210.00	
Post office box rental	11.00	
Bank charges	1.87	
Interest on T.D.R.		47.10
Pre-registration fees - 1977 Annual Mtg.		335.00
TOTALS	$1,258.22	$1,532.01
Cash on Hand - August 31, 1977		$ 273.79 Cr.

STATEMENT OF ASSETS AND LIABILITIES

Assets	Debit	Credit
Cash on hand		273.79
Term deposit receipt		1,000.00
Liabilities		
Pre-registration fees - 1977 Annual Mtg.	335.00	
TOTALS	$335.00	$1,273.79
Net surplus - August 31, 1977		$ 938.79 Cr.

PROFIT AND LOSS STATEMENT

	Debit	Credit
Income		
1976 Annual Meeting		895.62
Interest on T.D.R.		47.10
Expenses		
Printing and stationery	35.35	
Incorporation fees	210.00	
P.O. Box rental	11.00	
Bank charges	1.87	
TOTALS	$258.22	$942.50
Net profit		$684.50 Cr.
Surplus October 9, 1976		$254.29
Net Surplus August 31, 1977		$938.79 Cr.

E. H. Bolstad, Treasurer

Director

THE CANADIAN ACOUSTICAL ASSOCIATION

DRAFT COPY FOR INFORMATION AND DISCUSSION PURPOSES

Recommendation

It is recommended that the mailing and membership lists of the Canadian Acoustical Association should not be released or published and that their use should be restricted to internal use for the good of the Association only.

Discussion

My reasons for recommending the above policy are as follows:

1. The privacy of the membership of the Canadian Acoustical Association should be respected.

2. The news letter of the Association will be supported if those wishing our mailing list are encouraged to make their announcements in it instead. At sometime in the future, the Directors may decide to levy a charge for announcements of a commercial nature and thus generate continuing revenue.

3. Those individuals wishing to put their name on a mailing list can submit them directly as a result of a request published in our news letter. Income can then be obtained by charging for the placement of the announcement, or else by selling the sub-mailing list so developed.

Submitted,

October 17th, 1977

D.J. Whicker
Director

A RAPID BARRIER HEIGHT CALCULATION METHOD

J.R. Hemingway, P.Eng.
Senior Environmental Engineer
SNC/GECO Canada Inc.
Toronto, Ontario

One of the difficulties in designing a barrier to attenuate sound levels outdoors is that although it is easy to calculate the attenuation a certain barrier height will give, it is not so easy to reverse the process to determine what barrier height is necessary to provide a certain attenuation.

The attenuation provided by a Barrier is recognized (1,2) as being a function of the Path Length Difference (PLD) or that extra distance sound is obliged to travel due to the presence of the barrier, see Fig. 1.

$$PLD = a + b - d \tag{1}$$

$$PLD = \left[(H_B-H_S)^2 + (SB)^2\right]^{1/2} + \left[(H_B-H_R)^2 + (BR)^2\right]^{1/2} - \left[(H_R-H_S)^2 + (SB+BR)^2\right]^{1/2} \tag{2}$$

Once the PLD has been calculated it must be converted to Fresnel number form by either knowing the frequency of the sound being attenuated or, for a broad band source by assuming a representative frequency.

$$\text{Fresnel Number (N)} = \frac{\text{frequency}}{565}\ \text{PLD (ft)} \tag{3}$$

Once N has been calculated then the attenuation can be obtained from curves as shown in Fig. 2 for either a point or line source.

The problem with reversing this procedure is that although the PLD required to give a certain attenuation is easily found, determination of the barrier height required to give this PLD is not so simple, primarily due to the "heavy" quality of Eqn. (2). As a first stage in simplification of Eqn. (2) it was rewritten as follows:

$$PLD = SB\left(1 + \left|\frac{H_B-H_S}{SB}\right|^2\right)^{1/2} + BR\left(1 + \left|\frac{H_B-H_R}{BR}\right|^2\right)^{1/2} - (SB+BR)\left(1 + \left|\frac{H_R-H_S}{SB+BR}\right|^2\right)^{1/2} \tag{4}$$

The approximation

$$(1+X^2)^{1/2} = 1 + \frac{X^2}{2} \qquad (5)$$

was then used to simplify Eqn. 4 still further. Such an approximation is acceptable for barrier calculations as although PLD is a small difference between larger numbers the quantities represented by X^2 are usually small in barrier work. Any errors which do arise can be easily compensated for as is shown later.

Using the approximation of Eqn. 5 in Eqn. 4 necessitates some straightforward if rather tedious algebraic manipulation but eventually a simple quadratic equation for PLD in terms of the barrier height emerges.

$$PLD = A.\, H_B^{\;2} + B.\, H_B + C \qquad (6)$$

where

$$A = \frac{SB + BR}{2.\, SB.BR}$$

$$B = - \left| \frac{H_S}{SB} + \frac{H_R}{SR} \right|$$

and

$$C = \frac{1}{2} \left| \frac{H_S^{\;2}}{SB} + \frac{H_R^{\;2}}{SR} - \frac{(H_S - H_R)^2}{SB+BR} \right|$$

This equation can of course be solved very simply using the general solution for a quadratic equation.

$$H_B = \frac{- B + \sqrt{B^2 - 4A(C-PLD)}}{2A} \qquad (7)$$

The usual negative sign in front of the square-root is ignored as although it is a possible algebraic solution acoustically it is not, the receiver being in the "bright zone". Eqn. 6 applies for a "thin" barrier but can be easily modified to apply to a "thick" barrier (assuming the PLD concept still applies) such as a continuous row of buildings made up of garages or townhouses. For such a thick barrier (of thickness T) only C is altered as follows:

$$C = \frac{1}{2} \left| \frac{H_S^{\;2}}{SB} + \frac{H_R^{\;2}}{SR} - \left(\frac{H_S - H_R}{SB+T+BR} \right)^2 \right|$$

BR is measured from the <u>rear face</u> of the barrier to the receiver.

In order to simplify the calculation of PLD from the required attenuation the approximations shown in Fig. 3 can be used. These were deliberately chosen to be pessimistic for high values of Fresnel Number to counteract inaccuracies resulting from the use of the approximation in Eqn. 5. This should make the method accurate to within 1 dB even for higher values of PLD. The equations shown on Fig. 3 can easily be reversed to give PLD in terms of the attenuation:

For a point source $$PLD = \frac{565}{frequency} \cdot 10^{0.18\,(attenuation-10.7)} \quad (8a)$$

For a line source $$PLD = \frac{565}{frequency} \cdot 10^{0.12(attenuation-13.0)} \quad (8b)$$

By way of example, for traffic noise, a commonly used representative frequency is 500 Hz (3).

A complete calculation sheet is shown in Fig. 4 and a worked example shown in Fig. 5.

To demonstrate the accuracy of the method, for the example presented in Fig. 5 (which represents a fairly extreme case with a relatively high barrier) the attenuation resulting from the 27 ft. barrier was calculated in the usual way.

$$PLD = 5.13 \text{ ft}$$

$$\therefore N = 4.53 \text{ (for traffic noise)}$$

$\therefore$ Attenuation = 14.14 dBA

As 15 dBA was asked for, the method is within 0.6 dB, however if the actual line source curve in Fig. 2 is used then 15 dBA of attenuation is in fact achieved. This indicates that errors due to the approximation inherent in Eqn. 5 are less than 1 dBA and counteracted by assuming the pessimistic attenuation curves shown in Fig. 3.

Of course, the usual restrictions for barrier calculations apply to this method, the barrier should be sufficiently long or wrapped around the receiver at the ends and be massive enough to avoid sound transmission through it. Also, no more attenuation should be asked for than the maximum indicated by the two curves shown in Fig. 2.

To conclude, it is felt that this method provides a simple, rapid and convenient procedure for calculating the barrier height to provide a required sound attenuation with acceptable accuracy.

References

1. Z. Maekawa, "Noise Reduction by Screens", Memoirs of Faculty of Engineering, Kobe University, Japan 11, pages 29-53, 1965.

2. U.J. Kurze and Y.S. Anderson, "Sound Attenuation by Barriers" Applied Acoustics, Vol. 4, pp. 56-74, 1971.

3. "Acoustics Technology in Land Use Planning", Ontario Ministry of the Environment, Canada, 1977.

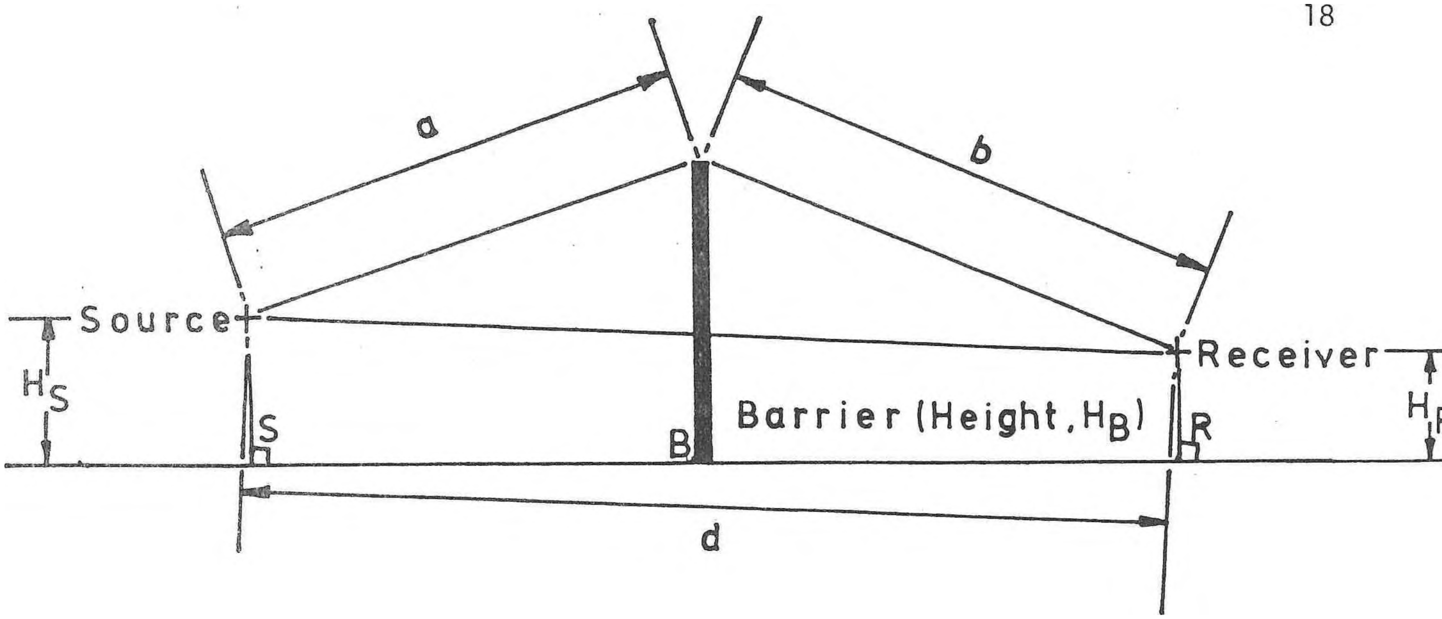

a
b
Source
Receiver
H_S
H_R
Barrier (Height, H_B)
S
B
R
d

FIG 1

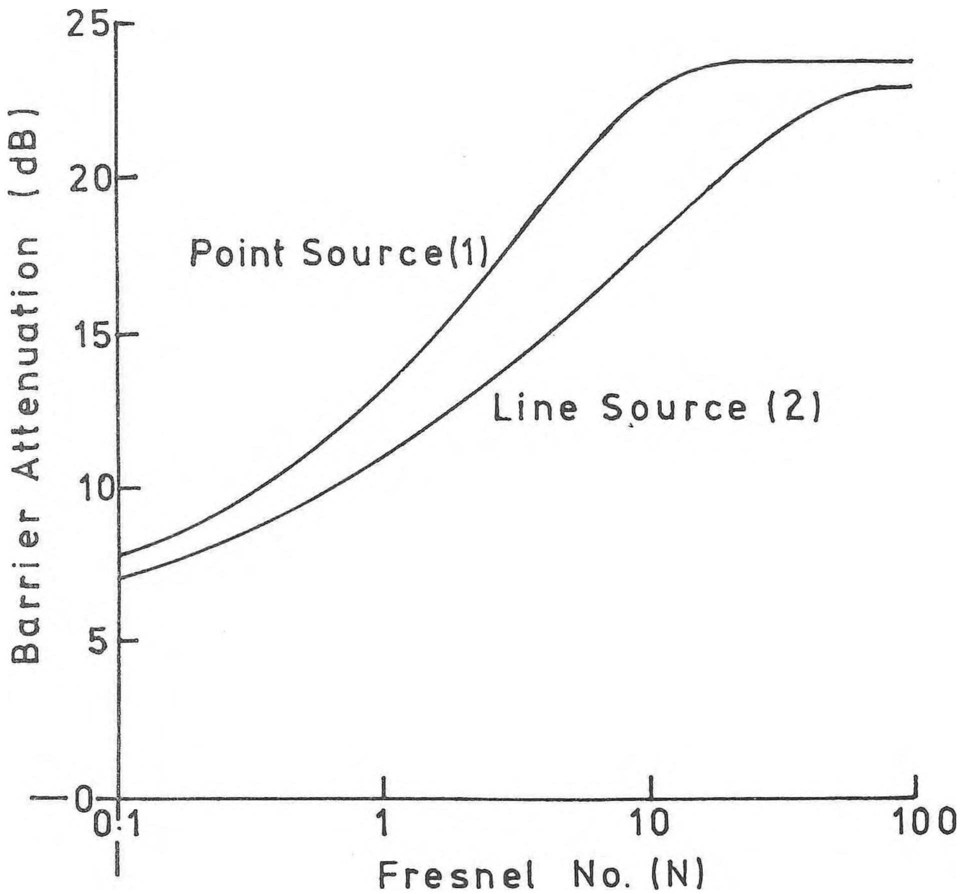
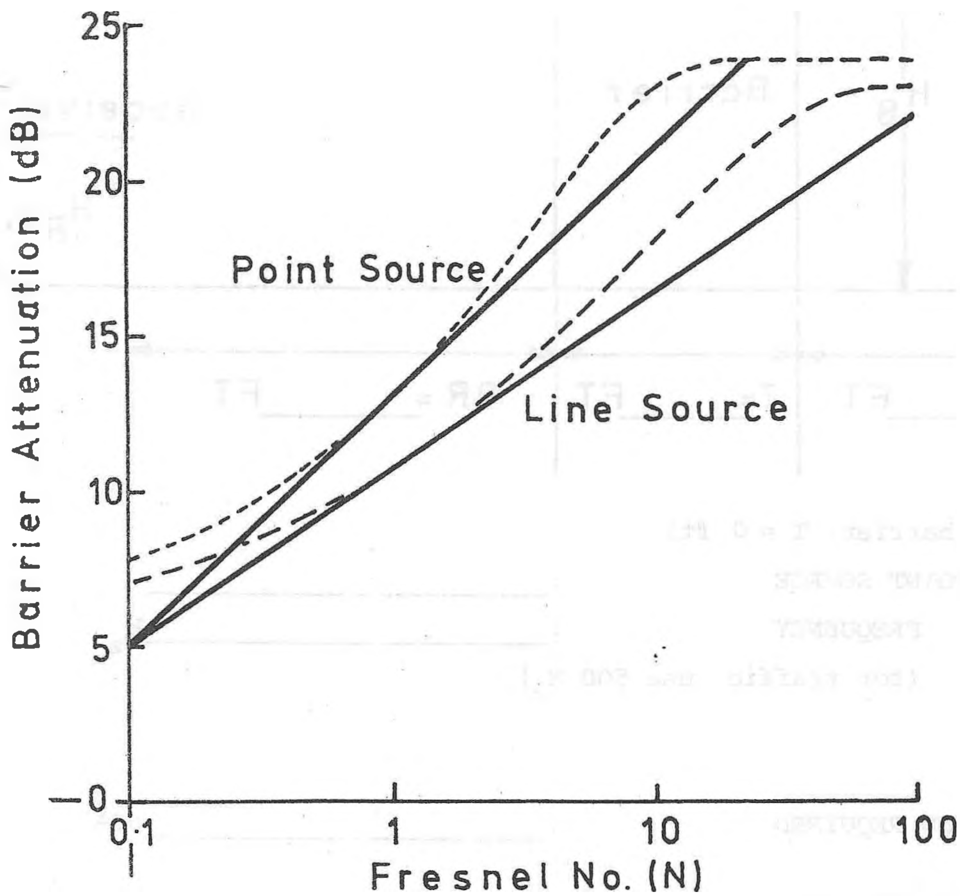

Barrier Attenuation (dB)
25
20
15
10
5
0
Point Source(1)
Line Source (2)
0·1
1
10
100
Fresnel No. (N)

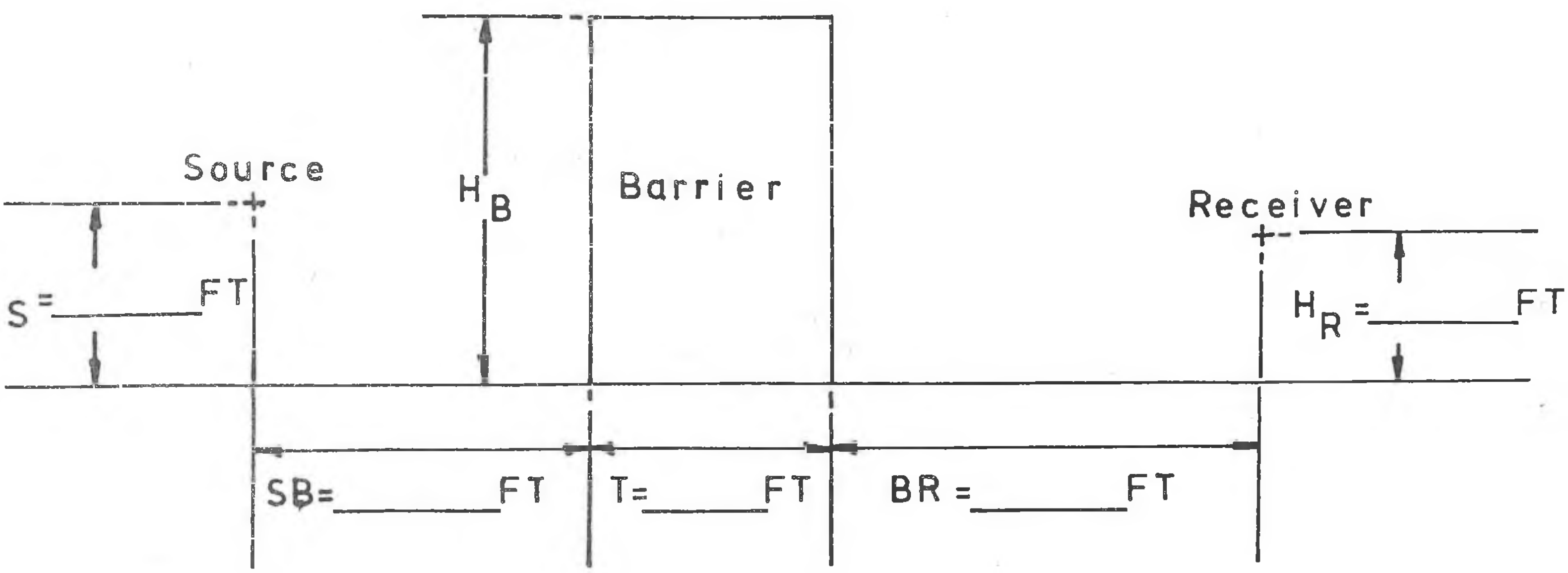
FIG 2



25
20
15
10
5
0
Barrier Attenuation (dB)
Point Source
Line Source
0·1
1
10
100
Fresnel No. (N)

FIG 3

BARRIER HEIGHT CALCULATION WORKSHEET



(for a thin barrier, T = 0 ft)

LINE OR POINT SOURCE : ____________________

FREQUENCY : ____________________ H_z

(for traffic use 500 H_z)

ATTENUATION REQUIRED : ____________________ dBA

1. Calculate A $= \dfrac{SB + BR}{2.\ SB.\ BR} =$

2. Calculate B $= -\left[\dfrac{H_S}{SB} + \dfrac{H_R}{BR}\right] =$

3. Calculate C $= \frac{1}{2}\left[\dfrac{H_S^{2}}{SB} + \dfrac{H_R^{2}}{BR} - \dfrac{(H_S - H_R)^{2}}{SB+T+BR}\right] =$

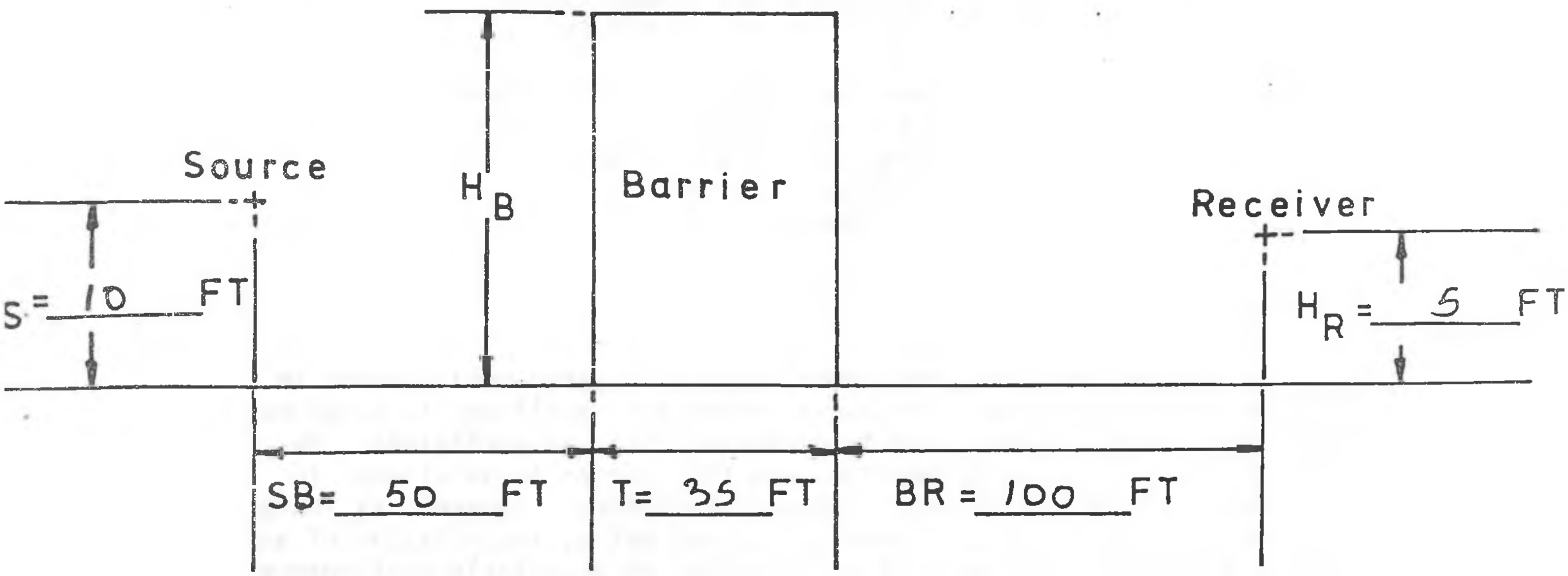
4. Calculate PLD
   a/ Point Source PLD $= \dfrac{565}{\text{frequency}} . 10^{0.118\,(\text{attenuation} - 13.0)} =$

   or b/ Line Source PLD $= \dfrac{565}{\text{frequency}} . 10^{0.175\,(\text{attenuation} - 10.7)} =$

5. Calculate H_B $= \dfrac{-B + \sqrt{B^{2} - 4A(C-PLD)}}{2A} =$

FIG 4

BARRIER HEIGHT CALCULATION WORKSHEET



(for a thin barrier, T = 0 ft)

LINE OR POINT SOURCE : LINE

FREQUENCY : 500 H_z

(for traffic use 500 H_z)

ATTENUATION REQUIRED : 15 dBA

1. Calculate A $= \dfrac{SB + BR}{2.\ SB.\ BR} = 0{\cdot}015$

2. Calculate B $= -\left[\dfrac{H_S}{SB} + \dfrac{H_R}{BR}\right] = -0{\cdot}25$

3. Calculate C $= \frac{1}{2}\left[\left(\dfrac{H_S}{SB}\right)^2 + \left(\dfrac{H_R}{BR}\right)^2 - \left(\dfrac{H_S - H_R}{SB+T+BR}\right)^2\right] = 2{\cdot}11$

4. Calculate PLD

a/ Point Source PLD $= \dfrac{565}{\text{frequency}} .10^{\,0.118\,(\text{attenuation} - 13.0)} =$

or b/ <u>Line Source</u> PLD $= \dfrac{565}{\text{frequency}} .10^{\,0.175\,(\text{attenuation} - 10.7)} = 6{\cdot}39$

5. Calculate H_B $= \dfrac{-B + \sqrt{B^2 - 4A(C-PLD)}}{2A} =$ 27 ft

FIG 5

EXPERIENCES WITH A NEW SINGLE NUMBER SOUND ISOLATION RATING METHOD

D.J. Whicker, G.D. Hall and M.T. Rivard
Barron and Associates
Consulting Acoustical Engineers
3284 Heather Street
Vancouver, B.C.

Introduction

At the present time, the specification of party wall systems to provide air-borne sound isolation in multiparty dwellings is based on laboratory tests of the Sound Transmission Class of partitions. Designers and regulatory authorities use this rating in an attempt to provide a desired, or minimum, acoustic isolation. However, as sound is transmitted from room to room by several paths, installation of an adequately rated party wall is no guarantee of acceptable performance of the finished building.

The American Society for Testing and Materials (ASTM) has published a recommended practice (E 597-77T) which provides a method for "Determining a Single Number Rating of Air-borne Sound Isolation in Multi-Unit Building Specifications". This method states that "other sound paths are often of equal importance and must be included in any measurement of acoustic isolation" and "this isolation is readily measured in terms of the simple noise reduction between a pair of rooms". If for some non-evident reason the noise isolation of a room pair falls short of the anticipated value, then the path at fault may be identified by procedures of Recommended Practice E336, "Measurement of Air-borne Sound Insulation", or other valid method.

In this paper, we discuss the development of a noise source meeting the requirements of ASTM E597-77T and discuss our experiences in its calibration and field use.

It has been recommended that the resulting single number be referred to as "Privacy Index", and that term has been used in this paper.

Noise Source

The Recommended Practice requires an accurate, calibrated and stable sound source employing specially shaped source and absorption frequency spectra. After approximately two years of development, construction, and testing, Barron & Associates produced a noise source meeting these requirements. Originally, field transmission tests required packing, transporting, and unpacking (usually by hand and up 10 flights of stairs) many individual pieces of equipment. Out of desperation, a compact noise source was developed and used primarily for traditional air-borne field transmission loss testing. It was decided that it would be relatively simple to modify that box to meet the requirements of the new ASTM standard (or so we thought!).

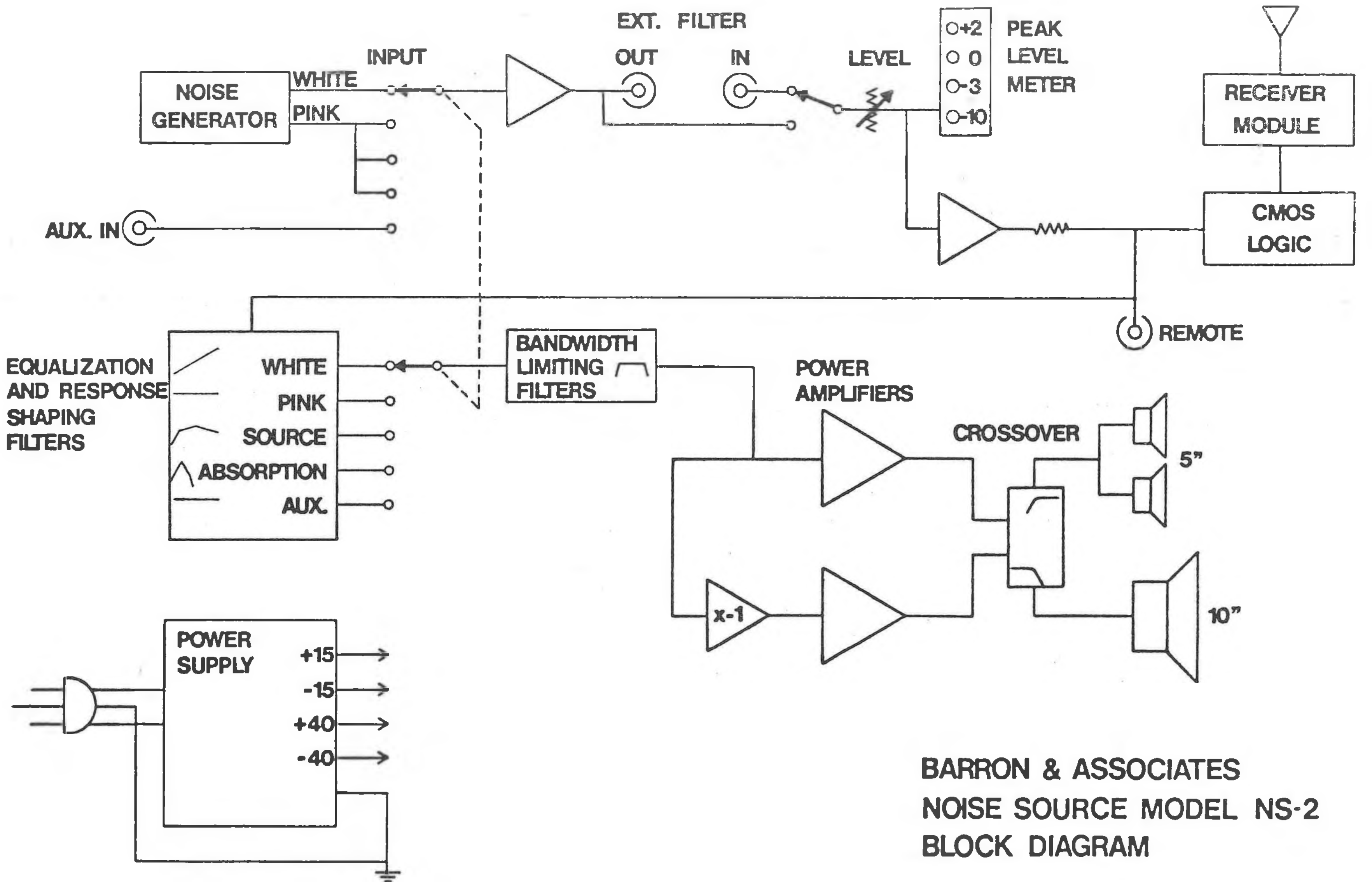
After approximately one year of "modifications", a box meeting the ASTM requirements evolved. The output signals available for testing are: pink noise, white noise and special source and absorption spectra. Also, inputs for auxiliary equipment and external filtering are provided. Total weight is approximately 45 pounds. The box contains a radio operated remote control which allows on/off operation from distances up to 300 ft. The output levels and the special spectra meet the requirements of ASTM E 597-77T, and are stable within $\pm$ 1 dB with line voltage variation from 90 V. to 125 V.

The block diagram shows the basic circuitry. All low level signal amplifiers and active filters utilize operational amplifiers with final power amplification by two 50 watt Hybrid IC power amplifiers connected for bridging operation to give a total output power of approximately 130 watts rms into an 8 ohm load. The remote control receiver is a prebuilt assembly connected to a digital logic circuit controlling the audio. The loudspeakers include a single 10" JBL full range unit, and two 5" JBL extended range loudspeakers. Originally only one 5" tweeter was used but it was discovered that although it could produce the acoustic power required on the "Pink" and the "Source" settings, the first time the box was operated in the "White" noise mode, it reverted to a low frequency generator permanently! Two 5" tweeters are now standard.

The result of all the construction, changes, testing, etc., is the TL Noise Source Model NS-100, being manufactured under license by TRACOUSTICS, Inc. of Austin, Texas. This is an ultra-stable device which can be used for privacy testing between dwelling spaces according to the new ASTM Recommended Practice as well as for standard transmission loss tests. The remote control permits tests of receiving room background noise level without leaving the receiving room to shut off the source, and permits one person to make reverberation decay measurements in large theatres, auditoria, or arenas. Finally, it can, with only the addition of a simple microphone and preamplifier, perform as a portable public address system.

Test and Analysis Procedures

Having constructed this unit it was now necessary to test it. The procedure which we have followed is to take every opportunity to carry out both a Privacy Index test and a Field Noise Isolation Class (NIC) test on the same party wall system. Our clients bear the cost of one of these tests and we absorb the other. To date, we have carried out 25 such tests, the results of which have been quite encouraging. As recommended in the Standard, tests have been confined to multi-family dwellings, hotels, and offices.



BARRON & ASSOCIATES
NOISE SOURCE MODEL NS-2
BLOCK DIAGRAM

Project: 100 971

May, 1977

The tests are performed using a calibrated ANSI Type 1 sound level meter and the special noise source. The procedure is to measure the space averaged sound level in the source room and the receiving room using the source spectrum. The difference between these levels is the Privacy Index. To normalize this value to a standard room finish, the source is moved to the receiving room and near and far field measurements are made of the absorption spectrum.

Noise reduction measurements and reverberation decays are made with a precision meter and recorded onto tape. The sound measurements were subsequently analysed by TOBADS which provides a video display and hard copy printout of one third octave band levels. Noise Isolation Class (NIC) is calculated by computer.

The resultant decay recordings are analyzed by computer and peripherals which sample and display the measured decays. The system, which allows considerable operator interaction in evaluation of decay sections, calculates and prints decay times by means of a least squares fit to a video displayed segment selected by operator controlled pointers.

Calculations and Results

The recommended practice describes the method of calculation which may be summarized on Figure No. 1.

The results of the 25 tests are available in the form of a Privacy Index Field Data Sheet and a graph showing the measured one third octave band noise reductions and reference NIC curve. These results have been summarized on Figure No. 2.

Graph A illustrates the relationship of D to NIC. The recommended practice suggests that D "will usually be 1 to 2 dB less than the measured value of the Noise Isolation Class (NIC)". The mean difference of NIC-D for the 25 tests performed is 1.37 dB $\pm$ 2.1 dB for 90% confidence limits.

An attempt to correlate the difference of NIC-D and the amount of absorption (furnishings) of a room or some other common test factor has not yielded any significant conclusions. There appears to be a slight trend for rooms containing no furnishings (bare) to exhibit smaller differences of NIC-D. However, this trend may be attributable to other factors. Tests in rooms that contain moderate amounts of absorption appear to provide values of D that are consistently 1 to 2 dB less than NIC.

Tests were performed in two executive offices (Tests No. 8 and 9) furnished with only a heavy carpet. One room (the boardroom) also contained a large conference table. The rooms appeared lightly furnished (i.e. no soft furniture). However, due to the heavy carpet, a suspended acoustical ceiling, and large areas of glass, the absorption was approximately equal to the floor area, as determined by decay measurements. The L_N - L_F measurements were approximately 2 dB larger than the values for other tests where the floor area was approximately equal to the ab-

SUMMARY OF TEST RESULTS

Test No.	D_n	D	NIC	NIC-D	B'	T60 (sec.)	Furn. Code
1	38.0	37.0	39	2.0	8.2	0.51	C
2	48.1	47.3	50	2.7	7.2	0.40	F
3	53.5	50.7	50	-0.7	8.5	1.00	B
4	52.5	49.4	50	0.6	8.5	1.00	B
5	44.2	43.9	47	3.1	8.2	0.43	F
6	37.9	38.1	38	-0.1	8.8	0.44	F
7	40.3	38.9	40	1.1	7.9	0.49	C
8	39.1	41.1	43	1.9	12.0	0.55	F
9	32.4	35.5	36	0.5	12.0	0.45	F
10	47.0	44.5	48	3.5	7.0	0.55	C
11	46.5	42.8	45	2.2	8.5	0.78	C
12	47.8	44.3	46	1.7	8.7	0.77	C
13	46.8	43.5	44	2.5	7.0	0.75	C
14	48.5	44.5	46	1.5	7.3	0.85	B
15	46.9	43.0	44	1.0	9.5	1.30	B
16	47.4	41.5	42	0.5	8.6	1.75	B
17	50.0	43.5	43	-0.5	8.2	1.60	B
18	50.8	47.5	48	0.5	8.5	0.85	C
19	49.8	42.5	43	0.5	8.2	2.20	B
20	43.0	38.0	42	4.0	7.7	1.20	B
21	41.1	36.5	38	1.5	7.5	1.80	B
22	46.1	47.8	51	3.2	8.8	.36	F
23	46.2	47.2	48	0.8	9.7	.49	C
24	43.1	41.1	41	-0.1	6.3	.92	B
25	45.0	43.7	44	0.3	10.5	.91	B

Note - Furnishing Code:

F - Furnished; normal room absorption, carpets, beds, etc.
C - Carpet, light room absorption
B - Bare; low room absorption

Figure No. 1 Calculation Formulae

1. Check Background Noise: If $L_R - L_B \leq 10$ apply correction

2. Determine D; A-weighted Sound Level Difference (Privacy Index):

$$D = L_S - L_R$$

3. Determine Ar; Receiving Room Sound Absorption in Metric Sabins:

$$Ar = \text{Log}^{-1} \frac{L_N - L_F - B}{10}$$

4. Determine D_N = Normalized Sound Level Difference (Normalized Privacy Index):

$$D_N = D + 10 \log \frac{S_{fl}}{A_r}$$

Where S_{fl} = Floor area of the receiving room in m^2

Note: $D_N = D + 10 \log S_{fl} - (L_N - L_F - B)$

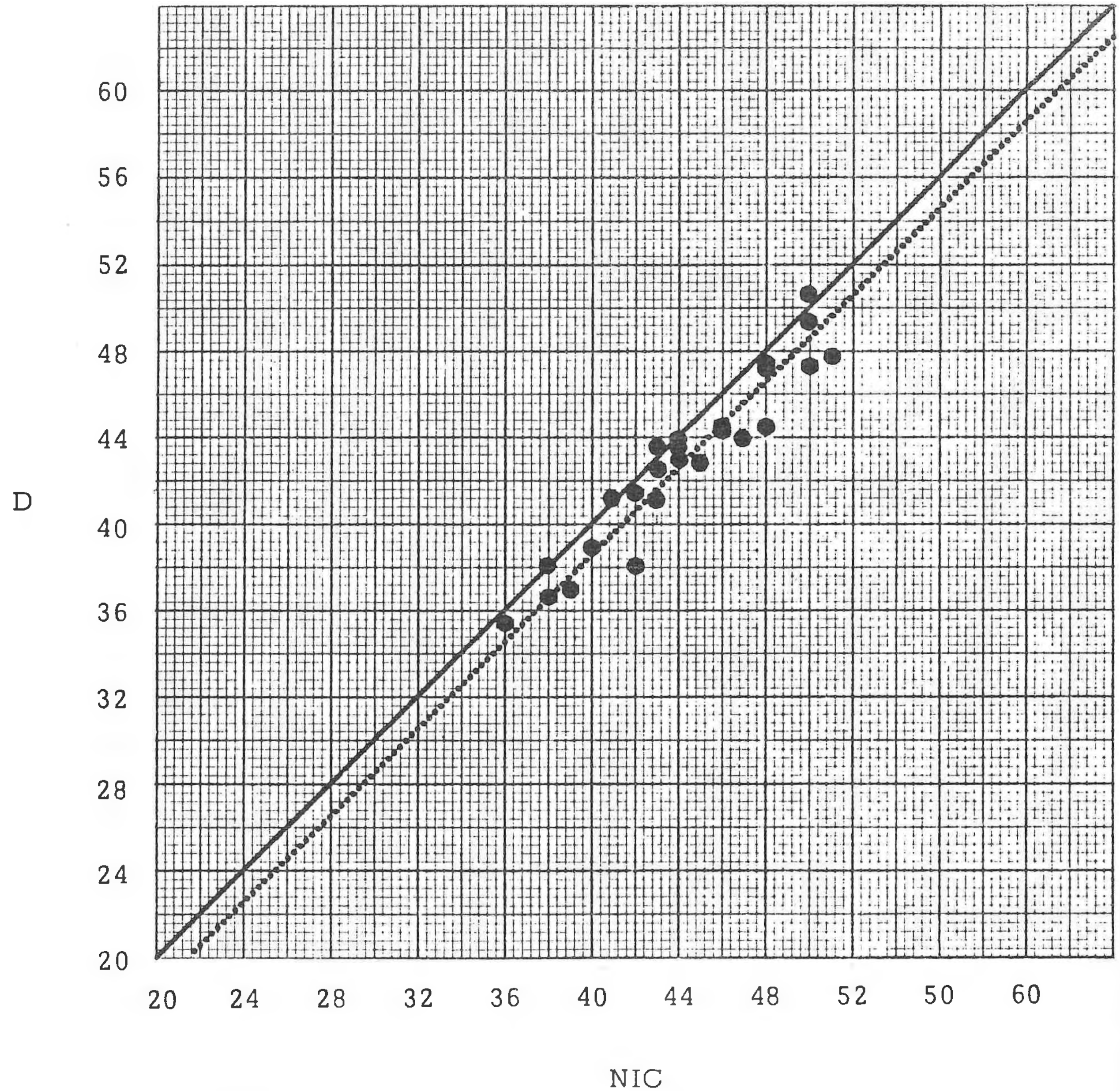
L_S = Source Room Level (Source Spectrum)

L_R = Receiving Room Level (Source Spectrum)

L_B = Receiving Room Background Level

L_N = Near Field Level (Absorption Spectrum)

L_F = Far Field Level (Absorption Spectrum)



LEGEND

Reference: D = NIC

D - NIC - 1.37

Measured Values

PROJECT DESCRIPTION

Privacy Index

GRAPH TITLE

Relationship of D to NIC

GRAPH NUMBER A

PROJECT NUMBER	DATE
100 971	October, 1977

sorption. The larger difference in L_N - L_F is supposed to indicate that room absorption exceeds the floor area and result in a D_N value less than D. Based on measured decay value, the larger value of L_N - L_F cannot be justified. The discrepancy may be due to an error discovered in the "Absorption Spectrum" shape of the prototype Noise Source and/or a function of the test room finish and shape.

Several tests in the series exhibited audible air-borne flanking of mid and high frequencies. Small amounts of high frequency flanking under particitions and at mullions were audible in several tests and showed on the noise reduction graphs for each, but did not affect the NIC rating or appear to affect the Privacy Index rating. Two of the rooms tested exhibited a flanking problem due to a resonance at Band 28 (630 Hz). Calculations were performed to estimate the effect of this flanking on D and NIC, and indicate that both values were reduced by approximately 3 to 4 dB due to the flanking. The audible effect of an unusual flanking problem of this nature may not be detected by untrained personnel and may lead to results which are not representative of final conditions. DNE test was severely flanked by cracks in a concrete block wall and gaps around joists. The NIC and D values for this test are both significantly reduced due to the flanking.

Tests 23 to 25 were carried out in rooms considerably larger than that recommended by the Standard. Although these do exhibit lower NIC-D differences they are within the 90% confidence limits. Further testing will be necessary to determine whether or not the restrictive room dimensions of the Standard (6m maximum dimension) are overly cautious.

Noise Source Calibration for Absorption

Calibration of the two prototype Noise Sources for determination of the "Standard Sound Source Calibration Constant B" was performed in a vacant carpeted room in the offices of Barron & Associates.

Measurements conforming to Section 9 of the standard were performed for each Noise Source at two locations in the room, providing the results tabulated in Figure No. 3.

The results of the measurements indicated a 1 dB lower L_{Nc} - L_{Fc} value for each Noise Source when directed toward the flat window wall rather than the hallway opening/closet end of the room. This effect, although small, is attributed to the open hallway entrance and should be considered when calibrating or testing in the field under similar circumstances. Decay times were consistent for all cases.

Calculation of "B" was based on the average values of L_{Nc} - L_{Fc} and the formulas shown on Figure No. 3.

A calculation of B values for other rooms was performed for comparison. The values are tabulated on the "Summary of Test Results",

CALIBRATION RESULTS AND FORMULAE

Noise Source	Location	$L_{Nc} - L_{Fc}$	Decay Time (T_{60})
1	1	19.3	0.50
1	2	18.2	0.49
2	1	19.8	0.52
2	2	18.6	0.51
Average		19.0	0.51

$$B = L_{Nc} - L_{Fc} - 10 \log \frac{Ac}{Ao} = 8.2 \text{ dB}$$

where, $Ac = \frac{0.9210 \, Vd}{C}$

$V = 38 \text{ m}^3$
$C = 344 \text{ m/sec}$
$d = \text{rate pf decay} = \frac{60 \text{ dB}}{0.51 \text{ sec}}$

and, Ao = 1 metric sabin

Figure No. 3

Project: 100 971 October, 1977

Figure No. 1 and are labelled B'. With the exclusion of Tests No. 8, 9, 23, 24 and 25, the average of B' provided 8.2 dB with a Standard Deviation of .67 and a Variance of .45.

Again, with the exception of Tests No. 8, 9, 23, 24 and 25, comparison of the B' values with the associated room dimensions and finish details (Tables and Graphs No. 1 to 25), does not indicate any significant correlation. The small variations in B' are attributed to inaccuracies in meter scale readings and variables associated with field test conditions. Tests 23 to 25 indicate that source calibration should not be undertaken in rooms which exceed the recommended dimensions.

The foregoing implies that there is reasonable latitude in selection of calibration rooms subject to previously mentioned constraints of room dimensions, geometry and apparent light furnishing.

Summary and Conclusions

A series of tests conforming to ASTM E 597-77T "determining a single number rating of air-borne sound isolation in multi-unit building specifications" performed in conjunction with one-third oactave band noise reduction measurements graded for NIC has allowed a preliminary evaluation of this method. The test results indicate the non-normalized air-borne noise reductions correlate with NIC ratings as NIC-D = 1.37 (± 2.1 dB for 90% confidence). This result is considered to be satisfactory, given the possible bias of test results due to noise source development factors and field test conditions. It will be necessary to review a much larger population of tests to provide results which may reduce the uncertainty or point to other factors that require consideration in practice.

Experience provided by this series of tests indicates that training of operators, correct calibration of Noise Sources and thorough reporting of test detail will be required to produce reliable, meaningful results. Any shortcomings of the procedure in terms of pinpointing deficiencies must be considered with the advantages of:

1. Relatively Low Equipment Cost

2. Portability of Equipment

3. Minimum Testing Time

4. Simplicity of Procedures

The above factors make the method prescribed by ASTM E597-77T ideally suited for screening the air-borne noise isolation or "Privacy Index" of multi-unit structures by persons with reasonable levels of skill and training.

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3. Barron, K.E., & Rivard, M.T. - "Design, Development and Field Testing of a Stable Sound Source for Privacy Testing Between Dwelling Spaces According to ASTM Recommended Practice E 597-77T", Paper L1, 93rd Annual Meeting, ASA, June, 1977.

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5. Schultz, T.J. - "How Noise Creeps Past the Building Codes", Noise Control Engineering, NOCOA, Vol. 1, No. 1, Summer 1973. pp. 4-14.

Appendix

Note: Table No. 1 and Graph No. 1 have been included for explanation purposes. Requests for the full appendix containing graphs and tables No. 1 to 25 should be made to:

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PRIVACY INDEX - Testing to ASTM E 597-77T

Project: 100 971 Date: May 13/77 Engineer: GDH Page: 1

Title: Privacy Index - Barron & Associates

Location: Laundry Room (S) to Library (R)

Meter Calibration: + 4 dBA Source Calibration (B) = 8.2

Room Description	Source - (S)	Receiving - (R)
Length:	6.1 m	5.0 m
Width:	5.0 m	3.2 m
Height:	2.4 m	2.3 m
L x W:	30.5 m^2	16.4 $m^2 = S_{fl}$
Room Finish:	Cupboards, Concrete, Laundry	Carpet

(Note: Use other side for a sketch and additional notes)

Area of Common Partition: 9.9 m^2

Measurements — Position —

(dBA)		VU	1	2	3	Average
Source Spectrum	- Source Room	0	105.0	105.5	104.5	L_S = 105.0
	- Receiving Room	-	66.0	68.0	70.0	L_R = 68.0
Absorption Spectrum	- Near	0	91.0	-	-	L_N = 91.0
	- Far	-	71.0	72.0	72.0	L_F = 71.7
Background Noise	- Receiving Room	-	45.0	-	-	L_B = 45.0

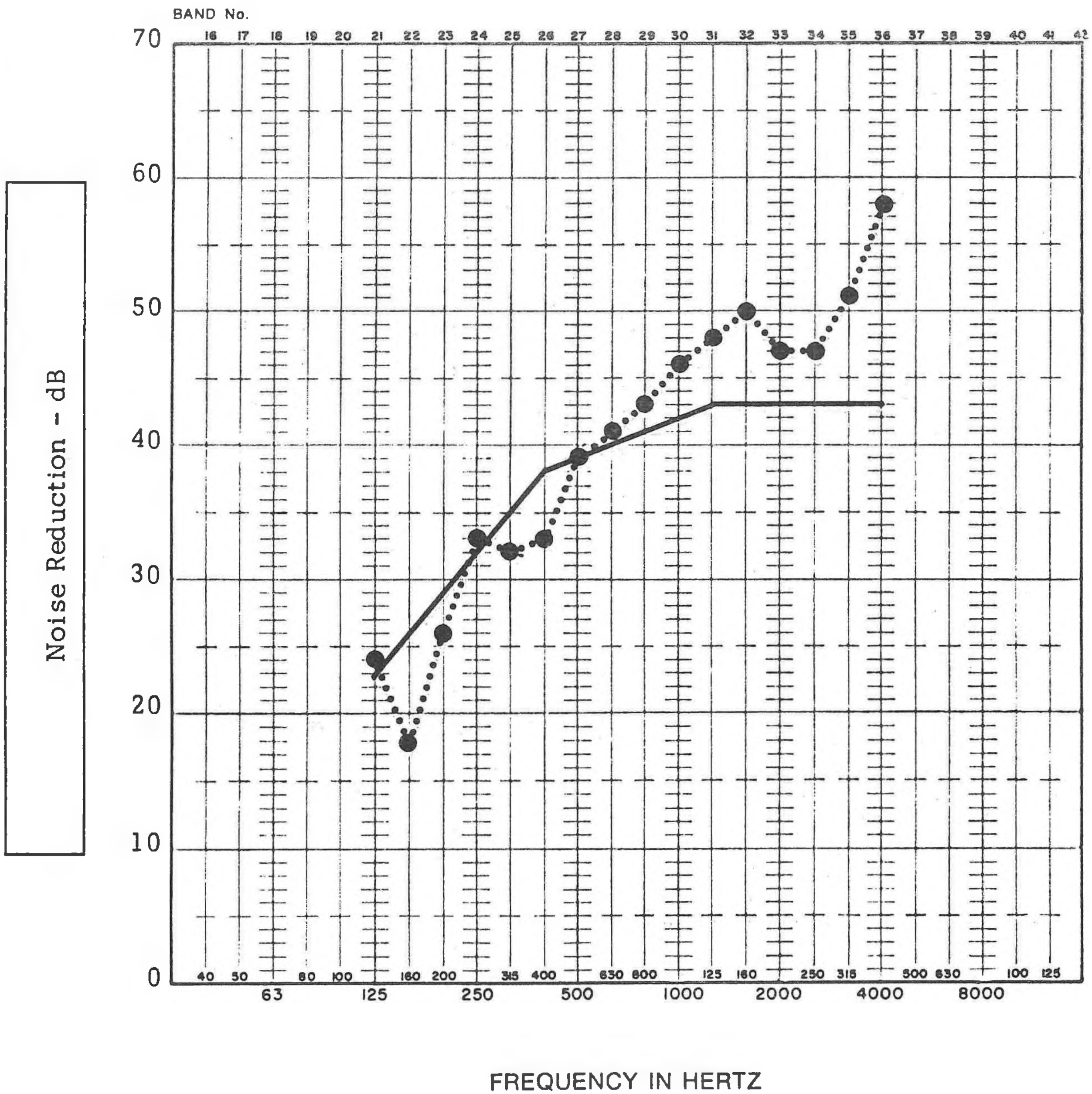
$$A_r = \text{Log}^{-1} \frac{(L_N - L_F - B)}{10} = 12.0$$

$$D = L_S - L_R = 37.0$$

$$D_N = D + 10 \text{ Log } \frac{S_{fl}}{A_r} = 38.0$$

Note: If $L_R - L_B \leq 10$ apply correction

Project: 100 971 Table No. 1 May, 1977.



LEGEND

Measured Noise Reduction

Standard NIC 39 Grading Curve

Note:

(1) (R) room - carpet

(2) Wood stud and G.W.B. construction

(3) Windows 1 m^2 approx.

PROJECT DESCRIPTION Privacy Index	
GRAPH TITLE Laundry Room (S) to Library (R)	
GRAPH NUMBER 1	
PROJECT NUMBER 100 971	DATE May, 1977.

ACOUSTICS AND NOISE CONTROL IN CANADA