Acoustics Australia

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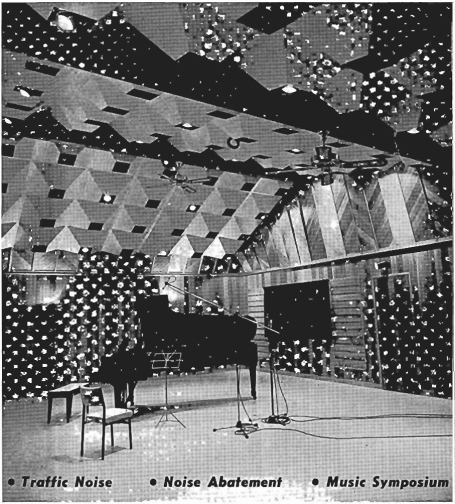

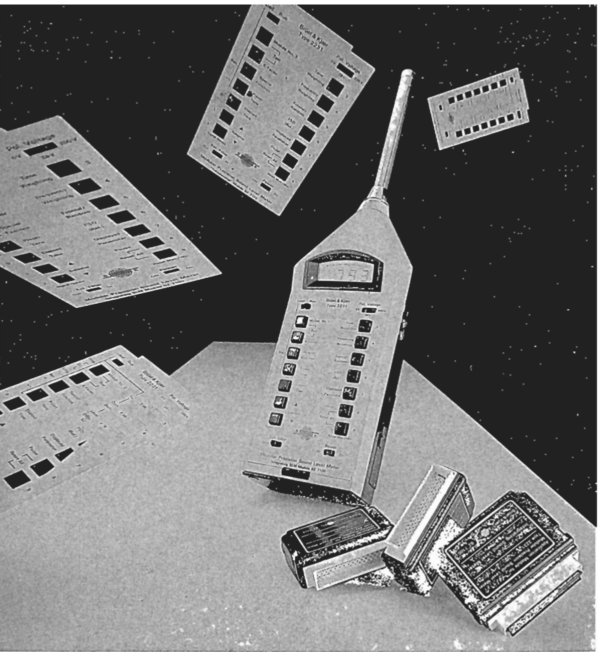

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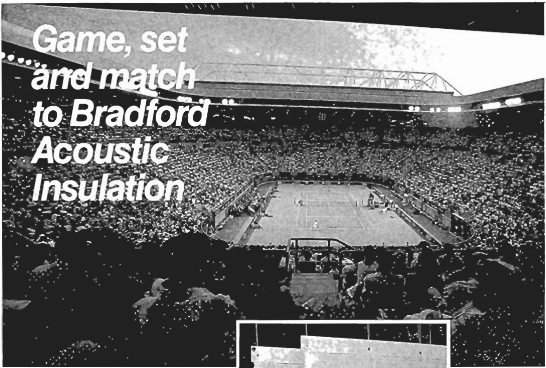

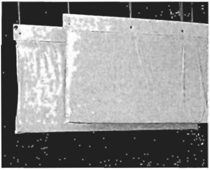

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NEWS

Council Reports

The 41st and 42nd meetings of Council were held at Victor Harbor, SA over the period 23 to 26 November under the chairmanship of the President Mr Bob Boyce.

Membership. Although 24 new members were admitted to the Society in the year since the last meetings of Council, the total membership dropped by 15. A large part of the decrease was due to a move to reduce the number of unfinancial members on the Registrar.

Finance. Council is budgeting to spend $25,070 this financial year. The increase in expenditure is mainly due to printing of the Directory of members and the Articles of Association. Although the budget also shows an increase in cost for publishing the journal "Acoustics Australia", this is not a real increase since expenditure last year was low due to a changeover from calender year to financial year financing. This year's activities will result in Council's expenditure exceeding its income by $3,230.

Society Logo. After some unsuccessful attempts in the past, Council has agreed upon a logo. The breakthrough was achieved by Stephen Samuels who arranged for creative artists to develop several concepts. The one Council decided upon is the shape of Australia, shaded with vertical lines to suggest a sound wave across it. Letterhead is being prepared for all Divisions and the Council executives. The possibility of producing ties and scarves for sale or presentations is being explored by WA and Victoria Divisions.

Directory of Members. A new edition of the Directory of the Society, last printed in 1986, will be issued in August/September this year at a cost of about $2000. Members are asked to keep Science Centre advised of any changes to their employment situation, address and telephone number.

Federation of Scientific and Technological Societies. Council decided to financially support the activities of FASTS at a cost of $3.50 per member. The decision was not unanimous as there was a view that the Society's membership was not benefitting members sufficiently. However, it was generally believed that FASTS was becoming an effective lobby group having some influence on the Government's science and technology policies. Some of the effects of their activities are now being seen in relation to the training of future scientists, restructuring of research and higher education and financial support for science and technology. Withdrawal of our support at this stage was thought to be undesirable.

Following a request from FASTS the Society has made a submission to the Committee to Review Higher Education Research Policy seeking financial support for a wide range of research in tertiary institutions and a reasonable emphasis on research in the humanities areas.

NAL Research on Noise. Council decided to make representations to the Ministers for Health and Community Services and the Arts, Sport, the Environment, Tourism and the Territories and the President of FASTS to try and reverse a decision to terminate some research being conducted by Dr Norman Carter at NAL on the non-auditory effects of noise.

1990 Society Conference. Victoria Division has agreed to host the 1990 conference.

President's Prize. Council agreed to award a prize, to be known as the President's Prize for the best paper submitted to the Society's annual conference. The prize will be a suitably inscribed medal in a presentation case. The award will be open to members only and papers of an academic/research nature and those of a practical/case study nature will be equally eligible. The award is expected to be presented for the first time at the conference in Perth in November 1989.

Ray Piesse,
Secretary.

ACT

February Technical Meeting

The February meeting of the ACT Group was held at the National Film and Sound Archive. The chairman for the evening, Graham Caldersmith, introduced the curator of the Sound and Radio Collection at the Archive, **Terry McGee.** After a short explanation of the history and activities of the National Film and Sound Archive, Terry demonstrated some antique/veteran recording machines using cylinders and discs from the collection. Terry explained the problems regarding cataloguing and preserving all the material in the archive. Most of the commercially produced sound material is quite stable but the recordings which were planned to be of a temporary nature requires the most attention. Many of these recordings are worth preserving because of their unique value in the history of Australia.

Terry then demonstrated the modern equipment which is used to transfer the signal from old and damaged discs to recording tape. Even very damaged recordings can be used to produce a tape with reasonable quality — this does take considerable expertise and time. Many questions followed the demonstrations and continued during the following dinner.

Marion Burgess.

VIC

End of Year

The end of year function was held at Bozzie's Seafood Restaurant in Mount Waverley. Following the success of a previous "Anecdotal Acoustics" night this theme was again followed. Members recounted their most memorable experiences in acoustics. The evening concluded with two presentations, Paul Dubout with his fellowship and Graeme Harding for his service to the Division.

Mike Snell.

WA

December Technical Meeting

A technical meeting was held on 8 December 1988 at CSR Building Products Division, Welshpool. The meeting featured inspections of the Gyprock plant and the Bradford Insulation plant. Of particular interest was the use of a large quantity of Bradford rockwool with perforated foil facing as an acoustic wall and ceiling lining in the Gyprock factory. The acoustic quality of this space was remarkable considering its size.

A delicious meal was laid on by CSR following the meeting, providing a fitting close to the year's activities. The members thanks go to **Barry Carson** and his staff at CSR Building Products for their hospitality.

John Macpherson.

WESTPAC

The history of the Western Pacific Commission on Acoustics dates back to the ICA Conference held in Sydney in 1980. Professor Ken'iti Kido, Japan, together with members of the Chinese and Australian Acoustical Societies, mooted the formation of an Acoustics Commission to promote research and development in acoustics in the Western Pacific Region. As a result, the first WESTPAC Conference was held in Singapore in 1982 followed by WESTPAC II in Hong Kong in 1985 and WESTPAC III in Shanghai in 1988. The WESTPAC series is held on a triennial basis and the Commission plans to hold its 1991 Conference in Brisbane.

The Commission was formalised as a standing organisation during the Shanghai Conference. Professor Kido was elected the first Chairman of the Commission in recognition of his initiative which led to its formal constitution. The following countries are represented on the Commission: Japan, China, Korea, Australia, Singapore, Hong Kong, India, and Indonesia.

Report — WESTPAC III

The third Western Pacific Conference on Acoustics (WESTPAC III) was held in Shanghai, China from 2-4 November 1988. It was attended by 298 delegates representing 14 countries. Being primarily a regional conference, the main representation was from China, Japan, Korea, Hong Kong, Indonesia and India. Approximately 280 papers covered many areas of acoustics, including Physical Acoustics (28), Ultrasonics 47), Underwater Acoustics (27), Architectural Acoustics (21), Noise and Vibration (53), Speech Communication (28), Transduction and Measurement(42) and Musical Acoustics, Bioacoustics and Psychological Acoustics (30).

During the Conference, technical visits were organised to the Institute of Acoustics, Tongji University and Shanghai Acoustics Laboratory, Academia Sinica.

The Institute of Acoustics is one of the earliest acoustic research and teaching institutes in China, being established in the 1950's. The main fields of research are ultrasonic detection, noise

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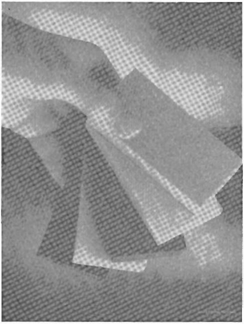

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control engineering, architectural acoustics, environmental acoustics and vibration and damping control. The facilities of the institute are quite impressive and include two reverberation chambers (268 m^2 and 95 m^2), an anechoic chamber (1200 m^2), a sound insulation test facility, a flow noise test facility and an anechoic water tank. It is also equipped with a microprocessing system for collection and analysis of acoustic signals. An Acoustic Test Centre at the institute is renowned for its work in audio — and ultra-sound.

The Shanghai Acoustics Laboratory was founded in 1960 and is a branch of the Institute of Acoustics, Academia Sinica. The laboratory has 157 staff members and encourages research towards M.Sc. and Ph.D. degrees. The facilities of the laboratory include an impressive set of instrumentation and laboratories, a 15,000 book library collection and a test centre for underwater acoustics. Research work centres around theories of underwater acoustics and signal detection, underwater acoustic expedition in both shallow and deep water and development of new types of sonars. Much attention is being paid to the application of acoustic techniques in the construction industry, and acoustic applications in ocean fishery, coastal oil exploration, marine geology and harbour survey work. The laboratory is also designing medical ultrasonic instrumentation, electro-acoustic equipment and ultrasonic equipment for energy saving.

Noela Eddington.

ASA — ASJ Meeting

The second joint meeting of the Acoustical Societies of America and of Japan was held at the Sheraton-Waikiki Hotel in Honolulu in November. One must be precise about the hotel, since there are five Sheraton hotels within two blocks of Waikiki Beach, and this was the newest and most splendid, with its own beach frontage, pool, tropical gardens, etc.

It was a massive meeting, with over 1600 participants and, at a guess, a quarter of them from Japan. There were more than 1000 papers in 72 sessions, each of three hours, in the four days, so that at any moment there was a choice of about eight papers to hear. Clearly one person's impressions cannot be anything but fragmentary, but let me try.

The balance of the papers presented was particularly interesting. Overwhelmingly the most popular field was speech and hearing, with about one-third of all contributions. Understandably these sessions were all held in the larger halls too, reflecting the balance of interest of those attending. Sessions ranged from basic studies of hair-cell transduction mechanisms through psychophysics of binaural localisation to speech-processing and hearing aids for the handicapped. Participants in these sessions seemed to be particularly enthusiastic in discussions.

The three other major areas of interest to participants, judging from the number of papers, were architectural, musical and underwater acoustics, each having about one-tenth of the total of contributions. The remaining third of the papers were distributed widely among fields not fitting this simple classification. The notable thing was, perhaps, the small number of papers concerned with noise problems — presumably the trend is for these now to be presented at Internoise.

There was little opportunity for non-conference activity — neither the Americans nor the Japanese believe in half-day breaks in the middle of meetings. The conference dinner was popular, though an hour-long presentation of authentic hula-dancing in missionary-imposed mu-mus instead of grass skirts lacked the impact the programme led one to expect!

It will presumably be another decade before the next joint ASA-ASJ meeting in Honolulu. For those of you who are still around then, I recommend the experience of attending.

Neville Fletcher.

Standards

AS 2763. This Standard deals with general methods for measuring and reporting hand-transmitted vibration exposure in three orthogonal axes for the one-third octave bands having centre frequency from 6.3 Hz to 12.50 Hz, for octave bands having centre frequency from 8 Hz to 1000 Hz, and for a frequency-weighted measure covering the frequency range from 5.6 Hz to 1400 Hz.

This new Standard provides guidance for the evaluation of hand-transmitted vibration specified in terms of a frequency-weighted acceleration and daily exposure time. It applies to periodic and to random or non-periodic vibration. Provisionally, this Standard may also be applied to repeated shock type excitation.

AS 1045. This is a revision of the 1971 edition of the Standard for measurement of sound absorption in a reverberation room. It reflects some of the innovations and new technique presented by the International Standard, and its purpose is to promote uniformity in the methods and conditions of measurement of sound absorption in reverberation rooms, so that values determined by different laboratories agree to the greatest extent possible.

FASTS

The Australian Acoustical Society is a member of the Federation of Australian Scientific and Technological Societies (FASTS). This Federation has about 70 member societies and the objectives are to foster close relations between scientific and technological societies in Australia and to take concerted action for promoting science and technology in Australia. FASTS has a Council which meets every two years, a Board which meets twice a year and an Executive which meets every 2-3 months. Dr David Widdup is the Executive Director for FASTS.

FASTS has been working with the Australian Association of Mathematics Teachers (AAMT) on a nationwide survey of mathematics teachers. The initial analysis of the results was released in January 1989 and there was considerable press coverage, including a page one item in the Melbourne "Herald".

Other activities of FASTS include meetings with the Committee to Review Higher Education Research Policy which will report to the Minister, John Dawkins, in April 1989. FASTS has also had media coverage for its comments on government policies for science and technology.

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Letters

Acoustics and the Organ

David Rumsey's rating scale for organs certainly seems to have the right sort of methodology for the aesthetic assessment of sound. In this, he has taken a course comparable with Leo Beranek (Music, Acoustics and Architecture, pp. 472, 473), who used rating scales for concert halls and opera houses.

Beranek found that the most important parameter for the auditorium is the "initial time delay gap". This was confirmed by A. H. Marshall (J. Sound Vib., 5(1) 100-112, 1967; Archs. Sci. Rev. 11(3) 81-87, 1968, and J. Sound Vib., 7, 116, 1968), although in terms of the shape of the auditorium. This probably corresponds with Rumsey's "Werkprinzip".

Further to David Rumsey's work on organs, and their buildings, there is a need for a more extensive analysis of

church acoustics along the lines of Beranek and Marshall. It would be necessary to seek the views of organists, choristers and clergy and subject their responses to multivariate statistical analysis.

Campbell Steele
10 February 1989

People

Geza Benke, formerly Senior Consultant at the Victorian Department of Labour, has now been appointed an Industrial Hygienist at Analabs Occupational Health Services, East Melbourne. Geza, who was involved in occupational noise and hearing conservation at the Department of Labour, will continue his work in these areas with Analabs.

* * *

Graeme Harding

Graeme has recently retired from the Victoria Division Committee after a continuous period of 27 years. This must be something of a record, particularly as he was an office-bearer during all that time. In addition, he was the Society's Registrar for many years, served as Vice-President for two spells, was responsible for our People column for several years and was President from 1985 to 1987. We wish him well for his future activities.

* * *

Brian Johnstone

It was with considerable pleasure that we note that Professor Brian Johnstone has been elected as a Fellow of the Australian Academy of Sciences. It is gratifying to know that he has received official recognition for his pioneering work in physiological acoustics at the University of Western Australia.

NEW MEMBERS

* Admissions

We have pleasure in welcoming the following who have been admitted to the grade of subscriber while awaiting grading by the Council Standing Committee on Membership.

New South Wales
Mrs J Ablamowicz-Potapowicz (ACT), Mr G B Douglas, Mr L J Elliott (NZ), Dr J L Goldberg, Mr D Lindsey, Mr B H Meldrum, Mr Pan Nan Hung, Dr S Thwaites.

Queensland
Mr R B Brennan.

Victoria
Mr P J Pearson.

* Graded

We welcome the following new members whose gradings have now been measurement range is 20 μm/s to

Subscriber

Western Australia
Mr G D Simpson, Mr R Sutherland.

Member

New South Wales
Ms S A Ridler, Mr D J Spearitt.

Victoria
Dr A S Szczepanik.

Western Australia
Mr A R Baker.

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National Exposure to Road Traffic Noise

A.L. Brown and D.I. Cliff
Australian Environmental Studies
Griffith University,
Nathan QLD 4111

ABSTRACT: Seven studies have been conducted in Australia to estimate the exposure of various metropolitan populations to noise from road traffic. The methodologies used in these studies is reviewed and found lacking to the extent that none has been able to estimate likely errors in the population exposures. Despite this the studies concur in that somewhere between 3% and 15% of the population in metropolitan areas is exposed to $L_{eq,24h}$ levels greater than 65 dBA. However there is little agreement at the lower exposure levels and the absence of error estimates means that these differences cannot be accepted at face value. The study methodologies used to estimate exposures of populations in the UK and France, based on rigorous sampling of the population of interest, provide a suitable model by which benchmark estimates of exposure in Australia can be obtained.

INTRODUCTION

While the National Noise Survey (Hede *et al*, 1987) confirms that some 27% of the Australian population perceive road traffic noise in their own homes as a major source of annoyance, and 17% indicate that road traffic is the noise they would most like to rid themselves of there is still no agreement as to how many Australians are exposed to noise from road traffic. This is somewhat surprising given that there have been more than two decades of work on road traffic noise in this country and policy decisions on the resources to be devoted to its control would best be based on knowledge of the extent and intensity of the problem.

A project is in progress at Griffith University to estimate the national exposure and this has provided the incentive to bring together the results of past Australian studies which have been specific to particular cities and based on a variety of methodologies. Assembling these studies is of considerable interest, particularly to those who would wish to use the results, but in doing so it has become clear that different assumptions and methodologies adopted by the studies make comparisons between them difficult, possibly spurious. This paper reviews the methodologies and assumptions used in the Australian studies and also looks briefly at those used in the UK and France.

AUSTRALIAN STUDIES

The results of seven Australian studies are plotted in Figure 1 and show, for each study, estimates of the percentage of the population exposed to any level of traffic noise or greater. Figure 1 shows both $L_{10,18h}$ and $L_{eq,24h}$ noise scales. Reduction of the different noise scales used in the studies to these common bases has used the transformation reported in Brown (1989). All levels refer to the exposure to the dwelling facade except for the Carr and Wilkinson study in which exposure of the property boundary has been estimated.

Sydney — Carr and Wilkinson

Carr and Wilkinson (1975) made separate estimates of the number of people in Sydney exposed along major roads and the number along minor roads. Some 5,500 kilometres of the 12,900 kilometres of roadway in Sydney were defined as major roads and the rest were defined as local roads.

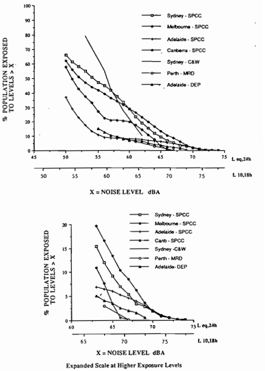

Figure 1
Estimates of the exposure of the populations of Australian cities to road traffic noise.

For the population living along major roads the Delaney model (Delaney, 1972) was used to predict noise levels at property boundaries. The source of traffic flow and mix data used in the model was not described but it is probable that it was the output of a traffic assignment model rather than actual counts (Urban Transport Study Group, 1974). Traffic speed was assumed to be uniform at 60 km/h. Noise levels at the second and subsequent rows of properties away from the roadway were also predicted assuming a screening effect of 5 dB for each row of housing. In this way, the areas of land adjacent to the major roadways and lying within successive 5 dB noise intervals could be calculated and these areas converted to the number of people exposed using 1971 population densities for Local Government Areas. Some 23% of the Sydney population were estimated to be exposed to noise from this strata of roadway.

The remaining 77% of the Sydney population were assumed to be in dwellings not exposed to noise from major roadways — that is, they lived on local roadways. The noise exposure of this group was obtained by measuring at a sample of local roadways but the sample size was 12 — quite inadequate for reliable estimates.

Noise exposure estimates from the two strata were combined. Calculations used the L_{10} scale but results were published in 5 dB bands of L_{dn} (no conversion specified).

Several weaknesses in the model include the small sample used to measure exposure for the second strata of roadways along which over three quarters (77%) of the population lived; the simple assumption concerning the propagation of noise through the rows of houses adjacent to the major roadways; the assumption of a uniform residential density along the major road networks equivalent to the average for the whole Local Government Area in which those roads were located; and the possibility that the categorization of roads into major or local may not necessarily have matched reality. It is not possible to assess if these would have led to an over or underestimate of exposure. The advantage of such a model are, of course, the minimal resources required because of the extensive use of existing data.

Sydney — SPCC

Stewart *et al* (1986) developed a more sophisticated model, again based on available traffic data. The starting point for the model was the compilation of a complete list of existing traffic counts available from roads throughout the city and the generation of a frequency distribution of these counts. The pivotal assumption is that this *distribution of traffic counts*, obtained at approximately 1500 sites, can be representative of the *distribution of traffic volumes* along the complete road network in the Sydney area. To increase the validity of this assumption, there were two further steps in the model. Firstly, as existing traffic counts are known to be biased towards the high volume roadways — there are many more counts done per kilometre of major roads than there are per kilometre of local streets — a sub-model had to be developed to estimate the traffic volume distribution on these local streets. Details are not yet published for this local street model. Secondly, as it is possible firstly to calculate vehicle kilometres travelled (VKT) from the traffic count distribution and secondly to compare this result to another estimate of VKT for the Sydney area based on Australian Bureau of Statistics data (ABS, 1982), a partial calibration of the traffic count distribution used in the model is possible. The model VKT was calculated by partitioning the frequency distribution of traffic counts into four categories of roadway (arterial, sub-arterials, collectors and local roads) and multiplying the traffic volumes in these categories by the estimated length of each category of road in Sydney. If this estimate of VKT did not agree with the Australian Bureau of Statistics estimate of VKT then the traffic count distribution was adjusted until it did. This adjustment procedure has not been described but presumably it relies primarily on adjusting the modelled counts for local streets.

With this adjusted distribution of road traffic counts assumed to be representative of road traffic volumes along all roadways in the Sydney area, calculation of noise level exposure was relatively straightforward. For each road traffic volume in the distribution, the DoE prediction model (UK DoE, 1975) was used to estimate the noise level at dwellings either adjacent to the road or one or two removed. Speed of traffic, traffic mix and distance to the dwelling were assumed to be constant within any of the four categories of roadway. The proportion of dwellings in Sydney with that particular noise exposure was simply the proportion of roadways with that traffic count. An average residential density was assumed across Sydney to convert estimates of dwelling exposure to population exposure.

The model calculated $L_{10,18h}$ for a typical weekday (based on AADT) but a constant 3 dB was substracted from the results of the calculations to estimate $L_{eq,24h}$. (In Figure 1 an additional 0.5 dB has been subtracted to conform with the 3.5 dB translation between these two scales adopted for scale convertions in this paper (Brown, 1989).

This model is an effective use of existing data but it must be appreciated that its prime purpose was to examine trends and to test the relative effectiveness of future noise control scenarios. Some details of the model are not yet published, but of the known assumptions several are potential sources of error. These include non-representativeness in the traffic count data caused by the absence of counts on some roads yet multiple counts available on others; oversimplification in using a single distance to dwelling facades within each road type, and an even distribution of population across the whole city. The latter may be a major source of bias as the model does not recognize whether a particular road segment has fronting residential or other land uses — nor are roadways through high density residential areas differentiated from roadways through low density residential areas. From the considerably more detailed data available on some of these parameters (e.g. the 1984 NAASRA National Roads Study) assumptions of uniformity appear unwarranted. Without more details on the working of the model it is not clear whether these assumptions have led to an underestimate or overestimate of exposure.

More recently, this model has been applied in Sweden (Stewart and Sandberg, 1987). In this latest application the authors have addressed, somewhat, the question of the representativeness of the traffic count distribution and have also modified the model to cater for variable setback of dwellings. The Swedish application was also different in that much more detailed input data were available: for example, 20 categories of roadway were defined instead of four in Sydney, and these categories were classified not only by traffic volume but also by speed and vehicle mix. As before, the purpose of the model was to predict the future effect of different noise control strategies, but the authors have more confidence that model outputs are reasonable estimates of population exposures.

Canberra, Melbourne and Adelaide — SPCC

The SPCC model, as applied to Sydney, has also been run recently for other Australian cities (pers comm, Stewart, A.C.). However, Stewart notes that the input data provided from these cities for the model could be refined further.

Perth — MRD (WA)

Limb (1987) reported the results of a study in the Perth metropolitan area. The study considered *only* those roads carrying more than 5000 vehicles per day and used available information on traffic composition, speed and road configuration for each section of roadway. The number of dwellings facing each section were estimated using drive-by counts but no details are provided of the estimation of set-back from the roadway. Based on this data, $L_{10,18h}$ noise levels were predicted at the facades of all dwellings fronting these roadways (UK DoE, 1975 and NAASRA correction (Saunders *et al*, 1983)). A uniform residential density was assumed across the city to convert exposure of dwellings to exposure of the population. The method does not, of course, provide estimates of the number of people exposed to lower levels of noise. The results are quite dependent on ensuring that roadways included in the study exhaustively include all "busy roadways". The method differentiates between residential and non-residential land uses along the roadway but does not consider dwellings which do not directly face a roadway but may still be affected by noise from it.

Adelaide — Department of Environment & Planning (SA)

A quite different method of estimating exposure was developed in Adelaide which can best be described as a systematic sampling of road sections. Separate studies were performed on major and minor roads (South Australia Department of Environment and Planning, 1988a and 1988b) which together make up the 8224 km of roadways in Adelaide.

For the major roads, a 3 kilometre grid was placed over the city and the nearest section of major road to each grid intersection was selected for the sample — a road section being defined as one with uniform traffic and geometric conditions along its length. For each road section, traffic flow and mix were obtained from existing records and dwelling setback was estimated from aerial photographs and averaged over the road section selected. The DoE model (UK DoE, 1975) and NAASRA correction (Saunders *et al* 1983) were then used to calculate $L_{10,18h}$ at the average facade setback of dwellings along every section of road and the number of people exposed to that level were estimated using average residential densities appropriate to that road section. The exposure of the sample was scaled up to the exposure of the population using the ratio of sample length of major roads to total length of major roads in Adelaide. A similar procedure was used for the population living along minor roads, but using a grid of 1 km square.

This procedure avoids the problem of bias in existing traffic count data and takes cognizance of the different land uses and residential densities along different roadways. These are important advantages but there are still two potential problems. Firstly, the method does not allow for the fact that the major noise exposure of a dwelling could be from other than the road immediately in front of the dwelling. Secondly, there is bias in the sample selected when a grid of uniform size is used. For example, in outer urban areas the density of major roadways is likely to be less than in inner urban areas and the systematic grid sampling may result in too high a proportion of outer road sections being selected at the expense of inner road sections. It is possible that both these factors have led to some underestimation of noise exposure.

DISCUSSION

The Australian Results

Figure 1 invites comparisons between the exposures in the different Australian cities, but as *none* of the studies has provided estimates of the magnitude of sampling and measurement errors, confident statements about apparent differences cannot be made. It is quite possible, for example, that the errors *within* any of the exposure estimates shown in Figure 1 could be greater than the differences *between* any of the exposure estimates. The untested assumptions on which some of the models are based, the known bias introduced by some of the assumptions (such as non-differentiation between residential and non-residential land uses fronting roadways) and sampling errors, are potential sources of error across the different studies.

However there is strength in numbers. The convergence of all the results at the higher levels does suggest that somewhere in the region of 3% to 15% of the population in Australian cities are subject to high exposures, say above an $L_{eq,24h}$ level of 65 dBA. However, this range would still be far too wide to use as a base for some policy decisions — a compensation or insulation scheme for dwellings for instance. There is also agreement that something less than 2% of the population are exposed to an $L_{eq,24h}$ of 70 dBA or more, though it should be noted that most of this agreement comes from the application of the same model to three different cities.

At the lower noise exposures there is not the same agreement. The proportion of the population exposed to $L_{eq,24h}$ levels greater than 55 dBA — the lower bound of the OECD defined "grey areas" (OECD, 1986) — ranges from 10% to 70% across the different estimates. One would like to be able to look to city size, traffic density and built form to explain why the populations in different cities appear to experience such different noise exposures (for example, does a strong road hierarchy such as Canberra's really mean less people are exposed to traffic noise, and does Melbourne's rectilinear street network result in more exposure than Sydney's topographically constrained radial network?). If these differences in exposure are real then there are important lessons for urban and transport planners. However, in the absence of any estimates of error variance it is not possible to be certain if these differences are real or model-specific. About the most that can be said is that, at a coarse level, the results are intuitively consistent, with Canberra and Adelaide exposures lower than Sydney and Melbourne, though the low estimates for Adelaide, relative to those for Canberra, are somewhat surprising.

Taken overall, the Australian estimates lie roughly among the lower half of the estimates made for fourteen OECD countries (OECD, 1986) though one suspects the quality of the latter data may have been highly variable. In addition, the OECD data purport to be *national* exposure estimates, that is the exposure of the population over both city and country areas whereas the Australian results are for metropolitan areas only.

Different Study Methodologies

Most of the study methodologies have used a traffic-count oriented approach, accessing the considerable amount of traffic data collected for traffic engineering purposes and already in existence in the records of state and local road authorities. As discussed above, using existing traffic data as the starting point introduces bias which may, or may not, effect the adequacy of estimates of exposure, but the fundamental problem is that the magnitude of errors cannot be gauged from the original data set. Without benchmark studies with known error variances with which the accuracy of the traffic-count oriented approaches can be validated, their results remain problematical. The Adelaide (DEP) and the Perth study methodologies do not suffer from these same weaknesses though other potential sources of error have been mentioned above.

There is an alternative to traffic-count oriented methodologies which is represented by studies in the UK and France. These have a completely different starting point which is to first obtain a rigorous sample of the population and then to predict or measure the noise exposure *for this sample*. The method requires almost no assumptions, beyond those involved in the procedure to predict or measure noise levels at the sampled locations and, most importantly, can provide estimates of the sampling errors of the noise exposure of the population. The drawback is that this approach to estimating national noise exposure requires very large measurement resources and deceptively difficult procedures for ensuring that the sample of the national population is random. The UK and French studies are briefly reviewed below as they provide suitable models for further work in Australia.

The UK and French Studies

The UK study was carried out in conjunction with a survey of the attitudes of 7200 people towards traffic and traffic noise (Sando and Batty, 1974). The multi-stage sampling scheme for the opinion survey was rigorous and the survey was designed to be representative of the adult population in England living in private households — but was clustered for efficiency. Noise measurements were reported by the Transport and Road Research Laboratory (Harland and Abbott, 1977) for 529 dwellings of the 7200 respondents in the opinion survey. While measurements were made at 529 dwellings, it was realized during analysis that only 271 of these could effectively be assumed to be independent (clustering for efficiency in the social survey resulted in inefficient dependence in the noise level survey) and it was on this subset that estimates of the exposure of the population were made.

The 1976 French survey (Maurin, 1984; Maurin *et al*, 1984), was also conducted in conjunction with an opinion survey concerning noise nuisance. It was similar to the UK survey in many respects and produced estimates for the exposure of the whole of the population of France. Similarities to the UK study included the rigorous approach to sampling from the national population and measurement of exposure at the building facades. The sampling frame used in France was the population of dwellings rather than the population of residents, and the physical measurement programme was restricted to urban areas with more than 5000 inhabitants (67% of the population of France). A supplementary procedure, based on models of traffic noise prediction and of the disposition of dwellings with respect to roadways in rural areas, was used to estimate the exposure of the remaining 33% of the French population. The survey was repeated in 1986/87 (Maurin *et al*, 1988) with noise measurements made at the most exposed facade of 375 dwellings and results from this recent survey are reported here.

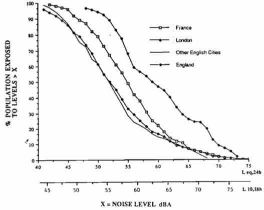

Figure 2

Estimates of the exposure of the population of England and France to road traffic noise.

Selected results of the UK and French studies are shown in Figure 2 (a correction of −4.5 dB has been applied to the French $L_{eq,0800h-2000h}$ to estimate $L_{eq,24h}$ — author's unpublished data). The estimates have measurable error variances based on known sampling and measurement errors and can be used as a firm base for comparisons and for policy decisions.

CONCLUSIONS

Current estimates of road traffic noise exposure in Australian cities need to be viewed with some caution and comparisons between different cities based on available data are unwise. This does not mean that the existing data is wrong, but that there are no estimates of the errors associated with present methodologies, nor benchmarks against which current data can be compared.

The rigorous sampling procedures used in the UK and the French studies provide suitable models for further work in Australia.

ACKNOWLEDGEMENT

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Comparison of STC Rating to dB(A) Reduction for Aircraft and Traffic Noise

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ABSTRACT: The sound transmission class (STC) rating for 104 different building elements has been compared to the dB(A) reduction offered against intruding aircraft and traffic noise. It is found, on average, that aircraft noise and traffic noise is attenuated by 4.6 and 6.0 dB(A) respectively, less than the numerical value of the appropriate STC rating.

1. INTRODUCTION

When the Australian Standard AS 2021-1977 (Code of Practice for Building Siting and Construction Against Aircraft Noise Intrusion) [1] was being drafted, it was determined that the dB(A) reduction of aircraft noise (when passing through a building element) was less than the value of the STC for the building element concerned. For the then existing blend of aircraft spectra (early model 727, DC9, ect.), the difference between the dB(A) reduction and the STC of the building element was between 4 and 6 db (p. Dubout, pers.comm., 1977).

Later, when the same Standard was being revised (eventually to be reissued as AS 2021-1985 [2]), the estimated difference between the dB(A) reduction and the STC value of building elements was redetermined. This was partly in recognition of the fact that the shape of aircraft spectra had changed with the next generation of aircraft (727, 747, A300, etc.), and partly as an attempt to improve the estimate of the difference between STC and the evaluated dB(A) reduction.

To achieve the calculation, a computer program was written which determined the dB(A) reduction achieved when known aircraft spectra were attenuated by 104 different building elements of known transmission loss (TL). The average difference between STC and the evaluated dB(A) reduction was determined as 4.6 dB.

The similarity of purpose between AS 2021 and Draft Standard DR 87252 [3] (Acoustics — Road Traffic Noise Intrusion — Building Siting and Construction) was obvious, and it was therefore natural to press the same computer program into service to determine for traffic noise what had previously been done for aircraft noise. To this end, the program was expanded to convolute the 104 building elements with a total of 17 different spectra; 6 were the original aircraft spectra, 1 was a 'flat' reference spectrum, and the remainder were traffic spectra from various sources. Of the 10 different traffic noise spectra, only 4 were eventually considered reliable enough to draw conclusion from; the average determined between the dB(A) reduction and the STC values was 6.0 dB.

2. THE SPECTRA

2.1 Aircraft Spectra

Analogue recordings of aircraft operations at Melbourne airport (Jan. 82) were gathered and provided by the Department of Transport. The recordings were analysed and representative spectra were obtained for 727, 747 and A300 landings and take offs. Table 1 summarises the number of events used.

TABLE 1
Summary of aircraft movement used to obtain representative spectra

Aircraft	Landings	Take offs
747	5	5
727	7	10
A300	2	3

The six aircraft noise spectra used are energy averages of the relevant contributing spectra. Each contributing spectrum was formed by averaging the (1/2 s) spectra existing during the central interval in which the aircraft was producing sound within 10 dB of its noisiest (1/2 s) level.

2.2 Traffic Spectra

The four traffic noise spectra which were employed in this paper originate from measurements made by the Royal Melbourne Institute of Technology (RMIT), the University of NSW, and this Division of CSIRO.

The RMIT traffic noise spectrum is the result of averaging five minutes of city traffic noise monitored at the intersection of Swanston and Latrobe Streets, Melbourne.

The Univeristy of NSW traffic noise spectrum is from measurements made one metre out from the facade of their Experimental Building. It is based on 'about 100, 5 min or 10 min samples', which is a total sampling time of between 500 and 1000 minutes, and as such represents a reliable sample of that site's traffic noise.

The Rohans Road and AAS Canberra data originate from measurements performed by the (then) CSIRO Division of Building Research (DBR). The Rohans Road spectrum is based on a 30-minute sample of traffic (1030 vehicles per hour) in the Melbourne suburb of Moorabbin. The AAS Canberra spectrum is based on a 60-minute sample of traffic outside the Australian Academy of Science, Canberra.

The six other traffic noise spectra processed by the computer program, but not eventually used, came from a NSW State Authority. Each of these six spectra was obtained from 10-minute recordings of traffic noise and analysed on a Bruel & Kjaer 2131 Digital Frequency Analyser using a 1 s averaging time. Unfortunately, the analysis was performed with the 2131 set on the 'MAX HOLD' setting which provides the upper envelope of the instantaneous sound levels rather than the average levels. A single noisy event during recording (such as a car horn operating, a squealing tyre, or even a whistling bird near the microphone) has the ability to completely modify the upper spectral envelope. Consequently the spectra were considered to be of limited value as representative traffic noise spectra and were therefore not used in the final analysis of results.

A graph of the mean aircraft spectrum (energy-averaged over 6 spectra) and the mean traffic noise spectrum (energy-averaged over 4 spectra) is given in Figure 1. Both spectra are unweighted and normalised to realise a 0 dB linear sum of band energy.

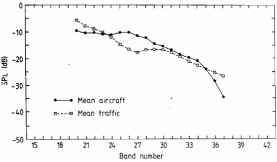

Figure 1
Normalised energy-averaged aircraft and traffic spectra.

3. THE BUILDING ELEMENTS

Of the 104 building elements considered, 95 are extracted from EBS Technical Study No. 48 [4]. Of the remaining 9 sets of TL data, 8 are of measurements made at DBR (6 roof structures, and 2 fixed single-glazed windows); the source of the single remaining TL data is unknown but it is understood to be of a clay-brick wall.

Averaging over the 104 building elements is intended to provide an estimate of the reduction offered by a 'typical' building shell. A summary of the building elements used in the analysis is given in Table 2.

TABLE 2
Summary of the 104 building elements used in analysis

Concrete masonry walls	17
Clay brick walls	16
Roofs	12
Windows (fixed double glazing)	29
Windows (fixed single glazing)	10
Windows (openable)	5
Doors	9
AC sheets	4
Concrete slab	1
Misc. wall	1
Total	104

4. METHOD

To determine the difference between the reduction in the A-weighted sound pressure level and the STC rating of each building element, the following steps were performed. Firstly, the indoor band levels were determined by subtracting the appropriate band values of the TL curve from the unweighted outdoor noise spectrum. This was performed for each 1/3 octave frequency band from 100 Hz to 5 kHz inclusive. These indoor and outdoor band values then had the relevant A-weighting values subtracted from them. and the resulting spectra were energy-summed to form the appropriate indoor and outdoor A-weighted levels. Finally, the difference between the reduction in the A-weighted sound pressure level and the STC rating of each building element (outdoor dB(A) — indoor dB(A) — STC) was evaluated and printed out on the final computer output sheet. For each spectrum, the mean (and standard deviation) of the values was determined across the 104 different building elements. The results for all those spectra used are summarised below.

5. RESULTS

The results obtained by running the computer program are given in Tables 3 and 4. The 'mean' column gives the average value (over the 104 building elements used) of the difference between the dB(A) reduction and the STC value. The 'overall average' represents averaging across the spectra and the building elements. The column headed 'Std dev.' indicates the standard deviation of values across the 104 building elements.

5.1 Aircraft Noise

It can be seen from Table 3 that the mean value of outdoor dB(A) — indoor dB(A) — STC, when averaged over a range of typical building components, is -4.6 dB. That is to say, aircraft noise is attenuated by about 5 db less than the numeric value of the STC rating.

TABLE 3
Mean and standard deviation of (outdoor dB(A) —indoor dB(A) — STC) for aircraft noise

Event	Mean (dB)	Std dev. (dB)
747 landing	−4.5	1.9
747 take off	−4.5	1.8
727 landing	−4.8	2.1
727 take off	−4.7	1.7
A300 landing	−3.9	1.7
A300 take off	−5.0	2.0
Overall average	−4.6	

5.2 Traffic Noise

Similar to the aircraft noise case, Table 4 shows that, on average, traffic noise is attenuated by about 6 dB less than the numeric value of the STC rating.

This present study also showed that the average dB(A) reduction achieved for a 'flat' spectrum is very close to the STC value; the average discrepancy (over the 104 building components tested) is only 0.4 dB. Indeed, it is possible that the 'zero' of the STC value scale may have been chosen with this in mind.

TABLE 4
Mean and standard deviation of (outdoor dB(A) —indoor dB(A) — STC) for traffic noise

Event	Mean (dB)	Std dev. (dB)
RMIT traffic	−5.6	2.4
Univ. NSW	−5.2	2.4
Rohans Road	−7.0	3.1
AAS Canberra	−6.1	3.4
Overall average	−6.0	

6. CONCLUSION

The convenience of using a single number index like STC to quantify how a building element performs, is self-obvious; the alternative requires 18 values (for the case of 1/3 octave TL spectrum from 100 Hz to 5kHz) to be known.

Unfortunately, the STC value does not indicate by how many decibels a particular noise spectrum will be reduced after passing through a building component. This study has determined the relationship between the STC of a component and the expected dB(A) reduction for the two most troublesome sources of noise annoyance — aircraft and traffic noise.

Both cases gave similar results. If the STC value is regarded as a 'decibel reduction' value, then for both aircraft and traffic noise the average result is overly optimistic by some 5 and 6 dB respectively. For example, given a wall with an STC value of 30, on average, one would expect aircraft noise to be attenuated by 25 dB(A), and traffic noise to be attenuated by 24 dB(A).

This present study has also shown that the average db(A) reduction achieved for a 'flat' spectrum is very close to the STC value of the particular building element concerned.

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(Received 18 October, 1988)

REPORT

Ron Craig Productions Recording Studios Colo Vale, New South Wales

The Studio, situated in the Southern Highlands, only 90 minutes from Sydney, was designed with the serious musician in mind, and consists of a large acoustically tuned room with as much ambience as possible. This allows instruments that require reverberation to be recorded with a natural sound. Additional reverberation can be added later, if necessary, but the natural ambience induces inspired performances, which is something that cannot be added later.

It is ideally suited for student pianists and other soloists who need audition tapes of high quality, as well as the professional, who may require edited masters for duplication or broadcast purposes.

Although the studio is located on a peaceful 2 acre block, substantial soundproofing has been built in. A separate tea and recreation area is also provided.

The studio's interior walls are constructed from ash hardwood panels, some of which are actually louvres that can be opened to expose broad-band absorbers. Apart from the wood's aesthetic appeal it makes a fine reflector of the higher frequencies. The ceiling is covered with a total of 84 pyramids, made from African Ash Brimsboard. Internally they act as absorbers via nine inch hole and fibreglass filling, externally, as diffusers.

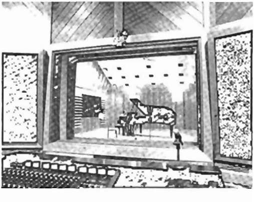
The floor (measuring 11.4 x 7.3 metres) was left as a hard surface, further enhancing the 'live' feeling for acoustic instruments (however, carpets and free-standing 'flats' are available to change the character of this surface if desired).

The studio's instrument list boasts a model D Steinway concert grand which has been used by many of the world's most famous artists. Other instruments include a double manual harpsichord, harmonium, Yamaha electronic organ and a restored player piano.

The Bergonzi Ensemble and The Song Company are among some of the people who have already used the studio and its facilities.

The Control Room is separated from the main studio by a thich wall and double glazed observation window. The 6½ cubic feet brick monitors are carefully positioned with precise spacing and horizontal and vertical angles. This precision results in an extremely good stereo imaging.

(Photography by Gordon Clarke)



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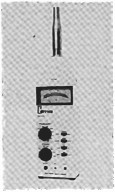

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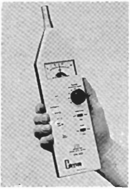

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Australian Noise Abatement Policies — Some Findings on Their Effectiveness

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ABSTRACT: Australia was selected as one of six case study countries for an OECD project on the effectiveness of noise abatement policies. The objectives for the case studies were to produce a detailed analysis of the policies for which a meaningful assessment could be obtained, to produce a synthesis at the national level across the various policies and to provide conclusions and recommendations. This paper includes some of the findings from the Australian report, in particular those relating to the various components of policy and the various policy instruments and their enforcement.

1.0 INTRODUCTION

Australia was one of six case study countries selected to participate in a project undertaken by the Organisation for Economic Co-operation and Development (OECD) on an Exchange of Information on Noise Abatement Policies. The other case study countries were Japan, France, the Netherlands, West Germany and Switzerland. A report on the Effectiveness of Noise Abatement Policies was prepared by a consultant appointed by the OECD for each of the study countries. These reports will form the basis for a synthesis report to be published by the OECD.

The objectives for each of the case studies were to produce a detailed analysis of the policies for which a meaningful assessment could be obtained, to produce a synthesis at the national level across the various policies and to provide conclusions and recommendations. It was not the intention of the project to undertake a fully comprehensive study of all policies on noise abatement; the emphasis was to be on those policies for which quantitative data was available.

For the Australian report, information was obtained from those government agencies which have some involvement with implementing and enforcing noise abatement policies. Information was also obtained from organisations and companies in the private sector which need to comply with the policies, in particular the noise labelling requirements. As the amount of quantitative assessment data for noise abatement policies in Australia was limited, it was necessary to utilise qualitative assessment data on the effectiveness of policies. Some of the findings which resulted from the Australian study are given in this paper.

2.0 BACKGROUND INFORMATION ON AUSTRALIA

The federation of the States of Australia was proclaimed on 1 January 1901 and there are three levels of government: Federal (or Commonwealth) Government, State Government and Local Government. With the exception of policies related to the control of aircraft noise, the control of environmental noise is implemented at the State and local council level. This structure, which effectively allows each individual State to adopt its own approach to noise control, has significant implications on the development and implementation of noise control policies in Australia.

As a predominantly urbanised society, with approximately 70% of the population living in the 13 major cities, the types of noise experienced by the majority of the population are similar to those experienced by the populations of cities and towns in other developed countries. A National Noise Survey undertaken in 1986 [1] involved interviews with 2,332 people throughout the country and found that noise was the most serious type of environmental pollution perceived by people in their homes. Overall, 40% reported disturbance to listening activities or to sleep because of some form of noise pollution. The study also showed that complaint statistics give a poor indication of community reaction to noise.

It has been estimated that 1.25 million Australians (approx. 8%) occupy residences exposed to an outdoor L_{eq} in excess of 65 dB(A), a further 6 million (approx. 38%) live in the "grey area" between 55 and 65 dB(A) [2]. About 8 million Australians (approx. 55%) live in what could be considered based on international guidelines [3], as an acceptable acoustic environment with regard to road traffic noise. With the future development of existing cities and towns, the noise exposure of the population is likely to increase unless effective noise abatement policies are implemented and enforced.

3.0 ENVIRONMENTAL NOISE CONTROL IN AUSTRALIA

In 1972, the Australian Environment Council (AEC) was established to provide a forum for consultation, co-operation and liasion between Federal, State and Territory Governments on matters concerning environmental management and pollution control. The members of the Council are the Federal, State and Territory Ministers with responsibilities for environmental matters. The Council is advised by a Standing Committee of senior officials. The committee structure is shown in Appendix A, Part 1. In the area of noise controls for motor vehicles there is considerable co-ordination and communication between the AEC and the Australian Transport Advisory Council (ATAC); see Appendix A, Part 2.

There had been some statutes in the States and Territories to control environmental noise under a variety of different Acts, but it was not until the 1970s that comprehensive noise legislation was independently introduced by each of the six

States [4] and 1988 for the ACT. Since the introduction of comprehensive noise legislation a number of regulations have been introduced under the various principal Acts and in most cases the Acts themselves have been amended. While there are significant differences between the noise control Acts of the various States, successive amendments have indicated a trend towards a common approach.

In most States there are central agencies with the overall responsibility for the development, implementation and enforcement of noise control legislation. In recent years local government and the police have been given an increasing responsibility for resolving local problems, with the central State agency providing co-ordination and specialist advice. In addition to the central State agencies there are other State Departments which have some responsibility for noise policies (the names of these Departments vary from State to State).

Most of the States have introduced control measures to deal with specific types of noise in addition to the broader based policies. The total number of identifiable noise control measures is as high as 45 for one State. In the other States, measures to deal with individual noise sources are applied in accordance with the broader based legislation. A number of different policy approaches may be used for the control measures associated with any one noise problem; for example noise emission limits, limits to hours of operation and restrictions on areas of use, can all be applied to control noise from specific items. The policy approaches for different noises differ between the States. While the AEC produces Technical Bases (essentially models for legislation) which are designed to provide for uniform legislation, these are not mandatory. It is the decision of each State that determines which, and which type of, policies will be adopted and included in legislation.

4.0 VARIOUS COMPONENTS OF POLICY

When the central State agencies were established in the early 1970s, industrial noise was seen to be an area where complaints could be resolved following the introduction of noise abatement policies. Even though the total number of persons affected by noise from industry is less than for other noise sources (1), it is considered that the effects of such noise can be quite severe and a major proportion of the resources of the central State agencies responsible for noise abatement has been, and is still being, devoted to the control of industrial noise. However, some noise abatement policies are targeted towards two other areas: domestic noise and transportation noise. These three main areas will be dealt with separately in this section.

4.1 Noise from Industry

The ability to control the noise output from industrial and commercial premises is a major component of the noise control legislation in each of the States and can be considered as a major achievement. The enforcement of this legislation is essentially the responsibility of the central State agency. For smaller premises, more responsibility is being given to local councils.

Most central State agencies have involvement at the planning stage for new premises and when alterations are proposed to existing major premises. This is usually in the form of assessment of an environmental impact statement, or similar document seeking development approval, and/or the issuing of some form of licence. Noise emission limits and other controls, such as limits to hours of operation, are established and are based on noise levels related to the surrounding land use areas or on measured/estimated background noise levels. When a problem arises with existing minor premises, notices, or similar instruments, can be issued; these can require an improvement in the environmental noise levels.

In the legislation there are allowances for exemptions from the provisions of the Acts. These are generally applied where inappropriate planning or uncontrolled development has taken place and where, even the "best practicable means" have been applied, the desired levels cannot be achieved. This is an acknowledgment of the possible prohibitive costs of controlling the noise emission from some premises. Consideration is also given to the public worth of the complex in terms of economic advantages to the community and to the country as a whole. There is not a high number of cases where these exemptions are applied. Although such exemptions allow a means of escape from some of the provisions of an Act, in many cases the conditions of the exemption require the introduction of a programme for modifications over an extended time period, ultimately leading to compliance with the relevant noise provisions of the Act.

4.2 Domestic and Recreational noise

The control measures in the various noise control Acts and regulations for the States are enforced by local council officers, police and/or officers of the central State agency. The increasing responsibilities given to local council officers and police mean that the implementation can be applied over a wide area of the State and more rapidly than would be the case if only the central State agency officers were involved.

For specific items, such as lawn mowers, air conditioners, etc., the control measures include maximum noise emission levels, noise labelling, limits to hours of operation and limits to areas of use. The latter two control measures have been found to be very effective as they do not require special measurements, are easy to enforce and are easily understood by the general public.

For behavioural noise, such as the "noisy party", there has been a general trend away from specified noise emission (or immission) limits to an assessment of audibility and "offensiveness" and an establishment of limits to hours. This means that it is easier both for the potential polluter to understand the control measures and for enforcement by police and local council officers.

For noise arising from recreational activities, such as entertainment venues, outdoor concerts, etc., various control measures in the form of noise emission limits, hours of operation, number of events per year, etc. can be applied. For other noisy form of recreation, such as shooting ranges, motor vehicle racing tracks, etc., similar control measures apply and special attention is paid to noise control at the development stages of new venues.

A major deficiency in this area relates to the noise from animals, in particular barking dogs, which have been shown to cause significant noise annoyance [1]. The ability of the authorities to issue notices or impose fines applied under a "Dog Control Act", noise abatement Act or local councils Ordinance, when the animal is found to be causing a public nuisance, has solved individual cases but has not overcome the problem as a whole.

There appears to be a lack of general public awareness of the potential noise problems which may result from the use of specific items of equipment. Product noise labelling and the associated education campaigns should overcome this deficiency.

Noise from mobile recreational activities, such as trail bike riding, has been difficult to control. The open areas used by the riders are often close to residential areas and frequently the offenders move before they are able to be apprehended by the appropriate authority.

While there is a co-ordinated strategy within each State to deal with domestic and recreational noise problems, there are great variations in the strategies adopted by the States. The variations relate to the types of noise which can be dealt with and to the methods of implementation and enforcement. The AEC has produced Technical Bases which endorse control measures for specific noise sources, eg noise labelling [5, 6]. These measures are not mandatory but may be adopted by each of the States if it so desires. If any of the States does adopt control measures for which there is an AEC endorsed method, then that method will usually be the measure chosen. Arising from the priorities and legislative procedures of each of the States, the time for the introduction of any control measure varies throughout the country. Such geographical variations are of disadvantage in providing uniform control of the noise from specific items. As the Australian market is comparatively small, uneven application of a policy such as noise labelling adversely affects both the manufacturer and the distributor of the products.

4.3 Transportation Noise

The control measures for motor vehicles are implemented and enforced through complementary actions at the Federal and State levels. The administration of the type approval certification is the responsibility of the Federal government and all States have adopted the requirements of the Australian Design Rules (ADRs), although such legal adoption has occurred at different times. The controls on in-service vehicles are the responsibility of the separate State departments for the environment or for transport. The police are also involved in the enforcement of the policies association with in-service motor vehicles.

There has been a reduction in the noise from individual vehicles following the impementation of controls for both new and in-service vehicles. Various policies regarding limits for road traffic noise in residential areas have been adopted at the State level and these have led to design guidelines for new and altered road systems, the construction of acoustic barriers and (in a limited number of instances) improved design and increased insulation of residential dwellings. The individual noisy vehicle still leads to annoyance from road traffic noise even though there has been considerable effort to control maximum noise levels.

The ADRs, which are endorsed by AEC and ATAC, specify the noise emission limits for new vehicles. In order for this endorsement to be gained, agreement must be obtained from the members of the appropriate committees (see Appendix A) which comprise membership from various State and Federal agencies. The ACVEN noise sub-committee also has representatives from the automotive industry. The need for agreement among all these different bodies introduces delays in the introduction of ADRs containing lower noise emission limits. Once the ADRs have been endorsed, the need for each State to adopt them separately means that they are not introduced simultaneously because of the delays associated with the various parliamentary procedures. When one of the more populous States introduces the appropriate legislation for the most recent ADRs, which to date have involved reductions in the noise emission limits, new vehicles must satisfy these requirements before they can be registered in that State. Hence the requirements of the most recent ADRs have "de-facto" implementation in all the States once they have been adopted in one State. There is always the possibility that any one State may introduce requirements which differ from those throughout the rest of the country; however, this has not yet occurred.

In-service testing of motor vehicles is not enforced in all States. Even in those States where it is enforced, there is a variation in the level of enforcement between the country and the metropolitan areas where officers are more likely to "spot" noisy vehicles. The emphasis for in-service testing of either noisy heavy vehicles or cars with modified/faulty mufflers varies from State to State.

For bulk road traffic noise, the design criteria for roads are not mandatory and hence their application is uneven both within and between States. In addition, there is still disagreement about the design criteria between the environment, planning and transport agencies within some of the States.

With respect to aircraft noise, there has been a reduction in the number of people affected as a result of noise certification of aircraft, application of flight path restrictions and curfews and planning controls. There has been a lag between the introduction of new aircraft (for example airships, and helicopters) and the legislative and enforcement means to deal with them. Special leniency has been exercised in the controls of noise from certain older models of aircraft, which continue to operate. Planning controls, such as restrictions on the location of houses with respect to airfields and specifications for the type of insulation required, are not mandatory and can be waived by the appropriate authority. The implementation of aircraft noise controls, with the exception of planning controls, is essentially the responsibility of the Federal government and applies throughout the country. This contrasts with the situation for motor vehicles where the possibility exists for some States to depart from conformity with the ADRs for new vehicle certification

5.0 VARIOUS POLICY INSTRUMENTS

Instruments used regularly include the following:

* noise notices and licences
* control of activities by limits to hours of operation, areas of operation, etc
* noise limits on specific items by type approval
* in-service testing of motor vehicles
* noise labelling

Permits and licences are used widely for industrial noise control and appear to be very effective. They are applied at the planning stage, allow for flexibility and can be tailored to particular situations. A clear statement of the requirements means that they are understood by both the potential polluter and the body responsible for enforcement.

Limits to hours of operation are effective as they are easily understood by both the potential polluter and the complainant. They can be enforced without the need for measurements to be undertaken by skilled personnel.

Experience with noise limits on chain-saws has shown that the application of noise limits on specific items does not necessarily achieve the desired result. Any system for noise limits must take into consideration the realistic values which can be achieved. For a small market, as is the case with Australia, any local noise limits for imported items should not be more stringent than the limits imposed in other countries.

It is apparent that many of the policy instruments neet to be used in combination to be effective. For example:

* Substantial education campaigns, specifically targeted at certain groups, must be used in conjunction with noise labelling. Incentives, such as those which can be included in government tendering, and controls, such as limits to hours of operation and areas of use, can improve the effectiveness of noise labelling.
* Planning controls and requirements for permits and licences should also be used in combination.
* In-service controls should be used in conjunction with type approval controls; the levels and test procedures for both types of control should be in agreement.

Economic incentives are not regularly used in Australian noise abatement policies. Government procurement policies do include requirements for noise emission specifications for items but these are often not checked. Fines can be applied for non-compliance with noise control notices or licences but it is only rarely that such fines are imposed. Usually the problem is solved without resort to court action.

6.0 ENFORCEMENT OF NOISE POLICIES

The role that enforcement plays in noise control policies varies throughout the country as it depends on the approach of each central State agency. A common trend for all agencies is the emphasis placed on solving an existing, or potential, problem by negotiation or conciliation as a first step in the enforcement process.

Planning type controls, eg licences for new and existing industry, type approval testing and noise labelling, are enforced by the appropriate authority as part of normal procedures; that is they are not initiated by complaints.

The enforcement of other controls is usually as a result of complaints. The first action on receipt of the complaint involves negotiation with the alleged offender. If it is necessary to add weight to this negotiation stage a notice is issued (or some similar level of official action taken). It is only as a last resort that prosecution is implemented. In most States, the legislation for air and water quality control was introduced prior to that for noise abatement. It is considered that the publicity associated with the enforcement of these controls in a few key cases has meant that industry is more willing to comply with the requirements of noise legislation. The costs associated with, and time involvement of the agency officers in, legal cases often discourage such actions. For minor matters, such as in the case of noisy in-service vehicles, on-the-spot fines are considered to be a more efficient approach for enforcement than a legal summons requiring court action. In general it is considered more efficient to encourage the polluter to fix the problem rather than to resort to legal action.

Enforcement is considered to be an integral part of the policies but the level of enforcement depends on the manpower and financial support available at the time, the area of current emphasis of the agencies and the nature of complaints. In addition, the level of enforcement varies throughout each State. This results from the concentration of expertise, experience and equipment in the metropolitan areas; there is only a limited number of personnel in the remainder of the State. The greatest variation occurs for domestic noise where most of the enforcement is not carried out by specialist officers. The noise officer from the police or local government (who is usually also a health department inspector) may have competing priorities, of which noise will not usually be the highest. A simialr unevenness of approach applies where the police have the responsibility for enforcement.

The costs of development, implementation and enforcement of noise abatement policies are paid for from general revenue. There are no taxes or charges which are specifically reserved for environmental control. Fines and fees which are collected by the States and result from implementation and enforcement of noise abatement policies pass into general revenue accounts.

7.0 CONCULSIONS

There has been an increased awareness throughout Australia of most forms of pollution over the last decade. The establishment of central environmental agencies in the States has meant that members of the public have an organisation to which they can address their complaints. The work of the environmental agencies has also gone some way to encourage consideration of the issue of noise by other State agencies, eg planning, transport. The successes that most environmental agencies have achieved, with minimum recourse to legal enforcement, show that most noise polluters are willing to conform with the aims of the legislation. Even restrictions on activities in residential premises (as utilised in the limits to hours of operation for certain items) have been accepted generally throughout the community.

The introduction, in each State of Australia, of comprehensive noise legislation in the early 1970s, has been a major achievement in the area of noise abatement. While initially there were significant differences between the various noise control Acts, the successive amendments introduced by each of the States and the guidelines provided by the AEC have led to a trend towards a common approach. The activities of the AEC, and its establishment of communication links between officers of the various State agencies, have helped in this area. An important component of noise legislation is the control of noise from industry and, while the instruments in each State differ, their effect is comparable throughout the country. Over the last decade there has been a greater recognition of the importance of noise controls at the planning stage of developments.

The introduction of limits to the noise emission from specific items, such as aircraft, motor vehicles, lawn mowers, etc., has led to the availability of quieter items. It is difficult to establish clearly that this has been the result of Australian controls only and not partially due to the controls placed on the items in other countries. The noise controls for motor vehicles have been strengthened by the implementation of in-service checking.

In general, throughout Australia, there has been no clear identification of the goals for environmental noise control policies in terms of exposure of the population, targets for noise levels, etc. The actions of each of the agencies have been related primarily towards complaints. This has resulted in "scattered" policies with no specific co-ordination. This gap is now being addressed by some of the State agencies who are producing policy statements listing policy goals and the means of achieving those goals. A major weakness in noise control throughout the country is that, whilst there is a mechanism for the development of nationally uniform control policies (via the AEC), there is no guarantee that this uniformity will be maintained at the implementation stage.

There has been no real assessment of the effectiveness of noise control policies in terms of the noise reduction achieved for a proportion of the population at a specified cost. The scattered nature of the policies also makes such studies difficult to undertake. The changes that have occurred in policies have usually been introduced to streamline the administration.

There are specific noise sources which have been shown to cause great annoyance, such as barking dogs and trail bikes, but for which no effective control measures have been established.

In some of the States there is a trend towards a co-ordinated approach to pollution control as a whole. This will mean that there will be fewer specialist noise staff in the central State environmental agencies; most will be required to be skilled in all areas of pollution control. Financial restraints are being placed on the public sector which will lead to continuing reductions in resources and staff. There is also a general move towards de-regulation and self-regulation in relation to government policy. It is not clear what influences the combined effects of all these trends and changes will have on future noise policies.

On the positive side, the prospects for the future include the development of goals and targets for ambient noise levels and for the noise emissions from specific items. The general policy for greater harmonisation on noise limits agreed to on an international basis, such as OECD goals, ECE limits for motor vehicles, etc., means that these limits will be adopted in Australia within a much reduced time scale than is currently the case. There is also an increasing awareness of the importance of noise control measures at the planning stage of developments.

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9.0 ACKNOWLEDGEMENTS

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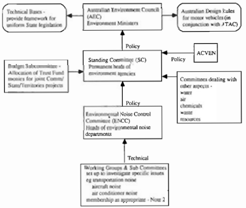
(Received 22 November 1988)

APPENDIX A

Committe structures, relevant to noise issues, associated with the Australian Environment Council (AEC) and the Australian Transport Advisory Council (ATAC).

Part 1 Structure associated with AEC

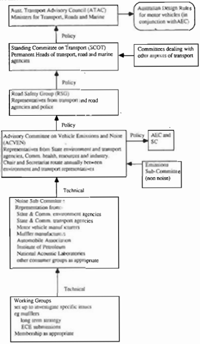


Note 1 All committees, except working groups and technical subcommittees, have representation from 6 States, 2 Territories and the Commonwealth. Papua New Guinea and New Zealand have observer status on AEC and SC.

Note 2 Example of membership of typical sub-committee such as Transportation Noise Sub Committee (TNSC):-
State Planning Agencies
State Environment Agencies
Australian Road Research Board
National Assoc. of Aust. State Road Authorities

Note 3 Secretariat for all AEC committees normally provided by the Commonwealth environmental agency.

Part 2 Structure associated with ATAC



Note 1 All committees, except working groups and technical subcommittees, have representation from 6 States, 2 Territories and the Commonwealth Government. New Zealand has observer status on ATAC.

Note 2 With the exception of ACVEN, the secretariat for ATAC committees is provided by the Commonwealth transport department.

Music — Its Effect on Hearing and Community Response

The following papers were presented at a symposium conducted by the Australian Acoustical Society on 21 September, 1988 at the National Acoustic Laboratories.

SUMMARY OF PAPERS

1. N.L. Carter: "The Effects of Rock Music on the Hearing of Audiences and Performers".

Concern that amplified music may be impairing the hearing of large numbers of young people goes back to the 1960's and continues to the present day. Data from four studies carried out in Sydney by the National Acoustic Laboratories spanning 12 years (1972-1984), and involving 1338 young people aged 10 to 32 have shown that this concern is misplaced. Overseas data on hearing in rock musicians indicate somewhat greater risk, but prevention of this source of hearing loss is largely up to the musicians themselves.

2. L. Wicks: "Practical Problems in Applying General Industrial Restrictions to the Music Industry".

The music industry has been described as a classic free market industry. The performers are mostly very young, with only about 5% staying in the industry for more than two years. The venues are mostly registered clubs, hotels or licenced restaurants, small businesses which depend to a large extent on the bands to attract and hold custom. For the patrons music is one of the two or three main leisure pursuits and they demand high sound levels in their music. On the whole the industry is a thriving and very successful one which has a strong export component. All of these things make the industry very sensitive to regulation but also make it very difficult to regulate in a sensible manner.

3. D. Woolford: "Hearing Loss in Orchestral Musicians. A Dilemma".

A number of orchestral musicians have been found to have hearing losses. Part of this hearing loss is believed to be due to the high sound pressure levels of much orchestral music. However, hearing damage risk criteria that have been developed for industry are not readily applicable to orchestral music because of its continuously varying and unpredictable sound spectra. It is suggested that more work be done to clarify the peak levels encountered in orchestras, the consequences, if any, of mild hearing losses for musical perception, and the administrative steps which may help to modify exposure to intense sound exposures in orchestras.

4. M. Foster: "Noise and Its Avoidance in Symphony Orchestras".

The techniques available to musicians in symphony orchestras to minimise their exposure to very loud sounds will be discussed.

5. M. Sherman: "Proposed N.S.W. Hearing Conservation Regulations and Their Implications For The Music Industry".

The Occupational Health and Safety Act No. 20 (NSW) has two clauses relevant to sound levels in the music industry (clauses 15 and 16). Clause 15 refers to the responsibility of employers to employees. Clause 16 refers to the self-employed person's responsibility not to carry out activities injurious to the public. It is proposed to promulgate regulations that set statutory requirements under this Act which will apply to the music, as well as others, industries, and which specify upper permissible limits of 85 L_{Aeq}, 8h, and 140 dBA (peak).

6. A.R.G. Hewett: "Amplified Music From Hotels and Clubs".

The Noise Control Act of 1975 charges the State Pollution Control Commission (SPCC) and local governments with the control of amplified music if it is likely to be harmful, offensive, or interfere unreasonably with "comfort or repose". The current practice of the State Pollution Control Commission with regard to amplified music from hotels and clubs, etc. is to take action via the Liquor Act. The Commission, the Liquor Administration Board and the Licensing Police have agreed that all complaints regarding amplified music be referred to the local licensing police for action with the Commission providing technical assistance by means of noise surveys and expert witness advice. The internal control advocated for protection of bar operators, waiters, etc. is set at 95 L_{Aeq}. There would seem to be some direct conflict between the proposed D.I.R. legislation and the Noise Control Act, 1975 as to which Act would take precedence.

Effects of Amplified Music on the Hearing of Listeners and Performers

N. L. Carter, National Acoustic Laboratories

Comparison of the sound pressure levels of amplified music with industrial Damage Risk Criteria (DRC) for hearing, studies of temporary hearing loss due to amplified music, and studies of cochlear damage in animals have been used to support the view that amplified music may be a serious threat to the hearing of large numbers of people.

However, industrial DRC assume that people are exposed to the 'noise' daily for many years, typically a working lifetime. They are also based predominantly on data on the effects of continuous, not intermittent noise, with an allowance for intermittency based on the equal energy rule. Studies of TTS, while they are helpful in some circumstances, have not been shown to be good quantitative indicators of risk of permanent noise induced hearing loss. Finally the results of the studies with animals (chinchillas) are difficult to interpret because their susceptibility to noise induced loss is greater than that of humans.

Some overseas studies attempted to assess the effects more directly, by measuring the 'resting' hearing thresholds of groups of young people and comparing the hearing of 'attenders' with that of 'non-attenders' of pop music events [1,2,3]. Such studies were limited, however by one or more of the following: a small number of subjects; inadequate otological screening for medical sources of hearing impairment; and inadequate history taking to exclude other types of noise or medical factors as causes of high tone hearing loss. These studies also restricted their attention to school or university students and consequently ignored those young people who were already in the workforce and therefore had more time and money to attend events featuring amplified music.

Three studies were carried out at NAL in the '70s and early '80s. The first study [4], carried out in 1976-77, examined 231 university students, 263 stage I and 257 stage III apprentices from 15 different trades, and 193 office workers under the age of 21. All were volunteers, but the acceptance rate was over 99%, so that there was little chance of bias due to self-selection of subjects on the basis of their hearing. Audiometry, ENT examination, tympanometry and very detailed medical and noise exposure histories were carried out. The main findings were: (a) There was a very wide range in the amount of attendance at pop music events; (b) Hearing levels were generally very good; (c) There was no association between hearing level and amount of attendance at pop music events.

These results contradicted the conventional wisdom of the time. Retrospective designs such as the one used here are the weakest designs, epidemiologically speaking, however. Also, the subjects were all under 21 at the time of testing, and it was considered possible that the effect of loud music on hearing may be cumulative, not becoming apparent in pure tone threshold tests until, say, age 30. A second, 'longitudinal' study and a third study, of older subjects, were carried out to test these ideas. The longitudinal study [5] used as baseline the hearing of 386 10-12 year old children tested in 1972-4 as part of a separate study, but which used identical methods. In 1980 these children, now aged 18-20, were sought out and those willing (141) were retested. Again no relationship was found between attendance at pop music events and hearing level, and there was no overall deterioration in hearing levels during the teenage period.

The third NAL study [6] examined the hearing of two groups of office workers: 117 aged 16-21 and 136 aged 28-33 years. This study indicated a slight decline in average acuity for the higher test frequencies with age but no effect of amplified music.

These results have convinced us that amplified music alone is not a threat to hearing comparable with many occupational noises. Nevertheless studies carried out with rock musicians as subjects indicate that here also there is a discrepancy between the putative 'noise' exposure and the degree of permanent hearing loss observed after a number of years [cf 7]. It was the present writer's view that there may be a saving factor or factors in addition to intermittency of the noise which could help to account for less effect on hearing occurring than expected. Lindgren and Axelsson [8] have since obtained data indicating that TTS due to music is less than that due to broad band noise with the same spectrum and energy level. They speculated that noise which induces some 'positive' subjective response may be less hazardous to hearing, because of some as yet unknown physiological mechanism. This may be so. On the other hand a study of TTS in soldiers due to noise from armoured personnel carriers also showed less TTS from these vehicles than was calculated on the band noise [9]. More precise measurements of the physical nature of broad band noise and music and their subjective significance would appear to be indicated.

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Background to the Noise Debate and the Contemporary Music Industry

L. Wicks, Industrial Officer
Musicians' Union of Australia

A recent study equates the music industry to the textile, clothing and footwear industry in terms of both employment and income generation. Overwhelmingly, activity centres on popular music. For many years it has been the invisible industry by virtue of its extremely scattered nature.

At present much of their activity is done in breach of regulations both current and proposed. The Union has long held that unenforced and unenforceable legislation does little good for any of the parties involved. I have sought to give some assessment of the nature of the key players as far as this can be done.

1. The "Average Musician"

- Most are young — mid twenties or younger.
- Turnover is high — probably less than 5% remain in the industry after two years.
- Breaks from performing (often long) are quite common for both individuals and bands.
- Half of one survey the Union conducted do music part-time.
- A key point to keep in mind is the motivation of musicians. Because of the high financial risks and turnovers most starters evidence an odd grab bag of reasons for starting ranging from "personal worth", ego, fun, "making an impact on society" and dreams of wild success. This is substantially at variance with employees in other industries.

2. Venues

Traditionally small business. Owner operators have considerable capital tied up in their business but entertainment is usually a subsidiary activity designed to counter the long term decline in hotel, nightclub or club patronage.

Leaseholders see a very high failure rate. Their motivations are often as complex as the musicians. Lack of resources is also common.

Most venues only operate entertainment on the weekends.

3. The Industry

- Extremely free market in its orientation.
- Despite its size extremely vulnerable. A significant decline in work opportunities is recently evidence due to several factors each supposedly small in impact.
- There is a growing maturity in industry operation but still in early stages.

4. Other Factors

Unlike other industries, noise is "product" not "by product". It competes for a young audience. Essentially they want to "rage" and demand volume. The very nature of the social event plus a number of technical restraints means a limit of 95 dBA (for example) is simply unattainable . . . ambient noise from the crowd often exceeds this.

5. Union Response

We are yet to be fully convinced that hearing loss is a major problem amongst our membership though we're by no means closed to the idea. As far as health risks to bar staff (mainly casuals and noting the weekend-only nature of venues) we believe the issue negligible. Ditto for audience.

Nonetheless, there is a commitment to the long term reduction in the volume levels. Bands averaging around 115 dBA can't be doing anyone any good.

The way forward needs to be a programme geared to the realities of our industry.

We don't want job losses. We don't want a scheme that is ridiculed or ignored by artists, venues and audiences alike.

Firstly the Union proposed co-ordinated discussions with industry groups and the three government departments charged with limiting noise levels. A general exemption from regulations for the entertainment industry is recommended in the short term. Further work should be done on what damage is done (if any) and an industry specific programme should be drawn up where public and bands can be educated and noise reduced starting with the loudest bands.

Further reading:

"Noise Legislation in New South Wales and the Entertainment Industry", Musicians' Union of Australia.

"The Australian Music Industry", Hans Guldberg, Australia Council.

Hearing Loss in Orchestral Musicians. A Dilemma

Donald H. Woolford
Australian Broadcasting Corporation, Sydney

This discussion is directed to opera and symphony orchestras and their musicians, but there is relevance for musicians who perform in other types of musical presentation.

Hearing Impairment Among Orchestral Musicians

The notion that orchestral musicians could have less than normal hearing is surprising to most. Perhaps many expect their hearing is better than normal!

Even though the orchestra has a long tradition, the term "orchestral musicians deafness", that is pursuant to music exposures, is unknown. Not so for "boiler makers" deafness or "industrial deafness".

But those audiologists and otologists who have examined the hearing of full orchestral complements know that hearing impairment from all causes can be present [1].

The Problem of Intense Sounds in Orchestras

1. The preliminary report of a sound level survey among major orchestras in the USA is presented in Senza Sordino [2]. Members from twenty-three orchestras were concerned about excessive sound levels on stage. Some players mentioned resultant nervousness, tension, anger, disturbed concentration, fatigue, tinnitus and the fear of hearing loss. The report also mentioned various methods used to reduce intense sound exposures.

2. A review of recent studies into hearing among orchestral musicians reported that some players sustain hearing changes presumed due to the music, but these losses are often slight.[3].

Hearing Conservation in Orchestras

The criteria for hearing conservation are often exceeded in orchestras [3], but noise doses are unpredictable and the working week is shorter than for industry. Also there is the hearing loss presumed due to the music, and the disturbance factor.

Whence a dilemma. Hearing conservation is directed to the preservation of hearing by the reduction of noise, unwanted sound, from say machinery. But the orchestra creates sound the listener chooses to hear and which the musicians must necessarily hear. Parts of the orchestral and opera repertoires demand intense sounds, but the application of hearing conservation appears an incongruity.

The basic tenet of hearing conservation is the control of sound at its source, which presents a paradox for the musician, in that it defeats the purpose of the orchestra [3].

A dilemma arises for the musician in deciding whether to use ear plugs when performing loud sounding music. He chooses between protection from possible hearing damage or psychological/physiological disturbance; and the hearing impediment introduced by the ear plugs.

For these reasons, perhaps a different name should be used to embrace the changes and adjustments necessary to modify or reduce intense sound exposures in orchestras. For example "repertoire factor" or "sound level management", interpreted to mean program planning, noise rating of compositions, scheduling of rehearsals and performances, and other methods such as the use of shields, risers, distancing and ear plugs. These techniques employ the second and third line methods for hearing conservation, viz. administrative and engineering "noise" control; and hearing protection. But the goals are different to those for industry, since the musician must hear the quality and relative intensities of the sounds. The modification of intensity should therefore be minimal, but sufficient to reduce disturbance and protect hearing as appropriate.

Regulation of Sound Levels

Guidelines for the regulation of sound levels in orchestras appear necessary and are consistent with nature of the orchestra, since the regulations for hearing conservation cannot be directly applied. The development of appropriate guidelines will be facilitated by the techniques at present used for the management of sound exposures in orchestras.

Conclusion

The presence of hearing loss among orchestral musicians due to various causes is established. Together with possible hearing loss presumed due to the music, and the disturbance factor, the hearing problem can present other dilemmas, both for individual musicians and for the orchestra in concert.

Resolution of the problem appears possible using a variety of solutions, some requiring further development, but the opera and symphony orchestra in their present forms will continue to offer a robust resilience to change.

REFERENCES

1. Jansson, E., Axelsson, A., Lindgren, F., Karlsson, J., & Olaussen, T. "Do musicians in the symphony orchestra become deaf?". A review of the investigations of musicians in Gothenburg and Stockholm. In S. Ternstroem (Ed.), Acoustics for choir and orchestra. Publication No. 52, Royal Swedish Academy of Music, 1986, 62-74.

2. "Senza Sordino" (1985). Official Publication of the International Conference of Symphony & Opera Musicians. Vol. 23 No. 5. June, 1-2.

3. Woolford, D. H., Carterette, E. C., & Morgan, D. M. (1988). "Hearing impairment among orchestral musicians". Music Perception, University of California Press, Vol. 5 No. 3, 261-284.

**Martin Foster, V-President of the Sydney Symphony Orchestra and a (20+ year) member of the SSO in probably the most noise-vulnerable position in the orchestra. He plays Contrabassoon which is positioned at the end of the bassoons. The larger scored compositions generally push this position into the centre of the blast area of the trumpets and trombones.*

Symphony Orchestra Noise, Sound Levels & Hearing Conservation

Martin Foster*

Preliminary Comments

Before turning to the material I have prepared for this address I would like to give some attention to points raised by the previous speakers. This is important as this seminar is a presentation of views which bear upon hearing conservation regulations being promulgated in NSW and which will have a significant bearing on the Commonwealth approach to the same problem in due course.

It appears to me that the previous addresses concentrated on historical aspects and suggested conclusions not dissimilar to those of the coal mining industry on the withdrawal of child labour at the turn of the century.

The first address was primarily statistical and indicated that at least amongst rock music fans the study could not reliably identify music induced deafness.

The second address was also largely statistical and concluded that rock music was an industry of itinerant musicians who would ignore any noise controls because the fans demanded the sound levels they had been getting. Faced with this demand rock musicians would ignore the regulations.

The third address came more to grips with the problems faced by the orchestral musician. Studies were quoted indicating that there was hearing loss amongst orchestral musicians but that these losses may well be attributable to other causes. Further, it was concluded, musicians can pursue their professions quite successfully with some degree of hearing loss and many deaf musicians were enjoying good and otherwise healthy retirement.

Most certainly the above are not views I share. I have been working in a vulnerable position in the SSO for over twenty years amounting to more than 5,200 symphony concerts and final rehearsals. Sound pressure levels regularly exceed 130 dB and I have employed whatever means available to me to keep my hearing (largely) intact. This involves shifting out of the brass blast area, selective use of ear plugs, perspex shields, fingers in ears or on occasion simply getting up and leaving the rehearsal studio.

Sources of the Problem for Today's Performer

Why is the problem greater now than previously? Well, of course the problem itself may not be new but it has not been helped by the historical progression of composition from the smaller more intimate scores of the earlier composers when compared with today's "new music". For example compare Hayden and Mozart with say, Mahler or more lately with Smetanin. (Smetanin's "Black Snow" was recently banned by the Melbourne Symphony Orchestra because of the unrelenting phalanx of sound produced by an enlarged orchestra producing the maximum sound levels possible for the duration of the composition.) Furthermore, brass instrument manufacturers have researched their subject very successfully and the modern brass instrument produces a very powerful and focussed sound. Today's brass player poses a substantially greater risk to those in front than previously and it requires sensitivity on the player's part to use the instruments to best advantage — not necessarily loudest advantage.

Performing venues and their stages are always a compromise. Compare the Sydney Opera House Concert Hall stage (which is walled in with wood panels two metres high) with the Sydney Town Hall stage (which has structured risers which put trumpet bells literally a hand span behind the ears of exposed players).

From an industrial standpoint impaired hearing in musicians costs cash compensation and this alone may create a demand for a regulated industry. However, even today there is an attitude that a musician embarking on a musical profession does so knowing the risks and is therefore personally liable for the dangers of the profession. Musicians who perform on brass or high noise-level instruments often share the prevalent management view of personal professional responsibility for hearing loss.

The personal ego of performers is out of all proportion given that one player's refusal to co-operate can frequently disrupt new seating arrangements and thus frustrate good "blast area" arrangements. Minor repositioning of musicians is often met with intransigence or a major ego problem which management is thus far reluctant to confront.

Are There Solutions to These Problems?

I firmly believe that solutions will not be implemented without the force of Statutory Regulation. There are solutions available which require a willingness from management and musician to co-operate in hearing conservation for exposed players.

In Sydney the rehearsal venue for the SSO is not the performance venue. A Mahler symphony may get up to five calls of rehearsal and normal format is morning and afternoon separated by an hour meal break. Calls, previously 3 hours, have just recently been reduced to 2.5 hours. To accommodate shorter available rehearsal time, sectional work may occupy two calls during the day with a combined evening call — no musician working over two calls in the day. This new roster format together with repertoire planning and regulation will minimise exposure. Chicago Symphony Orchestra is well advanced with repertoire planning based on known noise exposure levels.

Performances need to be tailored to the available acoustic space. Variations in the size of the stage of the performance venues causes difficulty with performances of large scores. If we take the Opera House Concert Hall stage as standard and relate the available area of other venues then it should be possible to make an elementary correlation with suitable works for performance. However, the Concert Hall stage is a dubious standard. It is well recognised that it is too small and there are plans in progress for its enlargement. It should be a question of fact as to whether the size of a performance stage precludes certain works.

Management flexibility and planning is necessary. With commitment and recognition of the seriousness of the problem there should be an end to the "take it or leave it approach" which has prevailed. Repertoire planning to limit the weekly sound dose is well advanced in the Chicago Orchestra. Furthermore it is Chicago Management policy not only that noise regulations are observed but that vulnerable musicians are "comfortable". Their philosophy is that the comfortable musician will give the best performance. Chicago Orchestra is "comfortable" amongst the top few in the world.

Education and awareness by musicians themselves is a prerequisite to a successful sound-level management programme. Only recently has there been *any* recognition by musicians at large that noise in the orchestral environment is dangerous. Those who have suffered hearing loss tend to minimise the problem publicly so as not to jeopardise their employment. The musician, after all, is the first to recognise the necessity of keeping his hearing intact. However, the conflicting pressures on the musician have made this problem a private one. Only in recently years has there been a realisation amongst musicians that they have a right to retain their hearing into retirement. For many this is still a novel concept.

A forceful conductor can be difficult to handle (with or without tact). Fortunately there are not, today, many who do not recognise noise as an industrial liability. Nevertheless, ego in the conductor and performing musician is a force to be reckoned with and must be handled by management with *conviction* so that musicians in high risk positions can be assured of a high level of co-operation and not stigmatisation arising from ego-driven perceptions.

There is a musician-initiated movement in orchestras of the US which monitors the various sound-level problems. The Executive Director of the Chicago Orchestra is the Chairman/Convenor of the national noise committees. We have an excellent chance to use information already researched. From the US studies it may be possible to determine a relationship linking the performance stage area to appropriate works.

With the adoption of hearing conservation regulations at the State level it appears it may only be a question of time before similar regulations are adopted in other states and in due course, federally. Additionally, even if areas of the music industry remain unregulated there is still an obligation in employment related Symphony Orchestras. This may be seen by some as contrasting with the self-employed Rock Band which, provided it protects its audience, can send itself deaf if it likes — not unlike the rights of consenting adults in private.

Conclusions

It may not yet be fully understood that without a high level of co-operation from within the industry, noise regulations will very substantially alter our expectation of the Symphony Orchestra performance. Indeed whilst not threatening the demise of orchestral playing, certain well-loved works may be heard less often in the concert hall.

Answers, in most cases not complicated, are already well known. It will take a commitment and willingness by management and musician alike to implement programming and procedures to reduce excessive noise exposure in the Symphony Orchestra.

The regulations as drafted may not be ideal. Nevertheless some form of statutory compulsion is required to implement hearing conservation in the Symphony Orchestra given the history of neglect of the problem and universal hostility to change.

Proposed N.S.W. Hearing Conservation Regulation

A. M. Sherman
Division of Occupational health
Lidcombe 2141

Introduction

This proposed regulation is intended to become part of the Occupational Health and Safety Act, 1983, subsequently superseding the following current hearing conservation regulations:

Factories Shops and Industries Act 1962

(i) "Factories (Health & Safety) Hearing Conservation Regulation 1979."

(ii) "Timber Industry (Health & Safety) Regulation 1982".

Construction Safety Act, 1912

"Construction Safety Regulations Part XIIc Subsections 157K to 157U, 1980".

However, because the mining (including coal mining and quarrying) industries are covered under separate acts, these industries are excluded from this proposed regulation.

This draft has been prepared by the Occupational Health, Safety and Rehabilitation Councils' sub-committee (Occupational Hearing Conservation and Vibration Committee). This committee comprises a balanced representation from both industry and union and a representative from the Department of Industrial Relations & Employment.

Overview of Draft

It is intended that this proposed regulation will embrace all types of industries and occupations (excluding mining industries). Thus employers involved with industries such as the waterfront, NSW coastal and local shipping, fishing, rural, transport, service industries, etc. would be bound by the statutory requirements of this draft.

In theory all factory, timber industries and construction sites should be familiar with the Damage Risk Criteria (D.R.C.) stimulated in the current legislation:

"no employee shall be exposed to

(1) a D.N.D. 1.0, i.e. an LAeq.8h 90 dB(A)

(2) an S.P.L. 115 dB(A) SLOW".

However, in this draft proposal the D.R.C. have been revised to

"no employee shall be exposed to:

(1) an LAeq.8h 85 dB(A)

or

(2) a Peak S.P.L. 140 dB PEAK".

If this proposed regulation comes into effect, all existing hearing conservation programs in factories, construction sites and timber industries would have to be revised in view of the new "action level", which commences wherever any employee's D.N.D. 0.32. This would involve the preparation of a noise reduction program with the ultimate objective of implementing engineered noise control for work processes that could result in an employee's LAeq.8h 85 dB(A). Also administrative procedures and hearing protection programs would have to be introduced for work places that exceed the proposed D.R.C.

Other legal ramifications under this draft that a future employer will have to be aware of are:

Noise Surveys

Noise surveys are to be conducted by authorised personnel known as *Authorised Noise Officers*. The names of those who are approved by the Co-ordinator of the Occupational Health, Safety & Rehabilitation Council will be recorded on an appropriate register.

Screening Audiometry

Where directed, screening audiometric tests are to be conducted by authorised personnel known as *Authorised Screening Audiometrists*. The names of those who are approved by the Co-ordinator of the Occupational Health, Safety & Rehabilitation Council will be recorded on an appropriate register.

Engineered Noise Control Measures

With any equipment fitted with noise control measures, the employer has an added responsibility to examine these measures every three months to ensure they are operating effectively.

Noise Level Labels

(a) Designers, suppliers, etc. to supply labels on machinery where the S.P.L. 85 dB(A).

(b) Employers to ensure these are both in place and visible.

Signs

Employers to provide conspicuous signs for:

(a) areas designated for the mandatory use of hearing protection, and

(b) portable tools and mobile plant to inform the operator of potential hearing hazard.

Hearing Protection Relief Period

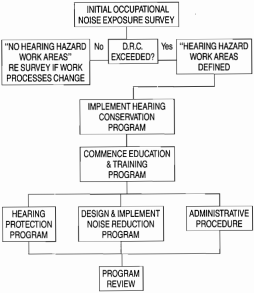
Where employees are required to wear hearing protection for more than 4 hours per day there is to be provision for rest (respite) areas with an ambient noise level to be less than 75 dB(A). This level has been chosen as constitutes minimal risk of hearing loss and low speech interference with vis-a-vis communication. However, for the sake of overall economics of deciding on the 75 dB(A) level, telephone communication has to be compromised, as a background ambient noise that is above 60 dB(A) in the presence of a telephone communication can often cause unacceptable speech interference.

Hearing Protection Selection

Selection of suitable hearing protection has been addressed by defining a maximum LAeq.8h of 80 dB(A) at ear canal entry that represents a low hearing risk and minimises risks associated with "over protection". Over protection, although this errs on the side of minimal risk of injury to employees' hearing, could however seriously impair their personal safety by denying them the ability to hear essential audible alarms.

Summary

The implementation of an effective hearing conservation program can be easily understood by the following flow chart.



Amplified Music from Hotels and Clubs

A. R. G. Hewitt
State Pollution Control Commission
Southern Sydney Region

Under the Noise Control Act, 1975, the SPCC and local governments are charged with the control of amplified music which if by reason of its level, nature, character or quality, or the time at which it is made, or any other circumstances, is likely to be harmful to, offensive to or to interfere unreasonably with the comfort or repose of a person who is, if the noise is made in premises that are a public place, within or outside of those premises.

Thus the Commission or local government may set control levels of times of use within the premises to control the noise as they affect for instance bar operators or patrons as well as setting controls or times of use external to the premises as they effect nearby residents. A public place would include dance hall, hotel, motel, licensed club, shopping centre, etc. The control vehicle would be a section 40 or 45 Noise Control Notice.

The current practice of the Commission, however, with regard to amplified music from hotel and clubs, etc. is to take action via the Liquor Act. The Commission, the Liquor Administration Board and the Licensing Police have agreed that all complaints regarding amplified music be referred to the local licensing police for action with the Commission providing technical assistance by means of noise surveys and expert witness advice.

The internal control level advocated for protection of bar operators, waiters, etc. is set at 95 dB(A) — Leq. at the operator position and has been endorsed on many liquor licences.

However, there would seem to be some direct conflict between the proposed D.I.R. legislation and the Noise Control Act, 1975 with regard to which Act would take precedence.

BOOK REVIEWS

TRAFFIC NOISE — A Bibliography of Surface Transportation Noise 1979-1986

C. Green (Editor)

Technical Communications, 100 High Avenue, Letchworth, Herts, UK, SG6 3RR. 1987, pp 211, soft covers.

A comparison volume to an earlier version covering the 1964-78 period, this Bibliography is a successful attempt to assemble a collection of collated references dealing with all aspects of surface transportation noise. Material has been obtained from books and monographs, from conference proceedings and from both papers and reports. Only selected references have been included, with the editor claiming in his introduction that no attempt was made to make the Bibliography comprehensive. The aim was rather one of broad coverage of a range of topics with the 700 abstracted references all being available from the British Library Document Supply Centre.

Topics covered are as follows:

Surface transportation noise in general,
Traffic noise,
Railway noise,
Vehicle design for noise reduction,
Highway design for noise reduction,
Urban planning and building design,
Social and economic impacts of traffic noise,
Traffic noise and health,
Surface transportation noise measurement and analysis,
Legislation,
Other bibliographies,
Surface transportation noise compared to aircraft noise.

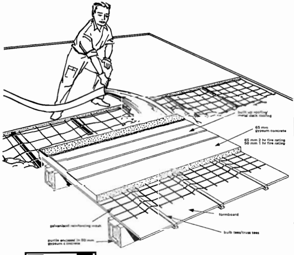
It is an interesting range which correctly reflects current concerns and technological developments. State Road Authorities, Environment Agencies, Planning Authorities, the Motor Industry, Academia and Research Institutes will all find the Bibliography of both interest and relevance. Apart from two Appendices which merely list relevant papers from the 85 and 86 Inter-Noise Conferences, all papers included in the Bibliography are accompanied by an abstract, the majority of which are clear and readable. In cases where an entire conference, book or monograph are cited, a brief summary is attached giving a broad overview of the topic coverage.

However, the Bibliography suffers from two notable drawbacks. Firstly, it is dominated by material originating from the UK and the USA. For example, of the 23 citations under 'Traffic Noise and its Abatement', eight originated from the USA, 11 from the UK, two from Europe, one from Australia and one from India. Throughout the Bibliography too few citations ensue from the important and technically active European centres. Indeed it is disappointing that the substantial and well documented achievements from Australia are also under-represented. Perhaps this reflects the reliance in several instances on compendia such as those published in the US Transportation Research Record and Society of Automotive Engineers series.

A second drawback is the incomplete coverage of the Bibliography. While entitled from 1979 to 1986, the majority of citations were published from 1979 to 1982, and only few inclusions in the latter period to 1986 are to be found (with the exception of the 1985 and 1986 Inter-Noise listings). Furthermore, some important references have been omitted. Notable exclusions are the proceedings of the 1979 International Tyre Noise Conference (Stockholm, Sweden) and of the 1985 Australian Acoustical Society Motor Vehicle and Traffic Noise Conference (Leura, Australia).

In summary, the Bibliography represents an interesting, relevant yet incomplete resource document that should adorn the shelves of all those with an active interest in the traffic and transportation noise fields.

Stephen Samuels.



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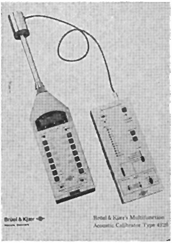

such as sound level meters, dose meters, etc.; and for checking filter sets and other frequency-dependent instruments.

The frequency response of microphones and instruments can be checked from 31,5 Hz to 16 kHz in octave steps with an extra tone at 12,5 kHz. The accuracy of the calibration level is ensured by a compressor loop driven by a reference microphone placed in the acoustic coupler. Three reference levels of 94 dB, 104 dB and 114 dB are available, plus a reference level of 94 dB inverse A. This makes checking A-weighted instruments particularly easy. The stability of the various test frequencies is guaranteed by a crystal oscillator. By inserting one of the built-in correction networks in the compressor loop, it is particularly easy to simulate a free field or a random field for the Bruel & Kjaer microphone under calibration and to obtain its free field or random response. If no correction is inserted, a pressure response is obtained.

Other functions enable the user to check the time-weighting characteristics (F and S) of measuring instruments, as well as their crest-factor-handling capability. The built-in timer accurately defines noise dose for the calibration of dose meters. To increase the versatility of the instrument an external generator can be connected. Continuous frequency sweeps with a constant level throughout the frequency range are then possible. An electric test signal, similar to the acoustic signal, is available to check instruments without acoustic input.

* * *

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(Class 2 instruments are safe for accidental momentary viewing.) It can measure vibration in the frequency range 0 Hz to 20 kHz. The velocity measurement range is 20 μm/s to 1 m/s. Displacement measurements are also available at the flick of a switch.

Further information: Bruel & Kjaer Aust., 24 Tepko Road, Terrey Hills, NSW 2084.

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Further information: Matrix Industries Pty. Ltd., 14/26 Wattle Road, Brookvale, 2100. Phone (02) 905 0644. Fax: (02) 905 0645.

Primers from Bruel & Kjaer

Human vibration, the study of the vibrations to which human beings are exposed, is important as some of these vibrations have a detrimental effect on people who are exposed to them for this reason we are interested in measuring, assessing and evaluating such vibrations. They are analysed to find out which measurement parameters can be used to quantify them.

Measuring Light is both a means of learning about photometry and a useful source of information on international standards. A list of suggested further reading appears at the end of the booklet. Although it is targeted mainly at readers with a limitited knowledge of photometry, the booklet also acts as useful revision material for those who already have a fairly broad knowledge of the subject.

Measurement Microphones introduces the design features and operating principles of measurement microphones and gives excellent explanations of technical jargon and specifications. It will be an invaluable source of reference for people responsible for selecting or purchasing these microphones.

Further information: Bruel & Kjaer, 24 Tepko Road, Terrey Hills, NSW 2084.

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Volume 19

Format: Author, issue, pages, title.

1989 AUSTRALIAN ACOUSTICAL SOCIETY CONFERENCE

DATE: 23 and 24 NOVEMBER, 1989

VENUE: COTTESLOE BEACH RESORT

THEME: INTERIOR NOISE CLIMATES

Interior noise climates are of interest to a wide range of acousticians as people spend much of their lives in man made spaces where the acoustic climate has significant effect on the benefits they gain from using that space:

- if music is their interest, the interior noise climate should enhance their listening and playing pleasure
- if communication is important, the interior noise climate should ensure this can be achieved with clarity and accuracy
- if travelling is the purpose, the interior noise climate of the vehicle should be as quiet and restful as possible
- if relaxation is the aim, the internal noise climate should provide a peaceful, quiet environment where intrusive noises are held to a minimum.

We are sure you will find an area of interest within this theme on which to base a paper. However, if you want to submit a paper on another topic this will be considered.

* * *

Cottesloe is about half way between Perth and Fremantle and is well served by buses and trains to and from these centres. It is one of Perth's favourite beaches and the Cottesloe Beach Resort is only fifty metres from the sand. Accommodation at this resort is varied. Conventional hotel rooms and chalets, which can provide full facilities including a kitchen for up to six people, are available.

Further information: Clive Paige, C/- BHP Engineering, 221 St. Georges Terrace, Perth 6000.

New Zealand Acoustics

The New Zealand Acoustical Society has announced the publication of New Zealand Acoustics, a new journal of the New Zealand Acoustical Society. The first issue was published in March 1988. The journal will be published quarterly, and will be sent to all members of the society. The new editor is Stuart Camp.

Further information: NZ Acoustical Society, P.O. Box 1181, Auckland, New Zealand.

ADVERTISER INDEX

Readers are asked to mention this publication when replying to advertisements.

FUTURE EVENTS —

● Indicates an Australian Conference

1989

May 22-26, SYRACUSE
MEETING OF ACOUSTICAL SOCIETY OF AMERICA
Details: Murray Strasberg, ASA, 500 Sunnyside Blvd., Woodbury, New York 11797, USA.

May 23-27, GDANSK
4th SPRING SCHOOL ON ACOUTO-OPTICS
Details: Prof. A. Sliwinski, Inst. of Experimental Physics, University Gdansk, Wita Stwosza 57, 80 952 Gdansk, Poland.

June 7-10, PECS
6th SEMINAR ON NOISE CONTROL
Details: Optical, Acoustical & Film-technical Soc., FO u. 68, H-1027, Budapest II, Hungary.

July 3-7, MADRID
ULTRASONICS INTERNATIONAL 1989
Details: Conference Organiser, Ultrasonics International 89, Butterworth Scientific Ltd, PO Box 63, Westbury House, Bury Street, Guildford, Surrey GU2 5BH, UK.

● August 8-10, SYDNEY
COMPUTING SYSTEMS AND INFORMATION TECHNOLOGY 1989
Details: Conference Manager, Institution of Engineers, 11 National Circuit, Barton, ACT 2600.

August 16-18, SINGAPORE
INTERNATIONAL CONFERENCE NOISE & VIBRATION 89
Details: The Secretariat, International Conference Noise & Vibration 89, c/- School of Mechanical & Production Engineering, Nanyang Technological Institute, Nanyang Ave., Singapore 2263.

August 19-22, MITTENWALD
INTERNATIONAL SYMPOSIUM ON MUSICAL ACOUSTICS
Details: Sekretariat des ISMA 1989, c/- Muller-BBM, Robert-Koch-Str 11, 8033 Planegg, W. Germany.

August 24-31, BELGRADE
13th ICA

SYMPOSIA

September 1-3, ZAGREB
Electroacoustics

September 4-6, DUBROVNIK
Sea Acoustics

Details: 13 ICA Secretariat, Sava Centre, 11070 Belgrade, Yugoslavia.

September 26-28, PARIS
EUROSPEECH 89
Details: D. Bovis, ESCA Secretary, EEC-DG XIII/ESPRIT, 25 Rue Archimede, Brussels, Belgium.

October 4-6, MONTREAL
IEEE/UFFCS
Ultrasonics Symposium.
Details: Allied-Signal Inc., Atten.: H. van de Vaart, PO Box 10221R, Morristown, NJ 07960, USA.

October 16-18, SICILY
INTERNATIONAL CONFERENCE ON MONITORING, SURVEILLANCE AND PREDICTIVE MAINTENANCE OF PLANTS AND STRUCTURE
Details: Italian Society for Nondestructive Testing, via Arnaldo Foresti No. 5, 25126 Brescia, Italy.

October 18-19, BARCELONA
II WORLD CONGRESS OF CHRONICAL RONCOPATHY
"Snore and OSAS Syndrome."
Details: Prof. E. Perello, Facultat de Medicina, Universitat Autonoma de Barcelona, Passeig de la Vall D'Hebron, S/N 08035 Barcelona, Spain.

November 14-16, ADELAIDE
● AUSTRALIAN INSTRUMENTATION AND MEASUREMENT CONFERENCE
Details: The Conference Manager, AIM 89, The Institution of Engineers, Australia, 11 National Circuit, Barton, ACT 2600.

November 15-17, BILBAO
INTERNATIONAL SESSIONS ON THE SINGING VOICE
Details: Dra Esther Cantera, Apartado de correos 1346, Bilbao, Spain.

November 23-24, PERTH
● 1989 AAS CONFERENCE
Interior Noise Climates.
Details: C. Paige, C/- BHP Engineering, 221 St. Georges Terrace, Perth 6001 Australia.

Nov 27-Dec 1, ST LOUIS
MEETING OF ACOUSTICAL SOCIETY OF AMERICA
Details: Murray Strasberg, ASA, 500 Sunnyside Blvd., Woodbury, New York 11797, USA.

December 4-6, NEWPORT BEACH
INTER-NOISE 89

ENGINEERING IN NOISE CONTROL
Details: Inter-noise 89, Inst. Noise Control Eng., PO Box 3206, Poughkeepsie, NY 12603, USA.

December 10-15, SAN FRANCISCO
INTERNATIONAL SYMPOSIUM ON NUMERICAL METHODS IN ACOUSTIC RADIATION
Details: Prof R J Bernhard, Ray W Herrick Labs, School of Mech Eng, Purdue University, West Lafayette, IN 47907.

December 11-12, RIO DE JANEIRO
3rd INTERNATIONAL SEMINAR ON NOISE CONTROL.
Details: Organising Committee, Laboratorio de Acustica e Vibracoes, Pem-Coppe/UFRJ, C.P. 68503, 21.945, Rio de Janeiro, Brazil.

1990

May 21-25, PENNSYLVANIA
MEETING OF ACOUSTICAL SOCIETY OF AMERICA
Details: Murray Strasberg, ASA, 500 Sunnyside Blvd., Woodbury, New York 11797, USA.

June 6-8, BRIGHTON (UK)
16th CONGRESS OF A ICB
The Future for Noise Control — towards an interdisciplinary approach.
Details: Dr. iur. Willy Aecherli, Rechtsanwalt Hirschenplatz 7, CH-6004, Luzern.

August 8-10, GOTHENBURG
INTERNATIONAL TIRE/ROAD NOISE CONFERENCE.
Details: Intern. Tire/Road Noise Conference, C/- Sandberg, Swedish Road and Traffic Research Institute, S-581 01 Linkoeping, Sweden.

November 26-30, SAN DIEGO
MEETING OF ACOUSTICAL SOCIETY OF AMERICA
Details: Murray Strasberg, ASA, 500 Sunnyside Blvd., Woodbury, New York 11797, USA.

1991

May 5-9, BALTIMORE
MEETING OF ACOUSTICAL SOCIETY OF AMERICA
Details: Murray Strasberg, ASA, 500 Sunnyside Blvd., Woodbury, New York 11797, USA.

November 4-8, HOUSTON
MEETING OF ACOUSTICAL SOCIETY OF AMERICA
Details: Murray Strasberg, ASA, 500 Sunnyside Blvd., Woodbury, New York 11797, USA.

Inter-Noise 88 Proceedings

The Proceedings of Inter-Noise 88, held in Avignon, are now available. The three volume set contains almost 400 papers presented during the Conference. The vast majority of the papers are related to the physical aspects of noise control engineering as can be seen from the following distribution of papers:

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The cost for the set is US $100 plus $45 for overseas postage.

Further information: Noise Control Foundation, P.O. Bix 2469 Arlington Branch, Poughkeepsie, NY 12603, USA.

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