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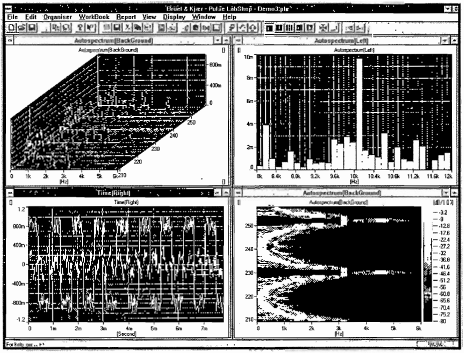

- Noise Policy
- Aircraft Noise
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Australian Acoustical Society

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PHOTOGRAPHS WANTED

Council has decided to produce a booklet entitled "A Career in Acoustics" which is to be distributed to careers officers in schools and can also be given to anyone who seeks such information from the Society. The level is intended for year 10 to 12 students.

We are seeking photographs for possible inclusion in the booklet. They should illustrate some interesting aspect of acoustics, and preferably should be in colour.

If you have any photographs which you believe could be useful, please send a copy to:

A/Prof. Charles Don,
Department of Physics
Monash University
Clayton, Victoria 3168

We would appreciate receiving photographs before the end of January as we aim to have a final draft of the booklet ready for inclusion in the April issue of Acoustics Australia.

From The President

In July this year I was privileged to attend a board meeting of the International Institute of Noise Control Engineering (I-INCE) in Liverpool to which representatives from the International Institute of Acoustics and Vibration (IIAV) had been invited. One of the reasons for the meeting was to discuss possible conflicts in the scheduling of conferences. In particular, a problem was looming in Australasia where three major international conferences and several satellite meetings involving acoustics were scheduled to occur within a month in 1998.

Each year since 1974, I-INCE has held a major meeting — for example Internoise 98 will be held in New Zealand from 16-20 November, 1998. They are closely associated with the International Congress in Acoustics (ICA) which is holding a joint meeting with the American Acoustical Society in Seattle in June 1998. This is sufficiently separated in time and place that it should not clash with the Australasian meetings. A separate body, the International Commission on Biological Effects of Noise (ICBEN) holds a congress every five years and the next is planned for Sydney during 23-27 November, 1998. It was considered that this and Internoise 98 would complement each other as their themes did not greatly overlap, yet some international delegates would be drawn to both. A small problem was that November is the time normally chosen by the Australian Acoustical Society to hold its annual conference and AGM. However, it was proposed to combine this activity with ICBEN in 1998. Concern arose when IIAV decided to hold an international congress on sound and vibration in Adelaide during the week before Inter-noise 98. Would such a conference bring more international delegates to this part of the world, boosting all three major events, or would it undermine one or both of the already scheduled conferences? Of particular concern to New Zealand was the influence the new congress would have on Australians, who could well opt to forgo the flight across the Tasman in favour of the local meetings. A change of less than 50 delegates could spell financial disaster.

We shall never be sure what would have occurred because IIAV decided to move their congress ahead and hold it from December 15-18, 1997. This just avoids clashing with Westprac97 to be run in Hong Kong during November 1997. (Of course, you may already be over-conferenced if you have been to Internoise 97 in Budapest in August.) To avoid having yet another meeting, the AAS annual conference in 1997 will be held in association with the IIAV congress in Adelaide.

The IIAV is a relatively new group which has grown from their first Congress in 1990. There has been some animosity between the more established I-INCE and IIAV, the former believing that there is too much overlap in the content of the respective conferences and in scheduling. One of the results from the meeting in Liverpool this year was an agreement to work together, in particular to cooperate in the scheduling of major events. The AAS Council considered the matter of possible conflicting groups and decided it was the role of the AAS to support all worthwhile activities involving acoustics in our region, irrespective of organisation. Thus our members are supporting ICBEN and we urge our members to attend Internoise 98. We also hope you will participate in the Adelaide congress and the associated AAS conference and don't forget Westprac97. It will be a busy time in our region for acoustics, but perhaps not as frantic as it might have been. The success of these conferences will largely depend on you, the participants.

Charles Don

FIFTH INTERNATIONAL CONGRESS ON SOUND AND VIBRATION — AUSTRALIAN ACOUSTICAL SOCIETY ANNUAL CONFERENCE

December 15-18, 1997, University of Adelaide, South Australia

The Congress programme will include keynote addresses, tutorials on specialised topics and invited and contributed papers in all areas of sound and vibration plus a technical exhibition and a social program.

The following topics will be presented in plenary sessions :

Shock wave dynamics, Sir James Lighthill UK,
Helicopter rotor aeroacoustics, Hanno Heller Germany,
USA, Vibration suppression, Dan Inman USA,
Diagnostics of bearings and gears, Bob Randall Aust,
Statistical Energy Analysis, Frank Fahy UK,
Recent developments, Malcolm Crocker
Active control, Chris Fuller USA,
Hearing protectors, Samir Gerges, Brazil

A registration of interest brochure is an insert in this issue of journal. For additional details contact:

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WWW: http://www.io.org/~webland/icsv5.html

Guest Editorial

Environmental Noise Standards

Environmental noise has long been of concern to people, and it is necessary to balance the legitimate complaints of those annoyed by it and the interests of the people who are causing the noise. As annoyance is a subjective attribute, it is desirable to use a scientific system of assessment that will be acceptable to the majority of people, and that will also, if necessary, withstand challenges in a court of law.

Originally, environmental noise complaint assessment was carried out by local government health inspectors, who, although usually not formally trained in acoustics in those days, added noise to the many other community health problems for which they were responsible. When the Standards Association of Australia first published AS 1055-1973 "Noise Assessment in Residential Areas" it was stated in the Preface that "it has been assumed that the user of the code will be *familiar with, or at least acquainted with,* the basic essentials of noise measurement" [my italics]. There were two areas of application – firstly as a guide to acceptable noise levels for planning purposes, and secondly "as a means of estimating the validity of complaints of noise nuisance at specific locations."

Measurements, in A-weighted decibels, of both the noise under investigation and the background noise level, were made using a hand-held sound level meter, and various numerical adjustments were made to take into account other factors contributing to annoyance, e.g. impulsiveness, noise spectrum, time of day, and type of neighbourhood (rural to industrial).

The standard was revised in 1978, and the greater experience and expertise in noise measurement was reflected in the Preface, which stated "it has been assumed that the user will be *adequately trained in the science of acoustics and thoroughly experienced* in noise measurement and assessment" [my italics again]. The actual assessment methods were basically unchanged (the eyeball readings of the meter deflections of a hand-held sound level meter) but the two areas of application were separated.

When AS 1055 again was due for revision, the corresponding ISO standard, 1996, was also under revision, and the Australian committee, AK/5 decided to concentrate its efforts in the international arena. As it happened, AS 1055-1984, in three separate parts, was published ahead of the revised ISO 1996. The title was changed to "Acoustics – Description and Measurement of Environmental Noise." Although simple sound-level meter measurements were still allowed, comparing the (adjusted) maxima of the noise level with the minimum (background) sound level, "for more complex problems, and for long-term planning purposes, the equivalent continuous A-weighted sound pressure level or other descriptor(s) such as the percentile A-weighted sound pressure level may be used as the basic quantity or as specified by the relevant regulatory authority." Many new descriptors were introduced and a new Appendix was included to assist users with the application of the standard.

The next edition of AS 1055 was published in 1989, and was little changed in principle. This 1989 edition is now under review – the intention was that it would become a joint Australia/New Zealand standard. However, New Zealand found too many differences compared to their current assessment methods and it has now been decided to proceed with an Australian-only revision. Both countries, though, intend to participate in the proposed revision of ISO 1996, with the intention of adopting the revised international standard in both countries.

The proposed revised standard has been circulated for public comment, and the committee has agreed to proceed to vote on the draft, which acknowledges the many technological advances that have been made in acoustical instrumentation since the first version was published over twenty years ago, and, although simple sound-level meter readings may still be taken, it is expected that more sophisticated measurement methods will normally be used.

Although this short history of AS 1055 may seem straightforward, the many members of its drafting committees (AK/5 and then AV/5) will remember the days-long, sometimes emotional, debates which finally led to each edition being adopted as a "consensus" document, in the true Australian tradition!

Anita Lawrence

Approaches to Environmental Noise Policy in Australia

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ABSTRACT: Since the 1970s there has been comprehensive noise legislation in most of the States of Australia. Its goal in all cases has been to provide adequate means of controlling unacceptable noise. However significant variations in State approaches to noise control are evident within the details of this noise legislation and associated policy. An international study of the effectiveness of environmental noise policies was undertaken by the Organisation for Economic Co-operation and Development (OECD) in the late 1980s. Eight points were identified in order to prevent further deterioration of the acoustic environment. In this paper Australian approaches to environmental noise policy are examined in the light of the OECD recommendations.

1. INTRODUCTION

In the late 1980s the Organisation for Economic Co-operation and Development (OECD) undertook an international study to analyse trends in noise exposure and assess the effectiveness of noise abatement policies. Australia was one of the six countries investigated in detail. This study [1] concluded that to prevent further deterioration of the acoustic environment noise abatement policies need to be strengthened. Specifically it recommended that the countries should:

- develop a coherent national strategy;
- coordinate this policy between national, regional and local authorities;
- provide the resources needed for proper enforcement of measures adopted;
- monitor policy implementation;
- generalise the use of economic and non economic incentives;
- take vigorous steps to change the behaviour of the public and of decision-makers;
- integrate noise concerns in the development of transport policies and traffic management policies; and
- in the longer term introduce stricter emission limits for the noisiest vehicles and equipment.

In this paper the approaches to environmental noise legislation in Australia will be examined with a view to assessing if these elements have been taken into consideration in Australia.

2. ENVIRONMENTAL LEGISLATION IN AUSTRALIA

Australia is a Federation of States and Territories (hence "State" refers to "State and Territory") and there are three levels of Government: Federal, State and Local. While there had been some means of controlling clearly excessive noise, it was not until the 1970s that comprehensive noise legislation was introduced by most of the States of Australia. The goal of the legislation is to provide adequate means of controlling unacceptable noise. This legislation typically sets limits for various noise generating activities and mechanisms for enforcement.

Each of the States has either a Department or Agency which is responsible for the development and implementation of environmental legislation as shown in Table 1. While the need to control unacceptable noise is common to every State's legislation, the fact that the legislation has been developed independently has led to the emergence of a range of noise control approaches among the States. Within the legislation itself there are significant differences in the detail embodied in definitions, criteria and procedures.

In the 1970s these Acts were often specific to noise, eg Noise Control Act for NSW. In the light of approximately twenty years of experience in implementing the legislation, most States either have, or are in the process of, introducing new legislation in the 1990s. The current trend is to have an integrated environmental legislation to cover all the aspects of the environment. This is supplemented by policies or regulations that address specific environmental media. These policies or regulations can be included as sub-ordinate regulation under the relevant Act or as separate non mandatory documents. There is always a considerable time lag between the decision to introduce a new Act and its actual passing by the Parliament. In some States the introduction of these policies requires community consultation, further delaying the passing of the Act and the relevant noise policy.

Table 1. Summary of Environmental Departments/Agencies and Acts

State	Department/Agency *	Act
Australian Capital Territory (ACT)	Office of the Environment within the Environment and Land Bureau	Noise Control Act 1988
New South Wales (NSW)	Environment Protection Authority	Noise Control Act
Victoria (Vic)	Environment Protection Authority within the Department of Conservation and Environment	Environment Protection Act 1970
Tasmania (Tas)	Environment Tasmania within the Department of Environment and Land Management	Environmental Management and Pollution Control Act 1994
South Australia (SA)	Environment Protection Authority within the Department of Environment and Natural Resources	Environmental Protection Act 1993
Western Australia (WA)	Department of Environmental Protection Authority	Environmental Protection Act 1986
Northern Territory (NT)	Environment Protection Division of the Department of Lands, Planning and Environment	Summary Offences Act 1992**
Queensland (Qld)	Division of Environment within the Department of Environment	Environmental Protection Act 1994

*It should be noted that the structure of Departments can be changed quite readily by the Government.

** The Summary Offences Act is administered by the Police rather than the Department of Lands, Planning and Environment.

At the Federal Level, the Environmental Protection Agency is within the Department of Environment Sport and Territories and its gaol is to work with all levels of government, business and the community on nationwide solutions to environmental problems and to fulfil international environment protection obligations.

A milestone in the quest to achieve a coherent national strategy was the Inter-governmental Agreement of 1992 [2]. This stated that there would be a cooperative national approach to the environment. In the section on National Environmental Protection Measures, it was agreed that there should be uniformity for noise related to protecting amenity where variations in measures would have an adverse effect on national markets for goods and services. It also endorsed national motor vehicle emission and noise standards. This meant that control for community and industrial noise, while attempting to maintain a cooperative national approach, was the responsibility for each State government. While the Noise Sections of the various State Governments have informally held discussions on the most effective manner to achieve this cooperative national approach, to this time no formal body or committee has been established.

3. COMPONENTS OF POLICY

Industrial Noise

The basic method for assessing offensive or intrusive noise involves measuring (or predicting) the noise level, making a correction for the nature of the noise, and comparing this value with criteria. However while this basic method is applied throughout Australia differences arise in the interpretation of each of these components.

In four of the States, the descriptor required for the measurement of the noise itself is the L_{A10}, the level exceeded for 10% of the time period. This descriptor is used to describe the average of the maximum levels. In other States the L_{Aeq}, the equivalent energy level, is used instead.

The corrections for the character of the noise are mostly in accordance with the relevant sections of the Australian Standard, AS1055 [3].

For the establishment of acceptable criteria there are two options. One is to define noise limits based on the type of area and time of day. The other is to use a relative method based on the background noise level in the area. Both these methods are used around Australia. The greatest difference between the approaches of the various States is in the establishment of the criteria for acceptability, as shown in Table 2.

Table 2. Main descriptor for environmental noise assessments

State	Descriptor for Noise	Acceptable Criteria	Time periods
ACT	L_{A10}	L_{A90} +5 dB(A)	0700-2200
		L_{A90} +0 dB(A)	2200-0700
NSW	L_{A10}	L_{A90} +5 dB(A)	
Vic	L_{Aeq}	Noise Limit	
Tas	L_{Aeq}	L_{A90} +5 dB(A)	
SA	L_{Aeq}	Noise Limit & L_{A95} +5	
WA	L_{A10}	Noise Limit	
NT	no objective criterion	no objective criterion	
Qld	L_{A10}	L_{A90} +5 dB(A)*	0700-2200
		L_{A90} +3 dB(A)	2200-0700

* The criteria for Qld are from the Draft Environmental Protection (Noise) Policy of 1996.

The various States justify the need for different criteria on the basis of the characteristics of the area and the expectations of the population. This lack of consistency can cause difficulties for industry. It is quite feasible for an operation that fully meets the requirements in one State to be judged to produce excessive noise in a similar area in another State. It also has the potential for cross border disputes where the activity complies with all the criteria one side of the border yet can be considered as producing excessive noise on the other. There is a move towards use of the L_{Aeq}, rather than the L_{A10}, as descriptors for the noise. The L_{Aeq} has been strongly supported in discussions between some State authorities and acoustical consultants. The adoption of L_{Aeq} by all of the States would be a worthwhile step towards uniform noise assessment policy in Australia. The Australian standard AS1055 [3] is in the process of revision, and changes in the descriptors or the assessment methods may also lead to changes in the methods adopted by the States.

Specific Noise Sources

In addition to the criteria for general industrial noise, most of the States have criteria for specific noise sources such as entertainment noise, shooting ranges, standby generators etc. NSW was the first State to produce a comprehensive manual [4] specifying the assessment and criteria for a range of specific noise sources and this has been used widely as a guideline.

Transportation Noise

The Federal Government is responsible for controlling aircraft noise and setting noise emission limits for new motor vehicles. For all other aspects of transportation noise the control is at the State level. A thorough environmental impact/effects statement is required under the Environmental or Planning Legislation before any new large construction can proceed. This generally includes the setting of design criteria, an assessment of potential noise impact and measures for its mitigation. Once the process has been completed, should there be any complaints, it is up to the appropriate authority to show that the design criteria have been met or where this is not possible, for technical or economic reasons, that best management practices have been implemented. It is not normal for the environmental agency to become involved at this latter stage.

In recent years road traffic noise has been identified as the most prolific form of noise pollution throughout Australia. The growing community outrage to noise from proposed new and upgraded roads has also demonstrated the current road traffic noise design criteria do not provide adequate noise protection. In recognition of these facts, a number of States are developing, in the process of, or are intending to, develop more stringent noise goals for road traffic noise.

4. MONITORING

Monitoring the effectiveness of existing policies can provide valuable input for the development of new policy. A study of the effectiveness of noise abatement policies in Australia in the 1980s [5], found that there had been no real assessment of the effectiveness of policies in terms of the noise reductions achieved or the costs. This is partly because the goals for the policies are considered to be met if the noise criteria are achieved. The Draft Policy for Queensland [6] does include clearly stated noise management objectives:

a) by 1 December 1999 - completing an assessment of the ambient acoustic environment ...; and
b) by 1 March 2002 - achieving an ambient acoustic environment of 55dB(A) or less for more than 60 per cent of Queensland's population living in residential areas; and
c) by 1 March 2010 - achieving an ambient acoustic environment of 55dB(A) or less for more than 90 per cent of Queensland's population living in residential areas

The clear statement of these objectives will enable monitoring of the effectiveness of the policy.

The Federal Government has established a national State of the Environment(SoE) reporting program to fulfil its requirement as a member nation of the OECD. Most States and some Local governments also produce their own SoE reports, some obligated by legislation to do so. One of the aims of SoE reporting is to generate an accurate picture of environmental trends to monitor the effect of policies. To date these reports show that the regulations have been enforced but do not address the issue of effectiveness. The policy is considered effective if there have been few complaints and few problems. If parts of the regulations are found to be difficult to implement or inappropriate, then changes are made.

Some State and Local governments are now considering undertaking ambient noise monitoring programs. If these programs proceed in a coordinated manner and can be maintained in years to come, it should be possible to gauge policy effectiveness at the National level. It would also allow assessment of the effectiveness of the noise abatement strategies implemented by the various States.

5. ENFORCEMENT, INCENTIVES AND PUBLIC SUPPORT

Enforcement is considered to be an integral part of noise abatement policies in all the States. Increased public pressure for adequate control of environmental pollutants has ensured that the agencies enforce the policies. More emphasis has been placed on industry self monitoring with many environmental agencies taking on an environmental auditing role. As legislation is reviewed, maximum penalties for breaches have been increased and the methods for application streamlined, leaving less opportunity for disputes and appeals.

Incentives have not been important aspects of environmental noise policy in Australia. However incentive based schemes are now being considered and implemented in a broader environmental approach, some having potential to influence noise abatement strategies of industry. Some incentive based strategies emerging include:

a) load based licensing, where companies are required to pay licence fees based upon total pollution emissions;
b) grants available for environmental improvement - which can include noise;
c) industries seen to be environmentally well managed can be rewarded by reduced licence fees, extended licences and less frequent reporting requirements.

The extension of these incentives into noise policy is limited by the current approach to noise control. For example, in many States noise is not licensed and therefore incentives based on reduced licence fees are not applicable.

All of the States have promotional and educational material which is available to the public. Coupled with media coverage of some disputes, there has been an increasing awareness by the public of rights under the policies. The increased amount of public consultation for many issues associated with the environment and with planning have also helped to increase support for environmental control issues. This has undoubtedly had an effect on the actions of the public and of the decision-makers but this effect cannot be quantified.

6. CONCLUSION

The OECD study on environmental noise policies[1], carefully identified the elements which are necessary to prevent further deterioration of the acoustic environment. Of the eight points, six are specifically relevant to environmental agencies. The other two relate to transportation noise which is the responsibility of transport or road construction agencies. Although guidelines and goals for transportation noise can be specified by the environmental agency, it is often other agencies which are responsible for its implementation.

There is some commonality between the environmental noise legislation for each of the States and a coherent national strategy is emerging with the introduction of integrated environmental legislation. However within the details of the policy and regulations there is a lack of uniformity and to date there is no mechanism place to address these anomalies. While there may be some justification for local specific differences it is hard to understand why the basic descriptors and the criteria differ from State to State.

Monitoring the effectiveness of the policy is still not an integral part of policy review and development. With the increased emphasis on SoE reporting, there is potential for monitoring to be conducted. However this will depend on the allocation of resources to this process. Currently, as long as the criteria have been met it is assumed that the policy has been effective. There are few defined goals for the policies except for lack of complaints.

The use of incentives to reduce environmental pollutants is emerging. However their application in controlling noise is extremely limited at present. Promotional material, public consultation and media coverage have all lead to an increased awareness of noise issues which have hopefully had effects on the actions of the public and decision makers.

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Sleep Disturbance Due To Environmental Noise: A Proposed Assessment Index

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Abstract: Traditional methods of assessing the impact of environmental noise are generally based on the use of "equal-energy" measures of noise exposure, such as $L_{Aeq,24hr}$ or ANEF. These have been derived from studies of the annoyance generated by the noise. This paper presents a proposed methodology for directly assessing the level of sleep disturbance due to intermittent night-time noise, independent of the degree of annoyance caused. The procedure is based on calculation of a Sleep Disturbance Index (SDI) which is numerically approximately equal to the average number of awakenings per night due to the noise. Typical values of SDI would range from less than 0.2, representing a relatively insignificant level of disturbance, to greater than 5, representing a very high level. Details of calculation procedures, and possible criterion values in terms of SDI, are discussed. The use of this methodology in addition to traditional "equal-energy" noise indices should allow for a more comprehensive assessment of the impact of night-time noise on residential communities.

1. INTRODUCTION

This paper describes a proposed methodology for direct assessment of the impact of certain types of environmental noise on sleep. The method described is intended to provide a practical tool for regulators and practitioners, and is seen as being complementary to existing assessment procedures which are based largely on studies of the annoyance (or similar psychological constructs) generated by the noise.

Throughout the world, existing regulatory procedures for assessment of environmental noise are based on the calculation of noise exposure indices, such $L_{Aeq,24hr}$ or ANEF, and comparison of these values with specified "criterion" levels. In almost all cases, indices based on the "equal-energy" principle (such as the two above) are used. A useful review of noise exposure indices and criterion levels which are adopted in various countries is provided by Gottlob (1995).

The use of "equal-energy" noise exposure indices is based on results from a series of studies (e.g. Fields, 1984; Bullen & Hede, 1986) which indicate that they provide the most appropriate basis for prediction of the annoyance generated by various types of environmental noise - or, at least, no alternative methodology provides a significantly better prediction of annoyance. Since most people describe their reaction to environmental noise in terms related to annoyance, this appears to be a reasonable procedure.

However, there has been continuing concern, both in the published literature (e.g. Ohrstrom & Bjorkman, 1988) and among the general community, that certain impacts of noise are not adequately predicted by "equal-energy" noise indices - or in other words, they are not adequately described by the "annoyance" generated by the noise. Chief among these additional impacts is sleep disturbance. It is argued that sleep disturbance may be associated with physiological or other effects of which a respondent may not be fully aware, and which would therefore not be reflected in their reported annoyance. This raises a particularly emotive issue, which has been the subject of considerable debate (see, for example, Stansfeld, 1992). Recent results in this field are summarised by Kawada (1995).

The present paper introduces a new index, and a methodology by which the extent of potential sleep disturbance due to noise may be assessed, independent of the degree of annoyance caused by the noise. Annoyance should still be assessed using standard "equal-energy" descriptors. The methodology applies only to intermittent noise which can be regarded as consisting of a series of isolated "events". However, this is the form of noise which is most commonly associated with disturbance to sleep.

2. MEASURES OF SLEEP DISTURBANCE

In studies of the effect of noise on sleep, the degree of disturbance may be assessed by a number of methods, including:

- the number of awakenings due to the noise, which may be measured using an electro-encephalograph (EEG); recorded using a device such as a button which subjects are required to push; or simply reported by subjects the following morning;
- the number and type of changes in sleep state which occur during the night, as recorded using an EEG;
- the number of body movements during the night, recorded using an actimeter;
- measures of performance the following morning, such as simple unprepared reaction time; and
- subjective reports of sleep quality.

These measures are all reasonably well correlated. However, the first two are most directly related to actual sleep quality. Body movements are difficult to interpret, since they occur in normal dreaming (REM) sleep as well as in periods when sleep is disturbed. Performance measures are related to a number of factors other than quality of sleep, and scales for reporting subjective sleep quality have not been standardised, so results from different studies are difficult to compare.

Of the first two measures, numbers of changes in sleep state are highly correlated with numbers of awakenings (awakenings are a subset of changes in state). While total changes in sleep state may provide a more sensitive measure of noise effects than awakenings, the significance of sleep state changes for overall sleep quality is not clear. In addition, because awakenings are reported in a large number of studies, conclusions concerning the frequency of awakenings can be drawn with greater certainty.

For this reason, in the proposed methodology, assessment of the impact of noise on sleep is based on prediction of the number of awakenings which would be caused by the noise per night.

As noted above, awakenings may be recorded in various ways. In situations where subjects are not exposed to noise, an EEG typically records seven to nine awakenings per night, whereas only one to two awakenings are remembered or are recorded by pushing a button. However, results from Eberhardt et al (1988) indicate that the number of EEG awakenings due to noise (that is, the number of additional awakenings in a noisy environment) is approximately the same as the number of remembered awakenings due to noise. In other words, although most EEG awakenings are not remembered the following morning, those which are caused by a noise event are generally remembered. This result allows data from various studies using different methodologies to be combined, giving greater confidence in the results.

3. COMPARISON OF RESULTS FROM PUBLISHED STUDIES

Studies of sleep disturbance due to noise have almost exclusively involved intermittent noise, consisting of a series of discrete events - generally actual or recorded passbys of aircraft, trains or road vehicles. The noise level of these events is typically characterised by the maximum A-weighted level, "Fast" speed. The number of events per night and/or their maximum noise level are varied, and the effect on sleep quality is assessed. In most cases, maximum noise levels of events are well above the ambient level - at least 20 dB higher. Figure 1 shows a comparison of results from a number of studies. The Appendix indicates the major characteristics of each of these studies.

Studies included in this comparison include all published studies which could be located for which the number of awakenings per night experienced by subjects could be related to a maximum noise level and a number of events per night. They include both laboratory and field studies, and subjects cover a range of demographic groups. In the case of laboratory studies, only results obtained after at least several nights' acclimatisation are included.

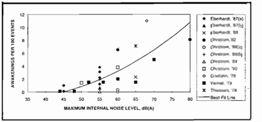

Figure 1. Probability of awakening - results of 11 studies.

In Fig. 1, the number of awakenings recorded has been standardised as the number per 100 events - or equivalently, the percentage probability of awakening per event. This form of analysis tacitly assumes that the number of awakenings per night is directly proportional to the number of events heard. There is some indication from results in Ohrstrom (1990) that for large numbers of noise-related awakenings (greater than approximately five per night) the actual number of awakenings may be lower than predicted from a direct relationship. At this point, subjects simply become too tired to wake up even for loud events. However, this level of disturbance would be well beyond reasonable criterion limits, and it can be assumed that for lower levels of disturbance there is a direct relationship between number of events and number of awakenings.

The scatter of results shown in Figure 1 is due to many factors, including differences in experimental methodology, types of subjects studied, differences between laboratory and field studies, differences between response to various types of noise, and statistical variation resulting from limited sample sizes. There is some suggestion from these data that recorded numbers of awakenings are lower for field studies than for laboratory studies. However, the difference is not statistically significant at the .05 level. It is also likely that differences in age, gender and other characteristics of the subjects are associated with some difference in susceptibility to awakening. However, data to confirm this are not available, and the implications foro planning purposes are in any case not clear.

The degree of agreement between studies shown in Figure 1 is considered to be sufficient to warrant the use of a best-fit line, as shown, to summarise the results. This relationship explains 50% of the total variance in number of awakenings, and the standard error of estimate is 2.6 awakenings per 100 events.

It should be noted that results in Figure 1 represent an average across all subjects. Very little information is available on inter-subject differences, but these can be expected to be large. Based on available data, criteria would need to be determined from these results for an "average" subject, recognising that some individuals will experience more, or less, disturbance than indicated.

4. PROPOSED ASSESSMENT METHODOLOGY

The proposed methodology is based on calculation of a "Sleep Disturbance Index" (SDI) which is numerically equal to the estimated average number of awakenings per night which would be caused by the noise in question. Typical values of SDI would range from less than 0.2, representing a relatively insignificant level of disturbance, to greater than 5, representing a very high level. Possible criterion values, expressed in terms of SDI, are discussed below.

The value of the Sleep Disturbance Index depends on the number of individual noise events heard per night; the maximum noise levels of events; and the "emergence" of events above the ambient noise. Calculation of the index is based on the results discussed above, and is described in detail below.

4.1 Basic Procedure

If there are N events per night, all with a maximum internal noise level of L_{max} dB(A), "Fast" speed, then the Sleep Disturbance Index is

$$SDI = N \cdot W(L_{max}) / 100$$

where W(L) is the weighting factor for a noise level of L. To calculate W(L) precisely, use

$$W(L) = 0.142\,(L - 45) + 0.00473\,(L - 45)^2 \text{ if } L > 45 \quad (1a)$$

$$W(L) = 0 \quad \text{if } L <= 45 \quad (1b)$$

which is the formula representing the best-fit line shown in Fig. 1. Alternatively, Table 1 can be used. If there are several types of noise event with different levels, a partial SDI for each type should be calculated, and these should be added to give the total SDI.

Table 1 Weighting factors for calculating SDI

Maximum Internal Noise Level, L - dB(A)	Weighting Factor, W(L)
< 45	0
45 - 49	0.4
50 - 54	1.3
55 - 59	2.5
60 - 64	3.9
65 - 69	5.6
70 - 74	7.5
75 - 79	9.6
80 - 84	12.0

4.2 Example 1

Suppose a service station has 40 customers per night between 10 pm and 6 am. For each customer there are three separate audible events at the nearest residence - driving in at 62 dB(A), starting up at 70 dB(A) and driving away at 65 dB(A). It will be assumed that the residence has open windows, and that the internal noise level is 10 dB below the external level. (In practice, the difference between internal and external noise levels may vary depending on the degree of opening of windows, and may also differ between noise metrics. These factors would need to be considered in applying this methodology in practice.) The SDI due to these events is shown in Table 2.

Table 2 Example calculation of SDI

Event	Number Per Night	Max. Noise Level, dB(A)		Weighting Factor	Partial SDI
		External	Internal	(Calculated)	
Drive In	40	62	52	1.23	0.5
Start-Up	40	70	60	3.19	1.3
Drive Away	40	65	55	1.89	0.8
		TOTAL SDI			2.6

4.3 Modified SDI

The above procedure does not take account of the emergence of noise events, i.e. the difference between the level of the event and the general ambient noise level. For large numbers of events with low noise levels, it gives values of SDI which are anomalously high.

Of the available studies, only Eberhardt et al. (1987) provides direct information on this effect. Indications from this paper are that the above procedure is applicable if the noise level of events is well above the overall L_{eq} noise level - say 20 dB higher than L_{eq}. If events are within 5 dB of the L_{eq}, the sleep disturbance due to the individual events reduces to almost zero.

This can be handled by modifying the weighting factors above. Modified weighting factors can be defined, using the factors found from Equation 1 or Table 1, by

$W_{mod}(L_{max}) = W(L_{max})$ if $L_{max} >= L_{eq} + 20$ (2a)

$W_{mod}(L_{max}) = W(L_{max}) * (L_{max} - L_{eq} - 5)/15$ if $L_{eq} + 5 < L_{max} < L_{eq} + 20$ (2b)

$W_{mod}(L_{max}) = 0$ if $L_{max} <= L_{eq} + 5$ (2c)

where L_{eq} is the internal $L_{Aeq,8hr}$ noise level for the entire night-time period 10 pm - 6 am.

A problem with this formulation is that a measured $L_{Aeq,8hr}$ noise level may include noise from the events themselves as well as the ambient noise, and this may have some influence on the measured "ambient" level. Where events are definite and individually definable - such as in the case of rail traffic or aircraft noise - noise from these events should be excluded when measuring or calculating the ambient L_{Aeq} noise level. However, a special case exists for road traffic noise, which in practice consists of a series of noise events ranging continuously from infrequent high-level events which may result in sleep disturbance to a large number of low-level events which effectively constitute the "ambient" noise level. It is not clear which events should constitute "sleep disturbance" events and which should constitute the "ambient". In this case, preliminary indications are that an appropriate value for SDI may be found by using the overall measured (or calculated) L_{Aeq} noise level to represent the "ambient" from which higher noise level events arise.

4.4 Example 2

Suppose noise events from traffic are recorded throughout a night, outside a residence. Assume the bedroom window is open, and the external noise level is 10 dB higher than the internal level. The number of measured events with noise levels in various ranges is shown in Table 3. The measured $L_{Aeq,8hr}$ noise level was 53 dB(A). Table 3 shows the modified procedure for calculating SDI. A refinement of this assessment procedure would be to calculate the modified weighting factor separately for events in each hour, using the $L_{eq,1hr}$ value for that hour. This would be necessary if the L_{eq} noise level changed significantly during the night.

Table 3 Calculation of modified SDI

Noise Level Range, dB(A) (External)	Number of Recorded Events	Internal Noise Level, dB(A)	Weighting Factor		Partial SDI
			Basic	Modified	
75 - 79	2	65 - 69	5.6	5.6	0.1
70 - 74	12	60 - 64	3.9	3.6	0.4
65 - 69	53	55 - 59	2.5	1.5	0.8
60 - 64	206	50 - 54	1.3	0.35	0.7
55 - 59	316	45 - 49	0.4	0	0
		TOTAL SDI			2.0

5. MEASUREMENT OF SDI

5.1 Definition of an "Event"

The value of SDI at a measurement location can be calculated directly from measured noise levels, provided one has a suitable definition of what constitutes a "noise event". For the purpose of measurement, an "event" is defined to occur when:

- the noise level reaches a maximum;
- the noise level drops by at least 5 dB between this and any other maximum; and
- the maximum is separated from any other maximum by at least 15 seconds.

The period of 15 seconds relates to the definition of an "awakening" in an EEG trace - to be counted, the subject should be in an awakened state for at least 15 seconds.

5.2 Equipment Required

Isolated noise events can be simply measured using a sound level meter on "Fast" speed, noting the maximum level and the number of events per night.

Quasi-continuous noise such as traffic noise is slightly more difficult. Using current measurement equipment, events can most easily be detected with a chart recorder, applying the above definition to the recorded trace. The recorder needs to run all night. Events can then be counted and assigned to ranges according to their L_{max} values. However, with appropriate software it would not be difficult to detect events automatically and save their maximum levels in a logger.

The value of SDI for a particular measurement night can be calculated directly as indicated in Table 3. From experience, values appear relatively stable between nights, but perhaps averaging over a number of nights would be useful.

6. PREDICTION OF SDI

For isolated events, prediction of the value of the Sleep Disturbance Index is relatively simple, requiring only a prediction of the maximum level and number of events per night, as well as knowledge or prediction of the ambient L_{eq} level.

For traffic noise, it would be necessary to divide vehicles into classes and predict maximum levels and numbers for each class. Maximum levels from individual vehicles can be predicted relatively easily, using ENM or any other appropriate model. The standard FHWA procedure can be easily modified to predict maximum levels rather than L_{eq} values. Predicted maximum levels would probably be more accurate than predicted L_{eq} levels using the standard CORTN or FHWA procedures.

If the traffic volume is high enough (or the distance from the road is large enough), there is a possibility that noise events may be due to more than one vehicle being present at the same time. This situation is more difficult to handle, and would require a statistical model to predict maximum levels accurately. However, such situations are not as important as the case of isolated events, because in these cases the maximum level is not greatly above the L_{eq} level, and hence the partial SDI from the events is low.

7. CRITERION LEVELS

Like any assessment methodology, the calculation of SDI represents a method of gauging the extent of sleep disturbance due to noise, and does not presuppose any specific values which should be adopted as criteria. The setting of criterion levels is primarily the responsibility of relevant regulatory authorities, based on judgements regarding the benefits and costs of various noise control strategies.

Nevertheless, some consideration of the level of impact associated with various values of SDI is appropriate, to define a level which could, for example, be described as "unacceptable" for planning purposes. One point of reference is the fact that studies indicate subjects experience an average of approximately 1.5 (remembered) awakenings per night for reasons unrelated to noise. Thus, an SDI of 1.5 would represent approximately a doubling of the "ambient" level of sleep disturbance. Such a level may be considered an appropriate criterion for transportation-related noise sources, where some consideration is traditionally given to the benefit of the noise source to the community and the cost to the community of noise mitigation measures.

For other noise sources, such as industrial sources or those associated with entertainment, more stringent criteria are traditionally applied, representing a point at which the impact of a new noise does not add significantly to existing impacts. A value of 0.5 for SDI (representing one additional awakening every two nights) may be considered an appropriate criterion under these circumstances.

In further refining these values, consideration would need to be given to the appropriateness of defining different criteria for existing and new sources, and of controlling the cumulative sleep disturbance due to a number of sources.

8. CONCLUSION

This paper presents a proposed methodology for assessment of sleep disturbance due to intermittent environmental noise. It is based on published research data, and takes account of the three factors which have been identified as being most important in determining the extent of this impact, namely:

- the number of individual noise events heard per night;
- the maximum noise levels of events; and
- the "emergence" of events above the ambient noise.

To the authors' knowledge, no existing alternative system allows all these factors to be considered in a systematic and quantifiable way.

Other acoustic factors, such as duration, rise time and information content of the noise, as well as non-acoustic factors such as age and personal sensitivity, will also affect the level of disturbance in any particular case. Corrections for such effects could conceivably be included in the methodology at a later date. However, reliable data to allow such corrections are currently unavailable.

The Sleep Disturbance Index, as defined above, is presented as a viable method for assessment of sleep disturbance from most types of night-time noise. Criteria of acceptability, in terms of the index, may be determined by relevant authorities. Possible criterion values are suggested for consideration in Section 7 above.

The methodology advanced in this paper now needs to be applied by practitioners in real situations. It is believed that use of the Sleep Disturbance Index in addition to an appropriate "equal-energy" index will result in a more comprehensive assessment of the impact of night-time noise on residential communities.

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APPENDIX
SUMMARY STUDIES CONSIDERED IN SYNTHESIS

Reference	Type of study	Noise Source	Measure of Awakenings	Maximum noise levels, dB(A)	Numbers of events	Comments
Eberhardt et al, 1987	Laboratory	Recorded traffic	EEG and reported	45 - 55	50 per night	Includes data on effect of emergence
Eberhardt & Akselsson, 1987	In subjects' homes	Existing traffic noise	EEG	Range of normal traffic	45 per night with max. level > 50	Data used not obvious from paper - requires calculation.
Eberhardt, 1988	In subjects' homes - children 6 - 11 yrs	Recorded truck passages	EEG	65	68 per night	Brief report in referenced paper
Ohrstrom & Rylander, 1982	Laboratory	Recorded traffic	Self-reported	60 - 80	37 per night	
Ohrstrom & Bjorkman, 1988	Laboratory	Recorded traffic	Self-reported	60	57 per night	Subjects grouped as noise-sensitive and not sensitive - mean value used
Ohrstrom et al, 1988	In subjects' homes - comparison of two areas	Existing traffic	Self-reported	Range of normal traffic	54 per night with max. level > 55	Plotted change in number of awakenings vs number of events > 55 dB(A)
Ohrstrom, 1989	In subjects ' homes - comparison of two areas	Existing traffic	Self-reported	Range of normal traffic	97 per night with max. level > 55	Plotted change in number of awakenings vs number of events > 55 dB(A)
Ohrstrom & Rylander, 1990	Laboratory	Recorded traffic	Self-reported	50 - 60	4 - 64 per night	Plotted data for 64 events per night
Thiessen, 1978	Laboratory	Recorded traffic	Pressing button	65	7 per night	Plotted data are after adaptation for at least 12 nights
Griefahn & Muzet, 1978	Summary of laboratory studies	Various	EEG	68 - 87	Not stated	Summary line shown in report; plotted values for 60 dB(A) and 68 dB(A) which are mentioned in text
Vernet, 1979	In subjects' homes	Existing train noise, two sites	EEG	40 - 70	80 per night one site, 10 per night the other	

Reducing Aircraft Noise Impact by Sound Insulation of Houses

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ABSTRACT: Aircraft noise is a major environmental issue of concern to people living close to airports. Several thousand houses are situated on land near Sydney Kingsford Smith airport which is not considered suitable for new residential development due to high aircraft noise exposure. Aircraft noise reduction provided by existing houses near the Sydney airport has been measured and typical data is presented. Acoustic upgrading measures that can be undertaken to improve the aircraft noise insulation of houses are described. Information on typical costs of acoustic upgrading measures is also given.

1. INTRODUCTION

Environmental issues, of which noise is a major one, are likely to place significant constraints to the future development and expansion of airports around the world as well as in Australia. On the other hand, the need to increase the capacity of existing airports is becoming acute as air travel by jet aircraft for both business and leisure activities has become a routine part of modern societies. The factors that will contribute to increase in air travel in Australia include: growth in tourism, increasing integration of the Australian economy with emerging global markets and reductions in real airfares due to competition and market deregulation. Figure 1 shows forecasts of total passenger movements and total aircraft movements made by the Federal Airports Corporation in 1993 for Sydney's Kingsford Smith airport up to the year 2011–2012.

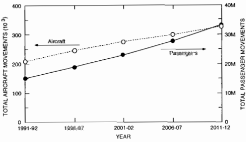


Figure 1. Forecast of total passenger movements and total aircraft movements for Sydney's Kingsford Smith airport.

While the general economy benefits from growth in the number of air passengers, for people living near the airport it can mean a greater degree of aircraft noise annoyance. Georgiou [1] has estimated that, in 1990, approximately 0.2% of the Australian population were exposed to ANEF greater than 30 and 0.7% were exposed to ANEF greater than 25.

The jet age commenced in 1958 when Boeing 707 and Douglas DC8 aircraft started commercial flights. Their maximum A-weighted sound levels were typically about 20 dB(A) higher than the propeller-type aircraft that they replaced. In early jet engines, the noise was controlled by multiple, corrugated nozzle-based devices which shifted much of the sound energy to higher frequencies, but for each dB of noise reduction with such devices about 1% thrust loss occurred, which is a significant performance penalty. Further research led to the so-called low-bypass jet engines which improved the thrust performance and lowered the full-power jet noise during take-offs, but at the expense of increase in noise during landings. In the 1970s, a move to high-bypass ratio and advances in materials and engine cooling technologies led to significantly quieter aircraft. This led the Federal Aviation Administration in the United States to introduce new lower noise limits, called Stage 3 limits, for type certification of new aircraft. The earlier noisier limits were called Stage 2 limits, and limits for older unregulated aircraft were designated Stage 1 limits. Similar limits were developed by International Civil Aviation Organization and are published in its Annex 16 of November 1985.

Kingsford Smith airport in Sydney began operations in 1919 and over the past 30 years questions about its capacity to meet the needs of the Sydney region have been raised from time to time. The idea to construct a third runway at the Sydney airport was first proposed in the 1960s but was rejected in favour of a second airport in the 1970s. The delays for aircraft landings and take-offs became much worse in the 1980s and eventually in 1989 it was decided that a third runway, parallel to the existing N-S runway, be built. This third runway is now operational at the Sydney airport. The use of the E-W runway was restricted under the previous Government, but this policy was overturned by the present Government and a new policy that utilises all three available runways with an aim to spread and share the aircraft noise burden was adopted.

2. AIRCRAFT NOISE

Aircraft noise can vary depending on the aircraft type, engine type, aircraft weight, loading factor, landing or take-off mode and engine speed, and can exhibit directional patterns. Even a particular type of aircraft can be equipped with different engines or different models of the same engine. The aircraft pilot may have to choose different engine thrust to achieve critical airspeed in the runway length available and because not all aircraft take-off precisely from the same point on the ground, the height attained by an individual aircraft (and thus noise level) at a given location can vary. The propagation of sound waves from the aircraft to an observer on the ground can be affected by meteorological factors such as temperature, humidity, wind velocity and turbulence. Atmospheric turbulence should not affect the long-term average aircraft noise levels received at a given site but will cause fluctuations at shorter time scales due to scattering of sound waves especially at low frequencies.

Aircraft noise differs from road traffic noise in that the difference in noise levels between the frontyard and backyard can be as much as 20 dB(A) for traffic noise but for aircraft noise, little difference exists [2]. In jet engines the turbulent jets act as aerodynamic quadrupoles with radiated sound power that varies as the 8th power of the jet velocity. In propeller-type aircraft the propeller itself is the most important source of noise and, for a given thrust, the noise is a function of blade tip speed and consists of peaks at the fundamental blade pass frequency and its harmonics. These days propeller aircraft form a small proportion of the commercial fleet and generally aircraft with a capacity of more than 100 passengers have jet engines.

Many single number noise descriptors have emerged over the years for describing aircraft noise, usually they are related to the maximum A-weighted sound pressure level, L_{Amax}. The advantage of using L_{Amax} is that it is easily measured and understood, but it does not take into account the duration of the noise event or the rate of occurrence of noise intrusions. Time-integrated descriptors such as sound exposure level, L_{AX}, which integrates the sound energy present during the entire noise event can be used to include the duration factor. To ensure that integration time is sufficiently long for achieving a measurement accuracy of 0.1 dB, one has to integrate down to 20 dB below the maximum value during which signal-to-noise ratio problems might be encountered. To estimate L_{AX} from L_{Amax} for aircraft noise, the following approximate relation [3] that incorporates a duration correction can be used:

$$L_{AX} = L_{Amax} + 10 \log_{10} (t/2)$$

where t is the time in seconds between the 10 dB downpoints from the peak level.

The day-night sound level, L_{dn}, is used in the United States and is basically L_{Aeq} but includes a 10 dB penalty for noise levels that occur at night between 10.00 p.m. and 7.00 a.m. If no noisy operations occur during the night penalty hours, the L_{dn} becomes $L_{Aeq,24h.}$. For commercial aircraft, the L_{dn} and L_{Amax} are approximately related by:

$$L_{Amax} = L_{dn} + 20$$

For aircraft noise certification, a complexly derived number called effective perceived noise level, L_{EPN}, is used that expresses the noise annoyance caused by a single aircraft flyover at a given location. The L_{EPN} is determined by weighting the 24 one-third octave band levels between 50 Hz and 10,000 Hz in accordance with equal noisiness contours and then summing their values using a prescribed procedure which has allowance for tones as well as duration. The L_{Amax} values are lower than L_{EPN} values but the precise difference between the two will depend on the spectrum involved. Although L_{EPN} is a good measure of aircraft noisiness and is used for the certification of new aircraft, it is seldom used for setting noise level limits or noise level restrictions because of its complexity.

The loudness, described by the A-weighted sound pressure level, is not an adequate or sufficient attribute for subjective annoyance. The loudness does not include the duration, and the longer the duration, the more unacceptable and annoying the noise is likely to be. Furthermore, noise-induced annoyance includes both acoustic and non-acoustic factors. Loudness increases monotonically with levels but annoyance is not directly proportional to the absolute level of the noise, as can be gauged by the annoyance from a dripping tap. Non-acoustic factors include: adaptation, personality characteristics, predicability of noise, involvement with or economic dependence on the operation of noise source, apparent necessity of noise intrusions and socio-economic levels of individuals. Presence at home during the day and/or during the weekend also affects annoyance and persons always at home are likely to be more annoyed by noise intrusion into the house. If non-acoustic factors control the annoyance response, the degree of annoyance may not change in direct proportion to the reduction in noise exposure. As the noise is reduced to sufficiently low value, the annoyance curve becomes asymptotic, suggesting that a small percentage of people are very sensitive to noises and find them annoying even at low levels. Annoyance can, therefore, be only described in a statistical sense and a number of indices for predicting noise annoyance have been proposed, these are often based on regression analysis of data sets generated from community surveys. The correlation between noise exposure and annoyance in individuals is, however, generally low and correlation coefficients of about 0.4–0.5 are common.

Fidell et al. [4] carried out a review of a larger number of social surveys on noise annoyance and updated the earlier work of Schultz [5] on community annoyance from transportation noise. Their data and the least-square quadratic fit is shown in Figure 2 to illustrate the large scatter that is observed in such surveys. The best-fit equation expressing the percentage highly annoyed (% HA) as a function of L_{dn} is given by:

$$\% \text{ HA} = 0.0360\, L_{dn} - 3.2645\, L_{dn} + 78.9181$$

It should be mentioned that the equation is for general transportation noise and not for aircraft noise only. It is possible that by excluding data from other transportation noise sources, a different best-fit curve could result.

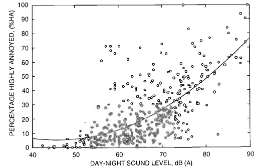
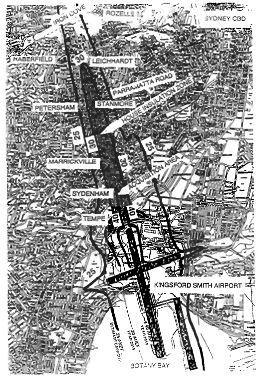


Figure 2. Relationship between percentage highly annoyed and L_{dn} based on community surveys on transportation noise (after [4]).

3. AIRCRAFT NOISE AND BUILDINGS

Aircraft noise as heard on the ground is transient and intermittent, with levels that first rise, reach a maximum and then fall. Field measurements near the Sydney airport indicate that typical aircraft noise reduction (ANR) for the bedrooms of houses with open windows is about 10–15 dB(A). For intermittent noise, interference with low-level conversation is not likely to become noticeable if the noise level at the listener's ear is less than 50 dB(A) [6]. The guidelines in the Australian Standard 2021–1994 [7] for the construction of houses exposed to aircraft noise suggest that design indoor sound levels for sleeping and relaxing areas be taken as 50 dB(A) for the purpose of determining the level of ANR required. Thus, internal sound levels for houses with open windows are likely to exceed recommended values if they are exposed to aircraft noise levels in excess of 65 dB(A). Because aircraft noise levels in excess of 65 dB(A) are common, it follows that lifestyle or building designs that call for open-window living cannot offer a satisfactory acoustic environment for locations near the airport.



For land use planning purposes and to define noise impact zone boundaries, it is convenient to draw contours using the ANEF concept described in AS 2021–1994. The ANEF contours around the Sydney airport adopted by the Federal Government for the aircraft noise insulation project are plotted in Figure 3. A number of assumptions on the future mix (number and type) of aircraft, flight paths, number of night-time operations and sound propagation conditions have to be made to arrive at the ANEF contours, and their accuracy will obviously depend on the accuracy of the underlying assumptions. According to AS 2021–1994 recommendations, land situated in the zone greater than ANEF 25 is not considered suitable for new residential development, but in the case of Sydney airport, it is estimated that approximately 4200 dwellings are situated in the ANEF 30–40 zone and about 16,000 are situated in the ANEF 25–40 zone. There were approximately 150 houses in the ANEF 40+ zone, but the government has offered to purchase these houses from the owners.

To determine the aircraft noise exposure of a given site, AS 2021–1994 states that one must use the long-term arithmetically averaged maximum aircraft noise levels provided in tabular form in the Standard. The use of field measurements, unless carried out over sufficiently long time to obtain an accurate long-term average, risks the possibility that short-term measurements may not be indicative of the long-term average, as noise levels from individual aircraft can vary due to several factors as discussed earlier in Section 2.

When using AS 2021–1994, one finds instances where improvements to the standard could be made and these include:

- The standard does not provide any information on the typical accuracy that could be expected from the tabulated noise levels for different aircraft types. Aircraft noise prediction models typically yield values that can vary by about 3 dB(A) from the measured values.
- The indoor design sound levels in Table 3.3 for houses and flats are divided into two categories only and there has been confusion/conflict in the interpretation or intentions of the standard as far as various internal spaces of a house are concerned.
- The method in the standard is based on calculations that have to be carried out on a room-by-room basis. During the aircraft noise insulation project, it was found that many householders prefer a perimeter insulation approach, and alternative guidelines for achieving recommended internal levels by building an effective acoustically shielded perimeter would be useful.
- For the Boeing 747 aircraft type, which is the noisiest aircraft type (excluding aircraft that are to be phased out), the tabulated data is for series 200 only. It would be desirable if the standard mentioned whether these levels also apply to other commonly used series such as series 300 and series 400, otherwise separate tables for these series are needed. Furthermore, as the noise levels received at a point on the ground, especially during take-off, can be affected by the loading factor, it would be useful if the standard stated whether the levels are based on light, moderate or fully loading condition or are the long-term average over all loading conditions.
- The standard provides numbers for the mean value only and does not provide any indications of the shape of the distribution curve around the mean. By evaluating a large number of measured data at distances up to 12 km, Meyer [8] of Germany was able to determine a statistical distribution function that yielded the rate of occurrence of certain maximum levels expected from a large number of aircraft passing over a given point. The distribution function was calculated by Meyer around the logarithmically averaged values, which can be slightly different from the arithmatically averaged values recommended and tabulated for use in AS 2021–1994. The distribution function is as follows:

If x is the difference between the individual value L_{Amax} and the logarithmically averaged value $\overline{L}_{Amax}$, then the number n of aircraft exceeding a maximum noise level $L_{Amax} = \overline{L}_{Amax} + x$ out of N aircraft of the same type, assuming that the maximum levels that are 10 dB(A) above and are more than 6 dB(A) below that mean value $\overline{L}_{Amax}$ do not occur, is given by:

for $-6 \le x \le -0.5$

$$\frac{n}{N} = 0.404408 - 0.28747x - 0.21019x^2 - 0.083947x^3 - 0.015333x^4 - 0.0010509x^5$$

and for $-0.5 \le x \le 10$

$$\frac{n}{N} = 1.005 - \frac{1}{\sqrt{2p}} \int_{-\infty}^{x} e^{-u^2/2}\, du$$

where $u = (x + 0.5)/3$.

It can be shown from the integral that the exceedance percentage for +3 dB(A) is 12.6%, for +4 dB(A) is 7.2% and for +5 dB(A) is 3.9%.

Caution is needed when using this distribution function as a universal function because the exact nature of the distribution around a specific airport may be dependent on the flight path patterns and other site-specific factors, but it does indicate that about 4% of the flyovers can generate levels that are 5 dB(A) above the logarithmically averaged value.

4. EXISTING AIRCRAFT NOISE REDUCTION (ANR) OF HOUSES

The results of the measurements of ANR provided by 20 houses situated in Sydenham near the Sydney airport are shown in Table 1. A typical house in Sydenham is of single-storey brick construction of about 100 m² floor area with a pitched tile roof in the front and a skillion metal-clad roof at the rear. The houses were occupied and furnished with normal furnishings at the time of measurements, and measurements were made with windows and doors closed. The external aircraft noise levels were measured by a Bruel and Kjaer outdoor microphone unit type 4184 connected to a Bruel and Kjaer real-time frequency analyser type 2143. The internal noise levels were measured at three locations (main bedroom, living room and kitchen) using Bruel and Kjaer's sound level analysers type 2260 and a precision integrating sound level meter type 2230 connected to Bruel and Kjaer sound level recorders type 2317. A-weighted sound pressure levels using 'S' time-weighting characteristic were measured at a microphone height of 1.2 m. The difference between the external and internal maximum A-weighted sound pressure levels during an aircraft flyover, averaged for typically about ten aircraft flyovers, was taken as the ANR of the area monitored.

TABLE 1

Typical ANR for houses near Sydney airport

S.N.	Main bedroom	Living room	Kitchen/dining
1	32	25	25
2	35	24	21
3	28	31	27
4	25	28	28
5	30	30	24
6	27	28	23
7	27	25	20
8	31	25	21
9	34	24	16
10	28	29	23
11	31	28	20
12	29	27	18
13	26	29	29
14	35	31	28
15	36	28	22
16	23	31	29
17	24	22	14
18	32	32	32
19	33	23	23
20	30	30	36

It can be seen from Table 1 that the ANR for bedrooms with windows closed is substantially higher than typical ANR with windows open, suggesting that one thing the occupants can do themselves to reduce the aircraft noise impact is to close the windows and doors, if practicable and convenient.

The individual ANR values for the main bedroom of the 20 houses range from 23 dB(A) to 36 dB(A); for unfurnished rooms the expected ANR would be somewhat lower than these values because of the absence of sound absorption. Kitchen/dining areas tend to have acoustically hard surfaces and generally also have openings for the removal of odours and fumes, and thus their ANR is frequently lower than the bedrooms.

5. ACOUSTIC INSULATION TREATMENTS

When a new house is to be built in an area affected by aircraft noise, usually there is a greater degree of flexibility in the choice of materials and design, but for existing dwellings the choice may be limited because of the construction materials and design features that already exist. There are four competing issues that require consideration when acoustic upgrading measures for existing houses to improve their sound insulation characteristics are being planned. These are:

- Acoustic issues – from an acoustic viewpoint, the upgrading work should start at the acoustically weakest component or element and then progress towards the next weakest link and so on. The relative areas of the building elements and the balanced construction concept (i.e. elements transmit equal amount of sound energy) should be kept in mind at all times.
- Cost issues – not only the cost in absolute terms but also the additional cost versus incremental benefit can be an important issue, especially if a large-scale sound insulation project is being considered.
- Practicability issues – this covers issues such as the need to minimise any impact on the functional use of the internal space and requirements for major structural alterations.
- Acceptability to occupants and local councils – proposed acoustic upgrading measures that are not aesthetically pleasing or are cumbersome to use are likely to be unacceptable to the occupants. Local Councils may not approve of changes that affect the heritage value, streetscape, or general appearance of a house, and will certainly not approve alterations that do not comply with relevant building codes and regulations.

The weakest links in a house are the gaps, openings and vents exposed to outside. These have to be identified and appropriately closed. The external doors (both front and back) should at least be upgraded to solid-core with perimeter seals and, in high noise exposure situations, one may have to use sound-rated doors. Existing fireplaces can be made airtight and, if not used, can be sealed. The need for timber floors to breathe means that in such houses the subfloor area cannot be sealed, however, adequate amounts of subfloor ventilation can be provided with noise-attenuated vents built using the lined-duct principles.

The next weakest links in a house are likely to be windows. In many houses near the Sydney airport, the existing windows are double-hung with no seals and generally cannot be replaced because of issues mentioned earlier. One can improve their acoustic performance slightly by adding seals. For extra cost, one can increase existing glass thickness from 3 mm to 5 mm (existing frames usually can't take higher thickness). New secondary windows are still necessary and can be installed behind existing windows without affecting street appearance. For domestic-type windows, the practical limits for glass thickness are 6–10 mm for float glass or approximate equivalent if laminated glass is used. The acoustic benefit of secondary glazing will depend not only on the glass thickness but also on the airspace between the panes. The minimum airspace recommended for acoustic applications is generally 100 mm and often the minimum airspace has to be adopted during sound insulation upgrading work because of small room size of houses near the Sydney airport and the need to minimise intrusion into the room as well as for aesthetic reasons. Doubling the airspace typically increases the STC by 3 and it can also improve the low frequency performance, as can be seen from laboratory STL measurements carried out at the CSIRO-DBCE North Ryde laboratory on 7 mm laminated glazing (3/1/3 mm) and 5 mm glazing at different airspaces (Figure 4). Further small increases in sound insulation can be achieved by adding sound-absorption in the window reveals. It should be mentioned that the overall noise reduction provided by a window system is governed by the window type and size, window seals, window frame, method used for glass mounting and of course installation details.

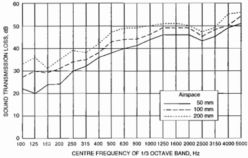


Figure 4. Sound transmission loss of 7 mm (laminated) and 5 mm double-glazing.

The typical STC range for a pitched roof/ceiling construction or metal-based roof/ceiling system is 33–35. By adding fibrous thermal insulation material such as batts or blanket, the sound insulation of the roof/ceiling construction can be improved, but further increases are necessary to reduce aircraft noise impact. One upgrading method is to add an additional layer or layers of plasterboard or rigid timber board on top of the ceiling joists after installing sound-absorptive material in the cavity between the joists. This method imposes significant practical difficulties and cost penalty and can involve structural upgrading. An alternative method in which one or two layers of loaded vinyl material (such as Wavebar or Acoustiflex) of mass/area in the range 4–8 kg/m^2 are installed on top of the ceiling joists by overlapping sheets and taping, has been used for houses near the Sydney airport. Additional mass/area of about 12 kg/m^2 can be easily added to the existing roof/ceiling of houses, but some structural strengthening may be necessary if higher values are used.

Ideally one would like to compare the STL versus frequency curve for complete roof/ceiling systems as modified by additional plasterboard and as modified by additional loaded vinyl, but in the absence of such data, one may make an approximate comparison by examining the STC for a layer of 10 mm plasterboard and a layer of 4 kg/m^2 loaded vinyl, keeping in mind the limitations of single-number STC ratings. Typically a layer of 10 mm plasterboard yields an STC of about 26–27 and, according to manufacturers' data sheets, the STCs of 4 kg/m^2 Wavebar and Acoustiflex are 26 and 25 respectively. Measurements made at the RMIT laboratory in Melbourne on 4 kg/m^2 Wavebar by installing the material in a steel frame comprising 64 mm steel studs at 600 mm centres, however, yielded an STC rating of 23. Changing the plasterboard thickness to 13 mm or changing the mass/area of loaded vinyl to 6 kg/m^2 is likely to add about 2 or 3 to the STC ratings.

For brick houses, considering the level of sound insulation of windows and roof/ceilings, after the upgrading treatment described above, the walls can be left untreated. On the other hand, walls of lightweight construction will require upgrading if they are not to become the weak link. Measures that can be undertaken for upgrading such walls include conversion to brick-veneer or improvements made by adding cavity absorption and additional mass in the form of layers of plasterboard or loaded vinyl. If sufficient internal space is available, the layers can be added internally by fixing timber battens to existing lining. Exposed timber floors can be upgraded by constructing a brick perimeter enclosure with sufficient vents (noise attenuated, if necessary) to allow the floor to breathe.

For the aircraft noise insulation project, the owners have been given some flexibility and choice in deciding on the acoustic treatments adopted for their houses. For example, an owner may prefer sliding windows instead of casement windows or may choose to leave a particular area untreated. As a result, the actual ANR achieved may be slightly less than the optimum possible value.

Finally, it should be mentioned that after the acoustic insulation work has been carried out on a house, some form of mechanical ventilation will become necessary for the well-being of occupants. Such systems have been installed in all houses that have been sound insulated near the Sydney airport. When offered a choice between reverse-cycle air-conditioning and other forms of mechanical ventilation system, the owners showed a clear preference for air-conditioning. Proper design and careful installation of such systems is necessary to prevent them becoming a source of unnecessary noise nuisance.

6. COST OF INSULATION TREATMENT

For an initial group of about 200 houses acoustically insulated in the Sydenham area, the typical acoustic upgrade costs have averaged almost $37,000 per house. Of this amount, provision of reverse-cycle air-conditioning averages about $9000–10,000. These relatively high air-conditioning costs reflect standards above those common in domestic installations. In particular, the units have been customised for the project to be concealed in the roof space wherever possible and to shut down in the event of smoke detection; they are designed to deliver adequate fresh air necessary due to the sealed nature of an acoustically insulated house; they are built to be highly economical in operation; and they comply with property boundary noise constraints. Typical costs for the treatment of building elements are about $3000–4000 for closing gaps, vents and installing or replacing doors/door seals, about $1300 per window for the sealing of existing window and the installation of secondary window, and about $90–105 per m^2 for installing a layer of sound absorptive material plus two layers of 6 kg/m^2 loaded vinyl in the roof/ceiling space.

7. IMPROVEMENT AFTER TREATMENT

Measurements made on brick houses after the acoustic upgrading treatment work described above, suggest that typically it is possible to achieve an ANR of about 40 dB(A) in the bedrooms. The actual ANR achieved will vary from house to house depending on several factors, including the amount of absorption present in the room concerned. The improvement in ANR for a particular house will depend on the initial ANR before acoustic treatment and for houses with relatively high initial ANR, the additional improvement expected should be smaller. The before and after ANR measurement results for the main bedroom of ten occupied houses which were monitored after acoustic treatment by commercial builders without specialist knowledge of acoustics are shown in Table 2. For house S.N. 10 in Tables 1 and 2, the main bedroom before treatment refers to bedroom 2, as the front main bedroom (bedroom 1) was being used as a home office, but the after-treatment ANR was measured in bedroom 1.

TABLE 2
The ANR of main bedrooms of houses before and after acoustic treatment

S.N.	ANR of main bedroom, dB(A)	
	Before treatment	After treatment
1	32	41
2	35	39
3	28	36
4	30	42
5	33	40
6	32	46
7	35	39
8	36	44
9	27	43
10	28	40

The final ANR of areas other than bedrooms will depend on the extent of the acoustic upgrading work undertaken for these rooms or spaces. If some areas are not treated, the possibility of sound entry via these areas to the treated areas should not be overlooked and should be prevented as much as practicable.

In timber houses, unless the external walls are upgraded to a masonry-type construction, such as by conversion to brick-veneer, an ANR as high as 40 should not be expected. However, the ANR of timber houses before acoustic upgrading treatment can be about the same as for brick houses because the overall sound insulation is generally controlled by the gaps, openings, windows and doors rather than the walls of the house.

8. CONCLUSION

There are several thousand houses near Sydney's Kingsford Smith airport that are located in ANEF zones not considered suitable for new residential construction if the criterion of the Australian Standard 2021–1994 is used. The majority of residents of these houses are likely to be highly annoyed by noise because of the exposure to high levels of aircraft noise. The aircraft noise reduction (ANR) provided for occupied houses near Sydney airport has been measured both before and after undertaking acoustic upgrading measures and the results indicate that, for brick houses, typically an ANR of about 40 can be achieved for bedrooms by carrying out the measures described in this paper. Some form of mechanical ventilation system is necessary after the acoustic upgrading work has been done, and the house owners have clearly preferred air-conditioning systems rather than other types of mechanical ventilation. Typical costs in 1996 dollars for carrying out the acoustic insulation work for the houses by licensed commercial builders are given in Section 6.

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Pilkington Float Glass Plant Noise Control

Environmental Noise Control Case Study

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In this case study we have set out to illustrate some of the problems and noise control methods that are routinely used by practising acoustical engineers to reduce environmental noise emission from a large engineering works. The mathematics on the reflection, diffraction, transmission, absorption, diffusion and dispersion of sound are both complex and fascinating and form an integral part of every noise control project. In this case study we have preferred to look at the why's and the how's of noise control on a major project, rather than get caught up in the mathematical intricacies of sound propagation. The principles of noise control are much the same whatever the size of plant involved. However, a float glass plant worth over $80M is large enough and noisy enough to be a trifle daunting. Overcoming some of the problems required more than a little ingenuity.

On 14 May 1987 the Minister for Planning and Environment, Mr Bob Carr (now Premier of NSW) approved a development application by Pilkington ACI to establish a Float Glass Plant on a green field site at Ingleburn, NSW. One of the conditions of consent was:

"The Applicant shall install noise control equipment in accordance with the requirements of the State Pollution Control Commission and the development shall be operated so as not to exceed noise levels approved by the Commission." Pilkington chose to leave the resolution of this seemingly innocuous requirement to the acoustical engineers at Day Design Pty Ltd.

The new Float Glass Plant location is approximately 1 km from the nearest quiet residential area in Ingleburn (to the South of the plant) and 400 metres from the nearest residential premises at Denham Court (to the North of the plant near the M5 Motorway). Undeveloped industrial land was located on either side.

In July 1987 the State Pollution Control Commission set L10 noise contribution limits at nearby residences at 38 and 43 dB(A) respectively for night-time and day-time operation of the plant.

Solving any large problem is often best achieved by reducing it to a number of more easily digested bite-size problems. We considered the plant in the following seven smaller segments:

Services Plant Room
Fin Fan Coolers
Furnace Building
Bath Building Lehr Building
Cullet Transfer Building
Batch Plant

Late in 1987 we were handed a set of architectural plans and given the best wishes of the project managers, Howie Herring & Forsythe Pty Ltd and asked to prepare a Noise Impact Report, complete with recommendations for cost-effective control of noise from the plant.

The starting point in preparing a Noise Impact Report is to find out how much noise the proposed development is going to produce. We determined the sound power levels for all major items of plant either by measuring the sound levels at a similar Pilkington float glass plant in Melbourne, or by obtaining sound power data from fan and other equipment suppliers. Determination of sound power levels of machinery operating inside or adjacent to factories cannot be achieved using classical laboratory or free field techniques. Over the years we have developed our own techniques for fast and accurate determination of sound power levels inside semi-reverberant factory areas and near large reflective surfaces.

Predicting the level of noise intrusion at nearby residential premises involves mathematical modelling on computer. We used our own well-proven custom-written software to estimate noise emission from the seven items of plant, making due allowance for distance loss, building element sound transmission losses, barrier losses, land topography effects, silencer insertion loss, directivity losses, molecular absorption, temperature inversion effects, wind refraction, etc, assuming the "worst atmospheric condition".

The predicted typical maximum level of noise emission from the float glass plant (without noise control) was found to be to be in the order of 60 dB(A) at nearby residences. To limit the L_{A10} noise emission to 38 dB(A) required 22 dB(A) noise reduction.

1. Services Plant Room

Float glass manufacturing is a continuous operation. Molten glass is drawn out of the furnace continuously, conditioned and cooled in the Lehr, then cut into large panels for distribution, or broken and recycled. Once started, the plant must operate 24 hour per day, 365 days a year, and can only be closed down (at great cost) for major furnace refractory repairs, etc. To cope with the possibility of electrical power failure a number of large standby diesel alternators and diesel pumps are required. These are housed in a Services Plant Room. Noise control was achieved by means of masonry walls, metal deck roof, insulated plasterboard ceiling, silenced cooling-air intake and discharge ducts and tandem engine exhaust silencers. Plant room doors were of solid-core timber fitted with acoustic seals. Ventilation openings were fitted with duct silencers.

2. Fin Fan Coolers

The float glass manufacturing process requires the dissipation of large amounts of heat. This is achieved by large air cooled fan-coil units termed Fin Fan Coolers by their suppliers Jord Engineers Pty Ltd. The initial proposal by Jord Engineers was for the supply of a set of six 4 metre diameter Fin Fan Coolers (running at 220 rpm) with a potential contribution of 55 dB(A) at the nearest residential area. The cost of erecting an acoustic enclosure with air intake and discharge silencers to reduce the noise by almost 20 dB(A) was estimated to be almost $200,000. The suppliers were approached with the problem and it was found more economical for them to offer a set of four 6.7 metre diameter Fin Fan Coolers (running at 70 rpm) that did not require any further noise control. Measurements by Day Design after commissioning of the plant confirmed that the 20 dB(A) noise reduction was achieved by this simple and cost-effective expedient.

Many engineers are skilled in the use of fan laws to predict noise emission for various diameters and speeds. A better selection at the initial design stage is often the most cost-effective method of controlling fan noise. A constant and bitter complaint of acoustical engineers is that we are not consulted early enough to influence the equipment selection. Too often the design team has the afterthought: "perhaps we had better call in an acoustical consultant to check the noise levels". Sometimes the equipment is on order and the only recourse is an expensive enclosure complete with duct silencers. Fortunately, this was not the case with the Pilkington Float Glass Plant at Ingleburn, NSW.

There is a danger of fatigue-failure when using large diameter aluminium blade rotors. In this case we made sure that the natural resonant frequency of the blades did not coincide with the forcing frequency of the fan. There has been no problem with blade fatigue-failure.

3. Furnace and Bath Buildings

The heart of the float glass plant is the gas-fired glass furnace, where the raw stock materials are melted down to glass and then floated out over a bath of molten tin into the Lehr. The furnace employs a dual regenerative combustion system in which the primary and secondary combustion air is pre-heated by passing through a refractory lined regenerator. Most of the combustion noise is contained within the heavy refractory-lined walls of the furnace.

Dissipating the excess heat from the furnace is a major problem. The furnace building was designed with a large expanse of open louvres in the furnace-building walls to allow the entry of cooling air. These large ventilation openings in the walls made the containment of noise very difficult. A 14m x 36m vertical-discharge Robertson natural draft Roof Monitor vent was provided to allow the discharge of hot air. Noise emission from this vertical-discharge roof vent was a source of concern. It was large enough to emit a considerable volume of sound, but the directivity loss for such a large vent was uncharted territory in 1987. It was decided to provide acoustic lining of the Monitor at a later date if required. It was later found to be unnecessary, so a significant saving was achieved.

The vast quantity of air required for cooling of the furnace walls was supplied by a number of large axial flow fans. These were a significant source of noise at nearby receptor locations, many of them requiring approximately 25 dB(A) noise reduction. This was achieved by fitting air intake and discharge duct-silencers, and/or providing acoustically lined air intake plenums. All combustion and regenerator fans were fitted with air intake duct silencers.

One of the major noise sources noted while inspecting the Pilkington, Victoria, float glass plant was that caused by the natural-gas pressure-reducing assembly. About 20 metres of large diameter piping on the downstream side of the pressure reducing valve emitted high noise levels (90 dB(A) at 1 metre) inside the furnace building. We recommended the fitting of micropore reactive-silencers downstream of the pressure reducing valves at the Ingleburn plant. This provided approximately 20 dB(A) noise reduction and pipe lagging was not required.

4. Lehr Building

The dissipation of heat was not such a problem in the Lehr building as in the Furnace building. With the exception of a ridge vent along the centre of the roof, we were able to seal this building to provide an adequate sound barrier envelope. The glass making process requires large quantities of cool air from outside the building to be drawn into the building by axial flow fans and blown into the Lehr. Hot exhaust air from the Lehr is drawn off by a series of centrifugal fans and exhausted to atmosphere. Air intake and discharge ducts were fitted with silencers.

5. Glass Cutting, Warehouse and Batch Plant

The major noise source in these areas is that caused by cullet and waste glass being broken and dropping into a waste hopper where it is conveyed back to the furnace for recycling. This is a cold process, therefore heat dissipation is not a requirement in this building. The buildings are therefore sealed and provide adequate sound insulation. The cullet dump hopper has since been enclosed to reduce occupational noise exposure, thus further reducing environmental noise emission from the plant.

6. Compliance Check After Commissioning of Plant

Given the significant distances to nearby residential areas and the presence of a Motorway and other industrial noise sources in the area, it is not possible to quantify the level of noise emission from an industrial development simply by measuring with a sound level meter in front of the nearest house. It is necessary to approach close enough to the factory to measure the noise emission above the background noise level, and then calculate the contribution from the plant at the nearest residences. We have carried out a number of annual noise compliance checks since the time of commissioning in 1988.

The first check was in April 1989, when it was found that the level of noise from the Pilkington float glass plant was either equal to or 2 dB(A) less than the specified criterion at each residential location. The next check was in August 1990, when we found the plant to be from 1 to 3 dB(A) less than the specified noise criterion at critical nearby residences. On the third occasion, in January 1992, under different weather conditions, we found the plant noise to be from 6 to 7 dB(A) below the specified noise criterion at the nearby residential premises. These results show that the "worst atmospheric condition" assumptions made for this project were correct.

Acoustics Memoirs - Some Byways

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Extract from Acoustics Memoirs, in course of preparation

Acoustics is both a science and an art – a science because it is a body of organized knowledge; an art because this knowledge requires imagination in its application. The science and art of Acoustics has a very long history: that of architectural and musical acoustics going back at least to the days of the Greek amphitheatres and the musical studies of Pythagoras (c. 570-500 BC). Most other branches of acoustics are of much more recent origin, such as the measurement and reduction of Noise (ie, unwanted sound).

The history of the conducting of noise tests in the sphere of public transport operations has quite a long history, in this country going back at least to M&MTB (Melbourne & Metropolitan Tramways Board) operations in the later 1920s. These early tests were conducted as a result of strong public complaint about "noisy" trams. Many of these complaints occurred in areas where, as a result of tram track construction, reconstruction or maintenance using tracks with concrete foundation, the wheel-on-rail noise ("wheel rumble" noise, including that of wheel "flats") had noticeably increased. Because it was known that a concrete track foundation was less resilient than ballast and sleepers, most of the early tests were conducted to compare the noise of a selected test tram travelling over tracks of ballast (both open and paved), concrete, and modified-concrete constructions. Modifications to a concrete foundation were generally of a kind that introduced some degree of resilience into the rail support by means of, for example, timber or rubber.

These early noise measurements made in the later 1920s were made with a locally developed "noise meter" consisting of a microphone, amplifier and indicating output meter. While the measurements of the noise made by a tram travelling over the various types of track enabled some *qualitative* comparisons to be made from the different output meter readings, there was then no satisfactory *quantitative* way of interpreting them. The noise testers of that time were still very much in the dark, for there were as yet no standardized form of noise meter and sound level and loudness units for satisfactorily interpreting the output meter indications in a fully quantitative way. In addition, such early instruments were not capable of coping with impulsive sounds.

With the introduction in the USA in the mid 1930s of national standards for *Noise Measurement* (ASA Tentative Standard Z24.2–1936), and for noise-measuring instruments such as the *Sound Level Meter* (Z24.3), the previous situation was greatly clarified. However, even then, many investigators concentrated too much on the sound level readings in decibels (dB), and tended to regard as of primary significance a change of ± 3 dB as representing a twofold change in sound energy (or intensity), or ± 6 dB as representing a twofold change in sound pressure, even though the relation between *Loudness and Loudness Level* (ASA Z24.3–1936, figure 2) showed that it was a change of the order of ± 10 dB which corresponded to a twofold change in the sensation of loudness.

For, in ASA Z24.3–1936 not only was *Loudness* only vaguely defined, but it was also not clearly stated that the loudness unit scale of ASA Z24.3–1936, figure 2 represented an arithmetic scale with scale numbers proportional to the sensation of loudness. This situation was not made clearer until, for example, in British Standard (BS) 661: 1955, Glossary of Acoustical Terms, *Loudness* was defined as "an observer's auditory impression of the strength of a sound (definition no. 3010)," and the sone (= 1 000 ASA Z24.3 loudness units) as "the unit of loudness on a scale designed to give scale numbers proportional to the loudness (defn 3011)."

Yet, these standard definitions, and other more general noise scales indicating, for example, that sound levels of 0 to 20 dB represented *very faint* sounds, 20-40 *faint*, 40-60 *moderate*, 60-80 *loud*, 80-100 *very loud*, and above 100 dB *deafening*, have not invariably been sufficiently persuasive to get the noise-makers to reduce their unwanted sound. It has taken other more detailed criteria – for example, the Maximum Permissible Speech Interference Levels for Reliable Speech Communication (AS 2822), and Maximum Noise Exposure Levels – and, ultimately, statutory Regulations for the Control of Noise to get the more stubborn noise-makers to act.

In Melbourne in the 1920s and 30s the chief remedies for minimizing tram wheel rumble were to maintain rail and wheel tread surfaces as smooth as possible, and free from corrugations and wheel flats. The M&MTB's continuing noise testing program was much helped by the purchase of a Sound Level Meter (a GR Model 759B) in the late 1930s, and by the establishment of an Engineering Testing Department in 1939 under the late Mr D H Eakins, whose organization included one or more engineers knowledgeable, inter alia, in making noise measurements. In this Testing Department, an early method of the statistical analysis of sound levels was developed in around 1950 by Mr K T Hall, by taking a large series of successive levels at about 3 seconds intervals, to obtain, for example, the resulting L_{10} and L_{max}. Also, the first M&MTB tape-recording of vehicle noise for later laboratory octave-band frequency analysis was carried out here by the author in 1957.

Over the intervening years, the problems of wheel-on-rail noise from trains and trams have been largely solved, through the use of resilient wheels, electric (including regenerative) braking, and resilient track foundations. The quieter operation of trains and trams in underground tunnels has been achieved, as is shown in the Melbourne Underground Rail Loop; and even "wheel squeal" on curved track has been significantly, if not always completely, reduced.

Product Feature

New PC-based Multi-analyzer System Enhances Productivity

By Roger Upton,

Brüel & Kjær Measurements A/S, 2850 Nærum, Denmark

1. INTRODUCTION

In recent years, productivity improvements from frequency analyzers have largely depended on improved technology allowing faster and faster measurements. As a result, most measurements in sound and vibration applications are already being performed as fast as the rules of physics allow. Further productivity improvements cannot therefore come from faster measurements alone, (although faster measurements are still beneficial for other reasons). They can only come from rethinking and restructuring the analyzer itself.

The PULSE PC-based Multi-analyzer System Type 3560 from Brüel & Kjær does just that. It does it by allowing multiple analyzers to be defined in the same system, enabling measurements to be made in parallel where previously they had to be carried out in series. It does it through a novel Windows-based graphical user-interface, using a Project, WorkBook, and WorkNote concept incorporating years of Bruel & Kjær applications experience, to help get the user up-and-running as quickly as possible. It also does it by utilising the latest software tools such as OLE 2.0 to significantly reduce the amount of time spent generating reports.

As a result, PULSE enhances productivity in three major areas. These are reduced testing time, reduced set-up and learning time, and reduced reporting time.

2. The PULSE Concept

2.1 Hardware and Software Overview

The PULSE hardware platform is based around standard commercially available PCs and a Brüel & Kjær front-end. One or more DSP cards are added to the PC to increase processing power. This approach has been chosen to take advantage of the rapid advances in technology being seen in the PC and DSP world. Up to four DSP cards, each capable of 250MFLOPS, can be installed in a single system. This makes PULSE a scaleable system which allows the user to select the degree of performance desired in terms of number of channels, frequency range, and/or real-time performance. Depending on the configuration, the maximum number of channels is 32, the maximum frequency range is 102,4kHz, and the maximum real-time bandwidth capacity is 1,6MHz. The signal conditioning and front end are external with digital transmission of data back to the computer. PULSE is available in both AC and DC powered configurations allowing, for instance, in vehicle as well as stationary use. Figure 1 shows a transportable version of PULSE being used for noise measurements in an anechoic chamber.

The PULSE software, which operates under MS Windows NT, has been designed, developed, and tested by Brüel & Kjær. The software is modular, and is collectively described under the name of the PULSE LabShop. Individual software packs are called LabShop Tools. Noise and Vibration Analysis and Data Recorder LabShop Tools will be available with the first deliveries of PULSE. An Order Tracking LabShop Tool will be available later in 1996, as well as Sound Quality software running on the PULSE platform. Further LabShop Tools software packs will become available throughout 1997 and beyond. An overview of PULSE is given in Fig. 1.

2.2 Multi-analyzers, Signals, and Signal Groups

An important part of the PULSE concept is the idea of multi-analyzers, signals, and signal groups. Multi-analyzers allow multiple different analyzers to be implemented and simultaneously operated in the same hardware. The current PULSE LabShop software allows FFT, real-time digital filter-based fractional octave (CPB), and overall analyzers. The Order Tracking software will add order tracking analyzers. Depending on the number of DSP cards installed, in the current version, a single PULSE system can have up to 8 different analyzers operating simultaneously.

The concept of multi-analyzers as implemented in PULSE offers the user the benefit of potentially large savings in testing time, by enabling measurements to be made in parallel which otherwise would need to be made in series. A good example here is FFT, CPB, (and overall), analyzers being used simultaneously for combined noise and vibration measurements.

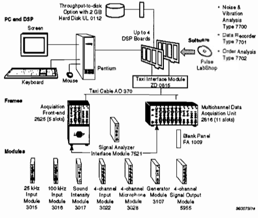

Figure 1. An overview of the PULSE hardware and software

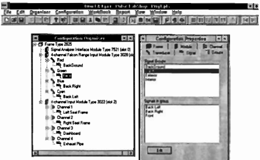

Figure 2. Channels, Signals, and Signal Groups, as defined in PULSE.

The concept of signals and signal groups are central to the set-up of PULSE and are illustrated in Fig. 2. The same physical input can yield multiple signals, connected for instance to different analyzers. The connection is made in software eliminating the need for extra external cabling. Each signal can be given a descriptive name which is carried through the entire system to identify that signal.

Multiple signals can then be collected into groups, for instance, signals to be connected to the same analyzer or signals representing the same physical source. Each group can then be handled as a single entity. This greatly simplifies set-up procedures on PULSE in multi-channel applications. Each signal group can also be given a descriptive name which is carried throughout the system to identify it.

2.3 Projects, The WorkBook, and WorkNotes

A major part of the PULSE human interface is the use of Projects, the WorkBook, and WorkNotes. They allow PULSE to be at the same time a system which can be operated at both high and low levels. Through Projects, the WorkBook, and WorkNotes, PULSE can be set up, for instance, by engineering staff, and then used by technical or even non-technical staff.

Projects allow customisation of PULSE to different applications. They allow complicated measurement procedures to be predefined and then accessed in a minimum of mouse (or keyboard) operations. Multiple Projects can be stored on PULSE. Each LabShop Tool software pack contains a number of predefined Projects for the more standard types of application, for instance mobility measurements, simple mode shape identification, or product noise measurements. They can be used unmodified or can be adapted to special user requirements. A further element of customisation is the possibility of externally programming special cursor and post processing functions and installing them on-the-fly.

A Project is a file containing anything and everything required to define the procedures needed for an application. The WorkBook is used to aid project management. The WorkBook contains those layouts needed by PULSE to carry out the application. The layouts are defined through a number of organisers. This will later be stored to the WorkBook. Projects and layouts alike can be given descriptive names to aid in their identification.

A single Project can contain many layouts in the WorkBook, so the need arises to provide additional documentation. This done through WorkNotes. A WorkNote can be attached to each PULSE layout in the WorkBook. The level of documentation in a WorkNote can vary from simple text to embedded objects such as MS Excel spreadsheets, and even video sequences used, for example, to indicate transducer locations in a complex measurement.

The concepts of Projects, the WorkBook, and WorkNotes, allow PULSE to be used by both experienced and inexperienced users. Experienced users can create their own Projects. Inexperienced users can use the predefined projects contained by the LabShop Tools software packs.

2.4 Report Generation

During the research into the specifications of PULSE, a major area for improvement in productivity was identified as report generation. Analyzer system users require fast and easy transfer of screen images to standard word processing software. In PULSE this is implemented through OLE 2.0 which enables in a few seconds the transfer of PULSE data to MS Word. Report templates can be created in advance, where required, allowing quick and easy report generation for repetitive tests.

3. Other Aspects of PULSE

3.1 Front-end and Calibration

To simplify set-up procedures, PULSE automatically detects the front-end hardware. Where a predefined project is being used, it is then only necessary to specify details of the transducers. To aid in transducer selection, PULSE has a transducer database that is used to contain details such as transducer sensitivities, last calibration data, calibration curves, and so on.

Calibration of a PULSE measurement chain is a straightforward matter and can be performed before or after measurement. It uses an automatic detection procedure that identifies which measurement channel contains the calibration signal and calibrates that channel accordingly. This allows the measurement channels of PULSE to be calibrated in any order, simplifying the calibration procedure for multi-channel systems. Calibration details are transferred to the configuration to enable any variations in transducer/input sensitivity to be logged.

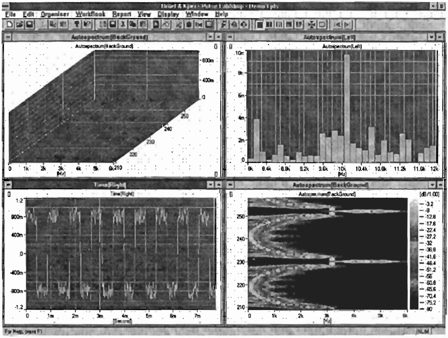

Figure 3. Typical data displays on PULSE. The actual display is in full colour.

3.2 Display of Data

The display of PULSE data takes place on a standard PC monitor. The number of windows which can be simultaneously displayed is limited only by the resolution of the monitor. Depending on the complexity of the screen display, screen refresh rates of up to 50 times/sec are possible to give true real-time response. This is beneficial in applications such as real-time noise source location.

PULSE takes full advantage of MS Windows NT to provide flexible display formats. A few of the many formats available are shown in Fig. 3.

3.3 Data Recorder

The Data Recorder LabShop Tool software allows the recording of time history data on a PC hard-disk. Up to 32 channels can be recorded and then replayed for analysis.

A Throughput-to-disc hardware option which ensures gap-free recording is also available and uses a dedicated 2GB SCSI-2 hard-disk. This hardware option allows simultaneous data analysis and throughput-to-disk. The maximum recording rate to disk is 400kHz channel-bandwidth product for over 16 minutes. This translates, for example, to 16 minutes/channel of real-time data in 32 channels with a frequency range of 12.5kHz. Reduction of the number of channels allows even higher real-time throughput rates. Reduction in the number of channels and/or the frequency range also allows longer time signals to be recorded.

3.4 Automation of PULSE and Systems Engineering

PULSE fully supports OLE 2.0 automation and can be automatically controlled from programs developed, for instance, in Visual BASIC or Visual C++. This, combined with the Project, WorkBook, and WorkNote concept described previously allows fast and easy automation of PULSE measurement procedures. These are highly relevant to repetitive testing. They also make PULSE a very open system in relation to systems engineering where PULSE is part of a larger measurement system.

4. CONCLUSION

PULSE is a next generation analysis system offering significant improvements in productivity, together with scaleable performance, openness to customisation, and a long term growth path through increasing numbers of LabShop Tool software packages becoming available with time. It has been built to meet the specific needs of today's (and tomorrow's) busy engineer. In this respect it is more than just an analyzer, and is as well a measurement platform and applications measurement tool.

Books...

Mechanics of Musical Instruments

Edited by A Hirschberg, J. Kergomard and G. Weinreich

Springer-Verlag, 1995, 369 pp. soft covers, ISBN 3-211-82801-X, Aust. distributor DA Information Services, PO Box 163, Mitcham Vic. 3132 Price A$99.

The zeroth order mechanics of musical instruments is easy: first year physics courses introduce linear, steady state standing waves in idealised strings and cylinders of air without loss or excitation mechanisms. To understand the musically important mechanics of instruments is not easy. To cite the example in the introduction of this book, the steady-state interaction between read and air column in a clarinet is dominated by the fundamental frequency of the periodic standing wave, of which the higher harmonics are quite small components. Yet the sound is dominated by the high harmonics which are more efficiently radiated and to which our ears are more sensitive. Thus the output sound, and especially the characteristic transients, are dominated by effects which are very small compared to the steady standing wave in the instrument. Conclusion: small, higher order effects cannot be neglected. Nor can the highly non-linear operation of the excitation mechanisms, nor of course the losses (among which radiated sound is usually a minor component) which determine the amplitude of steady vibration. Even if we understand one steady note we have a long way to go: what is important to a musician includes the variation of the instrument's behaviour over all its notes, its response to different input parameters and its transient response.

An advanced text like this one raises the fundamental question: is it worthwhile analysing musical instruments in the relatively great detail required to obtain musically useful results? The editors cite two examples: first, it is useful to be able to design in advance such features as the placement of tone-holes which will give a desired relative intonation. The quarter-tone flute, in which one extra key allows quarter-tone displacement of all the standard fingerings, was designed using a physical model. Virtual instruments provide another example: increasing processing power is making it easier to synthesize sounds using physical models of instruments which may or may not exist. (For example: the long strings of grand pianos offer advantages over those of uprights. How would a piano sound with even longer strings?)

This rather advanced text on the analytical mechanics of musical instruments is based on lectures given at a workshop at the International Centre for Mechanical Sciences in Udine, Italy. Its rather brief introduction is followed by a chapter on mechanical oscillations by P. Hagedorn. This is classical applied mathematics: linear and non-linear oscillators, forced oscillations, damping, self-excitation, bending waves in beams and plates. In short it has a detailed treatment of much of the sections of applied mathematics which are applicable to musical oscillations. This is a useful resource, but the drawback is that no applications to musical instruments are given.

Gabriel Weinreich's chapter is on vibration and radiation of linear, continuous bodies. His approach is more physical than mathematical, and he immediately addresses the relevant examples of sound boards and membranes.

Claude Valette treats vibrating strings, dealing in turn with the complications of real strings: the longitudinal and torsional modes which complicate the 1st order lateral vibrations, dispersion and inharmonicity, end effects, damping, non-linear modes and mode coupling. It is not light reading, but the reader is rewarded with regular examples, both experimental and simulated.

Jim Woodhouse's chapter takes a physical approach and deals chiefly with the complexities of the bow-string interaction, the detailed departures from steady Helmholtz motion which result from such things as frictional hysteresis, finite string curvatures, mode coupling, non-rigid boundaries (e.g. wolf-notes) and the starting transients which are so important to players.

J. Kergomard analyses what he calls a highly simplified interaction between the clarinet air column and reed, and the loss and dispersion in the former. Even treating the reed as a one dimensional oscillator subject to a couple of control parameters (a simplification which may disappoint those musicians, the reviewer included, who have spent hours choosing, scraping and fussing over pieces of cane) the behaviour is complicated, and many of the musical features of the real instrument are predicted.

The final chapter is Miko Hirschberg's introduction to aero-acoustics using the approximation of non-linear, locally non-compressible flow to discuss the onset of turbulence, flow separation and vortex production. I found this chapter both hard work and interesting for the simple reason that it was the area in which I was most ignorant, but this might be true for many students and researchers in musical acoustics.

There is no index, nor even a detailed table of contents. This is a disappointment in a book which will be consulted as a reference. Three of the chapters have lists of symbols and conventions.

Who will buy this book? Researchers in musical acoustics will certainly want a copy, but who else? It is not, and does not intend to be, an introduction to musical acoustics. It is primarily about the mechanics of the instruments, and not much about what goes into or comes out of them, or their raison d'etre. (Indeed there was something odd about the workshop whence this book comes: despite the subject matter and the many musicians present, there was no music.) The physical scientist or engineer seeking to understand how musical instruments work would do better to start with, for example, Fletcher and Rossing's "The Physics of Musical Instruments" and come to this book for a more detailed treatment of particular topics. I can think of other readers, however: a large fraction of physical scientists and engineers are musicians themselves and we cannot help asking Why? and How? Why doesn't the instrument speak more quickly? What parameters determine the starting transients? How are subharmonics produced? What goes on at the limits of bowing force? For many such questions this book will be a helpful guide for the reader who already has a general introduction to musical acoustics.

Joe Wolfe

Joe Wolfe is an Associate Professor of Physics at the University of New South Wales. He undertakes research on membrane biophysics and on musical acoustics, and plays the oboe.

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Writing a thesis

Joe Wolfe has recently written a document "How to write a PhD thesis" and placed it on the web at http://www.phys.unsw.edu.au/postgrad/thesis.html

Joe welcomes any comments on this document.

News...

International Congress Combined with 1997 AAS Conference

The 1997 annual conference of the Australian Acoustical Society will be held jointly with the 5th International Congress on Sound and Vibration at The University of Adelaide, South Australia, December 15-18, 1997. There will be four full days of technical sessions as well as an extensive social and cultural program. It is also planned to hold tutorial sessions on specialist topics in sound and vibration which will be given by specialists in the particular fields. The Fifth Congress follows previous congresses held in the USA, Canada and Russia in 1990, 1992, 1994 and 1996, all of which attracted several hundred delegates. There will be a total of eight keynote presentations given in plenary sessions by eminent acousticians as well as specialist keynote papers in some of the parallel sessions.

For those wishing to present papers, the deadline for abstracts is March 15, 1997 and the final papers are due (on special matts) by August 15, 1997.

The Dave Bies prize for excellence in Acoustics in South Australia will be presented. Nominations are very welcome.

Full advantage will be taken of the long balmy days with a complimentary cocktail reception on the Sunday evening preceding the Congress, a complimentary Australian BBQ at Cleland Wildlife Park on the evening of December 15, a banquet on the 17th, pre and post congress tours and a lively accompanying persons program.

Companies are invited to take part in the exhibition which will include instrumentation and electronics, acoustical apparatus and materials, sound and vibration isolation devices and software. Exhibition information and booth and table reservations are available from the Congress Secretariat.

Further information: Congress Secretariat, 5th International Congress on Sound and Vibration, Department of Mechanical Engineering, University of Adelaide, SA 5005 Tel +61-8-8303-5460, Fax +61-8-8303-4367 email:icsv5@mecheng.adelaide.edu.au WWW: http://www.io.org/~webland/icsv5.html

WESTPRAC 97

The Western Pacific Regional Acoustics Conference (WESTPRAC) is to be held for the second time in HONG KONG under the leadership of Hong Kong Institute of Acoustics. Over the last decade of rapid urban development, Hong Kong has changed remarkably not only in her urban townscape but also in the integration of many acoustic developments for the well being of her people. It's time for every one who has contributed to the acoustic achievements for a conference for refresh, renew and rally in Hong Kong again.

The conference will include Plenary lectures, structured technical sessions, contributed paper presentation, site visit etc. The technical sessions cover all areas of acoustics. WESTPRAC'97 will be held from 19 November to 21 November, 1997 in Hong Kong Nikko Hotel.

Further information: S.K.Tang, Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong, Fax: 852-27746146, besktang@polyu.edu.hk

INTERNOISE 97

INTERNOISE 97 will be the twenty-sixth in a series of international congresses on noise control engineering that have been held all over the world since 1972. The theme of INTERNOISE 97 is "Help Quiet the World for a Higher Quality Life". It will be held in Budapest, Hungary from 25-27 August. Proposals for papers in all areas of noise control engineering are welcome. Abstracts of papers proposed for presentation at INTERNOISE 97 must be received by the Technical Program Chairman no later the 30 November 1996. The abstract should be approximately 250 words in length, and must be submitted in the format attached to the announcement.

A major acoustical equipment, materials and instrument exhibition will be held in conjunction with INTERNOISE 97. The exhibition will include materials and devices for noise control as well as instruments such as sound level meters, acoustical signals processing systems, and equipment for active noise control.

Further information: Internoise 97, OPAKI, H-1027 Budapest, Fő u. 68, Hungary. Fax +36-1-2018843

ACTIVE 97

ACTIVE 97, the 1997 International Symposium on Active Control of Sound ad Vibration, will be held at the Technical University of Budapest, in the capital of Hungary from 21-23 August 1997. It thus immediately precedes INTERNOISE 97. In continuation of a series of meetings being held in Blacksburg, Virginia and Newport Beach, California from 1991 to 1995, ACTIVE 97 will be the first international conference on active control in Europe. According to it's predecessors, ACTIVE 97 is planned to present six plenary keynote lectures covering current aspects and latest developments of active noise and vibration control. In addition, approximately 150 technical papers are expected to give a broad overview of current activities and thus enable an intensive exchange of ides, concepts and results.

Technical papers in all areas related to the active control of sound and vibration are welcome. Abstracts for papers proposed for presentation at the symposium must be received by the General Secretary no later than 30 November 1996. The abstract should have approximately 250 words in length, and must be submitted in the format attached to the announcement.

Further information: Active 97, OPAKI, H-1027 Budapest, Fő u. 68, Hungary. Fax +36-1-2018843

Noise Effects 98

This will be held at the Sydney Convention Centre, Darling Harbour, from 22-27 November, 1998.

An International Congress on Noise As A Public Health Problem has been held every five years since 1968. The Congress covers all biological effects of noise, including effects on hearing, noise effects on speech communication, performance and behaviour, community response to environmental noise, effects on sleep, physiological effects, effects on animals, biological effects of noise and combined agents, and implications for standards and regulations. The Congress is held under the auspices and general direction of the International Commission on the Biological Effects of Noise (ICBEN), a panel of five scientists eminent in the study of noise and its biological effects, and its Executive Committee. Each of the nine categories of effects of noise listed above has a corresponding 'International Noise Team' of invited scientists from around the world. The Executive Committee comprises the Chairs and Co-Chairs of these 'International Noise Teams'. The five-yearly Congress follows a general format laid down by this body.

Apart from the first, which was held in Washington, all previous Congresses have been held in Europe. The 7th Congress, in Sydney, will therefore be the first to take place in the Southern Hemisphere.

These congresses are unique because they are devoted entirely to the effects of noise. The 1998 Congress is therefore a major event for acoustics in Australia, and has the endorsement of the Department of Public Health in the Faculty of Medicine at Sydney University, the Australian Acoustical Society, Workcover Authority, Audiological Society of Australia, Australian Hearing Services, and the EPA, NSW. It will give Australians an opportunity to make contact and share information with persons from around the world with a like concern for the effects of noise and their implications.

Organising Committee. ICBEN operates somewhat differently from most other international scientific organisations in that it 'selects' a scientist, not an affiliated society, to organise the Congress. That scientist becomes the 'President' of the Congress and has the job of forming an organising committee, and obtaining support from within his/her country. The President of the 1998 Congress is **Dr. Norman Carter**, of the University of Sydney's Department of Architecture and Design Science. The members of the 'core' Organising Committee are as follows (other members will be sought as the Congress approaches and the Committee's work load builds): **Associate Professor Lex Brown**, Department of Environment Planning, Griffith University; **Dr. Stephen Samuels**, Department of Transport Engineering, NSW University; **Mr. David Eden**, Acoustic Dynamics, NSW; **Dr. Soames Job**, Department of Psychology, University of Sydney

Scientific Programme. The Congress is a combination of Plenary Sessions with invited papers, free communications (a combination of oral presentations and/or posters), and workshops. Workshops also include invited papers. Each Plenary Session, Free Communication, and Workshop is devoted to one of the nine areas of noise 'effect'. Up to six parallel sessions may be required.

Social Programme. The Congress will include an opening ceremony and reception, banquet, closing ceremony and farewell cocktails. An accompanying persons programme, pre- and post-Congress tours will be arranged.

Exhibition. There will be opportunities for companies and government agencies to display their services in a trade exhibition during the Congress.

Further Information: Noise Effects '98, GPO Box 128, Sydney NSW 2001 Australia

I-INCE Board Meeting

The following has been extracted from the report to the AAS by Anita Lawrence.

The I-INCE Board met for two days prior to the I-INCE 96 meeting in Liverpool. **A.Cops,** the Secretary-General reported that there are now 40 member societies of I-INCE. There are also 6 sustaining members, 8 institutional members and 4 subscribers.

INCE-USA has a Home page on Internet, which includes some I-INCE material, such as information on member societies which have been profiled in NNI. Also lists of papers in IN 95, Active 95 and NNI's last 3 year cumulative index as well as calendars of conferences.

The Chairman of IN 96, B.Berry, reported on the current meeting. 678 papers were included in the Proceedings (78 posters). Over 1200 participants, including exhibitors and accompanying persons were expected from 42 countries. The largest delegations were from USA and Japan (95 each) and UK (91). Australia rated 6th with 29 delegates.

IN 97 is to be held in Budapest and arrangements were explained by the Hungarian organisers. IN 98 will be held in Christchurch and C.Day presented details. The New Zealanders are cooperating with the AAS organisers of ICBEN in Sydney. Planning for InterNoise 99 (IN 99) was discussed - it should be held in N.America. IN 2000 will be held in Europe in August-September. It is also proposed to hold I-INCE sponsored meetings of "Active" prior to IN 97 and IN 99. The latest version of guidelines for conducting IN meetings was tabled.

In 1991 it was proposed that there should be a European meeting on noise control engineering in years when IN is not held in Europe (similar to Noise-Con in the USA). Meeting were held in 1992 and 1995. I-INCE Board decided it should cooperate with the European Acoustical Association in holding Euro-Noise meetings every three years, the next will be in 1998.

The current President of International Commission on Acoustics (ICA) is **T.Kihlman,** who also an I-INCE Board member. He wants to make the organisation more democratic and to invite individual member societies to join the ICA so that its General Assembly will elect the commission. He hopes this can take place at the next ICA meeting in Seattle in 1998.

The Board was concerned about the actions of the International Institute of Acoustics and Vibration and there were discussions with representatives to resolve the relationship between I-INCE, IIAV and ICA.

Technical Working Parties. The final draft of Workplace Limits has been published in NNI and results of member society votes on Vehicle Noise Limits are awaited. There is merit in I-INCE preparing politically unbiased reports on noise control engineering topics of interest and this can help bureaucrats in some countries to persuade their political masters in matters of community interest. Noise walls and community noise levels are the topics of the other two WP's. The proposals for WP's on Building envelopes and Consumer noise information are being followed up. The final reports of the WP's, when accepted by the member societies, will be published in Noise Control Engineering, and reprints will be available. Member societies are to be asked to provide relevant addresses of government department bureaucrats, etc. who could be influenced by these reports.

Changing The Articles of Association

It is now 25 years since the Memorandum and Articles of Association of the Society were written, although amendments were incorporated in 1981 and 1985. Work has commenced to re-write them in "plain english" and remove "sexist" language as well as deleting many sections which are no longer relevant because of changes in the Corporations Law. A number of adjustments are also planned to facilitate the running of the Society. These include the method of applying for membership, the collection and distribution of fees and the ability to locate the Registered Office of the Society anywhere in Australia.

A sub-committee has been charged with producing a draft which will be distributed to Members for comment. It would help this committee if any Member wishing to make suggestions would send them to the General Secretary before the end of January, so they may be considered during the early drafting stages. One such comment is to allow for sending notices by mail or electronic means - thereby allowing for future technology when all may have access to email. Council hopes that the final version of the Memorandum and Articles will be ready for acceptance at the Annual General Meeting towards the end of 1997.

FASTS Update

The revised FASTS Policy Document has been referred to in many meetings with Policy Makers since its launch in June. It is a significant revision of the original policy, with new sections reflecting input from Member Societies, Board discussions, and from changing circumstances. Several of the new ideas were picked up in media coverage of the launch. FASTS is gaining increasing coverage in the media, either as the main point of a story or mentioned in reference to general funding or policy issues.

The Prime Minister has invited FASTS to join his Science and Engineering Council (PMSEC). The President of FASTS made a presentation in Sept and has stated that " I do believe there is a distinctive role for FASTS to play in PMSEC. We bring an Australia-wide geographic perspective and our member Societies cover a wide range of disciplines. The members of the Societies cover an even wider range of types of professional employment. We have the potential to continue to illustrate the significance of Science and Technology to the sustainable well-being of Australia and of its people."

"Many politicians do not consciously appreciate the good things from science and technology even though they use and benefit from them in their everyday activities. Rather they see us as communicators of problems, of costly needs (education, training, job creation etc.) and as generators of problems – CFEs, chlorinated hydrocarbons, radioactive substances etc. We have to regularly publicise the good things coming from Science and Technology throughout Australia, especially from Australian scientists and technologists, as distinct from overseas workers."

FASTS has been involved with a one day, high profile forum at the Academy dome. The aim was to highlight the parlous state of mathematics and science education, and to demonstrate possible solutions. This forum preceded the Annual Forum and Council Meeting for FASTS.

FASTS has moved to a new office in the Academy of Science dome. It is sited close to Parliament House, major Commonwealth Departments, the ANU and CSIRO headquarters, and to the Academy.

INTERNET NEWS

Two acoustics sites that may be of interest:

http://www.lib.ox.ac.uk/internet/news/faq/archive/physics-faq.acoustics.html

http://www.ecgcorp.com/velav/index.html

Copyright Agency

Acoustics Australia has been admitted as a member publisher to the Copyright Agency Limited (CAL). This agency now represents the journal in matters related to the reproduction of copyright material and licence schemes.

CAL is a not-for-profit company established by and represents many thousands of authors and publishers. In the last financial year, $12.4 million has been declared by CAL and distributed to over 4,100 publishers and authors. This amount includes the fees collected under the statutory and voluntary licence schemes which CAL administers. CAL is moving into the digital copying arena which will include works copied from CD ROMS and data bases. Acoustics Australia has primarily joined this organisation to indicate support for other authors and publishers who deserve adequate protection from unauthorised copying of their works.

STANDARDS Australia

The budget includes a massive cut - up to $2,000,000 - in funding for Standards Australia's national interest activities. Howard Paul, General Manager, Standards Australia Publishing, takes a suprisingly optimistic view. Standards Australia makes great efforts to be an economically efficient producer for Standards, and we welcome this new challenge. While there may be some pain adjusting to the new circumstances, in the long term and unsubsidised relationship with our customers will encourage a better evaluation of the cost-benefit of Standards. Pricing models based on cost recovery will facilitate both internal efficiencies and better understanding of market needs and demand. At the same time, we have to focus even more sharply on generating revenue and seizing every opportunity for developing new businesses and services.

New MOU

Standards Australia and Australia's peak engineering employer body, the Association of Consulting Engineers (ACEA) have signed an historic Memorandum of Understanding which aims to improve communication within the construction industry.

The MOU outlines a commitment for ACEA members to participate in the development of relevant Standards and be represented on the Standards Australia Executive Board. Both organisations will also seek to identify opportunities for joint publication of handbooks and other literature.

CD ROM

Standards Australia has led the world in the publishing of electronic Standards. Back in 1990, it took key decision to go down the full test route, capturing and storing all 6000 Standards - well over 100,000 pages - as pure data rather than as simple facsimiles. In the quest to find a native electronic publishing system capable of satisfying the customer's most demanding needs work began in late 1994 converting 15,000 graphic file sand reformatting all documents on the MSDOS system to make full use of the Interleaf capabilities.

The CD ROM development team is justly proud of its achievement. In the contemporary terminology, the new Standards on CD-ROM service is 'feature-rich'. These include: true on-screen viewing and print output which are an exact replica of the original printed page; fully customised access to meet Standards users' exact requirements; fully networkable; a graphical and text annotation tool that allows users to highlight test and add text to pages that can be shared over a network or kept confidential; cut and paste facility for text and graphics; the ability to provide instant access to additional Standards over the phone via a password system; a single CD-ROM disk solution; an update service that ensures that users always have the latest editions and amendments; a user-friendly Windows based ordering program; Windows environment.

The few remaining Standards not already on the disk will be added over the next six months. And in the unlikely event of a subscriber requesting a Standard not yet captured, it will be included in the next monthly update.

Minor Contract Works

Standards Australia has released a new Standard, AS 4305 - 1996, Minor works contract conditions. It is intended to be used for projects of a simple nature or contracts up to the value of $250,000. Minor works contract is a "straight down the line" contract, definitely no grey areas. It can be easily understood by both builders and clients alike, as it uses simple, clear, and concise language to help you carry out projects confidently. It is part of the suite of contracts based on AS 2124-1992, General conditions of contract, and incorporates the same philosophies, processes and procedures. A section has been included which when filled out becomes a legally binding document between the Contractor and Principal, and is issued as part of the tender document.

DR 96421 Octave-band and fractional-octave-band filters

This Draft is a revision of AS Z41-1969 and NZS 1499-1965 and proposed the adoption of IEC 1260-1995. This provides performance requirements and methods for testing the performance of analogue, samples-data and digital implementations of band-pass filters that comprise a filter set or spectrum analyser. Performance requirements are provided for three filter classes. Proposed as a Joint Australian/New Zealand Standard.

Further information: Standards Australia, PO Box 1055, Strathfield NSW 2135, Tel +61-02-97464600 Fax +61-02-97463333

❖ ❖ ❖

Tinnitus Study

Beethoven suffered from it before his deafness, and it is believed Van Gogh may have sliced off his ear to try to escape its torment. It is the debilitating condition of "ringing in the ears", or tinnitus, and a major new study at UNSW offers renewed hope for sufferers.

Dr Jane Henry from UNSW's School of Psychology is about to embark on the largest evaluation of psychological treatments for tinnitus ever undertaken. The study is being conducted in Sydney and Adelaide, with a free program of treatment for tinnitus sufferers offered at UNSW. Dr Henry said sufferers of tinnitus usually experience a loud ringing, buzzing, clattering or thumping noise inside their ears or head.

"About seven per cent of the population are troubled by it intermittently, and up to two per cent experience severe unrelenting tinnitus. Many people who suffer from the condition report considerable psychological distress. They may have high level of depression and irritability, have sleep problems and difficulty concentrating, suffer disruption to their work and social life, or experience suicidal tendencies," she said.

"There is presently no effective medical treatment for tinnitus, and people are generally told they will just have to learn to live with the condition. However, psychological approaches to the problem have shown to be of considerable benefit. The approaches aim to teach people ways to gain control over their reactions to their tinnitus so that it becomes less disruptive to their lives," Dr Henry said.

From Uniken June 1996

VICTORIAN DIVISION NEWS

Visit to Sunshine (Vic)

On 31 July 1996, approximately 20 members visited the Sunshine (Vic) Energy Park, being the Sunshine Landfill Power Station with its associated 8 MW methane gas power plant. Graeme Harding, responsible for the acoustical and mechanical design of the plant, opened the visit with a general description of both the design and operation of the power station, and distributed brief notes on it. The subsequent inspection of the power plant site was led by Peter West of GEC Alsthom Australia Ltd, the plant's operator.

Basically, heat and electricity are generated from the methane gas developed as a product of the decaying rubbish in a now capped City of Sunshine municipal rubbish tip. The heat is used in the Council's adjacent Parks and Gardens Dept hothouses, while the electricity, obtained from five gas engine-driven alternators, is sold to the region's electricity supplier. While some of the introductory description and site inspection were concerned with the plant's general operation, this was to allow understanding of those sections of it likely to produce high levels of noise, which would need acoustic shielding from the surrounding residential neighbourhood, the main sources of noise being the five methane gas engines and the associated fans, pumps and exhaust outlets.

With sound levels of the order of 110 dB(A) adjacent to the gas engines during operation, the engine room outer walls were designed to give adequate attenuation. Exterior fans and exhaust outlets were fitted with silencers.

The nearest potentially affected residential areas were of the order of 400 m to the north (but with intervening earth mounds alongside the Western Ring Road), 1 km to the north-east, and 650 m to the south. Statistical noise measurements made in these areas over 24-hour periods showed that, while L_{90} was generally of the order of 40 dB(A), it could, during times of electricity generation (eg, between 0600 and 0800 h, and 1400 and 1600 h), rise as high as 52 to 53 dB(A) to the north-east, 46 to 48 dB(A) to the north, and 46 dB(A) to the south.

Annual General Meeting

On the 25 September 1996, 27 members conducted a visit, in conjunction with the Victoria Division AGM, to Monash University Clayton campus in the Dept of Mechanical Engineering, to view the dept's wind tunnels. At the AGM, the financial statements were presented and adopted, a Division committee for 1997 was elected, and the chairman spoke to his annual report, outlining the division's activities over the past year.

The Technical Meeting was opened with a description of the two wind tunnels given by Prof Bill Melbourne, assisted by Robin Alfredson. The tunnels have been designed and built by Monash University engineering staff, and comprise a smaller tunnel for measuring, eg, the responses of structures to wind loadings; and a larger tunnel with lower and upper level chambers. The lower level chamber incorporates a conventional working section for testing, eg, aeroplane wings, together with an open jet section for testing, eg, motor vehicles; while in the upper level chamber, which is provided with top and bottom banks of heating elements, can be generated stratified, convective, sheer and twisting flows, for testing, eg, yacht sails.

Of particular acoustical interest were the various measures (splitters, well rounded wall edges) incorporated in the designs to minimize fan noise, and other extraneous noises from, eg, undesired turbulence. The motor vehicle testing includes noise measurements made inside the passenger compartment as the vehicle is subjected to various wind loadings.

The final technical meeting for the year, to be held on Dec 13, will include a talk by Hugh Hunt (Cambridge, UK) on vibration and noise from railway operations.

C Louis Fouvy,

New Members...

NSW

Member Mr DC Anderson, Mr K Scannell

Subscriber Mr R Storer, Mr P Johnston

QLD

Subscriber Miss R Carter

SA

Subscriber Dr P Teague

New Products...

INFOBYTE

Programmable Noise Logger

This noise logger saves data on standard 1.4Mb floppy disks providing data capacity not previously available in a logger of this type. No download cables are required. A Windows program displays the gathered data, converting selected data to a text file which can be read by word processors and spreadsheets. The logger is constructed from durable, light-weight, aluminium alloy sheet. The logger case has space to store all required parts, including batteries, security chain, microphone and accessories. The logger has been designed for ease of operation and flexibility. The DOS operating system and supplied source code allows fast custom program development in Basic, Pascal or C on a desktop PC.

Further information: Infobyte Pty Ltd 7 Hay Street, West Ryde, NSW 2114. Tel or Fax 02 98740946 Email gveale@tpgi.com.au

AUDITEC

Hearing Aid Loop Amplifiers

A new range of constant current output 2 rack unit Hearing Aid Loop Amplifiers with a wide range of features has been released. The Model 1088, has 120VA output for loops up to 150 metres perimeter or 7,500 square metres. No special loops are required and loop design is extremely simple. An alarm will flash on the front panel if the loop becomes disconnected. An extra 10 watt monitor amplifier with separate volume control is built in. They are covered by a five year warranty.

Further information: Auditec Aust., PO Box 228 Hornsby NSW 2077, Tel 02 94894116 Fax 02 94892567.

BRUEL & KJAER

DAT Recorder

The new PC-200Ax series from SONY is designed for a wide selection of scientific and industrial applications. PC-200Ax offers everything from 2 to 64 channels, with a choice of analogue as well as digital inputs and outputs, DC to 100 kHz bandwidth, up to 6 hours recording time and a choice of 3 different power supply alternative. So you can collect measurements in the field or in the laboratory with a lightweight, portable and rugged Sony instrumentation recorder. The do the detailed signal analysis in the comfort of your office.

Further information: B&K,, PO Box 177, Terrey Hills NSW 2084, Tel 02 4502066 Fax 02 4502379

KINGDOM

Digital Movies

ME'scope™ Modal Analysis and Animation software is a family of post test analysis software products which were developed by Vibrant Technology, that provide DIGITAL MOVIES and allow visualisation of machines and structures. ME'scope has features not found in any other vibration analysis package for example, ME'scope is the only PC based product that allows the interactive movement of a cursor in a set of measurements to observe the structure's operating deflection shapes in animation on a 3D structure model, ME'scope is MS/Windows based applications is available as several stand alone, upgradeable options. The ME'scope database has no practical design limits. The various models include: 3D Model Building, Measurements, Animation, Modal Analysis, Mimo, Structural Modifications.

Further information: Kingdom, PO Box 75 Frenchs Forest 2086, Tel 02 99753272 Fax 02 99753819

WARSASH

Scanning Vibrometer

The PSV-200 Scanning Vibrometer from Polytec of Germany is a non-contact, full-field system for automated vibration measurement, mapping, visualisation and analysis. It offers a faster and more convenient alternative to traditional methods involving accelerometers, without adding mass to the structure and with high spatial measurement density/resolution. Extensive mouse driven software runs under Microsoft Windows NT. A live, wide angle, high-resolution CCD video camera image of the test object is fully integrated into the software for setting up the scan geometry and overlaying the vibration data. Time consuming point-by-point scans are not required to generate each new image. The PSV-200 can test small, delicate objects with unknown modal density.

Further information: WARSASH Pty Ltd, PO Box 1685, Strawberry Hills, NSW 2012 Tel: 02 93190122 Fax 02 93182192

NVMS

Noise Monitoring Hardware

Noise & Vibration Hardware Systems have recently released two new products that offer solutions to noise logging situations: The TR-10 Trigger Unit and SL-10 Statistical Logger. The TR-10 allows a tape recorder to automatically record noise by monitoring the industry standard DC output signal from B&K Sound Level Meters. When the noise exceeds user defined limits for a given duration it activates a SonyTM DAT recorder. This product offers true noise source identification. The SL-10 Statistical Logger is a powerful extension to the popular B&K 2236 SLM. It offers up to 15 user defined percentile values in a variety of logging period options where three concurrent logging periods can be used or a user definable period. This stored data is readily exported to a PC where custom written Windows" based on software allows the user to archive, report and graph the percentile noise information. Both these units are compact, user friendly and extremely low powered for use in the field.

Further information: NVMS Pty Ltd., 433 Vincent St. West, Leederville WA 6007, Tel: 09 3814944 Fax: 09 3813588 email: nvms@ois.net.au, http://www.nvms.com.au

BORAL

Big Brick System

Boral has developed a new range of purpose made Big bricks which consist of: The Party Wall Brick, Sound Stop Common, Jumbo Common, Verticore. The Boral Big Brick System is an integrated building system designed for the economical construction of masonry walls as well providing big cost savings in labour, time and materials. Whilst still meeting all the requirements of the Building Code of Australia. Data sheets for these products, showing their acoustic performance are available.

Further information: Boral, GPO Box 910 Sydney 2001. Tel:02 92206300 Fax:02 92325192

POLYHEDRON SOFTWARE

Data Visualization Software

Version 7.0 of Tecplot is software that provides engineers and scientists with the broadest set of tools available for visualizing and plotting large amounts of data. Tecplot helps users work productively with the data sets generated by numerical simulation, statistical analysis, data acquisition, and other sources. The product's focus is harnessing the power of high-end data visualization in ways that benefit technical users in the day-to-day demands of their jobs.

Tecplot V7.0 runs on most UNIX workstations (under Motif) and PCs running Microsoft Windows (3.x, Windows 95 and Windows NT). In addition, Tecplot will soon be available on VMS, Linux, and Windows NT for DEC Alpha.

Further information: Polyhedron Software Ltd, Linden House, 93 High St, Standlake, Witney, Oxon OX8 7RH, UK, Tel +44 1865300579, Fax +44 1865300232 email: sales@polyhdrn.demon.co.uk, www: http://www.polyhedron.co.uk/

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Volume 24, 1996

A. ARTICLES

B. NOTES

ACEL
OHS Yearbook 1997

ACEL OHS Yearbook provides up-to-date information on thousands of occupational health and safety issues. Whether it's legislation, codes of practice or Australian Standards you're searching for - or where you can buy ear muffs or fume extractors, this book will point you in the right direction. This fourth edition is fully revised and updated to ensure that the information is as accurate as possible.

Engineering File

The ACEL Engineering File, contains hundreds of thousands of pages of product catalogues and is available via CD-Connect, ACEL's unique information delivery software. All the indexing is on CD, and seamlessly and instantly, the documents are delivered on-line. It means that a single annual subscription allows a whole organisation to have networked access to the most comprehensive collection of Australian engineering data. Over 1500 Australian suppliers representing many thousands of local and overseas manufacturers have complete catalogues in the File. ACEL continuously updates the File and the CD Index is replaced quarterly.

Further Information: ACEL Information, Central Green, Common Centre, 660 Chapel St, South Yarra, VIC 3141, Tel: 03 98266099, Fax: 03 98266886, www.acel.net.au, Email: info@acel.net.au.

Letters...

On the NRC

The RMIT Department of Applied Physics, Melbourne has acoustic measuring facilities that are available for tests required by industry. On many occasions a particular request has been for the Noise Reduction Coefficient (NRC) of a sample, the reason being that a tender has specified a certain minimum value. For most such requests the test required has involved the use of the impedance tube. This has prompted me to bring the correct story of NRC to people's notice.

NRC receives no mention in Australian Standard 1633 - Glossary of terms, but it is featured in the American ASTM C423-90a - Sound absorption and sound absorption coefficients by the reverberation room method. For such purposes it is defined in ASTM C634-89 - Standard terminology relating to environmental acoustics. The method for its calculation appears in sub-clause 11.7.1 of ASTM C423.

The most important point in finding the NRC is that it depends on the values of sound absorption coefficient determined in **one-third octave bands** with centre frequencies 250, 500, 1000 and 2000 hertz. This in turn means that it is not correct or valid to produce the NRC value when absorption coefficients, either the normal or statistical coefficient, have been determined using the impedance tube method by either AS 1935 or ASTM C384. One recalls that these standards involve the use of single tones.

Accordingly, potential clients for the testing of materials by use of the impedance tube must be reminded that derivation/expression of the NRC value is incorrect. As readers would be aware, work is in hand via draft ISO standards for terms which express the sound absorption properties by single values.

Ken Cook FAAS

Products for Asia

This has reference of our interest in promoting Australian construction materials and construction related systems in the Philippines. Since last year, the Philippines has started a good trend in construction that has not been experienced yet in the past. This trend is expected to continue in the next 5 years. Last year, we launched in the Philippines LINCRETE, an Australian patent precast concrete connector (also patented in the Philippines).

We are more than ever interested with innovations, inventions, new construction materials and systems not yet introduced in the Philippines. Please send us, under address below, brochures and/or technical information. We should be able to evaluate on how best the products or systems can be promoted in the Philippines.

Juan D. Misa, JM & Associates,
3 Alpha Rd, Alpha Villagr, Capitol Hills,
Diliman, Q.C.Phillipines

Diary...

CONFERENCES and SEMINARS

* Indicates an Australian Activity

1997

January 8-9, SINGAPORE
Society of Acoustics (Signapore) Annual Meeting
Details: Dr W. Gan, Acoustical Services Pte Ltd, Innovation Centre 209-212, NTU, Nanyang Avenue, Singapore 2263. Tel +65 791 3242 Fax +65 791 3665, chenzhen@pacific.net.sg

March 24-28, HAVANA
2nd Ultrasonics Symposium
Details: Carmen Alvarez, Calle 15 No. 551 e/C y D. C.P. 10400, Diudad de La Habana, Cuba. Fax +53 733 3373, cimaf@redacc.cu

April 2-4, TOKYO
ASVA 97
Details: Environmental Acoustics Lab, Faculty of Engineering, Kobe Uni., Rokko, Nada, Kobe 657, Japan. Fax: +49 8142 54735, 00621.1451@compuserve.com

April 13-16, BOSTON
23rd Int Symp on Acoustical Imaging
Details: S. Lees, Bioengineering Dept., Forthys dental Center, 140 Fenway, Boston, MA, USA. Fax +1 617 262 4021, slees@forthys.org

April 21-24, MUNICH
Int Conf Acoustic, Speech & Signal Processing
Details: H. Fastl, Technical University Munich, 80290 Munchen, Germany. Fax: + 49 892 105 8535, fas@mmk.e-technik.tu.muenchen.de

April 21-25, BEIJING
Int Conf on Shallow-Water Acoustics
Details: R. Zhang, Inst. of Acoustics, Academia Sinica, Beijing 100080, China. Fax: +86 10 6256 9079, zrh@canna.ioa.ac.cn

May 12-16, GDANSK
13TH FASE Symp on Hydroacoustics
Details: Inst Exp Physics, Ul. Wita Stwosza 80-952 Gdansk, Poland.
Fax +48 58 413175, fizas@halina.univ.gda.pl

May 20-22, TRAVERSE CITY
SAE Noise and Vibration Conf.
Details: SAE/MJA, 3001 W. Big Beaver Rd, Suite 320, Troy, MI 48084, USA. Fax +1 810 649 0425

June 3-5, GOTHENBURG
Low Frequency Noise and Vibration,
Details: Multi-Science Publishing Co. Ltd., 107 High St. Brentwood, Essex CM14 4RX, Fax: +44 1277 223453

June 15-17, STATE COLLEGE
Noise-Con 97
Details: INCE, PO Box 320 Arlington Branch, Poughkeepie, NY 12603, USA. Fax +1 914 463 0201

June 18-21, PRAGUE
3rd European Conf. on Audiology
Details: Paediatric Otolaryngologic Clinic, Faculty Hospital Motol, V Uvalu 84, 15018 Prague 5, Czech Republic. Fax +42 2 2443 2620

June 24-27, PRAGUE
1st Europ Conf on Signal Analysis & Prediction.
Details: ESCAP SEcretariat, Institute of Chemical Technology, Technicka 5 166 28 Praha 6, Szech Republic, escap@vscht.cz

June 30-July 4, LA SPEZIA
High Frequency Acoustics in Shallow Water
Details: Anna Bizzarri, SACLANT Undersea Research Centre, Viale San Bartolomeo 400, 19138 La Spezia (SP) Italy. Fax: +39 187 540 331, pace@saclantc.nato.int

July 14-17, SOUTHAMPTON
6th int. Conf on Recent Adv in Structural Dynamics
Details: N. Ferguson, ISVR, Uni. of Southampton, Southampton S17 IBJ, UK. Fax: +44 1703 593033, mxs@isvr.soton.ac.uk

July 21-25, CHILWORTH MANOR
4th int. Conf. on Natural Physical processes Related to Sea Surface Sound.
Details: Maureen Strickland, ISVR Conf. Secretary, uni. of Southampton, Southampton S017 1BJ, UK, Fax: +44 1703 592294, mzs@isvr.soton.ac.uk

August 19-22, EDINBURGH
Int. Symp. on Musical Acoustics.
Details: Dept. Physics and Astronomy, University of Edinburgh, James Clerk Maxwell Building, Mayfield Rd, Edinburgh EH9 3JZ. Scotland. Fax +44 131 650 5902, isma.97@ed.ac.uk,

August 21-23, BUDAPEST
Int. Sym on Active Control
Details: ACTIVE Secretariat, OPAKFI, Fo u. 68, 1027 Budapest, Hungary. Fax +36 1 202 0452

August 25-27, BUDAPEST
INTERNOISE 97
Details: OPAKFI, H-1027, Budapest FO U68 Hungary, Tel/Fax: +36 1202 0452

September 1-4, JAPAN
IMAC-XV 'Bridge Over Virtual & Real Design'
Details: IMAC-XV, Dept. of Precision Mechanics, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo, 112 Japan. Fax 81 3 3817 1820 jmac@okubo.mech.chuo-u.ac.jp

September 10-12, NEW ZEALAND
Biennial Conference - NZ Acoustical Society
Details: NZ Acoustical Society, PO Box 1181, Auckland, NZ Fax +64 9 623 3248

September 10-12, STUTTGART
Biomechanics of Hearing
Details: EUROMECH Colloquium 368, W. Schiehlen, Institute B of Mechanics, Uni of Stuttgart, 70550 Stuttgart, Germany. wos@mechb.uni-stuttgart.de

October 1-3, QUEENSLAND
* CM2 Forum - for more effective condition monitoring
Details: Centre for Machine Condition Monitoring, Monash University, Wellington Road, Clayton, Victoria 3168 Australia.
Ph: +61-3 9905 5699, Fax: +61 3 9905 5726. maltezos@eng2.eng.monash.edu.au, http://www.monash.edu.au/cmcm

October 8-10, WINDSOR
Acoustics Week in Canada 1997
Details: R Ramakrishnan, Vibron Ltd, 1720 Meyerside Drv. Mississauga, Ontario, L5T 1A3 Canada. Fax: +1 905 670 1698

November 19-20, HONG KONG
WESTPRAC '97
Details: S Tang, WESTPRAC Secretary, Dept. of Building Services Engineering, The Hogn Kong Polytechnics Uni., Hong Kong.
Fax +852 27746146 besktang@polyu.edu.hk

December 1-5, SAN DIEGO
Meeting of the ASA
Details: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797 USA.Fax +1 516 576 2377, asa@aip.org

December 15-18, ADELAIDE
* 5th Int Conf on Noise & Vibration
Details: Dept Mech Eng, Uni Adelaide, SA 5005, Aust. Tel +61 8 303 5698, Fax +61 8 303 4367, icsv5@mecheng.adelaide.edu.au

1998

March 23-27, ZURICH
DAGA 98 - German Acoustical Society Meeting
Details: DEGA, Physics/Acoustics Dept., Universität Oldenburg, 26111 Oldenburg, Germany. Fax: +49 441 798 3698, dega@aku.physik.uni-oldenburg.de

May 12-15, SEATTLE
IEEE Conf. on Acoust, Speed & Signal Processing
Details: L. Atlas, Dept. EE (FT 10), University of Washington, Seattle, WA, USA. Fax +1 206 543 3842, atlas@ee.washington.edu

June 8-10, TALLINN
Transport Noise and Vibration
Details: East-European Acousticat Assoc., Moskovskoe Shosse 44, 196158 St. - Petersburg, Russia.Fax: +7 812 127 9323 krylspb@sovam.com

June 20-28, SEATTLE
16th International Congress on Acoustics
Details: 16th ICA Secretariat, Applied Physics laboratory, Uni of Washington, 1013 NE 40th St. Seattle, WA 98105-6698, USA.

October 12-16, AMERICA
Meeting of ASA
Details: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797 USA.Fax +1 516 576 2377, asa@aip.org

November 16-20, CHRISTCHURCH
INTER-NOISE 98
Details: NZAS. P.O. Box 1181, Auckland, NZ, Fax +64 9 309 3540

November 20, QUEENSTOWN
Recreational Noise
Details: P. Dickenson, NZ Ministry Health, PO Box 5013, Wellington, NZ Fax +644 4962340 philip.dickenson@mohwn.synet.net.nz

November 22-27, SYDNEY
* Noise Effects 98 – ICBEN Congress
Details: Noise Effects '98, GPO Box 128, Sydney NSW 2001 Australia

1999

March 15-19, BERLIN
Forum Acusticum & ASA Meeting
Details: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797 USA. Fax +1 516 576 2377 asa@aip.org

November 1-5, COLUMBUS
Meeting of ASA
Details: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797 USA.Fax +1 516 576 237 asa@aip.org

2000

December 4-8, NEWPORT BEACH
Meeting of the ASA
Details: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797 USA. Fax +1 516 576 2377 asa@aip.org

AUSTRALIAN ACOUSTICAL SOCIETY ENQUIRIES

NATIONAL MATTERS

* Notification of change of address
* Payment of annual subscription
* Proceedings of annual conferences

General Secretary
AAS– Professional Centre of Australia
Private Bag 1, Darlinghurst 2010
Tel/Fax (03) 9887 9400
email: watkinsd@melbpc.org.au

SOCIETY SUBSCRIPTION RATES

From 1 APRIL 1996 membership subscriptions will be as follows:

Fellow and Member	$90
Affiliate and Subscriber	$72
Student	$20

DIVISIONAL MATTERS

Enquiries regarding membership and sustaining membership should be directed to the appropriate State Division Secretary

AAS - NSW Division
Professional Centre of Australia
Private Bag 1,
DARLINGHURST 2010
Sec: Mr D Eager
Tel (02) 9330 2687
Fax (02) 9330 2665
D.Eager@uts.edu.au

AAS - Queensland Division
PO Box 150,
OMMANEY 4074
Sec: Mr B Thorne
Tel (07) 3225 1772
Fax (07) 3376 6236

AAS - SA Division
C/–Department of Mech Eng
University of Adelaide
SOUTH AUSTRALIA 5005
Sec: Carl Howard
Tel (08) 303 3092
Fax (08) 303 4367
cqhoward@mecheng.
adelaide.edu.au

AAS - Victoria Division
PO Box 417 Market St PO
MELBOURNE 3000
Sec: Mr D Dolly
Tel (03) 9859 9447
Fax (03) 9859 5552

AAS–W A Division
PO Box 1090
WEST PERTH 6872
Sec: Mr T McMinn
Tel (09) 351 7175
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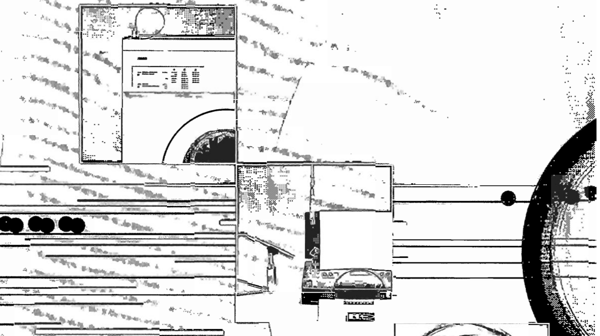

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