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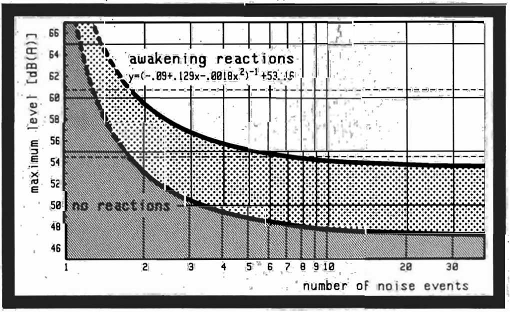

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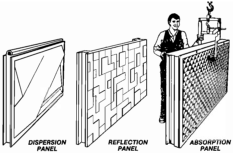

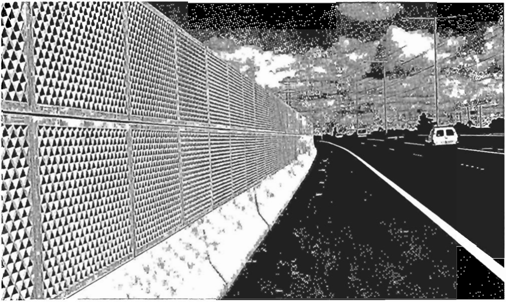

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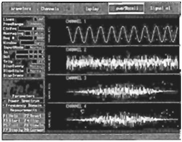

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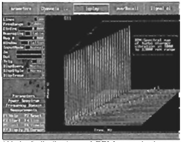

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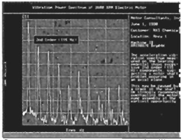

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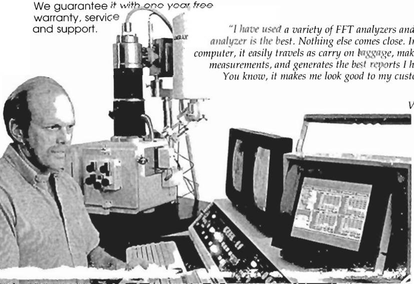

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FROM THE PRESIDENT

In this issue a matter is raised which justifies the attention of all members. It is the question of whether the Society should have a formal Code of Ethics.

Some time ago Council was asked to consider this question and as a result and after much research (i.e., reading as many codes as we could find from other similar bodies), the draft as presented in this issue was prepared.

Councillors and Division Committees have already examined this draft and their responses form a five-sided playing field. The boundaries seem to be:

(1) we should have a code of ethics and the draft is fine with minor amendments,

(2) yes, but the words need some significant changes

(3) it doesn't matter one way or another,

(4) no, our members are already committed through other society memberships

(5) it would be positively harmful, leading to dispute and dissension.

Please think through your viewpoint. We can even turn to the Sydney Morning Herald for a view: "Every society worth its salt should have one, i.e., a code of ethics". (17 June, 1992).

It is up to you, the members, to come to a decision on this matter, probably at the 1992 A.G.M.

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Code Of Ethics

A draft code of ethics has been prepared for consideration by members of the Australian Acoustical Society.
The history behind this code goes in two steps. A proposed code was put to the Annual General Meeting of 1981. After discussion, the proposal to adopt that code was lost - a majority in favour, but insufficient to achieve the three-fourths majority required for a special resolution.
In 1990 the second step was initiated by a request to Council to consider the need for a code and to prepare a draft.
A code of ethics would logically be along the lines that members act in such a way as to promote the objects of the Society, as listed in the Memorandum of Association - there are 28 objects in the list. In particular, object (c) is "To promote honourable practice ... by enjoining members of the Society to conform to a code of ethics relating to professional practice, etiquette and allied matters...".
Factors supporting the adoption of a code are:
1. A code is implied in the Memorandum of Association.
2. The code has been requested by some members.
3. The voting in 1981 was 54 in favour, 24 against.
4. Most professional societies have a code.
The following six-point code with accompanying notes is suggested. It is based on the Objects of the Society as expressed in the Memorandum of Association, the previous (1981) proposal, and on the codes of kindred societies.
It is proposed to present the code, amended in the light of comment received, to the 1992 Annual General Meeting, for voting on adoption or otherwise.
YOUR ACTION. Please consider, and send your comments to the General Secretary.

Draft Code of Ethics

1. Responsibility
The welfare, health and safety of the community shall at all times take precedence over sectional, professional and private interests.

2. Advance the Objects of the Society
Members shall act in such a way as to promote the objects of the Society.

3. Work within Areas of Competence
Members shall perform work only in their areas of competence.

4. Application of Knowledge
Members shall apply their skill and knowledge in the interest of their employer or client, for whom they shall act in professional matters as faithful agents or trustees.

5. Reputation
Members shall develop their professional reputation on merit and shall act at all times in a fair and honest manner.

6. Professional Development
Members shall continue their professional development throughout their careers and shall assist and encourage others to do so.

Explanatory Notes (To accompany Code of Ethics)

1. Responsibility
In fulfilment of this requirement members of the Society shall:

(a) avoid assignments that may create conflict between the interests of their clients, employers, or employees and the public interest.

(b) conform to acceptable professional standards and procedures, and not act in any manner that may knowingly jeopardise the public welfare, health, or safety.

(c) endeavour to promote the well-being of the community, and, if over-ruled in their judgment on this, inform their clients or employers of the possible consequences.

(d) contribute to public discussion on matters within their competence when by so doing the well-being of the community can be advanced.

2. Advance the Objects of the Society
Appropriate objects of the Society as listed in the Memorandum of Association are:

Object (a) To promote and advance the science and practice of acoustics in all its branches and to facilitate the exchange of information and ideas in relation thereto.

Object (f) (in part) To encourage the study of acoustics and to improve and elevate the general and technical knowledge of persons engaged or intending to engage in the science and practice of acoustics.

Object (i) To encourage the discovery of and investigate and make known the nature and merits of processes and inventions relating to the science, profession or practice of acoustics.

3. Work within Areas of Competence
In all circumstances members shall:

(a) inform their employers or clients if any assignment requires qualifications and/or experience outside their fields of competence, and where possible make appropriate recommendations in regard to the need for further advice.

(b) report, make statements, give evidence or advice in an objective and truthful manner and only on the basis of adequate knowledge

(c) reveal the existence of any interest, pecuniary or otherwise, that could be taken to affect their judgement in technical matters

4. Application of Knowledge
Members shall at all times act equitably and fairly in dealing with others. Specifically they shall:

(a) strive to avoid all known or potential conflicts of interest, and keep employers or clients fully informed on all matters, financial or technical, that could lead to such conflict.

(b) refuse compensation, financial or otherwise, from more than one party for services on the same projects, unless the circumstances are fully disclosed and agreed to by all interested parties.

(c) neither solicit nor accept financial or other valuable considerations from material or equipment suppliers in return for specification or recommendation of their products, or from contractors or other parties dealing with their employer or client.

5. Reputation
No member shall act improperly to gain a benefit and, accordingly, shall not:

(a) pay nor offer inducements, either directly or indirectly, to secure employment or engagement.

(b) falsify or misrepresent their qualifications, experience, or prior responsibilities nor maliciously or carelessly do anything to injure the reputation, prospects, or business of others.

(c) use the advantages of privileged positions to compete unfairly.

(d) fail to give proper credit for work of others to whom credit is due nor to acknowledge the contribution of others.

6. Professional Development
Members shall:

(a) strive to extend their knowledge and skills in order to achieve continuous improvement in the science and practice of acoustics.

(b) actively assist and encourage those under their direction or with whom they are associated to advance their knowledge and skills.

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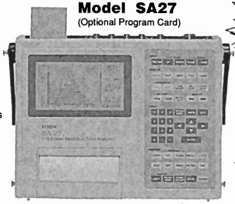

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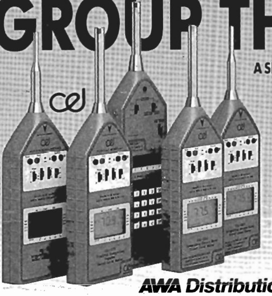

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Noise Control During the Night

Proposals For Continuous and Intermittent Noise

Barbara Griefahn *
Institute for Occupational Health
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Ardeystr. 67, D-4600 Dortmund 1/FRG

Abstract: The temporal structure of noise is the governing factor for the assessment of noise-induced sleep disturbances. Intermittent noises are more disturbing than continuous noise. The limit between both these acoustic conditions can be defined by a 'modulation depth' of 10 dB (A) between the maximum levels and the equivalent sound pressure level L_{eq}.

The critical level or load for continuous noise is located within a range from L_{eq} = 37 to 45 dB (A), but L_{eq} alone is not generally suitable for the prediction of sleep disturbance.

The admissible risk for intermittent noise is defined as a single awakening during the night in not more than 10% of the population. This risk corresponds to the peak noise level which must not be exceeded in order to avoid long-term effects on health. The results of several experimental studies were used to calculate a function which presents this admissible risk as a relation between the peak levels and the number of stimuli per night.

As different short stimuli are found to cause more or less the same extent of reactions after some habituation nights, the critical peak levels apply to different transportation noise sources. Examples of these peak levels, adjusted for age are 59.4 dB (A) for 2 events per night, 54.1 for 10 events and 53.5 for 30 events.

Key words: sleep - noise-induced awakenings - continuous and intermittent noise - critical levels.

1. INTRODUCTION

Sleep disturbance is measurable and is characterised as subjectively experienced deviations from the usual or desired sleep behaviour. It is increasingly caused by environmental stimuli, predominantly noise.

Moderate noise-induced sleep disturbance can be tolerated for a limited time. But, if it becomes chronic, it is assumed to accelerate the (multifactorial) genesis of particular diseases. This hypothesis is plausible in view of the fact that long-term residents in streets with high traffic noise levels continue to be affected by noise; they wake up more often, they assess sleep quality as worse and their performance is impaired. [Griefahn, 1985; Jurriëns et al., 1983]

2. DETERMINATION OF CRITICAL LEVELS

Disregarding the most sensitive and the most resistant people the relation between noise and its effects is almost linear. However, if both these groups (which amount to 10-15% each) are included, the dose-response curve becomes sigmoid -shaped indicating that some people react to very low intensities whereas others are not disturbed even by very high levels.

So, the protection of all people required the elimination of any noise immission. As this is impossible, limits must be established which protect at least a majority of the exposed population.

The determination of upper limits for noise-induced sleep disturbances requires specification of

(1) those indicators of sleep disturbance, which plausibly predict the (assumed) effects of health and
(2) those noise parameters, which predict sleep disturbances.

2.1 Descriptors of sleep disturbances

The effects of noise are usually described by the total sleep time, by the number and the duration of the particular sleep stages (including awake periods) as well as by the number of (noise-induced) awakenings, sleep stage changes and autonomic responses. After-effects are indicated by self-estimated sleep quality and by the alterations of mood and performance.

The predictive significance of these alterations is well founded only for awakenings. Awake periods of at least 4 minutes are recalled in the morning and they determine the subjective assessment of sleep as well as mood and performance [Baekeland & Hoy, 1971]. The resulting psychosocial stress may contribute to the genesis of chronic health disorders, particularly of cardiovascular diseases.

2.2 Noise descriptors

People are generally more disturbed by intermittent than by continuous noises. Additional alterations occur in the electroencephalogram (EEG) if continuous noises are interspersed with intermittent stimuli and if the maximum levels then exceed the equivalent sound pressure levels by at least 10 dBA [Eberhardt, 1987; Spreng, 1975]. A 'modulation depth' of 8-10 dBA was found to evoke cardiovascular responses [Vallet et al., 1983].

These findings suggest that the equivalent sound pressure level is not generally suitable for the prediction of sleep disturbances and that upper limits must be determined for both acoustic situations separately. Considering the literature it seems to be reasonable to define the limit between continuous and intermittent noises by a modulation depth of 10 dBA [de Camp, 1980; Eberhardt, 1987; Griefahn, 1985; Lukas, 1975; Öhrström, 1982; Wagner, 1988].

Furthermore, the cited papers suggest that the effects of intermittent noises are better predicted by the number and the maximum levels of the particular stimuli whereas the effects of continuous noises are better related to the equivalent sound pressure levels.

3. CRITICAL LEVELS FOR CONTINUOUS NOISES

Upper limits for continuous noises were elaborated for road traffic, which is - regarding the number of exposed people - the most important source of noise.

Eberhardt et al. [1987] recorded sleep in quiet and during continuous noises with equivalent sound pressure levels of 36 and 45 dBA indoors. As alterations of sleep were not observed before L_{eq} =45 dBA the authors assume the critical noise levels to be within the range of L_{eq} =36 and 45 dBA.

Vallet et al. [1983] related EEG-alterations and autonomic responses to the equivalent sound pressure levels (field study with 26 subjects). The correlation coefficient became significant if noises < 37 dBA were discarded. The authors conclude that 37 dBA must not be exceeded.

Griefahn [1986] exposed 36 subjects during 12 consecutive nights to recorded traffic noise with equivalent sound pressure levels from 37 to 63 dBA. On the basis of subjective assessments (which correlate with the EEG measures) an upper limited was determined at L_{eq} =40 dBA.

4. CRITICAL LEVELS FOR INTERMITTENT NOISE

Numerous experimental studies were executed until now and the upper limits suggested for intermittent noises vary within a large range from 45 to 68 dBA due to the fact that awakening reactions are not only related to the physical descriptors of noise but also to non-acoustic variables (e.g. age, sleep depth). This must be considered when elaborating admissible noise levels.

4.1 Basis for the analysis of awakening reactions

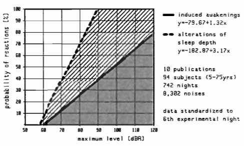
For the following considerations the results of experimental studies which are comparable in method and evaluation were pooled and recalculated. Male and female subjects from 5 to 75 years of age were exposed to up to 32 short-term noises (≤40 s) each night. Various types of aircraft noises were applied, sometimes interspersed with pink noise. A few data from truck and impulse noises were also included. Noise pressure levels were measured indoors. As a limited habituation was observed within the first 5-6 nights the material was standardised to the 6th exposure night.

4.2 Determination of upper limits for awakening reactions

The dose-response curves in Figure 1 relate the probability y of awakening reactions to the maximum noise levels x. The probability of awakening reactions is expressed by equation (1),

$$y = 1.32x - 79.67 \qquad (1)$$

However, a linear relationship is realistic only if the most sensitive and the most resistant people are disregarded, that is to say within an awakening probability of about 10-90%. Thereafter, 10% of the whole population are expected to wake up at 67.9 dBA presupposing a variable number of up to 32 noises during the night. This maximum level which is the threshold for the remaining 90% is called the critical load.



Alterations of sleep depth and awakenings intermittent noise and maximum levels

Figure 1.

4.2.1 Adjustment of the critical noise level to the most sensitive sleep stage

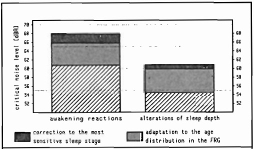
The chance of being awakened by noise is less during NREM-sleep than during REM-sleep. (Table 1). As the latter amounts approximately to one fourth of the total sleep time, it is reasonable to adjust the critical noise level to this stage, as if people spend their total sleep time within this stage.

As the age of the subjects whose data contributed to equa-

Table 1.

	AWAKENING REACTIONS	SLEEP STAGE CHANGES
Determination of maximum sound pressure levels (age of subjects: 5-75 yrs, x = 40 yrs)		
equation (1)	y = -79.67 + 1.32x	y = 282.86 - 3.17x
x% reactions at a maximum level of	10% awakening reactions 67.9 dBA	10% sleep stage changes 60.8 dBA
Adjustment to the most sensitive sleep stage		
sleep stages	Flat Deep REM	Flat Deep REM
probability of reactions	20% 8% 21%	52% 55% 62%
average prob. (all stages)	18.4%	54.9%
most sensitive stage	21.2% (REM)	52.0% (flat)
increase	2.7% (round -off error)	2.9%
according to equation (1)	2.1 dBA	0.9 dBA
Adjustment to the age distribution in the FRG (40 yrs 53%, 71 yrs 90%)		
equation age-reactions	$y = 7.3 + 1.43x - .028x^2 = .0002x^3$	y = 78.54 - .557x
reaction of 40 yrs people	17.9%	56.3%
reaction of 71 yrs people	24.7%	39.0%
increase	6.8%	17.3%
according to equation (1)	5.1 dBA	5.4 dBA
Total	7.2 dBA	6.3 dBA
Resulting Limit	60.7 dBA	54.5 dBA

tion (1) averaged 40 years - the results were adjusted to a typical sleep stage distribution of this age (60% stage 2, 16% stages 3 & 4, 24% stage REM). The higher probability of being awakened in stage REM corresponds to a sensitization of 2.1 dBA (Fig. 2).



Noise-induced awakenings and alterations of sleep depth
correction of the critical noise level to the most sensitive sleep stage and adaptation to the age distribution in the FRG

Figure 2.

4.2.2 Adjustment of the critical noise level to the age distribution in the population

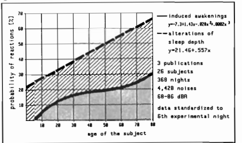
The critical noise level calculated above refers to an average age of 40 years. As the probability of being awakened increases with age and as 47% of the citizens of the Federal Republic of Germany (FRG) are over 40, the admissible level must be once more adjusted. The extension of preventive measures to at least 90% of the population required the consideration of people aged up to 71 years.

The relation between age and the probability of noise-induced awakening is plotted in Figure 3. According to equation (2),

$$y = .002x^3 - .028x^2 + 1.43x - 7.3 \qquad (2)$$

71 years old people are about 6.8% more sensitive than 40 years old subjects. This corresponds to a sensitization of 5.1 dBA. In other terms: if 71 years old people are exposed to sound pressure levels (SPL) of x dBA they probably wake up as often as 40 years old people who are exposed to an SPL of x + 5.1 dBA.

The consideration of most sensitive sleep stage and of the age distribution requires a reduction of the upper load at 67.9 dBA by 2.1 + 5.1 = 7.2 dBA. The admissible maximum level for awakening reactions is then 60.7 dBA (Figure 2), again for the case of up to 32 noises occurring during the night.



Alterations of sleep depth and awakenings
intermittent noise and age

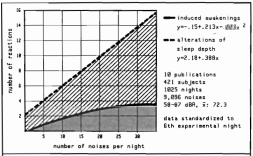
Figure 3.

4.3 Determination of an upper frequency

As the critical noise level calculated above refers to the individual stimuli the number of noise-induced awakenings varies with the number of stimuli during a night. The admissible risk, however, must take into consideration the overall risk of being awakened during a whole night's sleep. The awakening frequencies (as reported in several papers) are related to the number of stimuli per night in Figure 4. The relation is curvilinear; the risk of being awakened by a particular noise becomes gradually smaller. Using equation (3),

$$y = -.003x^2 + .213x - .15 \qquad (3)$$

a 10%-risk is reached if between one and two noise events (theoretically 1.38) occur during the night (the average peak level of the noise events used for this presentation was 72.3 dBA).



Alterations of sleep depth and awakenings
related to the number of noises per night

Figure 4.

4.4 Determination of an admissible frequency

As described above, after a few nights of habituation a theoretical number of 1.38 stimuli per night causes awakenings in 10% of the exposed people. This is defined as the upper risk, which must not be exceeded.

To avoid more awakenings an increasing number of acoustic stimuli must be compensated by an attenuation of the particular maximum levels. This relation is plotted in Figure 5. Equation (4),

$$y = (.09 + .129x - .0018x^2)^{-1} + 53.16 \qquad (4)$$

is deduced from equations (1) and (3). The data are adjusted to age and to the most sensitive sleep stage and it is additionally regarded that equation (3) is based on studies where the maximum levels averaged 72.3 dBA

According to Figure 5 the admissible sound pressure level decreases considerable from one to five noises. Thereafter it approaches gradually to 53.2 dBA.

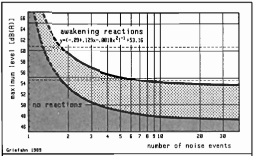
5. APPLICATION AND VALIDITY OF THE CURVE

Each point of the curve represents the same risk as defined above: one awakening will probably be evoked in not more than 10% of the exposed people if two noises with peak levels of 59.4 dBA or 10 noises of 54.1 dBA or 30 noises of 53.6 dBA occur during a night.

For two peak levels, 59 and 54 dBA the maximum admissible risk will be maintained for the following combinations:

	10 x 54 dB(A)	and	0 x 59 dB(A)
or	5 x 54 dB(A)	and	1 x 59 dB(A)
or	0 x 54 dB(A)	and	2 x 59 dB(A)

Regarding the underlying studies, the applicability of the curve is restricted to the assessment of short-term stimuli (≤40 sec), to a total number of 32 and (according to the calculations completed in chapter 4) to peak levels up to 60.7 dBA.



Limits for noise immission during the night
number of noises and maximum levels

Figure 5.

6. SPECIAL (ACOUSTIC) SITUATIONS

6.1 Rare Exceedances

The curve in Figure 5 represents the admissible risk for each single night. Regular exceedances during several nights are not allowed even if the actual risk is lower within an appropriate number of succeeding nights.

Incidental exceedances, however, are possibly tolerable. After noisy nights in the laboratory, many authors observed rebound effects within the following quiet nights. These compensations are also likely in the real life situation. But then a great variety of additional factors influence the organism rendering a compensation not before several succeeding nights. Incidental exceedances are admissible only in case that the upper risk is not exceeded during several consecutive nights. A number of 7 to 10 nights seem to be sufficient in this sense.

6.2 Assessment of the risk during the night

Sleep depth decreases gradually during the night elevating the reactivity in the morning. Accordingly, more noise-induced awakenings and larger autonomic responses are then registered compared to the evening [Griefahn, 1988 1989; Vallet et al., 1988]. This situation is probably not exclusively related to sleep depth. Additional factors, as for instance reduced tiredness and the circadian rhythm may contribute.

If noise exposure starts before sleep onset (which corresponds to the real life situation), sleep onset is not delayed but latency to deep sleep is prolonged. If exposure terminates after 2-3 hours deep sleep can be retrieved. On the contrary, noise in the morning provokes more awakenings, the time to return to sleep is prolonged and more difficult and compensation becomes impossible. Awakenings experienced in the morning are more often recalled and cause a worse assessment of sleep quality as well as a larger impairment of performance [Griefahn, 1988; Müller-Limmroth & Ehrenstein, 1974].

Considering the increased reactivity in the morning, it is recommended e.g. for air traffic or railway traffic to gradually prolong the intervals between consecutive noises and to reduce the admissible maximum levels during the night. Another alternative is to concentrate the flights in the beginning and at the end of the night and to keep free the hours between.

6.3 Content of information

The meaning of an acoustic stimulus which is determined by the physical parameters and by the experience of an individual with the particular noise is most decisive for sleep disturbance. A high emotional stress causes more and larger responses even during deep sleep. Therefore, sensitisations are possible particularly for those noises which annoy people during the day. On the other hand an initially adverse stress component may decrease and then cause smaller responses. The latter, the process of habituation, is often observed in residents living near railroad tracks or in streets with high traffic volume.

6.4 Special groups, poor sleepers, ill people

The arousal thresholds of poor sleepers do not differ from those of good sleepers, but once they are awake they need more time to return to sleep [Johnson et al., 1979].

No data are available concerning noise-induced sleep disturbances in ill people. Considering autonomic reactions, ill people were found to be more sensitive while awake. The increase corresponds to 11 dBA. This may serve as a criterion for further noise control in hospitals during the night [Griefahn, 1982].

6.5 Initial Stress

When new roads, airports, railroad tracks etc. are planned and realised the basic stress on the residents must be considered. As man reacts to the acoustic situation as a whole it makes no sense to assess separately the different noises. If the basic acoustic situation is continuous, additional strain is expected if the accessory noise causes modulation depths of at least 10 dBA and the curve in Figure 5 then may be used for the assessment of the new situation.

7. DISCUSSION

If a stress cannot be eliminated completely limits are required which improve the situation for all people concerned although these limits cannot ensure that each individual will be unaffected. These limits are usually set by politicians and by administrators. It may not be acceptable therefore that 10% of the population are disregarded in the calculations executed here. But this decision offers the possibility of elaborating a method for the determination of upper limits on the basis of the available data. The same procedure could be applied for other percentages (5%, 3% etc.).

The curve which presents the upper risk for intermittent noise was calculated using published data. Its validity is not yet proven but numerous facts support it's applicability e.g. for planning new airports, railroad tracks, etc..

The function which represents the admissible risk for intermittent noise was deduced from two equations where the awakenings are related to the number of noises and to their corresponding maximum levels.

The maximum risk was determined disregarding 10% of the population who are supposed to be most sensitive. After the adjustment to the most sensitive sleep stage and to the age distribution in the FRG the risk is - after a short period of habituation - far below 10%. The latter assumption is supported by Wagner [1988], who exposed his subjects selectively during the most sensitive hours in the early morning. After two habituation nights truck noises with maximum levels of 64 dB(A) led to awakenings in not more than 1.6%.

The curve of the upper risk was calculated from studies where the authors predominantly applied aircraft noises. The effects of a few other noises (truck, impulse, pink noise) are also included. This was possible after the analysis of the relevant literature revealed that different short stimuli cause more or less the same extent of reactions after some habituation nights [Griefahn, 1985].

It is almost impossible to simulate perfectly the field situation in the laboratory. As a rule, the reactivity increases in the latter environment. As all the basic data were taken from laboratory studies the frequencies of noise-induced awakenings are probably higher as if registered at home [Eberhardt, 1987]. This leads to a more stringent assessment which can be tolerated in consideration of preventative measures.

The awakening reactions were mostly verified by the recordings of the EEG and EOG. In a few cases the subjects signalled awakenings by pressing a button. This procedure is suspect as any active cooperation of the subjects increase the alarming content of the stimuli and thereby the probability of awakening reactions. But this is again acceptable from the viewpoint of preventative medicine.

8. GOALS FOR PREVENTATIVE MEDICINE

The establishment of limits is required if noise immission cannot be eliminated completely. Limits improve the situation for the whole population, they protect the majority of the people exposed, but they cannot exclude the risk for each individual. It is therefore desirable to remain below that risk by reducing the frequencies and the maximum levels as far as possible.

The recommendation to reduce noise 'as far as possible' is certainly not helpful to those who make decisions (politicians, administrators). On the other hand it is difficult to suggest a lower limit as the awakening reactions are the only ones which are - according to our present knowledge - possibly significant for the presumed health disorders. They are recalled in the morning, they determine mood and well-being and the resulting psychosocial stress may contribute to the genesis of multifactorial diseases.

The significance of the alterations of sleep depth is completely unknown. No correlations exist between these reactions and the assessment of sleep in the morning. Nevertheless, it may be desirable to avoid even these reactions and to maintain normal sleep. The establishment of limits based on this criterion reduces at least the number of those very sensitive subjects who awake if the upper curve in Figure 5 is regarded.

As for noise-induced awakenings a limit for 0-reactions (the lack of sleep stage changes in 90% of the population) was calculated and adjusted to the most sensitive sleep stage and to the age distribution (Table 1, Figure 2). The resulting maximum level of 54.5 dBA is 6.3 dBA below the appropriate maximum level for awakenings.

The upper curve in Figure 5, which was calculated for awakening reactions represents the upper risk which must not be exceeded in order to avoid long-term effects on health. The curve lower, calculated for the 0-reactions, however, represents the preventive goal, which should be realised if possible.

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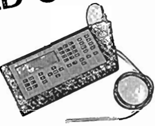

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Overnight Traffic Noise Measurements In Bedrooms And Outdoors, Pennant Hills Road, Sydney - Comparisons With Criteria For Sleep

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Abstract: Continuous noise recordings were made overnight, simultaneously in front bedrooms and at the facades of nine dwellings on Pennant Hills Road, Sydney. Continuous video recordings of the traffic were also made. L_{Aeq}, L_{Amax}, L_{Apk}, L_{A90}, L_{A10} and L_{A1} were obtained for each 20-second interval of each night. The recordings were also analysed for single noise 'events' exceeding 70 dBA for 2 seconds or longer (outdoors) and 50 dBA for 2 seconds or longer (indoor noise). The number and type of vehicles were counted for each 15-minute period of the night for six of the nine locations. Outdoor/indoor attenuation and reduction in number of noise 'events' were also determined, the relations between traffic count and mix were explored, and the results compared with some suggested criteria for adequate sleep. It was found that the amount of attenuation measured depended partly on the noise descriptor used, but that recent estimates of the typical outdoor/indoor traffic noise attenuation of suburban homes, with windows open slightly, were too low. Notwithstanding these variables the noise exceeded all sleep criteria at all locations, indoors and outdoors, except in the one case where the windows were closed and double glazing was used, where they were marginal.

1. INTRODUCTION

There is still disagreement as to acceptable and desirable limits of exposure to traffic noise during sleep, but even assessing the exposure of people to traffic noise in their own homes is not easy. Recommendations on methods of measuring and calculating exterior traffic noise levels are available [AS 2702-1984; AS 3671-1989], and a number of estimates of traffic noise levels at the facades of Australian suburban dwellings have been made [cf. Brown and Cliff, 1989]. Similarly, there are methods for the calculation of the transmission loss of building components [AS 3671-1989; Cops and Wijnants, 1988], and guidelines are available for estimating transmission loss of single and double-glazed windows, and insulated walls and ceilings [CSIRO, 1978]. However, the application of the concepts underlying these methods to assess typical indoor noise levels due to road traffic is limited, mainly because standards of building construction fall short of laboratory models, and buildings deteriorate with time [Lawrence and Burgess, 1983; Mizia and Fricke, 1983; AS 3671-1989]. The task of estimating interior noise levels from exterior ones is made more complex by the variety of physical factors determining facade noise levels [Mizia and Fricke, 1983], and by the effects of variations in noise spectrum [Dunn, 1989]. As well as this, the measurement locations inside the house assumed in these models may not always correspond to where people spend their time.

The lack of reliable data on the outdoor/indoor noise attenuation of typical dwellings, and on interior noise levels due to road traffic, was very evident in submissions made to the recent public enquiry into the proposed F2 Freeway linking Pennant Hills Road, Beecroft, to Pittwater Road, Ryde, near Sydney [Commissioners of Enquiry, May, 1990; July,1990]. Just prior to this Enquiry, we had simultaneously recorded noise at the facade, and in the bedrooms of a number of suburban dwellings on Pennant Hills Road, Sydney, in the course of research on the effects of noise on sleep [Carter et. al., 1991]. These recordings have the advantage of being gathered overnight (and therefore include a minimal contribution from human activities indoors), and were made continuously over periods of six to eight hours. The indoor microphone was placed in roughly the centre of the bedroom, and because the people were asleep, would approximate the noise exposure experienced by them for probably the longest single period of their day.

This paper summarises the results of analysing these indoor and outdoor noise recordings, and compares the results with (a) recent estimates of outdoor/indoor traffic noise attenuation, and (b) suggested acceptable levels of traffic noise for sleeping areas, discussed in the reports of the Commission of Enquiry into the proposed F2 Freeway, Sydney, [1990].

2. INSTRUMENTATION AND METHOD

2.1. Study Location

Pennant Hills Road was selected for the study because of its high annual average daily traffic volume (AADT), of 35,000 vehicles [Department of Main Roads,1983], much of it during the night and early hours of the morning, because of the high proportion of heavy vehicles in this traffic, and because the road is lined for most of its length by single family dwellings. These dwellings are predominantly brick veneer or double brick bungalows with tiled roofing, although there are also a number of timber and fibro homes. Most were constructed since 1945. The road traverses low hills, and has a number of intersections with traffic lights.

2.2. Noise Recording

A Bruel and Kjaer Type 4921 outdoor microphone system was placed between the houses and the roadway such that the microphone was at the centre position of the bedroom window and one metre from it, in accordance with Australian Standard AS 2702 [1984]. The output of the microphone system was fed through a slightly opened window to a high fidelity audio channel of a National Panasonic Type AG6800 video recorder, mounted in a rack placed in a room adjacent to the bedroom. The high fidelity channels had a frequency response of 20 Hz-20 kHz, and a signal to noise ratio of 43 dB. Calibration of the outdoor noise recordings used the microphone system's internal calibrator. This tone (1000 Hz at 86 dB) was recorded on the video tape prior to commencing recording.

The indoor microphone system used a Bruel and Kjaer half-inch condenser microphone Type 4165 and Bruel and Kjaer Type 2204 sound level meter (SLM). The SLM and microphone were mounted on a tripod, placed at the foot of the bed at a height of 1.2 metres from the floor, and pointed toward the bedroom window nearest to the outdoor microphone. The output of the SLM was fed to the second high fidelity audio channel of the video recorder. A reference tone from a Bruel and Kjaer pistonphone Type 4220 was recorded on the tape, prior to noise recording.

2.3. Video Recording of the Traffic

The passing traffic was videotaped by means of a black and white video camera (National Panasonic Type 1460N, with Cosmicar "auto iris" lens) in a Molynx environmental housing. The camera was mounted on a telescopic mast on top of a van, parked in the driveway of each house. The power supply of the camera was installed in the instrumentation rack in the house, and the output of the camera fed to the video recorders in the same rack.

2.4. Timing of Recordings For Subsequent Analysis

The reference time, 'Time Zero' (T_0), for all recorded signals was derived from the square wave calibration pulses generated by the Holter (cardiac) monitor (fitted to the subject) at the outset of its recording.

National Panasonics Type AG-6800 video recorders are capable of recording for a maximum of four hours. To enable recording for eight hours, a timer switched a second recorder to record mode at a time preset by the experimenter.

3. DATA REDUCTION

3.1. Traffic Volume and Composition

Six of the nine nights' video recordings of traffic passing the houses were replayed. The numbers of vehicles of each of several types were counted for each 15-minute period of the night. The classification was based on the method given in Australian Standard 2702 [1984]. Figure 1 of this Standard classifies vehicles into 12 types, but because of the poor light it was not possible to distinguish all of these types reliably, and our classification was restricted to three categories. These were (i) motor cycles; (ii) cars, vans and light trucks (AS 2702 Types (i) to (iii)); and (iii) Buses, trucks and semi-trailers (AS 2702 categories (iv) to (vi)).

3.2. Noise Data Reduction

The noise recordings were analysed by replaying the tapes into a Metrosonics db 604 Sound Level Analyser, controlled by a PDP-11 computer.

Two types of analysis ('Multiple Interval' and 'Single Event' analyses) were carried out of the indoor and outdoor noise channels in separate replays of the tapes, making a total of four analyses of each night.

In the 'Multiple Interval' analyses the Sound Level Analyser was programmed to log L_{eq}, L_{max}, L_{pk}, L_{90}, L_{10}, and L_1, in dBA, in each 20-second interval of the night. In these analyses L_{max} is the maximum value of L_{eq}(1/16 second) registered during each 20-second interval. L_{pk} is the maximum instantaneous sound level observed in each 20-second interval when no exponential averaging time constant is used.

In the 'Single Event' analyses the Sound Level Analyser logged every noise event that exceeded a preset level for 2 seconds or more. Onset time in seconds from T_0, duration above 'threshold' (in seconds), L_{Aeq}, SENEL (Single Event Noise Exposure Level, or L_{Aeq} normalised to a duration of one second), and L_{Apk} were recorded for each event.

4. RESULTS

4.1. Traffic Volume and Mix

Figure 1 plots the total number of vehicles, and the total number of heavy vehicles, in each 15-minute period of the night from about 10 p.m. to 6.30 a.m., averaged over six of the test nights. As can be seen from Figure 1, traffic density ranged from 500-750 vehicles per hour between 10 p.m. and midnight, fell to about 150 in the early hours of the morning and then increased sharply to reach about 700 vehicles per hour between 5 and 6 a.m. The standard deviation (SD) of the total number of vehicles (shown in Figure 1) ranged from 5.6 to 127.2, for 15-minute intervals from 11 p.m. to 5.45 a.m., with an average SD of 25.1. The average SD for heavy vehicles (HVs, our category (iii)) per 15-minute interval was 12.3.

The percentage HVs ranged from 10% at about 11 p.m. to 60% of all traffic between 3 and 5 a.m.

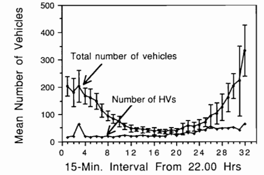

Figure 1. Means, and standard deviations above and below the means, of the numbers of vehicles (all types), and mean numbers of heavy vehicles (HVs) in successive 15-minute intervals from 22.00 hours. The counts were made from video recordings on six separate nights at six different locations on Pennant Hills Road.

4.2. Multiple Interval Noise Analyses

4.2.1. Intercorrelation of Noise Measurements

As a check on the reliability of the noise measurements, and to verify that indoor measurements were determined mainly from environmental sources and not from sources within the home, the results of the Multiple Interval analyses of indoor and outdoor channels were correlated separately for each subject/night, and for each type of noise measurement. If such intercorrelations are high, it can be assumed that the indoor and outdoor recordings and analyses were reliable, since any errors in the (independent) microphone systems, or in the Sound Level Analyser/PDP-11 analyses would be uncorrelated. Depending on the subject/location, 1257 to 1390 pairs of data points, corresponding to each 20-second interval of the night, were the basis for each correlation coefficient.

The correlation between L_{Aeq}, L_{Amax}, L_{Apk},, L_{A90}, L_{A10} and L_{A1} measured outdoors and indoors averaged 0.88, 0.80, 0.69, 0.90, 0.90, and 0.84 respectively, for subjects with windows open, confirming the reliability of the data. As might have been expected, similar correlations for subjects with windows closed were lower, averaging 0.51, 0.43, 0.31, 0.51, 0.57, and 0.49.

4.2.2. 15-Minute Multiple Interval Data - Outdoor Noise

The data consist, on average, of 1366 values, one for each 20-second interval of the night, for each of six noise variables, and for each of nine measurement locations on Pennant Hills Road. These 20-second interval data for each subject were combined in successive 15-minute intervals throughout the night.

For each subject/location the 15-minute L_{Aeq} were derived from the 20-sec L_{Aeq} data using the equation:

$$L_{(Aeq,LT)} = 10 \log_{10} \left[\frac{1}{N} \sum_{i=1}^{N} 10^{0.1 L(Aeq,Ti)} \right] \quad \text{dB(A)} \quad (1)$$

where $L_{(Aeq,Ti)}$ is the L_{Aeq} for the ith 20-second interval, etc.

15-minute L_{Amax} and L_{Apk} were obtained by taking the highest L_{Amax} and L_{Apk} values in the 45 20-second intervals of each 15-minute interval. The 15-minute L_{A90}, L_{A10} and L_{A1} are the means of the 45 20-second L_{A90}, L_{A10} and L_{A1} values respectively, in each 15-minutes.

The mean 15-minute outdoor L_{Aeq}, L_{Amax}, L_{Apk}, L_{A90}, L_{A10}, and L_{A1}, averaged over all nine subject/locations, are plotted in Figures 2(a) to 2(f).

4.2.3. 15-Minute Multiple Interval Data - Indoor Noise

Similar analyses were made of the indoor noise recordings. The means (across subjects) of the 15-minute multiple interval noise measurements for the seven bedrooms with windows open (derived from 20-second L_{Aeq}, L_{Amax}, L_{Apk}, L_{A90}, L_{A10}, and L_{A1}) are also plotted in Figures 2(a) to 2(f).

4.3. Single Event Analyses

The number of outdoor noise events in each hour which exceeded 70 dBA for two seconds or more was averaged over the nine subject/nights. The maximum and minimum numbers of events were also calculated. Similar statistics were calculated for indoor noise events exceeding 50 dBA for two seconds or more, separately for those locations with windows open, and closed. The results of these calculations are given in Table 1.

Noise Events	Statistic	Hour From Lights Out							
		1	2	3	4	5	6	7	8
Outdoor Events > 70 dBA 2 Sec or More	Mean	38	34	31	34	47	63	91	117
	Min	8	17	7	13	25	29	61	51
	Max	58	49	59	50	77	92	119	184
Indoor Events >50 dBA 2 Sec or More (Windows Open)	Mean	54	48	36	33	41	55	79	104
	Min	9	18	9	8	15	22	31	29
	Max	202	158	99	67	75	105	139	171
Indoor Events >50 dBA 2 Sec or More (Windows Closed)	Mean	7	4	1	3	4	2	4	72
	Min	0	0	1	0	1	1	3	7
	Max	13	8	1	5	6	2	4	136

Table 1. Mean, minimum and maximum number of noise events exceeding 70 dBA outdoors for two seconds or more, across nine locations. Similar data are given for noise events exceeding 50 dBA at seven locations with windows open; and exceeding 50 dBA at two locations with windows closed. Data are for each hour of the night after lights out (T_O).

4.4. Outdoor/Indoor Attenuation

For each subject/location the outdoor/indoor noise attenuation in L_{Aeq}, L_{Amax}, L_{Apk}, L_{A90}, L_{A10}, and L_{A1} was calculated by subtracting the indoor from the corresponding outdoor measurements for each 20-second interval, and taking the mean of the (on average 1366) differences. The results are

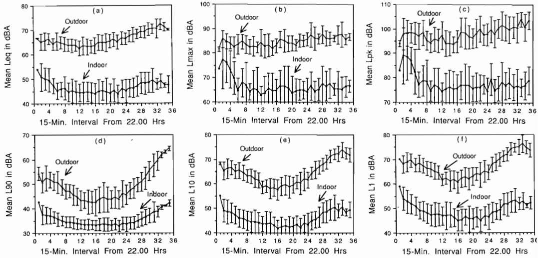

Figure 2. Upper curves: (a) mean L_{Aeq}, (b) mean L_{Amax}, (c) mean L_{Apk}, (c) mean L_{Apk}, (d) mean L_{A90}, (e) mean L_{A10}, (f) mean L_{A1} recorded at the facades of nine homes on Pennant Hills Road. Means are for each 15-minute interval of the nights from 22.00 hours. The vertical bars are the standard deviations above and below the nine mean values. The lower curves plot the corresponding data for indoor measurements for seven of the homes, i.e. for those with the bedroom window open.

given in Table 2. This Table also gives the mean attenuation for each measure, separately for subject/locations with windows open and closed.

Subject/ Location	Mean	Outdoor /	Indoor	Attenuation		
	LAeq	LAmax	LApk	LA90	LA10	LA1
AA(o)	19.25	19.82	17.84	16.19	20.27	20.19
AB(o)	13.74	13.40	14.56	11.11	13.82	13.87
FF(o)	13.14	11.88	12.48	12.11	13.49	12.31
PR(o)	18.32	18.40	19.44	14.58	18.86	18.55
HS(o)	20.73	22.10	21.46	16.34	21.58	22.06
JB(o)	18.31	19.09	18.27	14.22	19.22	19.25
FJ(o)	15.89	16.76	16.35	9.19	17.18	17.17
JG(c)	20.46	20.13	18.43	12.88	21.91	21.14
RF(c)	22.58	26.04	23.80	11.21	25.53	26.30
Mean(o):	17.05	17.35	17.20	13.39	17.77	17.63
Mean(c):	21.52	23.08	21.11	12.05	23.72	23.72
Closed-Open:	4.47	5.73	3.92	-1.35	5.94	6.09

Table 2. Mean outdoor/indoor attenuation for each noise measure and each subject location. Each value is the mean of the differences between noise measurements in c. 1366 20-second intervals of the night.

4.5. Relations Between Noise, and Noise and Traffic, Measures

As Griefahn [1991] has pointed out, traffic noise can be both intermittent and continuous, but the demarcation of the two types of noise has not been established. One way may be to look at relatively long term measures of traffic noise which take the difference between 'average' and 'peak' measures of noise, and examine their relation to time of night and traffic conditions. Three such measures are L_{A10}-L_{Aeq}, L_{Amax}-L_{A90}, and L_{A1}-L_{A90}.

Burgess [1978] has shown that simple mathematical relations exist between some commonly used noise measures such as (outdoor) L_{eq} and L_{10} for short term (one hour) traffic noise measurements, and suggested that these relations could vary for different conditions of traffic flow and frequency of heavy vehicles (traffic mix), such as may occur at night. Brown [1989] found that the differences between long term (24-hour) L_{eq} and L_{10} were a function of noise level and that in this case there was no simple translation between them. However, $L_{eq,24h}$ and $L_{10,18h}$ were simply related by :

$$L_{10,18h} = L_{eq,24h} + 3.5 \quad (2)$$

and the long term L_{10} and L_{eq} values could be approximated by measuring the maximum one-hour morning values and subtracting 3 dB.

Some information on the relations between these variables is available from the present data. Figure 3 plots the difference between L_{Aeq} and L_{A10} (mean outdoor L_{Aeq} -L_{A10}) for each successive15-minute interval of the night from 22.00 to 06.30 hours. A second order polynomial is fitted to these data. As can be seen from this Figure the difference varies from about -1.8 to 6 dBA, with the higher values occurring when the number of vehicles is low and the percent heavy vehicles, high. Figures 4 and 5 show the relationship of L_{Aeq} -L_{A10} to these two variables. The correlation (r^2) of L_{Aeq} - L_{A10} with percent heavy vehicles is 0.77, with total number of vehicles, 0.93. Its correlation with number of heavy vehicles (a fourth order polynomial) was least, at 0.52.

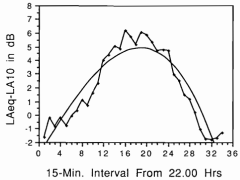

Figure 3. Mean, across nine subject/locations, of the differences between L_{Aeq} and L_{A10} (outdoors) in successive 15-minute intervals of the night.

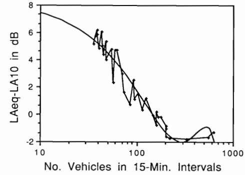

Figure 4. The relation between mean L_{Aeq}-L_{A10} and mean number of vehicles, in 15-minute intervals.

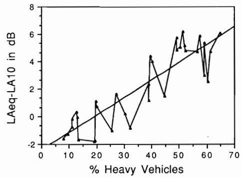

Figure 5. Mean L_{Aeq}-L_{A10} by percentage heavy vehicles, for each 15-minute interval of the night.

The NSW State Pollution Control Commission (SPCC) has suggested that the difference between outdoor L_{Amax} and L_{A90} (L_{Amax}-L_{A90}), should not exceed 15, for satisfactory sleep [Commissioners of Enquiry Report, Vol. 1]. Figures 6-9 show the relations between this variable and time of night, total number of vehicles, number of heavy vehicles and percent heavy vehicles respectively. The difference exceeded 15 dBA in all 15-minute intervals of the night, and was greatest when traffic volume was least. The correlation was greater with total number of vehicles (r^2=.75) than with the percent heavy vehicles (r^2=.67). The mean overnight L_{Amax}-L_{A90} equalled 35.78.

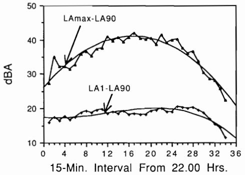

Figure 6. Mean L_{Amax}-L_{A90} and mean L_{A1}-L_{A90}, for each successive 15-minute interval of the night.

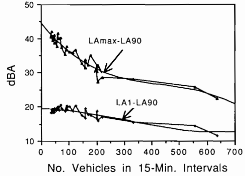

Figure 7. Mean L_{Amax}-L_{A90} and mean L_{A1}-L_{A90}, by mean number of vehicles in 15-minute intervals.

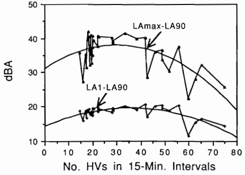

Figure 8. Mean L_{Amax}-L_{A90} and mean L_{A1}-L_{A90}, by mean number of heavy vehicles in 15-minute intervals.

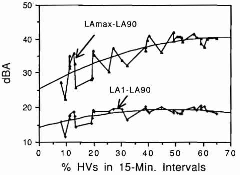

Figure 9. Mean L_{Amax}-L_{A90} and mean L_{A1}-L_{A90}, by percent heavy vehicles, in 15-minute intervals.

The SPCC criterion has also been defined in terms of the difference between L_{A1} and L_{A90}. Figures 6-9 also plot the mean (L_{A1}-L_{A90}) for each 15-minute interval of the night, total number of vehicles, number of heavy vehicles, and percent heavy vehicles. Again the suggested 15 dBA limit was exceeded for much of the night, though not by such a large margin as when it was defined as (L_{Amax}-L_{A90}). The relation of (L_{A1}-L_{A90}) to the total number of vehicles per quarter hour was also closer than it was to the percent heavy vehicles (r^2=.93 and .46, respectively), and least with number of heavy vehicles (r^2=.43). The mean L_{A1}-L_{A90} overnight on Pennant Hills Road was 18.26 dBA.

5. DISCUSSION

5.1. Outdoor/Indoor Noise Attenuation

In the course of the F2 Expressway enquiry the RTA's consultant estimated that outdoor/indoor noise attenuation, with windows open, would be 10 dBA. Others claimed that the minimum attenuation would be 5 dBA, quoting studies by the CSIRO [1978] and the University of Sydney [Mizia and Fricke, 1983]. The latter data were based on laboratory tests. Our data, from typical dwellings impacted solely by traffic noise, indicate that with windows open slightly, the attenuation is of the order of 13-20 dBA when measured in L_{Aeq}. Greater attenuation figures are obtained when measures which further emphasise the peak or maximum levels are used. The least attenuation is recorded when the descriptor is background noise level (L_{A90}).

Aside from the descriptor used, the main reasons for the discrepancies between the results of the laboratory studies and the present study would appear to be the amount the window was opened, and the position of the microphone in relation to the open window [Fricke, personal communication]. In our study the most the sash was raised was about 15 cm, and in some cases the window was opened just sufficiently to admit the cables from the outdoor microphone and video camera. It is our belief that many people living on busy highways cope with their needs for fresh air and quiet by such a compromise. Also, the microphone was placed at the foot of the bed, and roughly in the center of the room, further reducing the measured interior noise levels. The soft furnishings of these bedrooms would also have reduced the interior noise levels slightly.

As expected, the outdoor/indoor noise reduction was greater for the two locations where the windows were closed. The differences in attenuation between windows open and closed locations is less than would have been expected on the basis of experimental work, even though one of the rooms was double glazed. The reasons for this have already been noted. On the other hand it is also clear that the attenuation value depends also on the type of noise measure used, which should be borne in mind when translating indoor noise criteria into outdoor measurements and vice versa.

A less conventional way of looking at outdoor/indoor traffic noise reduction is by comparing the number of noise 'events' which exceed 50 dBA indoors with the number of 'events' exceeding 70 dBA outdoors (i.e. a difference in level roughly equal to the maximum outdoor/indoor attenuation). Table 1 shows that for windows open there is a variable, but roughly equivalent number of events exceeding 70 dBA outdoors as there are number of events exceeding 50 dBA indoors, the correspondence being closest in the early hours of the morning.

Table 1 also shows a dramatic difference between dwellings with windows open and closed, in the number of noise events exceeding 50 dBA for two or four seconds. One of these bedrooms had double glazing, attesting to the effectiveness of this form of treatment in suppressing the peak traffic noise events.

5.2. Noise Measures and Traffic Density and Mix

5.2.1. L_{Aeq}-L_{A10}

The suggestion by Burgess [1978] that the value of L_{Aeq}-L_{A10} may vary with traffic flow and mix seems to have been borne out by our Figures 3-5. The traffic variables plotted against L_{Aeq}-L_{A10} are not independent, and their relations with L_{Aeq}-L_{A10} are complex, but 93% of the variance of L_{Aeq}-L_{A10} is accounted for by the total number of vehicles in each successive 15-minute interval. The correlation of L_{Aeq}-L_{A10} with sleep disturbance is, of course, unknown.

5.2.2. L_{Amax}-L_{A90}; L_{A1}-L_{A90}

The average values of each of these measures in our data were very different, but since L_{A90} is frequently used as a measure of 'background noise', both measures could be regarded as rather coarse and long term estimates of signal to noise ratio, which Horonjeff et. al. [1982] found was the main determinant of awakening. In Figure 6 the greatest L_{Amax}-L_{A90} corresponds to those intervals of the night when traffic volume is lowest (i.e. L_{A90} was low), while L_{Amax}, due to heavy vehicles, would be relatively constant. Also, Figure 7 shows that L_{Amax}-L_{A90} is inversely related to the number of vehicles per 15-minute interval, presumably because of an increase in L_{A90}. Again, L_{Amax}-L_{A90} increases, and then decreases with number of heavy vehicles per 15-minutes, but only because of the relation between number of heavy vehicles and the total number of vehicles. There is a consistent increase in L_{Amax}-L_{A90} with increasing percent heavy vehicles (Figure 9), presumably for the same reasons.

It would seem that the 15 dBA limit, which the SPCC suggested for an acceptable L_{Amax}-L_{A90}, is either grossly in error, or the night-time noise environment on Pennant Hills Road is extremely unfavourable to sound sleep.

The pattern of data on L_{A1}-L_{A10} is very similar to that of L_{Amax}-L_{A90}, and the foregoing comments could be applied to these data as well, except that L_{A1}-L_{A90} is smaller than L_{Amax}-L_{A90}, and less sensitive to changes in traffic conditions.

5.3. Comparisons With Criteria for Adequate Sleep

The two volumes of 'noise' submissions to the Commission of Enquiry into the proposed F2 Expressway, show that there was considerable disagreement between the parties concerning night-time noise criteria for adequate sleep. These disagreements concerned the noise descriptors to be used, their relation to day-time noise measurements, the time period to which they were to be applied, and the percentage of people who would be affected. In some cases it is not clear whether the maximum permissible noise level applied to short term (e.g. hourly, or 15-minute) measurements made during the period from 10 p.m. (or midnight) to 6 or 7 a.m., or to long term measurements over the whole night. In the following table we compare the various suggested criteria in the Commission's report with noise measures derived from the present study.

Source of Criterion	Indoor or Outdoor	Time Period	Criterion	Observed Value (Penn Hills Rd)
AS 2107-1987	Indoor	60 sec	30-35 $L_{Aeq,60}$	Constantly exceeds Standard.
NSW SPCC Goal	Indoor	Short term	25-30 dBA	Constantly exceeds goal.
NSW SPCC	Outdoor	Short term	(L_{Amax}-L_{A90}) <15	Constantly exceeds Criterion.
NSW SPCC	Outdoor	Short term	(L_{A1}-L_{A90})	15min values 10pm-6am exceed Criterion.
WHO, OECD	Indoor	Short term	30-35 L_{Aeq} 45 L_{Amax}	All 15-min values exceed Criterion.
WHO, OECD	Indoor	Overnight	30-35 L_{Aeq} 45 L_{Amax}	All locations exceed Criterion.
WHO, OECD	Outdoor	Overnight	45L_{Aeq}	All locations exceed Criterion.
RTA (Renzo Tonin)	Outdoor	Overnight	55L_{Aeq}	All locations exceed Criterion.
RTA (Renzo Tonin)	Indoor	Overnight	45L_{Aeq}	Exceeds crit at 6 of 9 locations
Hornsby Building Code	Indoor	Short term	40 dBA	Exceeded except with double glazing
Goldberg/Scrivener	Outdoor	Long term	40 L_{Aeq} 50 L_{Amax}	Exceeded at all locations

Table 3. Comparison of Commission of Enquiry suggested criteria with noise measures derived from present study.

In the Final Report of the Enquiry into the proposed F2 Freeway Stage 1, the State Pollution Control Commission was said to have adopted a night time Traffic Noise Level (TNL) criterion (22.00-07.00 hours) of 55 dBA [cf. Hede, 1985]. Our composite $L_{Aeq\ (2200\text{-}0700)}$ from nine locations equalled 67.26 dBA, while the number of heavy vehicles per hour averaged 122, to give a $TNL_{(2200\text{-}0700)}$ of 79 dBA. The RTA (Mizia) also suggested that their criterion, an $L_{A10,18hr}$ of 63 dBA, would be equivalent to an overnight L_{Aeq} (outdoors) of 51 dBA. This figure is exceeded by the overnight L_{Aeq} at the nine locations on Pennant Hills Road by 11-18 dBA. The SPCC's suggested equivalent of 55 dBA overnight is also exceeded at all locations.

The 'Single Events' analysis, described above, was intended to provide measures which could be related to those suggested criteria which place a limit on the peak levels of traffic noise which can be experienced without significant sleep disturbance. Our single event criteria were somewhat more generous than the OECD [1986] and WHO [1980] criteria in that the instantaneous sound level was required to remain above 50 dBA (indoors) for two seconds or more. Even so the recommended limit of about 50 dBA peak was exceeded hundreds of times in the course of the night in all locations where windows were open, and many times where windows were closed. Only in the one dwelling where bedroom windows were closed and double glazed was the number of 'events' reduced to zero in any one hour of the night. Some research has shown that 20 truck noises of 55 dBA peak in the first one third of the night impairs sleep [cf. Anderson et. al., 1988]. Our 'Single Event' noise data show that the reduction of nightly noise on Pennant Hills Road to anywhere near this degree of exposure would require extensive acoustical treatment of front bedrooms in the area.

It is not within the scope of this report to discuss the bases of proposed noise criteria for adequate sleep. There is clearly, however, dissatisfaction with current criteria, and no basis for supposing that given levels will be sufficient for all, or even say, 90%, of people to get adequate sleep. There is also little basis for judgements of whether less than optimal sleep will have long term effects on health. Nevertheless it is apparent that some sleep criteria, for example those using L_{A1}-L_{A90}, are not very closely related to the number or percent heavy vehicles, which are claimed to be major factors in sleep disturbance. It is also clear that noise measurements, and the relations between them, vary with changing traffic conditions during the night, making overnight single number criteria for sleep rather suspect.

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Noise Levels In Hospital Intensive Care Areas

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Abstract: This paper presents results of noise level measurements in an intensive care unit. The levels were unlikely to cause hearing damage but were higher than recommended for the type of space. Many of the short duration noises were generated by people, both staff and visitors, and simple measures to reduce these noises are suggested.

1. INTRODUCTION

Intensive care units (ICUs) in hospitals are used for patients who are critically ill, or who need constant monitoring. As such, the health and well being of the patient should be a prime consideration. Studies of the noise in hospitals in other countries have shown that, while not at a level likely to cause hearing damage, the noise levels in many areas, including ICUs, can be very high [e.g. 1,2]. In view of the importance of all aspects of the ICU environment, a study was undertaken to monitor and identify the noise levels in the ICU in an Australian hospital, namely Royal Canberra Hospital in the ACT. The main sources of noise were identified, the levels were compared with those reported in the literature and some recommendations for reducing the noise are presented.

2. NOISE AND HEALTH

Hearing loss is the most obvious effect of high levels of noise on humans. The legislation in most States of Australia identifies the limits above which some form of hearing protection must be provided as a continuous 8-hour level of 90 dB(A), (85 dB(A) in ACT [3]) or a single event having maximum level of 115 dB(A) or peak level of 140 dB.

While there is little evidence that noise has been the cause of permanent physical illness, apart from hearing loss, there is considerable evidence for a variety of physiological and psychological effects [4]. These effects are similar to those of other stressors in the environment and include alterations of the endocrine, cardiovascular and neurological functions. There is a reduction in significance of these effects if either the noise stops, or it continues and is accepted as part of the environment.

The effects of noise on sleep cycles for hospital patients has been examined by Snyder-Halpern [2], with particular reference to the noise produced in critical care units. Snyder-Halpern concluded that the physical and psychological alterations, which can occur when noise interferes with sleep, could compound existing physiochemical and behavioural psychological problems for patients in critical care units.

While an individual may habituate to a continuous noise, a sudden loud or unexpected noise produces various physiological effects. These relate to the "flight or fight" or "startle" reaction and include changes in the cardiovascular, respiratory and digestive systems.

A patient in an ICU is particularly vulnerable to stressors and consequently the aim should be to minimise such factors in the environment. For noise this implies that the ambient, or background noise levels, ie that determined by the continuously operating equipment, should be at an acceptable level. A recommended design sound level for ICUs of 40 dB(A), with a maximum of 45 dB(A), is given in an Australian Standard [5]. In addition to control of the continuous noise, the magnitude and occurrence of short duration noises which are likely to produce the "startle" effect should be minimised.

3. MEASUREMENT PROCEDURE

The ICU at Royal Canberra Hospital comprised nine acute care beds with provision for expansion to twelve. Most admissions were post trauma but post surgical, neurology and thoracic cases were frequently stabilised prior to ward transfer.

The noise levels were monitored at six locations within the ICU. The measuring instrumentation included a Bruel & Kjaer microphone, type 4133, measuring amplifier, type 2606 and level recorder, type 2305. The performance check was made with the aid of a Bruel & Kjaer calibrator, type 4230 and spot measurements were made with a Bruel & Kjaer sound level meter, type 2203.

Available locations for the microphone were limited as work flow disruption had to be avoided. At three locations the microphone was 1.2 m above the floor and 1 m from the walls. One location was on a curtain rail above a bed (2.5 m from the floor) and another location was in the vicinity of the administration desk (2 m from the floor and 1 m from the desk). Prior to each monitoring session the performance of the instrumentation was checked with the portable calibrator and the sensitivity of the measuring amplifier was adjusted to the appropriate range for the sound levels in the area.

At five locations the noise was monitored for 24 hours and for 12 hours at the sixth location. During active monitoring periods, which were from 10 to 90 minutes, the source of individual peak levels were identified on the paper chart. The noise levels during these active monitoring periods were compared with the levels during the remainder of the time to ensure they were representative of the noise in the area. A typical chart with annotations is shown in Figure 1. The sound level meter was used to make spot measurements at various points in the area to check the variation of noise throughout the space.

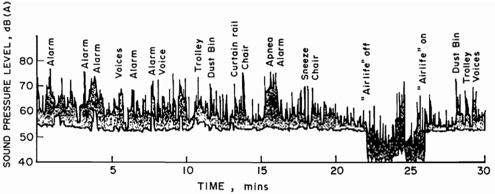

Figure 1 Noise levels monitored at a typical position in the ICU

4. RESULTS

4.1 Range of Noise Levels

The first thing noted was the high ambient noise level, (see Figure 1.) to which the peaks from other short duration sounds were added. This continuous noise was essentially broadband and produced by the operation of equipment in the room. For example the "airlife" nebuliser, which supplies a constant supply of air blended with oxygen to a set oxygen concentration nebulised with water, and the cooling blankets which use a temperature controlled water pump. With this equipment operating the ambient levels were in excess of 50 dB(A). On the few occasions that the equipment was turned off the ambient level dropped by at least 10 dB(A). Comparison can be made with the recommended design sound level of 40 dB(A) (maximum 45 dB(A)) for ICU areas given in the Australian Standard [5].

Monitoring Location	Room 1 Corner	Room 6 Corner	Room 7 Corner	Room 6 Above Bed	Room 6 Above Bed	Near Desk
Ambient noise levels with "Airlife" on	54-65	48-50	52-53	50-60	52	46-60
Ambient noise level with "Airlife" off	42					
Typical maximum noise levels	81-90	83-86	80-86	75-80	79-90	70-80

Table 1 Range of noise levels, in dB(A), at the six locations in the ICU

Source	Typical Maximum Noise Levels, dB(A)	
	Near Corner	Above Bed
Voices	-	70-76
Intercom	69-70	74-77
Apnea alarm	77	73-79
ECG Monitor	75	69-78
Disposal of used needles	67-69	-
Moving of plastic chairs	75-80	72-80
Sliding curtain	72	71
Bed winding	67-79	-

Table 2. Some typical maximum noise levels, in terms of dB(A), in room 6. Note that the levels were not measured simultaneously in the two locations.

A summary of the noise levels monitored in each of the locations is given in Table 1. Some specific noise levels are listed in Table 2, also illustrated on Figure 1. The specific noises could be divided into three main categories: people, equipment and room furniture.

4.2 Noise Generated by People

The noises generated by people comprised those from patients, staff and visitors. With the exception of coughs, the highest noise levels in this category were from voices and these were commonly in the 70 to 76 dB(A) range.

4.3 Noise Generated by Equipment

There is a variety of equipment used in ICUs. Some operates almost continuously and provides the baseline, or ambient noise levels. The "airlife" nebuliser and the cooling blankets were found to produce levels in excess of 50 dB(A) even at the room corner locations. The levels from the operation of intravenous infusion pumps ranged from 68 to 74 dB(A). The short duration, repetitive alarm signals, such as the apnea alarm and the ECG monitors, were from 73 to 79 dB(A). For some patients these alarms would be activated on a regular basis.

4.4 Noise Generated by Room Furniture

The noise levels from movements of room furniture were as high as 80 dB(A) when plastic chairs were being moved around and even 85 dB(A) when a garbage bin was being moved. Simple tasks, such as bed winding and use of a mop bucket, produced noise levels from 67 to 79 dB(A). The noise from other routine tasks such as disposing of used needles and other sharp objects, tearing paper from monitors, wheeling a trolley, dropping a cup, were commonly 10 to 20 dB(A) above the ambient noise levels of the continuously operating machinery.

4.5 Comparison with Other Studies

The noise levels measured in the ICU for this study are similar to those reported in the literature. For example, Hilton [1] found that in the ICUs of smaller and larger hospitals the equivalent sound energy level was commonly 40 to 50 dB(A) and 50 - 60 dB(A) respectively. The range of sound levels for specific sources showed quite a range, depending on the location, however the maximum levels were similar to those found in his study, eg monitor alarm 78 dB(A), garbage cans moved 83 dB(A), drawers opened/closed 75 dB(A), curtains opened/closed 70 dB(A). Hilton also found that more than half the talking occurred at levels greater than 60 dB(A).

5. DISCUSSION

It is surprising to find such high noise levels in an ICU; an area where the wellbeing of a patient should be the prime consideration. Anecdotal responses by patients and staff to unstructured enquiries about the noise in the ICU included "I still hear noises ringing in my head after going home", "...can't hear yourself think" and "everyone knows the ICU is noisy". The one positive response was that patients, staff and visitors can be reassured that the equipment is operating.

When an item, such as the "airlife" nebuliser, was operating continuously, the ambient noise levels were well in excess of the recommended noise levels for ICU areas given in the Australian Standard [5]. The design of these machines should be carefully examined with a view to reducing the noise levels.

The use of raised voices may be due to the high background noise levels, to the perception that a patient connected to a machine may not be able to hear clearly and to the consideration that the patient may be hard of hearing. For both the staff and visitors, some form of education campaign is required to ensure that the voices are not raised to levels higher than absolutely necessary for communication. A normal voice level is considered to be about 60 dB(A) at 1 m [7]. For staff, the education can be part of in-service training with appropriate reinforcement during normal working times. The education of visitors to avoid using raised voices would have to be in the form of a publicity campaign. The therapeutic benefits of a quiet environment could be included in the "Visitor Information Booklet" and "Quiet Please" signs could be prominently displayed.

Even though most alarms have adjustable sound levels, the warning and alarm signals were more than 20 dB(A) above the ambient noise levels. Current nursing practice, which ensures that a person is within each of the ICU wards at all times, removes any justification for such loud signals. A carefully designed alarm signal should be perceived, due to its particular characteristics, even if the level is close to that of the ambient level in the area. Other equipment which was shown to produce high levels of noise should be carefully examined with a view to applying noise reducing methods without affecting the function of the item. As mentioned by Hilton [6], a hospital purchasing policy which stipulates the maximum sound power or sound pressure levels from items would provide the incentive for the manufacturers to apply noise reducing principles to the items.

For general activities in the unit, much can be done to reduce the potential for the production of high levels of noise. For example; regular servicing could reduce the noise from some items such as bed winding mechanisms, buffers could be installed to minimise impact noise, trolleys could be designed to reduce vibration and noise, quieter floor cleaning machinery could be used. One factor contributing to the high noise levels throughout the ICU was the presence of predominantly sound reflecting surfaces. The introduction of carpet and sound absorbing material on the walls and ceiling would help to reduce the reverberant sound field but the cleaning requirements may limit the use of these materials. Attention should be given to the use of acceptable sound absorbing materials, for example with a disposable outer covering.

An education and publicity campaign could reduce the production of other types of "furniture" noises such as dragging chairs, disposing of items, banging of doors etc. Such a campaign could be similar to that outlined above for reducing the noise from voices. The important factor in these campaigns is to raise the awareness of the the staff and visitors to the noise they are producing.

6. CONCLUSIONS

While the noise levels in the intensive care wards at Canberra Hospital were unlikely to lead to hearing damage, the levels were much higher than those recommended for these types of areas. The first step in reducing the noise levels is to identify the main sources and adopt strategies for dealing with each of them. As many of the noises are generated by people, there are many simple measures which could be adopted to raise the awareness of staff and visitors and to minimise the noise levels. It is often difficult and expensive to modify existing equipment; it is usually more efficient to deal with the potential noise problem at the design stage. A purchasing policy which specifies the maximum sound levels from machines could be used to encourage manufacturers to incorporate noise reducing measures in their equipment.

7. ACKNOWLEDGEMENTS

Without the willing support of patients, relatives and staff of the ICU at Royal Canberra Hospital and the provision of instrumentation from the Faculty of Environmental Design at the University of Canberra, this study would not have been possible.

8. REFERENCES

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2 Snyder-Halpern R. *The effect of critical care unit noise on patient sleep cycles*, Critical Care Quarterly, March 1985, pp 41-51

3 Australian Capital Territory, *Noise Control Act*, No 71, 1988

4 Tempest, W (Editor), *Noise Handbook*, Academic Press,1985

5 Australian Standard AS 2107 - 1987 *Code of Practice for Ambient Sound Levels for Areas of Occupancy within Buildings*

6 Hilton, A. *The hospital racket*, American Journal of Nursing, Jan 1987, pp59-61

7 Australian Standard AS 2822 - 1985 *Acoustics - Methods of Assessing and Predicting Speech Privacy and Speech Intelligibility*

Pattern Recognition Applied to Transients

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CSIRO Division of Geomechanics
Lucas Heights Research Laboratories
NSW Australia

ABSTRACT: The extraction of meaningful information from recorded signals involves some form of processing and then the search for a pattern in the processed data. After a short review of some standard pattern recognition approaches a technique which can be useful in the analysis of transients will be described.

1. INTRODUCTION

Many of the signals obtained in the studies of noise and vibration are transient in nature. An investigator is then faced with the task of determining whether there is some pattern or trend associated with the observed data. Often an attempt to do this in a qualitative way is by observing the signals directly and using acquired knowledge and experience to delineate the possible different types of signals. The signals may be shifted into the frequency domain and visual observation is again used to delineate any groupings among the signals. These approaches can work but are very labour intensive and require considerable expertise being acquired by the investigator.

The other approach is to develop processing schemes which make it easier to separate the signals into different categories. The processing may be as simple as finding two sensitive variables which can then be plotted; the use of more sophisticated schemes operating on 'feature vectors'; or the use of artificial neural networks. An approach which is presented in this paper involves the plotting of two sensitive variable, however first a survey of some other approaches will be presented.

2. PATTERN RECOGNITION

Much pattern recognition involves the construction of a feature vector which is then passed to a computer program which operates on the components of the feature vector to produce some form of display where different events are evidenced by a clustering in the plotted information [1,2,3]. The choice of parameters to use in the feature vector can be somewhat arbitrary although some ideas about the origin of the waveforms can assist in this decision process. The parameters that may be used include from the time domain the peak value, rise time, mean, standard deviation, and higher order statistical moments. Parameters from the frequency domain include the position and energy associated with dominant peaks in the power spectral density and the energy associated with specific bands of frequencies. The parameters in the feature vector are then transformed usually by incorporating them into plynomials so that a plot can be producing to examine the clustering of different types of events.

3. ARTIFICIAL NEURAL NETWORKS

If a range of signals are available which have already been classified, then parameters computed from those signals can be fed into a computer engine referred to as an artificial neural network. These inputs together with the known outcomes (classifications) will initiate a learning process within the network so that when a given set of inputs are provided then a classification will occur [4,5]. This approach requires data which may not always be available, so that the network can be trained, however there are variants of this approach which can do some pattern recognition even when the outcomes are not known.

4. PROPOSED SIMPLE SCHEME

The application of some physical insights should provide two parameters which can be plotted and allow different categories of transient events to be identified from the clustering that occurs and also identify events which are significantly different from the majority. A microseismic monitoring station gave a series of transients and some idea of the range of waveforms observed is given in Figures 1 and 2 which show dissimilar waveforms.

Evidently the peak amplitude of the pulse is an important parameter but also the total energy in the pulse which is represented in the variance (mean square about the mean) is important since some pulses may have high amplitudes but low energy contents and vice versa. This observation leads to the use of one non-dimensional parameter which is the ratio of the peak value to the standard deviation (rms about the mean). Short duration high amplitude transients will have large values for this parameter while lower amplitude and longer duration transients will have lower values. This parameter being non-dimensional does not depend on the system gains employed.

Some measure associated with the power spectral density will be significant since the frequency content of the pulses may be different. Using the concepts of statistics and applying them to the power spectral densities can yield single values indicative of the behaviour in the frequency domain. The parameter chosen is the average frequency which is computed by weighting each frequency value by the value of the power spectral density at that frequency and then dividing the sum of these weighted frequencies by the sum of all the power spectral density values. The average frequency is also independent of the system gains.

Plotting the average frequency against the ratio of peak value to standard deviation for the data from the microseismic monitoring station yields the graph of Figure 3. There is strong evidence of some clustering in this graph so that categorisation of the transients has occurred. The choice of parameters is not unique however the combination chosen does produce clustering and the reasons for the choice of the parameters do have some physical basis and can be

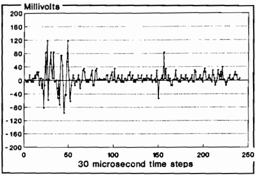

Figure 1. Waveform obtained from seismic monitor.

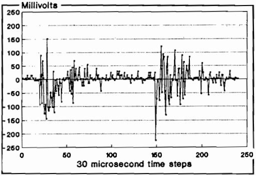

Figure 2. Different waveform obtained from seismic monitor.

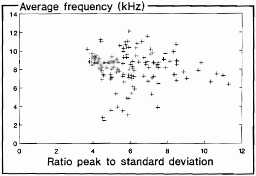

Figure 3. Pattern recognition plot for seismic monitoring.

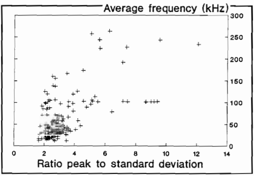

Figure 4. Pattern recognition plot for bridge monitoring.

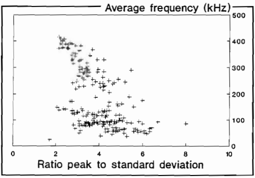

Figure 5. Pattern recognition plot for other seismic monitoring.

fairly readily implemented.

The evidence of clustering is also apparent in data obtained from monitoring the vibration and acoustic emission associated with a bridge (Figure 4) and seismic data from a different installation where the transducer had a higher frequency response (Figure 5).

5. CONCLUSIONS

Although sophisticated schemes for pattern recognition are available, the use of some physical insights can provide sets of suitable parameters that can be plotted and used to characterize transients.

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NEWS... NOTES... PEOPLE... BOOKS... PRODUCTS

News & Notes . . .

Speeches In Parliament

Since the opening of the new Parliament House in Canberra, there have been complaints about difficulties in hearing the speakers in the main chambers. Each member has a microphone and the principle of operation for the system is that only the microphone for the member identified by the Speaker of the Chamber is activated. The maximum reinforcement signal then comes from the loudspeaker group closest to that member to achieve directionality. The original speech reinforcement system comprised 8 groups of 4 column loudspeakers suspended from the ceiling in the central area of each of the chambers. The maximum output of the loudspeakers was limited to control the inevitable problems with feedback from such an arrangement. This led to problems with hearing the words from the members, particularly on the other side of the chamber. The design and placement of the loudspeakers also led to uneven distribution of the sound throughout the chamber. To overcome these problems new sound systems have been designed and one has been installed in the Senate with plans for the installation of the second in the House of Representatives.

The ACT Group was privileged to inspect both the current and the new systems during a technical visit in May. **Bert Gonzalez** from the Sound and Vision Office of Parliament House led the inspection which included the unique opportunity for the group to walk around both of the Chambers thus experiencing the "old" and the "new" systems. Technical staff assisted Bert to demonstrate the various features of the systems.

The new system for each chamber comprises 4 arrays each with 20 loudspeakers. Each loudspeaker array has been designed to provide maximum signal to the other side of the chamber with minimal amount going in the direction of the activated microphone. Thus 14 speakers form the main part of the column with only 6 speakers, having much lower amplification, providing reinforcement down in the areas near the activated microphone. This feature minimises the problems with feedback via the activated microphone without greatly limiting the amount of amplification that can be achieved. The orientation of the arrays has been carefully designed to provide an even distribution of the sound. As part of the new installation 200 new microphones will have been installed in the chambers along with new amplifiers with active cross over networks to drive the new loudspeakers. While a person activates the microphone for the nominated member who is speaking, the computer then takes over to balance the signal from each of the loudspeaker arrays

The system in the Senate is being carefully evaluated by staff from the Sound and Vision Office, with comprehensive sound distribution measurements, before a similar system is installed in the larger House of Representatives. The comments from the politicians, the main users for which the system was designed, have indicated satisfaction. The gallery areas also receive an improved signal so that the visitors can follow the discussions in the Chamber.

Marion Burgess

* * *

Post Graduate Course

The School of Mechanical & Manufacturing Engineering at the University of New South Wales has recently released details of two programmes for postgraduate studies in Noise and Vibration commencing in 1993. The Graduate Diploma program is for one-year, full-time and comprises course work only. The one-year full-time Master of Engineering Science involves both course work and a project. The subjects include Fundamentals of Noise, Fundamentals of Vibration, Fundamentals of Noise and Vibration Measurement, Advanced Noise, Advanced Vibration, Environmental Noise and Building Acoustics.

Further information: Assoc Prof Kerrie Byrne, School Mechanical & Manufacturing Engineering, University NSW, PO Box 1 Kensington NSW 2033 Tel (02) 697 4163 Fax (02) 663 1222.

* * *

Standards

Recently released **American** National Standards include *Maximum permissible Ambient Noise Levels for Audiometric Test Rooms,* (ANSI S3.1-1991), and *Specification for Personal Noise Dosimeters,* (ANSI S1.25-1991).
Details: ASA Standards Secretariat, 335 East 45th St, New York, New York 10017-3483, USA.

* * *

Worksafe Aust Grants

Three research projects on topics related to noise induced hearing loss have recently been awarded grants from Worksafe Australia.

• A grant of $100,000 is for a one year study on "Frequency Characterisation of Roof Talk and Derivation of Suitable Hearing Protection Parameters" to be undertaken at the Safety in Mines Testing and Research Station, Goodna, Qld with **Mr Stewart Bell** as the chief investigator. This project aims to determine the effect of hearing protection in underground miners perception of mine roof talk.

• A grant of $150,000 for a three year study on "Retrofit Techniques for the Control of Impact Noise in the Sheet Metal Industry" which will be undertaken by the Acoustics and Vibration Centre at the Australian Defence Force Academy (part of the University of NSW) in Canberra. The chief investigator is **Dr Hugh Williamson** and the project is being undertaken jointly with Lysaght Building Industries who are providing considerable support for the project.

• A grant of $55,000 to the Australian Coal Industry Research Laboratory, Booval, Qld represents a one year contribution to a 2year 3 month project on "Managing Noise Emissions and Exposures in Underground Coal Mining". The other support for the project is derived from a National Energy Research Development and Demonstration Project Grant and the chief investigator is **Mr Adrian O'Malley**.

* * *

B & K Golden Jubilee

In 1942 Per Bruel and Viggo Kjaer joined forces in a small town north of Copenhagen, Denmark, to form an electronics company. Five years later, a new partner, Holger Nielsen, joined the company. In 1992 their dream of having one of the world's leading electronics companies has come true. Bruel & Kjaer exports to almost every country in the world and their product range includes over 200 instruments. Congratulations on achieving a Golden Jubilee.

* * *

Corrections

1. Omissions from Article by Erik Jansson:

"Acoustical Measurements of Quality Rated Violins and a New Measurement Method" Acoustics Australia Vol 20 No 1 April 1992 pp 11-15.

We apologise for the inadvertent omission of the lower parts of Figures 3, 4 and 5. The complete article has been reprinted with corrections, copies of which are available from Mrs Leigh Wallbank (Business Manager, see contents page) or the author.

2. Incorrect People Item

On p 30 of the April 1992 issue of Acoustics Australia the item concerning the ACEA Highly Commended Award for the preparation of an Environmental Impact Statement for the proposed Tomago Aluminium Smelter Expansion was incorrectly credited to Renzo Tonin & Associates Pty Ltd. The recipient of the award was in fact Crooks Michell Peacock Stewart Pty Ltd of Sydney. We offer our apologies for this error.

* * *

Internoise 93

INTERNOISE 93 will be held in Leuven from 24 to 26 August 1993. The theme of this conference will be "People Versus Noise". The call for papers has been released and abstracts must be received by the organisers no later than 15 December 1992. Abstracts should be approx 250 words and submitted with the abstract cover sheet available from the secretariat.

Details: INTER-NOISE 93, TI-K VIV, Desguinlei 214, B-2018 Antwerpen, Belgium, Tel (32) 32 16 09 96 Fax (32) 32 16 06 89

* * *

Conference Proceedings

Three Sound Intensity Conference Proceedings are available from INCE: 1981 - Recent Developments in Acoustic Intensity Measurement, 1985 - 2nd International Conference on Acoustic Intensity and 1990 - Structural Intensity and Vibrational Energy Flow. Copies of the proceedings for all Conferences are available for a special price of US$150 (plus US$58 for air mail). The proceedings of the 1990 Conference only are available for US$100 (plus US$23 for air mail). Internoise 91 Proceedings are available for US$130 (plus US$45 for air mail).

Orders from International Noise Control Foundation, PO Box 2469 Arlington Branch, Poughkeepsie, NY 12603, USA

PRACTICAL ACOUSTIC SOLUTIONS

AAS Annual Conference
Ballarat, Victoria

26-27 November 1992

On behalf of the organising committee, I hope that as many members and interested friends as possible may be able to attend the 1992 Annual Conference in lovely old Ballarat on November 26th and 27th in a rural setting just 110km from Melbourne.

With an almost full compliment of papers promised, we are assured of a very successful conference but only if you make the effort. Keep your eye out for the next brochure in September, containing all the details - look forward to seeing you there !

John Upton, Convenor

P.O. Box 233 Moonee Ponds VIC 3039
Ph: (03) 370 7666 Fax: (03) 370 0332

Selby

Selby Scientific & Medical are now the agents for the Quest range of Sound Level Meters, Noise Dosimeters and Heat Stress Monitors. The addition of the Quest range compliments the portfolio of products Selby presently offers the industrial hygenists and environmental market.

Further information: Selby Scientific & Medical, Private Bag 24 Mulgrave Nth Vic 3170 , Tel: (03) 544 4844 [008 135 838] Fax: (03) 543 7295

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Audio Oz

Audio Oz are now the agents for the Nakamichi range of professional recording equipment. The range includes both two and three head professional cassette decks and the advanced DAT recorder.

Further information: Audio Oz, 137 Moray St, Sth Melbourne Vic 3205. Tel:(03) 696 5690 Fax: (03) 696 5691

* * *

New Company

Technology Integration Inc has opened a branch office in Australia. The new company is called Technology Integration Australia and the manager is **John Vestergaard**. The company will promote and provide after sales service for TII ANOMS, a software and hardware package for airport noise and operations monitoring systems.

Further information: Technology Integration Australia, 37 Benwerrin Drive, Burwood East Vic 3151. Tel:(03) 803 5944 Fax: (03) 803 7585

People...

NEW MEMBERS

•Interim Admissions

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

New South Wales
Mr D M Eager, Dr E L LePage,
Mr K Mathiasch, A/Prof J H Rindel (Denmark)

South Australia
Mr W L Huson

Victoria
Mr S Camp, Mr N G Clutterbuck,
Mr K Davidson, Mr T M Marks

•Graded

We welcome the following new members whose gradings have now been approved.

Student
Victoria
Mr O Church, Mr A S Keil, Mr R H Mills, Mr G Paolucci

Subscriber
New South Wales
Mr M J Harrison

Member
New South Wales
Mr R J Sleeman

Queensland
Mr F C A Gattegno

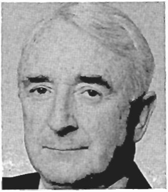
* * *

New General Manager

Bradford Insulation, a wholly owned subsidiary of CSR, has appinted **Mr Peter Cummins** as its new General Manager.

Prior to his appointment Mr Cummins was General Manager of CSR Hebel, a joint venture company between CSR Ltd and West German concrete manufacturer, Hebel.

In his new position Mr Cummins will oversee Bradfor Insulation's operations in Australia, Canada and Malaysia which employs about 10,000 staff.



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At the March meeting of the Victorian Division **David Watkins**, from the EPA Policy Division, spoke on the EPA Policy No 1 on control of noise from commercial, industrial and trade premises. This policy has been reviewed and an amendment released for public comment. Because the current method for assessing the noise is insufficiently realistic under present conditions, a new method is proposed. This introduces the concept of a Noise Management Plan for orderly implementation of the noise abatement measures.

Louis Fouvey

* * *

A site visit to the Smorgon Steel Plant and Rolling Mill at Laverton North was organised by the Vic. Division in May. The noise control measures and the ongoing hearing conservation program were discussed. The tour of the plant reinforced the importance of taking proper account of the acoustical effects of industrial processes at the design stage, before and not after the noise problems occur.

Louis Fouvey

* * *

In April, the SA Division organised a panel discussion on Noise and Land Use Planning. The speakers were **John Lambert,** Dept Environment and Planning, **Peter Maddern**, Peter Madden & Assoc and **Peter Swift**, Bassett PGD. The panel considered a series of court cases of land use in which noise was an issue. For each case a plot plan and general description of the matter at issue was briefly outlined. The speakers then addressed the issues presenting a brief description of their client's case. The audience was invited to comment and at the end of each case the judgement of the court was recited. In the cases considered, the issue most frequently crucial was the determination of reasonableness. Needless - to - say there was hardly ever unanimity of agreement between the audience, the speakers and the court!

David Bies

Books...

THE SCIENCE OF MUSIC

Joe Wolfe

ABC-FM Stereo (1991), ABC Radio Tape Service, PO Box 9994, Sydney NSW 2001 (tel 02 394 2658) $75.00

These six tapes, each running a little under one hour, are directed to a rather special radio audience prepared to exert a little intellectual effort in order to achieve, in an enjoyable fashion, a quite good understanding of the physics of musical instruments. Each tape pairs a distinguished Australian musician - Dene Olding, Nigel Westlake, Paul Plunket, Colin Piper, Paul Dyer - with the physicist host, Associate Professor Joe Wolfe from the University of New South Wales, to explore the physics of a family of musical instruments. The musician acts as a "straight man" in the discussion by asking pertinent questions which are then answered and demonstrated by Joe Wolfe in a delightfully clear and comprehensive fashion. The musician, often assisted by colleagues from the Australia Ensemble or other groups, also takes a turn to play short musical fragments to demonstrate particular points, and there are several longer musical excerpts. Separate cassettes cover strings, woodwinds, brass, percussion, and keyboards, and the final cassette is about musical composition.

The exposition is clear, accurate, and simple to follow, and should be quite comprehensible to a senior high-school student with some background in music and an interest in science. The presentation is excellent and holds one's interest, but one should have a reasonable break between cassettes. There is a good deal of emphasis on the harmonic structure of musical sounds (and occasional inharmonic sounds), and a fairly detailed discussion of the actual mechanics of sound production in the different families of instruments. At the same time the discussion is not uncritical, and we are introduced, by example, to some of the difficulties involved. The tapes therefore contain much that would be of interest even to those already with a good background in either music or acoustics, though for a physicist or acoustician the going is rather slow.

Nearly all major musical instruments are discussed, with violin, clarinet, trumpet and harpsichord featuring particularly in demonstrations. Exceptions are the pipe organ, which is represented by a musical example only, and electronic instruments, which are outside the scope of the programs. The sound quality, as one would expect from the ABC, is very good. The short booklet gives a clear and readable account (with a few formulae) of basic acoustics, with particular reference to musical instruments.

With their original broadcast purpose fulfilled, one must ask to whom these cassettes would now be valuable. To hear them once is instructive and enjoyable, but they are not then really useful as reference material. Certainly they should be in the library of every school, college and university with a music course or a physics-and-music option within the science course. Municipal libraries might also find them popular. If you collect cassettes of memorable radio programs, then you should add these to your collection. Otherwise, I certainly recommend that you borrow them from your local library.

Neville Fletcher

Neville Fletcher is a chief research scientist with CSIRO, and is located at the Australian National University. He plays the flute and the bassoon, and has written extensively on musical acoustics.

* * *

ACTIVE CONTROL OF SOUND

P.A. Nelson and S.J. Elliott

Academic Press, 1992, pp436, Hard Cover, ISBN 0 12 515425 9
Australian distributor: Harcourt Brace Jovanovich, Locked Bag 16, Marrickville NSW 2204. Price: A$241.85.

This is the first book to be published on the active control of sound and as such its timely appearance will be welcomed by students, researchers and practitioners alike. As the authors have deliberately omitted discussion on the related topic, active vibration control, they have been able to devote all of their efforts to a thorough treatment of the active control of sound. The result is a well written book, containing clear treatments of the fundamentals of acoustics signal processing and digital control, and how these fundamentals are applied together in active sound control. As stated by the authors, "the reader should not expect to find a cookbook description of the hardware and software necessary to implement active control. However the algorithmic principles which form the foundation of practical systems are dealt with at some length". In other words the book presents the fundamental knowledge and procedures required to design active noise control systems, but stops short of providing final electronic hardware and control software designs, and optimum control source and error sensor configurations for specific applications. This is left for the reader to do, using the information and practical guidance provided by the book.

The authors are, indeed, experts in the subject matter of the book, having been very active in its teaching and research (resulting in many technical publications) for more than ten years. Thus they are in a position to discuss all aspects with some authority and this becomes apparent in the clear writing style. The book is organised and written much like a textbook and its intended audience includes postgraduate (and perhaps undergraduate) students of acoustics and signal processing, professional acoustical and electrical engineers and researchers in the field of active control. With this audience in mind, the book attempts to treat the two fields of acoustics and signal processing (including some control theory) in a unified way and is largely successful in achieving this. Thus the first four chapters of the book are devoted to discussing fundamental principles of acoustics, frequency analysis, linear systems theory and digital filters. The chapter on digital filters includes sampled signals and the z-transform, finite impulse response (FIR) and infinite impulse response (IIR) filters, frequency domain filter design, optimal filter design and adaptive digital filters.

Chapter 5 contains a discussion of the physical mechanisms involved in the active control of plane wave one dimensional sound fields. In chapter 6, single channel feedforward control is discussed at some length with application to the control of periodic and random sound propagating in a duct. Both time domain and frequency domain control are covered. A variety of control implementation techniques are discussed including decomposing a periodic signal into its harmonic components and controlling each component independently with a separate analog controller consisting of an amplifier and phase shifter. Another technique discussed involves control by approximating the optimal control waveform by a number of time segments, each having a constant voltage and fixed duration. The voltage of each segment is then adjusted to minimize some error signal. Finally, adaptive FIR and IIR controllers are discussed, the latter used to compensate for acoustic feedback in systems where the acoustic signal from the control source affects the reference signal used to generate the control signal. Also discussed are the effects of measurement noise, turbulence noise and the electro-acoustic transfer functions and time delays associated with the control source and error sensor and propagation of the signal between them. One weakness of this chapter and the one which follows on feedback control is that the authors offer no explicit opinions on which type of control they would recommend for various practical situations. This is left for the readers to discover for themselves.

Chapters 8 and 9 are concerned with active suppression and active absorption of periodic sound radiated by point monopole, dipole and quadrupole source and vibrating surfaces. The analysis is concerned entirely with the acoustics of the problems; that is, determination of optimum control source strengths and locations and thus implicitly assumes the use of feedforward control, although this is not stated explicitly by the authors.

Chapters 10 and 11 are concerned with global and local control of periodic enclosed sound fields. Again the main emphasis is on analysis of the acoustics of the problems with the implicit assumption that control will be implemented with a feedforward controller.

The final chapter, chapter 12, considers the case of a multi-channel feedforward adaptive controller. Control of both periodic and random sound is discussed and also a number of different control algorithms and cost functions which include actuator effort and allow some error signals to be given greater priority than others. In summary, this book presents a thorough discussion of the fundamentals of the design and implementation of both feedback and feedforward active noise control systems. Practical problems associated with controller implementation and ways to overcome these are also discussed. Although the active control of sound has been a high profile research topic for the last decade, this book is the first to appear on the subject. It is appropriate that it has been written by two authors who have been at the forefront of many innovative developments in this field in recent times. "**Active Control of Sound**" is a unique book and an essential purchase for anyone interested in this subject, whether they be researchers, students or engineers.

Colin Hansen

Colin Hansen is a Senior Lecturer in Mechanical Engineering at the University of Adelaide. He has been involved in research on active control of sound and vibration for the past five years, has authored many papers on the subject and currently heads a team of thirteen full time staff and post graduate students working on projects in this area.

New Products...

HEAD ACOUSTICS

Binaural Analysis

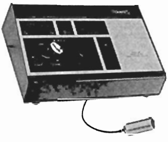
A number of items are now available for binaural analysis. The artificial head measurement system can recreate the exact hearing experience. The binaural analysis systems allow for dual channel analysis. The systems provide new capabilities for noise diagnosis, sound field analysis, recording and archiving of acoustic signals.

Further information: Davidson, 17 Roberna St, Moorabbin, Vic 3189, Tel: (03) 555 7277 Fax: (03) 555 7956

QUEST

Sound Level Detector/Controller

Model 261 continuously measures noise levels and automatically activates, or deactivates, an electrical signal device when a selected noise level is exceeded. It is particularly useful in industrial work areas and common signal devices are buzzers, lights or any device that uses up to 10 amps and 300 V DC or AC. The sound level activation range is 55 to 110 dB and the monitor is accurate to 1 dB.



Quest's Sound Level Detector

Noise Logging Dosimeter

Model 28 Noise Logging Dosimeter is a compact, pocket sized noise analyser. It provides computerised dosimetry and data logging functions with direct readout and printout of all accumulated data. It can be used as a survey instrument, a community/airport noise monitor and an industrial noise dosimeter.

Further information: Selby Scientific & Medical, Private Bag 24 Mulgrave Nth Vic 3170 , Tel: (03) 544 4844 [008 135 838] Fax: (03) 543 7295

BRUEL & KJAER

Microphone Positioning System

The **Type 9654** is a versatile, easy to use system for making automated, 3d acoustic measurements over a scanning area up to 3m x 6m. It can be expanded to a system with 5 degrees of freedom for full sound power measurements. The microphone positioning software, supplied with the 9654, allows definition of the measurement grid from a PC or with a joystick.

Bruel & Kjaer's Microphone Positioning System Type 9654

Building Acoustics Module

The **BZ7 114** module enables computer controlled airborne and impact sound insulation measurements and calculations to be made semi-automatically with the modular precision sound level meter, Type 2231. A plug-in module for the sound level meter and a floppy disc containing the new application software is provided. The calculated results are obtained without the need for additional program packages.

Further information: B&K, PO Box 177, Terrey Hills NSW 2084 Tel: (02) 450 2066 Fax: (02) 450 2379

VIPAC

Miniature Dosimeter

The featherweight (10g) **Model 705** Digital Noise badge meets all national and international dosimeter standards. The Leq, Max and peak levels are stored at one minute intervals, the Ln statistics are retained in the 32 kbyte memory and features include the user programable stop/start times, dose calculations etc. The dosimeter can communicate and dump data to a central location via telephone lines or even a cellular phone.

Vipac's Miniature Dosimeter

Cellular Phone for Data Logging

Vipac **Model V808** Telemetry Link enables analogue and digital signals collected in the field to be transmitted by cellular system to a personal computer at a distant location. The field monitor can be unattended and interrogated automatically by the PC at a pre-determined regular interval. Service personnel can dial up the device and check calibration and performance at any time. In implementing this project, VIPAC's engineers worked closely with Telecom Aust to provide both specialised hardware and software routines to allow the system to operate reliably under any conditions.

FFT Analyser

The **CF4210-4220** Personal FFT Analyser is compact. lightweight and capable of being carried easily. It features real time processing of dynamic phenomena changing at high speed and data acquisition with high accuracy with wide dynamic range. The provision of a floppy disc drive enables secondary processing of data in the off-line mode.

Further information: Vipac, 275 Normanby Rd, Port Melbourne Vic 3207. Tel:(03) 647 9700 Fax: (03) 646 4370

NAP SILENTFLO

Air Relief Silencers

Nap Silentflo has just released a new range of air relief silencers for the building industry. Appropriately named "**AIRVENT**", these silencers may be used wherever it is desired to transfer air from adjacent areas without transferring unwanted sound. The units allow for air flow in either direction and there is a range of models for flexibility in selection of location.

Further information: NAP Silentflo, 58 Buckland St, Clayton Vic 3268. Tel (03) 562 9600, Fax (03) 562 9793

AUDIO OZ

Classic Compressor

The **Classic Compressor**, manufactured by LA Audio, is a high performance dual channel limiter/compressor which has been designed for use in any situation including recording studios, sound reinforcement, broadcasting etc. It offers simple yet versatile operation, as the two channels can be operated totally independently, or in true stereo.

Nakamichi DAT Recorder

The Nakamichi **1000 DAT** tape system is the ultimate in current Digital Analogue Tape recorders. In addition to a wide range of features it has a Fast Access Stationary Tape Guide Transport (FAST) mechanism which is a major departure from VCR derived designs.

Further information: Audio Oz, 137 Moray St, Sth Melbourne Vic 3205. Tel:(03) 696 5690 Fax: (03) 696 5691

INTEGRATION INC

ANOMS

ANOMS is an airport noise and operations **monitoring system**. It provides an efficient facility to gather, evaluate and distribute information for noise monitoring programs. It is a multi-user, multi-tasking, graphics-oriented software system designed to provide a broad group of airport users with data, reports, maps and displays to assist in the prompt and accurate identification of aircraft noise source as and analysis of operational data.

Further information: Technology Integration Australia, 37 Benwerrin Drive, Burwood East Vic 3151. Tel:(03) 803 5944 Fax: (03) 803 7585

New Publications

The following exchange publications have been received. They are stored in the Dept of Applied Physics, UNSW where they may be consulted. Tel: (02) 697 4575

Journals

Acoustics Bulletin Vol 16, No 5 1991
Contents include "Digital Simulation of Concert Hall Acoustics" by **Kuttruff**, "Use of DSP for Adaptive Noise Cancellation" by **Perry** et al., "Railway Vibration Isolation at Birmingham International Convention Centre" by **Cowell**.

Acoustics Bulletin Vol 17, No 1 1992
Contents include "Acoustic Surveying of the Sea Bed" by **Chivers** and **Burns**

Acoustics Bulletin Vol 17, No 2 1992
Contents include "Sound Limiters for Headphones" by **Popat**, "Lack of Sound Insulation in Houses" by **Somerville**

Anales Otorrinolaringologicos Vol 19 Nos 1,2 1992

Applied Acoustics Vol 35 No 2 1992
Contents include "Statistical Investigations of Geometrical Parameters for the Acoustic Design of Auditoria" by **Chan H Haan & Fergus R Fricke**

Applied Acoustics Vol 35 No 3 1992
Contents include: "Influence of Compactness on Housing Sound Insulation Costs" by **B C Amarilla**; "Some Objective and Subjective Aspects of Three Acoustically Variable Halls" by **Rein Pirn**; "The influence of first reflection distribution on the quality of concert halls" by **A Fischetti & J Jouhaneau.**

Applied Acoustics Vol 35 No 4 1992
Contents include: "Sound-field Characterisation and Implications for Industrial Sound-intensity Measurements" by **R G D Williams & S J Yang.**

Canadian Acoustics Vol 20 No 1 1992
Contents include: "Application of Modern Room Acoustical Techniques to the Design of Two Auditoria: by **J P M O'Keefe.**

J Aust Assoc Mus Instr Makers Vol 11 No 1 1992

Shock & Vibration Digest Vol 24 Nos 4-7 1992

Reports

Quarterly Progress & Status Report 4/1991
Royal Institute of Technology, Stockholm
Contents include: "On the Influence of Neck on the Guitar Body Vibrations" by **Eberhard Meinel & Erik Jansson**; "Measuring the Motion of the Piano Hammer during String Contact" by **Anders Askenfelt.**

Publications By Australians

We are grateful to Dr Richard Rosenberger for preparing this list of publications.

Acustooptic Bragg Diffraction in Anisotropic Optically Active Media
R.S. SEYMOUR
DSTO Surveillance Research Laboratory, Salisbury, SA 5108
App. Optics 29 (6) 822-826 (1990)

Dimension of the Speech Space
M.D. ALDER, R. TOGNERI, Y. ATTIKIOUZEL
University of Western Australia, Nedlands, WA 6009
IEE Proc. I. Communications Speech and Vision 138 (3), 207-214 (1992)

Computerisation of V.R.O.A.A Double Blind Hearing Screening Technique
B.ALLEN, G. LAMBERT
Audiology Dept., Mona Vale Hospital, Coronation St., Mona Vale, NSW 2103
A.J. Audiology 12 (1), 11-15 (1990)

On the Insertion Losses Produced by Acoustic Lagging Structures which incorporate Flexurally Orthotropic Imprevious Barriers
A.C.K. AU, K.P. Byrne
School of Mech. & Ind. Eng., UNSW PO Box, 1 Kensington, NSW 2033
Acostica Apr. 264-291 (1990)

A Methodology for Detection and Classification of Some Underwater Acoustic Signals using Time-Frequency Analysis Techniques
B. BOASHASH, P. O'SHEA
University of Queensland, Brisbane, QLD 4072
IEEE Trans. ASS Proc. Nov. 1929. (1990)

Sound Generation in the Vicinity of the Sea Surface: Source Mechanisms and the Coupling to the Received Sound Field
D.H. CATO
Defence Science & Techn. Org., PO Box 706 Darlinghurst, NSW 2010
J. Acoust. Soc. Am. 89 (3), 1076-1095 (1991)

New 16-QAM Trellis Codes for Fading Channels
J. DU, B. VUCETIC
Services R&D, OTC Ltd., Sydney, NSW 2001
Electronics Letters 27 (6), 1009-1010 (1991)

Differential Phase Shift Keying in Two-Path Rayleight Channel with Adjacent Channel Interference
I. KORN
University of NSW, PO Box 1 Kensington, NSW 2033
IEEE Transactions on Vehicular Technology 40 (2), 641-471 (1991)

GMSK with Limited Discriminator Detection in Sattelite Mobile Channel
I. KORN
University of NSW, PO Box 1 Kensington, NSW 2033
IEEE Transactions on Communications 39 (1), 94-101 (1991)

Radiation Efficiency of Acoustic Guitars
J.C.S. LAI, M.A. BURGESS
Dept of Mech. Engineering, University College, UNSW Canberra, ACT 2600
J. Acoust. Soc. Am. Sept. 1222-1226 (1990)

An English Language Speech Database at the University of Western Australia

E.M.K LAI, et al
Dept. of Electrical & Electronic Engineering UWA Medlands, WA 6009
Proc. ICASSP 19990 (Distribution: IEEE, Hoes Lane Piscataway, NJ 08854 USA) April (1), 101-104 (1990)

Noise-Induced Permanent Threshold Shift (NIPTS) and Presbyacusis
J.H. MACRAE
NAL, 126 Greville St. Chatswood, NSW 2067
A.J. Audiology 13 (1), 23-29 (1991)

A Psychophysical Study of Spectral Hyperacuity
K.I. McANALLY, M.B. CALFORD
Vision, Touch and Hearing Res. Centre, Dept. of Physiology & Pharmacology, Univ. of Queensland, St. Lucia, QLD. 4067
Hearing Research 44 (1), 93-96 (1990)

Active Control of Noise Transmission Through a Panel into a Cavity: 1. Analytical Study
D.A. BIES, C.H. HANSEN, JIE PAN
Dept. of Mechanical Eng., University of Adelaide, SA 5001
J. Acoust. Soc. Am. May 2098-2109 (1990)

Ultrasonic Wave Propagation in Sap Compacts
J.M. BRETTELL
Dept. of Physics, University of New England, Armidale, NSW 2351
J. Physics 23 (5), 620-621 (1990)

High-Resolution Array Processing using Implicit Eigenvector Weighting Techniques
(1) C.L. BYRNE
(2) A.K. STEELE
(2) Maritime Systems Division, Weapon Systems Research Lab., Defence Science and Technology Organisation, PO Box 1700, Salisbury, SA 5108
IEEE J. Oceanic Engineering 15 (1), 143-164 (1990)

The Receptivity of Laminar Boundary Layer Flow to Leading Edge Vibrations
W.K. CHU, M.P. NORTON
Dept. of Mechanical Eng., University of Western Australia, Nedlands, WA 6009
J. Sound Vib., 141 (1), 143-164 (1990)

Analytical Signal Processing for Pattern Recognition
B.R. DAVIS, A. MAHESWARAN
Network Analysis Section, Switched Networks Branch, Telecom Research Laboratories, Clayton, Vic. 3168
IEEE Trans. on Acoustics, Speech and Signal Processing Sept. 1654-1648 (1990)

Speech Encryption in the Transform Domain
E. DAWSON, B. GOLDBURG, S. SRIDHARAN
Queensland University of Technology, Brisbane QLD 4000
Electronics Letters 26 (10), 655-657 (1990)

Nonlinear Theory of Musical Wind Instruments
N.H FLETCHER
CSIRO Div. of Radiophysics, Dept. of Electronic Materials Engineering, Research School of Physical Sciences, ANU, Canberra ACT 2601
App. Ac. 30 85-115 (1990)

* * *

ADVERTISER INDEX

Road Surface Noise

The N.S.W. Roads and Traffic Authority (RTA) is undertaking an on-going research and development program aimed at optimising and improving the performance characteristics of road pavement surfaces. Various factors are being considered in this study including drainage, skid resistance and noise. The Sydney office of Mitchell McCotter was recently engaged to determine the acoustic performance of several new cement concrete pavement surfaces. These surfaces were of varying surfaces and had been constructed along the F3 Freeway which runs from Sydney to Newcastle.

The surfaces were finished in one of two ways after the concrete had been conventionally "smoothed" with a straight edge. The first is known as "Hessian dragging" which gave a generally fine texture to the surfaces by dragging a hessian mat over the wet concrete. The second was achieved by a process which added grooves to the surfaces by using a raking implement. Variations in surface type were achieved by making adjustments to both these processes. Thus the surfaces varied firstly in texture coarseness and secondly, in the width and spacing of the grooves.

The pass-by noise levels of a car and a heavy truck on each surface type were measured over a range of speeds from 50 to 75 km/h.

Analyses of the data revealed that there were only small differences in the noise levels between the eight cement concrete pavements tested. Overall the quieter surface was found to be that with the finer texture coupled with the smaller grooves at the narrower separations. The low noise pavement of the present study was the quieter of all cement concrete pavements in both studies; it was recommended for future applications, on acoustic grounds alone.

From Mitchell McCotter Newsletter No. 2, 1992

ARL NOISE LOGGERS

The way to know

The way to go

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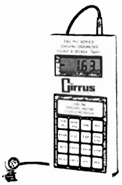

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National Acoustic Laboratories is a Division of Australian Hearing Services a Commonwealth Government Authority

Diary ...

CONFERENCES and SEMINARS

• Indicates an Australian Activity

1992

Aug 28 - Sept 1, TOKYO
INTERNATIONAL SYMPOSIUM ON MUSICAL ACOUSTICS
Details: ISMA 92 Tokyo Secretariat, c/ Acoustics Laboratory, Ono Sokki Co, 1-16-1 Hakusan Midoiku, Yokohama 226,Japan

September 1-3, SENLIS
FAN NOISE
Details: J Tourret, CETIM BP 67 - 60304, Senlis, France

September 3-10, BEIJING
14th ICA
Details: 14 th ICA Secretariat, Institute of Acoustics, P.O. Box 2712, Beijing 100080, China

September 12-14, NANJING
INTERNATIONAL SYMPOSIUM ON ACOUSTICAL IMAGING
Details: 14 th ICA Secretariat, Institute of Acoustics, P.O. Box 2712, Beijing 100080, China

September 14-17, LUXEMBOURG
EUROPEAN CONFERENCE ON UNDERWATER ACOUSTICS
Details: Commission of European Communities, DG XII/E (MAST Prog), Secretariat SDME 3/46, Rue de la Loi 200, B-1049, Brussels, Belgium

September 14-18, LONDON
EURONOISE 92
Details: Institute of Acoustics, PO Box 320, St Albans, Herts, AL1 1PL, England

September 20-24, CAMBRIDGE
AUDIOLOGY IN EUROPE
Details: Ann Allen, British Society Audiology, 80 Brighton Rd, Reading RG6 1PS, England

September 22-24, CRACOW
NOISE CONTROL 92
Details: Institute of Mechanics and Vibroacoustics, Technical University of Mining & Metallurgy, al Mickiewicza 30, 30-059 Cracow, Poland, Tel (48) 12 33 23 14 Fax (48) 12 33 10 14

October 12-16, ALBERTA
1992 INTERNATIONAL CONFERENCE ON SPOKEN LANGUAGE PROCESSING
Details: ICSLP-92, Catering and Conference Services, University of Alberta, 103 Lister Hall, Edmonton, Alberta, Canada T6G 2H6,Tel 403 492 7200, Fax 403 492 7032

October 14-16, BOLOGNA
2nd INTERNATIONAL CONFERENCE ON VEHICLE COMFORT
Details: ATA, Via Oettinati 20, I 10126 Torino, Italy

October 18-24, MEMPHIS
124th MEETING ASA
Details: ASA, 335 East 45th St, New York, NY 10017, USA

October 27-28, SENLIS
RECENT ADVANCES IN SURVEILLANCE
Using Acoustical and Vibratory Methods
Details: Mme F Chapelon, Revue Pratique de Controle Industriel, Editions Ampere, 25 rue Dagorno, 75012 Paris, France.

Oct 29-Nov 1, Windermere
REPRODUCED SOUND 8
Institute of Acoustics Conference
Details: K Dibble Acoustics, Old Rectory House, 79 Clifton Rd, Rugby CV21 3QG UK.

November 19-22, Windermere
SPEECH & HEARING
Institute of Acoustics Conference
Details: Dr W Ainsworth, Dept Comm. & Neuroscience, Keele Uni, Keele, Staffordshire ST5 5BG UK.

• November 26-27, BALLARAT
PRACTICAL ACOUSTICAL SOLUTIONS
AAS Annual Conference
Details: AAS Annual Conf, PO Box 233,Moonee Ponds,Vic 3039 Australia

• December 14-18, HOBART
11th AUSTRALIASIAN FLUID MECHANICS CONFERENCE
Details: 11 AFMC Secretariat, Dept Civil & Mech Eng, University of Tasmania, GPO Box 252C, Hobart 7001

1993

May 10-13, TRAVERSE CITY
NOISE & VIBRATION CONFERENCE
Details: Society Automotive Engineers, Communications& Meetings, Warrendale, PA 15096, USA

May 31 - June 3, ST PETERSBURG
NOISE 93
International Noise and Vibration Control Conference
Details: Malcolm Crocker, Mech Eng, 210 Ross Hall, Auburn University, Auburn, AL 36849-3501, USA

June 25-27, IOWA
INTERNATIONAL HEARING AID CONFERENCE
Details: University Iowa Conference Centre, Memorial Union, Iowa City, IA 52242, USA

June 26 - July 2, BERGEN
13th INTERNATIONAL SYMPOSIUM ON NONLINEAR ACOUSTICS
Details: Prof Halvor Hobaek, Dept Physics, University Bergen, Allegt 55, Bergen, Norway 5007, Tel 0475 21 27 87, Fax 0475 31 83 34

July 6-9, NICE
NOISE & MAN
6th International Congress on Noise as a Public Health Problem
Details: Noise & Man 93, INRETS LEN, Case 24, F 69675, Bron Cedex, France

August 24-26, LEUVEN
INTER-NOISE 93
People Versus Noise
Details: INTER-NOISE 93, TI-K VIV, Desguinlei 214, B-2018 Antwerpen, Belgium, Tel (32) 32 16 09 96 Fax (32) 32 16 06 89

August 31-September 2, SENLIS
4th CONFERENCE ON INTENSITY TECHNIQUES
Structural Intensity
Details: CETIM, BP 67, 60304, Senlis, France Tel (33) 44 58 32 17 Fax (33) 44 58 34 00

August 30-September 1, LEUVEN
INTERNATIONAL SEMINAR ON MODAL ANALYSIS
Details: ISMA, TI-K VIV, Desguinlei 214, B-2018 Antwerpen, Belgium,Tel (32) 16 28 66 11 Fax (32) 16 22 23 45

September 15-17, BUCAREST
10th FASE
Details: Comm. d'Acoust. de L'Acad Roumaine, Calea Victoriei 125, 71 102 Bucarest, Romania

1994

February 27 - March 3, AMSTERDAM
96th AES
Details: Sec, AES Europe Office, Zevenbunderslaan 142/9, B-1190 Brussels, Belgium

July 18 - 21, SOUTHAMPTON
RECENT ADVANCES IN STRUCTURAL DYNAMICS
5th International Conference on
Details: ISVR Conference Secretariat, The University, Southampton, SO9 5NH, England.

COURSES

In accordance with the recognition of the importance of continuing education, details on course held in Australia are included in this section at no charge. Additional details can be given in an advertisement at normal rates.

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Details: Acoustics and Vibration Centre, Aust. Defence Force Academy, Canberra, ACT 2600. Tel (06) 268 8241 Fax (06) 268 8276

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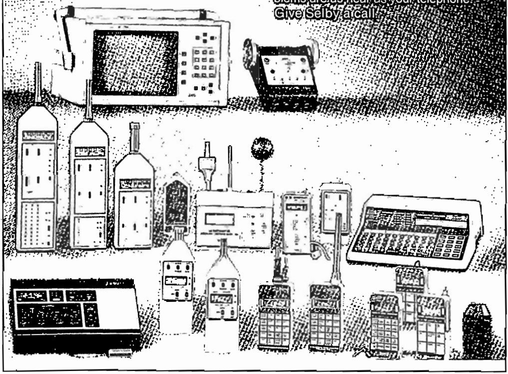

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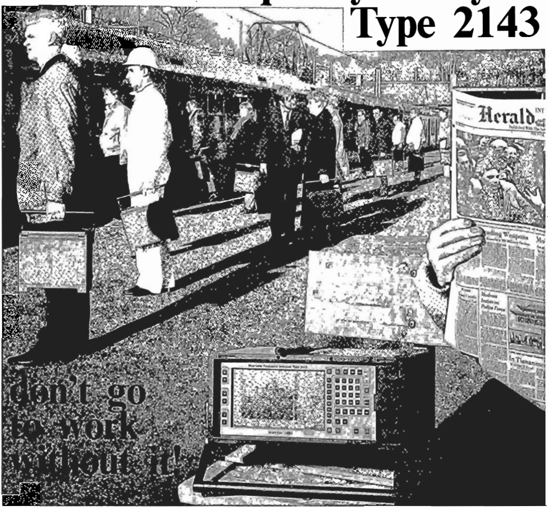

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