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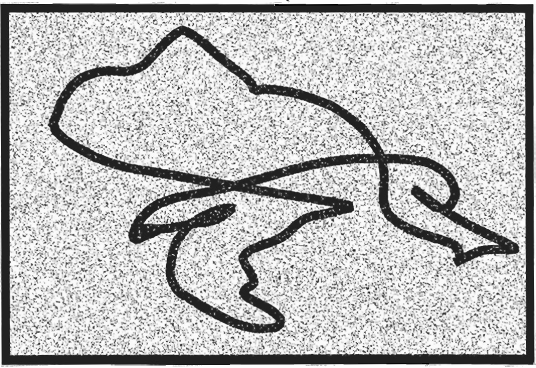

- Ventilation in Noise
- Occupational Noise
- Acoustics to 21st C
- Vibration Signal Processing
- Transfer Function Measurement
- Interview: Anita Lawrence

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Editorial

Members are the most important element in any Society. Without them the Society ceases to exist; without active members the Society will wither and become stagnant. Thus the Registrars Report to Council is always an important guide to the status of our Society. In November, 1992, the Society had a total of 413 members which grew to 418 in 1993 and, after allowing for new members and resignations, a further 7 were added to the total for 1994. Thus it would seem that the Society is growing, albeit slowly. Unfortunately, the true picture is not quite so rosy. At the present time, 98 members are non financial, which implies that the real membership of the Society could be less than 350. Divisions have been asked to take action to recover unpaid subscriptions and re-activate as many of our colleagues as possible. If you are one of our non financial members, please help swell our ranks by paying your membership. It's not just the registration fee that is important, but the extra momentum that a strong, active Society can generate.

One of the main charters of your Society is to promote acoustics in the wide arena. To this end, for example, the Society is a member of the Australian Foundation for Science which is currently developing material for promoting science, technology and the environment at primary-school level. In addition, members of our own Society are at present engaged in preparing publications on acoustics and noise to improve public awareness of our discipline, particularly at a high school level. Our annual conferences and *Acoustics Australia* are the Societies two main methods of disseminating knowledge amongst the acoustic community. The success of the 1994 Canberra Conference and the high quality of the magazine you are currently reading indicates that the Society, and its members, are ably fulfilling this goal.

Towards the close of the most recent Council meeting, the Society was asked to respond to an Australian Science and Technology Council (ASTEC) questionnaire on the future state of acoustics in Australia. In summary, we were asked what we considered to be Australia's strengths and weaknesses in the most promising areas of acoustic research, development and commercialisation over the next 15 years. The answer to such questions are difficult, yet important if we are to influence the politicians which direct the purse strings. While an initial response is currently being prepared, on advice from the various state Divisions, the questions deserve longer and more considered deliberation. At the most recent Council meeting there was a strong feeling that too much of Councils time was devoted to relatively mundane running of the Society and too little time was directed towards concepts such as those raised by the above question. Consideration is currently being given to streamlining the organisation to allow a shift in the balance of work of Council. For the first time in many years, it is proposed to have a mid-year Council meeting, rather than one immediately before and after the annual conference, in order to hasten this process.

Charles Don, Vice President

OPTIMISATION OF BUILDING VENTILATION OPENING SIZE IN A NOISY ENVIRONMENT

Chris Field and Fergus Fricke
Department of Architectural & Design Science
University of Sydney, NSW 2006

This paper was awarded the 1994 PRESIDENT'S PRIZE
The President's prize, established in 1990 by the Australian Acoustical Society, is awarded to the best technical paper presented in the Annual Australian Acoustical Society Conference.

ABSTRACT: This paper addresses the problem of achieving noise reduction in buildings that are exposed to road traffic noise while satisfying ventilation requirements. A design process has been developed that optimises the size of an opening in a building for ventilation while estimating the attenuation of external traffic noise inside the building. A fan with associated duct work is fitted to an opening in the building facade to provide ventilation. Therefore the optimisation of the opening size is used to determine the necessary fan characteristics which best suits the opening. The process allows the user to specify particular environmental conditions including traffic noise spectra, required ventilation rates, ventilation fan type, ventilation duct characteristics and building facade properties. Model results are presented indicating an optimum ventilation opening size with the associated internal noise levels. The work is part of a larger study into reducing noise through ventilation openings.

1. INTRODUCTION

The noise from road traffic in urban areas is a well known problem throughout the world. While there is an obvious requirement to reduce the level of external noise entering the building enclosure, ventilation standards must also be adhered to. Unfortunately, the methods of obtaining satisfactory levels of noise reduction and ventilation conflict. Therefore there must be a point of compromise between these two functions.

Extensive research has been carried out into the shielding of external noise provided by buildings [1]-[4]. While the need for ventilation is acknowledged, a method of ventilation and the noise characteristics associated with it has not been included in the research. Similarly, many references concerning heating, ventilation and air conditioning systems (including fan engineering) concentrate on the resulting sound levels in enclosures due to ventilation fans or devices performing the ventilation process, without taking into account other external noise sources (such as road traffic) affecting the enclosure being ventilated [5]-[9]. An important combination of these two functions involves a design process that optimises the size of an opening in a building to satisfy ventilation requirements while attenuating external noise from road traffic and noise generated by the particular ventilating device. This paper outlines the development of such a design process. Two case studies are presented to demonstrate the process.

2. THE DESIGN PROCESS

A design process has been developed that optimises the size of an opening in a building for ventilation while estimating the attenuation of external traffic noise and ventilation fan noise level inside the building. To provide ventilation, a fan with associated duct work is fitted to the opening in the building facade containing a window. Therefore the optimisation of the opening size is used to determine the necessary fan characteristics which best suits the opening. A spreadsheet program was used to provide a range of opening sizes in the wall for ventilation so as to obtain an optimum hole size.

Initial Conditions

Some initial conditions had to be established to begin the design process. Although particular conditions have been chosen, these could be set at any reasonable values according to the desired environment. This allows a sensitivity analysis of the results of the design process to be carried out.

The dimensions of the room to be ventilated were set to be similar in size to a normal bedroom, measuring 3x5x2.4 m high. These dimensions were used by Lawrence and Burgess [2] for a bedroom in an experimental building used to measure the reduction of traffic noise by facades containing windows. The facade exposed to traffic noise measured 5x2.4 m high. The design process was developed to allow a road traffic noise spectrum in octave bands from 63 Hz to 8 kHz to be used as the source of external noise. Typical values were taken from a relevant reference [10]. The ventilation rate of the room was required. Appropriate ventilation requirements were taken from Australian Standard AS1668 Part 2-1980 [11]. Different ventilation rates could be chosen according to the class of occupancy involved. The option was made for an inlet duct to attenuate fan and traffic noise entering the building through the ventilation opening (assuming that the air intake was on the noisy side of the building and the exhaust on the quiet side). The length of duct, number of bends and type of duct lining could be chosen as required. Calculations could be carried out without an inlet duct attached. The duct was assumed to be on the inside of the building and that no duct breakout occurred into the room.

Appropriate values for the absorption coefficient of the duct lining in octave bands from 125 Hz to 4 kHz were taken from a relevant reference [5]. The transmission loss characteristics of the walls of the building were chosen to correspond to single leaf brick masonry walls and the windows were chosen to be double glazed with an area of 10% of the total wall area [12].

Fan Selection

To select a suitable fan, the fan pressure needed to circulate the required flow Q had to be determined. The total pressure drop of the inlet duct system is estimated in a similar manner to that adopted in common fan engineering references [5], [6] [8], [9] i.e. the total pressure drop is obtained by adding together the elements of total pressure drop around the system including:

- Losses at entry to the inlet duct from atmosphere
- Losses due to friction along the duct length
- Losses at bends
- Losses at discharge from the system to atmosphere

The total pressure drop due to air flowing into and out of the room is calculated using the equation:

$$\Delta P_{TOTAL} = \left(\frac{0.02L}{D} + K_{entry} + nK_{bends} + \frac{0.02L_{wall}}{D} + K_{exit} \right) \frac{1}{2} \rho V_{air}^2 \quad \text{[Pa]} \qquad (1)$$

where

L= length of inlet duct (m), D= diameter of duct to fit opening (m), K_{entry} = coefficient accounting for losses at entry of inlet duct [6], K_{bends} = coefficient accounting for losses at the bends of inlet duct [6], L_{wall} = wall thickness, n = number of bends, K_{exit} = coefficient accounting for losses at discharge to atmosphere [6] and ρ = air density (kg/m³).

This pressure is the fan pressure needed to circulate the required flow Q. Normally there would be further resistance due to air flow through the interior of the rest of the building (as the room would be joined to other rooms). It has been assumed, however, that the air flowing out of the room flows to the surrounding atmosphere. Since the average velocity of air through the ventilation opening is inversely proportional to the area of the opening, the total fan pressure required to circulate the flow decreased rapidly at a rate of $1/A^2$ as the area of the opening A increased.

Obviously the most reliable method of determining the sound power level of a particular fan would be to obtain sound power levels in each octave frequency band from a fan manufacturer. In this design stage of the ventilation system, however, only the required duty has been established. The type of fan to be used has not been decided upon. Therefore an empirical formula must be used to estimate the likely sound power level that will be produced. An approximate idea of the sound power level of the chosen fan was gained from the following equation [7]:

$$L_w = 10\log Q + 20\log \Delta P_{total} + 37 \quad \text{[dB]} \qquad (2)$$

There are correction factors for different fan types in different frequency octave bands. These have been incorporated into the design process to illustrate the difference in optimum opening size according to fan type [7]. The application of these correction factors allows the sound power level of a fan, for a particular ventilation opening size, to be calculated in octave bands.

Attenuation of Noise Provided by Lined Inlet Duct

The level of attenuation provided by the inlet duct is a function of the absorption coefficient of the duct lining. For a straight length of duct L metres, variations of Sabine's equation have been used to provide reasonable estimates.

Estimates of the attenuation provided by lined bends were very difficult to find in relevant references. The data that were found are difficult to compare because many different measurements techniques are used and the fact that there is no consistent nomenclature for the noise reduction provided by bends. Field measurements indicate that the attenuation due to a 90° bend in the duct work would be 10 dB higher than that for the same length of lined duct [13]. This is valid provided the lining extends at least two diameters of the duct each side of the bend. Therefore the total attenuation provided by a lined duct of diameter D metres with n 90° metre bends can be calculated using the following equation:

$$Total\ attenuation = 4.2\alpha^{1.4}\left(\frac{L}{D}\right) + n\left(8.4\alpha^{1.4} + 10\right) \qquad (3)$$

where n = number of bends and α = absorption coefficient of duct lining.

The absorption coefficient is a function of frequency. Typical values in octave frequency bands were taken from a relevant reference [5] to obtain the total attenuation provided by the inlet duct.

Equivalent Transmission Loss of Wall with Inlet Duct Attached

The transmission loss of a wall with a window and an opening for ventilation with an inlet duct attached was calculated in two stages. Firstly, the equivalent transmission loss of the building facade with a hole and window in it, calculated in octave bands, was determined as an overall area-weighted average of the wall, window and duct cross sections. For this calculation, equation (4) was used.

Obviously as the percentage open area increased, the equivalent transmission loss of the wall, window and hole decreased. The area of the hole dictated the level of transmission loss provided by the composite combination. The equivalent transmission loss with the inlet duct attached was then calculated using an equation similar to equation (4). The equivalent transmission loss decreased in a similar fashion, but at a slower rate, however, than that for a wall with only a hole it since the inlet duct has the ability to attenuate noise.

$$TL_{eq} = -10\log\left(A_{wall}\tau_{wall} + A_{hole}\tau_{hole} + A_{window}\tau_{window}\right) / A_{total} \quad \text{[dB]} \qquad (4)$$

where $\tau_{wall} = I_{t\ wall} / I_i$
$\tau_{hole} = I_{t\ hole} / I_i$
$\tau_{window} = I_{t\ window} / I_i$

The terms I_t, and I_i, are the transmitted and incident sound intensities respectively

Noise Entering Room

The noise entering the room will be a combination of fan and traffic noise that has been attenuated by the lined inlet duct and building facade.

The sound pressure level of traffic noise entering the room is determined by subtracting the equivalent transmission loss in each octave band calculated in the equation similar to equation (4), from the traffic noise spectrum in octave bands set in the initial conditions. Since the attenuation provided by the composite building facade decreased as the area of the opening for ventilation increased, the level of traffic noise entering the room increased as the area of ventilation opening increased. The traffic noise entering the room, however, was largely low to mid-frequency noise (A-weighted). The noise levels in the 250 Hz to 1 kHz octave bands were the only significant contribution to the overall traffic noise level in the room. Hence the contribution of the traffic noise in the room to the overall sound level in the room is only significant for large ventilation openings in the building facade because of the lower equivalent transmission loss provided by the wall, window, hole and inlet duct at larger ventilation opening sizes.

In addition to the fan noise being attenuated by the lined inlet duct, end reflection occurs at the end of the duct run, unless the duct diameter is very large (compared to the wavelength of sound). The maximum end reflection occurs at low frequency as the wavelength is greatest compared with the size of the opening. Equation (5) was used to calculate the end reflection loss depending on frequency and diameter of the duct being used [8]:

$$\Delta L = 10\log\left[1+\left(\frac{c_o}{\pi f D}\right)^{1.88}\right] \quad \text{[dB]} \qquad (5)$$

where c_o is the speed of sound in air (344m/s), f is the octave band frequency and D is the diameter of the duct.

The sound power level of the fan entering the room in dB will therefore be:

$$L_{w\ room} = L_{w\ fan} - attenuation\ by\ inlet\ duct - end\ reflection \qquad (6)$$

where the attenuation by the inlet duct in each octave band is calculated from equation (3) and the end reflection loss in each octave band for a particular duct area is calculated in equation (5).

The sound power level of the fan in the centre of the room is converted to an equivalent sound pressure level using the standard equation for a point source located in the centre of the wall, assuming the fan noise radiates hemispherically on a single reflecting surface. The average absorption of the interior of the room was also taken into account:

$$L_{p\ fan} = L_{w\ room} + 10\log\left(\frac{D}{2\pi r^2}+\frac{4(1-\bar{\alpha})}{S\bar{\alpha}}\right) \qquad (7)$$

where $L_{w\ room}$ = fan L_w calculated in equation (6), D = directivity of fan, $\bar{\alpha}$ = average room absorption coefficient, S = surface area of room (m²), r = distance from duct exit to room centre (m).

The sound pressure level of the fan in the centre of the room decreased as the size of the ventilation opening increased in a similar fashion to the sound power level since all the terms in equation (7), except the fan sound power level $L_{w\ room}$ are constants.

Total Sound Pressure Level in Room

The total sound pressure level in the room could then be determined by adding the contributions made by the traffic noise entering the room and the noise from the fan entering the room. The overall sound pressure level of the traffic noise in the room was determined by adding the equivalent squared pressures of the traffic noise in the eight octave bands and then converting back to a total sound pressure level. Similarly, the squared pressures of the fan noise in the room were combined and converted to a total sound pressure level. The overall sound pressure level in the room due to the fan and traffic could then be calculated using a similar technique.

The fact that the sound pressure level of traffic noise in the room increases as the size of the ventilation opening increases and the fact that the sound pressure level of the fan in the room decreases as the size of the ventilation opening increases indicates that there will be a particular ventilation opening size where the total sound level in the room due to these two external noise sources is a minimum.

3. CASE STUDIES

Variation of Fan Type

The correction factors for different fan types previously mentioned indicate that the noise level in the room and hence the optimum ventilation opening size is greatly influenced by the type of fan used for ventilation. Figure 1 shows the total sound pressure level in the room as a function of percentage open area (corresponding to the size of the opening for ventilation) for different types of fans. The different fan types considered were forward curved centrifugal, backward curved centrifugal, radial, axial and propeller fans.

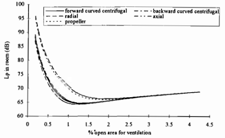

Fig.1 Total sound pressure level in room (different fan types) vs percentage open area for ventilation.

Forward curved and backward curved centrifugal fan types were the quietest while the radial type was the noisiest for the same volume flow and fan pressure. Correspondingly, the optimum ventilation opening size for forward curved and backward curved centrifugal fans is smaller, allowing a more compact size for a given duty than other fan types. The smaller ventilation opening size also increases the effective transmission loss of the building facade to the external traffic noise. Therefore the type of fan used will also affect the amount of traffic noise entering the room in addition to the amount of fan noise entering the room. From Figure 1, the optimum ventilation opening size for the quietest fans (forward and backward curved centrifugal) were approximately 1% of the total facade area exposed to external noise and 1.6% for the noisiest fan (propeller). From the nature of the curve for areas greater than the optimum percentage area, it is reasonable to expect that any opening size between 1 and 4% of the total wall area could be considered for ventilation purposes.

Variation of Traffic Noise Characteristics

The design process required that the traffic noise spectrum be set in the initial conditions. The typical spectrum chosen [10] characterised urban flow traffic (below 60 km/h) directly outside the building facade, which is dominated by the large amount of acoustic energy concentrated in the 63 Hz and 125 Hz octave bands (due to exhaust noise generated by heavy diesel commercial vehicles). Obviously this type of traffic noise will not always be present. For traffic flowing at steady speed (greater than 80 km/h) the spectrum contains energy concentrated at higher frequencies due mainly to tyre/road interaction noise (not present at low speeds) and mechanical noise from power train components. The nature of the noise will also vary with distance from the building facade. Hence it is necessary to investigate the effect of different traffic noise characteristics on the optimum ventilation opening size in the building facade exposed to the traffic noise.

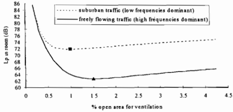

Fig. 2 Total sound pressure level in room (different types of traffic noise) vs percentage open area for ventilation.

A traffic noise spectrum with acoustic energy concentrated in the low frequency bands was used to simulate suburban traffic. Likewise, a spectrum with energy concentrated in the high frequency bands was used to simulate freely flowing traffic. To allow a comparison to be made between the two forms of traffic, the dB(A) values of the two spectra were kept equal. Figure 2 shows the total sound pressure level in the room for various ventilation opening sizes predicted using the design process. The optimum ventilation opening size for the suburban traffic noise was 1.0% of the total wall area and was 1.5% for the freely flowing traffic (both points are shown on Figure 2). This indicates that a larger opening size can be used for the freely flowing traffic because the building facade and attenuating duct are able to attenuate the high-frequency noise more effectively than the low-frequency dominant suburban traffic noise. The difference in attenuation of the two types of traffic flow can be seen by the distance between the two curves (the ventilation opening sizes where the two curves overlap is the region where the fan noise is dominant).

4. CONCLUSIONS AND DISCUSSION

From this work it is concluded that the optimum size fan for a ventilation opening, when there is a fan and a short length of lined duct, is about 1-1.5% of the total wall area. This compares to about 5-10% of openable area when natural ventilation is utilised. The difference in noise level inside a building, with brick veneer construction, facing a road will be approximately 17 dB(A).

If only a fan is used (without a lined duct), the optimum opening area for minimal sound level will be 0.75% with a sound level reduction of 9.2 dB(A) over the case for 10 % of the facade open for natural ventilation. Compared to the reduction due to a barrier this is significant.

The work described forms part of a project to reduce noise entering building ventilation openings. Future work will be concerned with developing alternative methods such as 'intelligent' openings, noise cancellation and systems where there is a road barrier between the inside and outside of the building.

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VIBRATION SIGNAL PROCESSING USING MATLAB®

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ABSTRACT: Vibration signal processing has traditionally been accomplished using analog and digital signal analysers, or by writing assembler, Fortran or C compiled code. The advent of higher level interpretive based signal processing software products like MATLAB has added a new dimension to vibration signal processing. This paper will outline the application of MATLAB to analysis of the vibration from rotating machinery such as rotors, gears and bearings. Sophisticated signal processing techniques can be developed within a very short period of time given the flexibility and interactive nature of MATLAB and the range of in-built functions such as Fourier transforms, cubic interpolations and digital filters. The three dimensional colour graphics included in this package provides a sophisticated visualisation capability for the more advanced signal processing techniques.

1. INTRODUCTION

Vibration is the study of the oscillatory motion of objects relative to a reference frame. Vibration is evident everywhere, and in many cases greatly affects engineering design and the performance of engineering devices. In some cases vibration can be harmful and should be avoided, in other cases it can be the crucial element in the success of a particular engineering process. In Mechanical Engineering, knowledge about vibration is very important and the measurement, analysis, modelling and prediction of vibration have provided engineers with important tools with which to understand engineering devices.

The measurement and analysis of engineering machinery vibration can be used to determine the performance of and the condition of the machine. Machinery vibration is often the important parameter which can be unobtrusively measured while the machine is operating, and from which knowledge about the condition or performance of the machine can be inferred using vibration signal processing. Vibration analysis of measured machinery vibration has been used for a long time and quite sophisticated techniques were developed over twenty years ago, [1].

Two basic approaches have been used for analysis of machinery vibration over the last twenty years. Firstly, there has been the development of dedicated hardware, (digital signal analysers), by a number of companies. These systems, many of which are extremely sophisticated, allow the engineer to connect the vibration measurement sensor directly to the hardware, where the signal is then digitised and may be analysed by a number of sophisticated techniques. The range of techniques now available on these systems is quite large and includes spectral analysis, narrow band zoom, time synchronous signal averaging, computer order tracking, high frequency envelope analysis and time-frequency analysis amongst others. These techniques form the bulk of the comprehensive techniques which are necessary for routine preventative maintenance of the majority of industrial type machines.

The second approach for vibration analysis was used widely prior to the advent of the dedicated vibration signal analysers, and involved writing software in Fortran, Pascal or C. This software was then used to analyse the vibration data which had previously been digitised by other hardware. This approach has become more important recently because of the need to analyse and interpret the measured vibration of complex machinery for condition monitoring. For complex machinery like helicopter gearboxes [2], and the Space Shuttle Main Engine Oxygen Turbopump [3], the dedicated hardware of the digital signal analysers were found to not have the necessary techniques or flexibility to correctly detect and diagnose the mechanical condition of the rotating machinery.

The writing of sophisticated vibration signal processing software from scratch using compilers is no easy task. In the past very few establishments have had the resources, knowledge or skills to dedicate manpower to the development of the software. The software tended to be platform specific and the adaptation to multiple computer types and the continuous computer operating system upgrades meant a considerable ongoing expense. Over the years new languages have arisen, sometimes rendering quite sizeable code obsolete.

More recent software developments have begun to have considerable impact upon the way that software is written for the more complex vibration signal processing tasks. In particular, a numeric computation and visualisation software product called MATLAB has been developed by The MathWorks Inc. This paper will attempt to address the MATLAB product, to describe its benefits in as far as the development of vibration signal processing software is involved, and provide examples relating to the vibration analysis of rotating machinery.

2. VIBRATION SIGNAL PROCESSING

An enormous wealth of information can be gained from the measurement and analysis of vibration data of rotating machinery in particular. The vibration signal contains the information of the oscillatory motion of the machine and its sub-components. Each of the sub-components of rotating machinery, ie: gears, bearings, shafts, couplings, engines, electric generators, pumps, fans, etc, can be modelled such that the vibration from various modes of failure can be predicted. For most of these sub-elements, such models can be quite sophisticated. A review of vibration failure models developed for rolling element bearings with localised damage [4, 5] found that they included the effects of load zone, variation of the transmission path between the defect location and the transducer and exponential decay of defect impulses due to internal damping. They also included single and multiple localised defects. Models have likewise been developed for the majority of mechanical components of rotating machinery covering the gross failure modes.

The goal of vibration signal processing is to analyse the vibration signal measured at particular locations on the machine, and extract enough information to determine the condition of each of the sub-elements of the machine. The techniques which are readily available for the bulk of rotating machines using digital signal analysers include spectral analysis, narrow band zoom, time synchronous signal averaging, computer order tracking, high frequency envelope analysis and time-frequency analysis. For those machines where the vibration environment is such that the existing techniques need further refinement or the mode of failure is complex, the standard techniques will need to be adapted or new approaches used to successfully detect impending failure. Whereas signal processing software can be written using Fortran, Pascal or C compilers, the author believes that the recent arrival of advanced signal processing tools such as MATLAB greatly changes the sphere of development of vibration software. The next section outlines the major reasons for using these latest tools instead of the traditional compilers.

3. MATLAB

MATLAB is a high performance numeric computation and visualisation software product developed by The Math Works Inc, Massachusetts, USA [6]. It involves the use of an interactive environment containing numeric computation, matrix computation, signal processing and graphics capabilities. The features which are particularly important in as far as vibration signal processing is concerned include its interactive nature, extensibility, multi platform capability, ability to link in existing code, standardised data format, range of built in functions and graphics capability.

Interactive Nature The interactive nature of MATLAB provides the vibration analyst with the powerful capability to develop and test what-if ideas on the run and with very little effort. This is particularly useful for vibration analysis of complex machinery as the analysis is most productive in a sequential operation with the next step often depending on what is observed in the current operation.

Extensibility MATLAB is open ended in the sense that a large number of toolboxes or additional built in signal processing capabilities can be added if needed, or written by the user if required. The user written code or additional toolboxes are ASCII text files (called M-files) which use the standard built in functions. The interactive nature often leads to processes which can be linked together to form a new function or M-file, allowing the analyst to quickly and easily develop his/her own suite of customised functions.

Multi Platform Capability MATLAB is available across a large number of popular computer and operating system platforms from the Cray to the PC. The same range of in-built functions, interactive nature, etc., is available on all platforms. This is particularly powerful for research groups having say a data acquisition capability on the PC and a more powerful computation platform for computationally extensive work. It also allows the ready exchange of techniques around the world due to the simple exchange of ASCII text files, regardless of the platform they were originally written on.

Linking With Existing Code An argument against changing software languages or operating systems is often the enormous amount of software that is already in place and working on the current system. MATLAB has the ability to link to software written in a number of languages, so that the original software is still useable, whilst the benefit of the new tools becomes available as well. One of the obvious benefits for vibration analysis is that an existing data acquisition capability can also be linked in to run with MATLAB as well. This should be particularly useful for the PC environment where it should now be possible to conduct data acquisition under Microsoft Windows straight into the MATLAB environment.

Standardised Data Format One of the headaches with vibration analysis is being given digital data to analyse where the format of the data is different to that which has previously been used. The binary data files used with MATLAB (MAT-files) have been standardised across computer platforms by having the original platform noted in the file header. When the file is read, the software takes account of the differing file formats automatically and does the correct read on the new platform. This functionality has been tested to the extent that MAT files have been sent around the other side of the world using internet and have been read correctly on differing platforms. This standardising feature of MATLAB may help to encourage research and development cooperation between differing organisations such as Universities and Industry.

Range of Built-In Functions The new versions of MATLAB, such as 4.0 released for the PC platform in August 1992, contain some 20 main categories of built-in functions ranging from the low-level file input/output functions, the polynomial and interpolation functions, three dimensional graphics functions and the data analysis and Fourier transform functions. It has been found by experience that the development of the majority of advanced signal processing techniques for vibration analysis can be accomplished using the built in functions and the additional signal processing toolbox functions.

Graphics Capability The three dimensional colour graphics capability of the recent versions of MATLAB have been a dramatic improvement over what could be readily accomplished using compiled code, particularly for the PC environment. Three dimensional colour surface and mesh plots with hidden line removal and axis labelling, from differing view points and with differing colour maps can now be achieved with the use of a small number of commands. The ability to animate the three dimensional plots and play back at predefined frame speeds has been particularly useful in the analysis of vibration from variable speed rotating machinery. The use of time - frequency analysis is very helpful in this regard and is one situation where the graphics display capabilities can be of significant benefit in understanding the nature of the vibration signal being analysed.

Other Comments Software environments like MATLAB change the typical nature of computing. For the vibration analyst, it opens up the possibility of conducting signal processing in a way that wasn't readily available before. MATLAB is fastest when the computation can be written using vectors or matrices. This means that the complete data array should be manipulated in memory at the same time. For typical machine condition monitoring techniques such as high frequency envelope analysis or time synchronous signal averaging, the implication is that the memory requirement is now much larger than that involved using smaller file based software routines. However, given enough memory (memory is cheap after all) the software now becomes easier to write, understand and use and hopefully faster than the previously file read write based routines. The amount of memory required to optimise processing speed for a particular application now becomes a significant factor, possibly even more significant than processor speed itself.

4. SIGNAL PROCESSING EXAMPLES

The following examples are given to indicate the type of vibration signal processing which can readily be accomplished using MATLAB. They relate to practical industrial type problems and illustrate both the sophistication and flexibility of the processing M-files which can be developed and the nature of the information which can be obtained from vibration data.

Rotor Vibration Displacement proximity probes are typically used to measure the relative motion and position of shafts with respect to the journal bearing housing of large steam turbine generator units. Normally two probes are set up 90° apart (usually horizontally or vertically) to measure displacement of the shaft at each bearing position. A tachometer signal is also obtained from the turbine shaft and provides a pulse once per revolution to determine the phase of the motion with respect to shaft rotation. Figure 1 shows a tachometer signal over eleven shaft revolutions and the corresponding x and y shaft displacements, digitally resampled to give 512 points per shaft revolution. This data was taken from a large turbine generator system with a rotational frequency of nominally 50 Hz.

Having digitally resampled the two shaft displacement signals over 11 shaft revolutions, an average orbit plot of the shaft motion can be constructed as a polar diagram. The resulting shaft orbit is shown in Figure 2a. The shaft motion in the two orthogonal axes can be considered as motion in the real and imaginary complex plane, which with the use of the complex Fast Fourier Transform (FFT) within MATLAB, provides the vibration analyst with knowledge about the resulting positive and negative rotating frequency vectors. The rotating frequency vectors are given in terms of shaft orders, and indicate the forwards and backwards whirl of the shaft motion, [7].

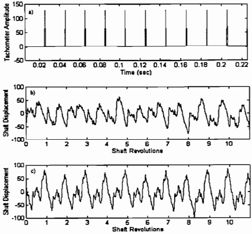

Figure 1. Rotor vibration of a steam turbine generator unit operating at 50 Hz. a) Tachometer signal over 11 shaft revolutions. b) Shaft displacement in one orthogonal axis, (relative units), c) Shaft displacement in the other orthogonal axis, (relative units).

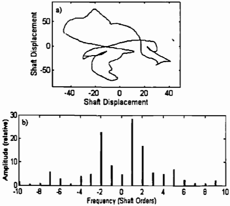

Figure 2. a) The average orbit plot over eleven shaft revolutions, (relative units), b) The forwards and backwards relative shaft whirl components obtained from the complex FFT of the orbit motion.

The trending of the complex Fourier transform frequency vectors has been found to be useful for monitoring the condition of rotor shafts for the presence of cracks [7], and it is likely that it could be used to determine the condition of the turbine generator journal bearings as well. The actual MATLAB commands to transform the orbit motion, as shown in Figure 2a, into the positive and negative frequency components, shown in Figure 2b, may be written using the complex FFT as given below,

*f = abs (fftshift (fft (x+i*y , length(h)))) / length(h);* (1)

where the in-built *fft* command is used to transform the real *x* and imaginary *y* shaft motion components into the frequency domain. The frequency components are then shifted using *fftshift* so that the spectrum runs from the negative frequency components through DC to the positive frequency components, and finally, the magnitude of the spectrum is obtained using the *abs* function. As shown in Figure 2b, the spectrum is drawn as a line spectrum since the orbit has been forced to be periodic over one shaft revolution.

Shaft Speed Estimation of a Diesel Engine A second example to highlight the flexibility of MATLAB involves the analysis of a tachometer signal obtained as a once per revolution pulse from the output shaft of a diesel engine gearbox coupled to a DC generator. Gearbox vibration analysis requires the precise angular position of all shafts in order to accomplish time synchronous signal averaging [8]. Normally, for approximate constant speed operation, a pulse once per revolution on one of the fastest shafts of the gearbox is sufficient to accurately determine angular positions for all shafts as a function of time.

A four stroke four cylinder diesel engine was coupled to a DC generator via a gearbox with a speed increase of approximately 1.6863. A pulse was obtained on the output side of the gearbox once per revolution. A portion of the tachometer signal over 0.4 seconds is shown in Figure 3a. By analysing when the tachometer pulse crosses a threshold level, the precise time of arrival of the pulse can be determined using cubic or spline interpolation. By repeatedly computing the time of arrival over a number of shaft revolutions, the actual speed of the gearbox shaft and hence the engine can be determined as a function of time, and more importantly, the precise angular position can be found at any instant in time. Figure 3b shows the speed of the gearbox shaft over a period of approximately three seconds obtained from the threshold crossing of the tachometer pulses.

The shaft frequency versus time illustrated in Figure 3b shows that the nominal shaft speed was approximately 42 Hz, and at times a deviation of over 1 Hz occurred in the actual shaft speed between single shaft revolutions. The large deviation in shaft speed for consecutive revolutions occurs because of the large torsional vibrations which exist in the diesel engine as the predominant forced excitation is due to the piston firing which occurs twice per revolution in a four stroke four cylinder engine. The large shaft speed difference between consecutive revolutions of the gearbox output shaft indicates that it is not possible to use a once per revolution pulse to infer variations in shaft speed that occur within each shaft revolution. Rather it indicates only the average shaft speed over that revolution. For a more precise indication of shaft speed and angular position, under torsional oscillatory environments, a higher frequency measure of shaft speed will be required such as is available using an optical encoder or a torsional laser velocity probe.

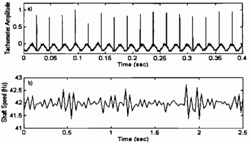

Figure 3. Shaft speed determination using a once per revolution tachometer pulse, a) Portion of a digitised tachometer signal, b) Resulting massaged gearbox shaft speed.

The MATLAB commands to detect threshold crossings are based upon the use of the *find* and *interp1* functions as shown below.

```
% create a new vector, time shifted by one data point
shiftdata = [data(1); data([1:length(data)-1])];

% find the time points which cross the threshold with positive going slope.
z = find(data>threshold & shiftdata<threshold);

% interpolate on each zero crossing to find an accurate estimate of actual
% crossing time
n = length(z);
for k=1:n
    % construct the short 3 pt x and y vectors for interpolation at each revolution
        y = [data(z(k)-1),data(z(k)),data(z(k)+1)];
        x = [(z(k)-1)*dt,z(k)*dt,(z(k)+1)*dt];
        s(k) = interp1(y,x,threshold,'spline');
end
```

The MATLAB vector operations as shown above make the resulting code very succinct and easy to understand once the nature of the in-built functions is understood.

The use of MATLAB is envisaged to be particularly useful for industrial applications of vibration analysis in a number of areas such as the monitoring of variable speed rotating machinery where the traditional black box approach is unlikely to provide the required flexibility to detect and diagnose faulty mechanical components.

High Resolution Frequency Analysis Frequency analysis of vibration data forms the major part of traditional vibration analysis. A number of techniques exist for estimating the power spectrum of a digitised signal apart from the use of the FFT, such as the maximum likelihood method, the auto regressive (AR) estimation technique and the moving average (MA) technique [9, 10].

The estimate of power spectrum using the FFT is based upon the power or magnitude obtained from the Fourier transform as

$$P(f) = E\,[\,X(f)\,X^*(f)\,], \qquad (2)$$

where $X(f)$ is the fast Fourier transform of the discrete time signal $x(t)$, * represents complex conjugation and $E[\ ]$ represents the expected value as obtained by spectral averaging. The smooth estimate of the power spectrum computed from stationary random time data is obtained by averaging over a number of windowed data records and is often referred to as the Welch method of power spectrum estimation.

The portion of an M-file to compute the power spectrum using the Welch method is shown below, where the time vector *data* is transformed into the power spectrum vector *ps*.

```
% loop over data vector using window of length lwin
for n = 1:nwin
        % extract data window
        dwin = data(istart:iend);
        % fft the windowed data segment
        freq = fft(win.*dwin);
        % compute the magnitude squared and sum
        ps = ps + (freq.*conj(freq)*dt/lwin)';
        istart = n*lwin + 1;
        iend = (n+1)*lwin;
end
% eliminate negative frequencies,
ps(np+1:lwin) = [];

% double positive frequencies;
ps(2:np) = 2*ps(2:np);
```

An example of the use of the power spectrum estimation on vibration data is shown in Figure 4, where torsional velocity vibration data was measured from the output shaft of a gearbox coupled between a diesel engine and a DC generator. The nominal speed of the engine, *fe*, was 24.9 Hz, the speed of the gearbox output shaft, *fo*, was 42 Hz and the intermediate gearbox shaft speed, *fi*, was approximately 16.66 Hz. A 100 second time record was digitised at a sample frequency of 2048 Hz, and a high resolution frequency spectrum was generated and averaged using twenty five 8192 point FFTs as shown in Figure 4.

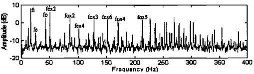

Figure 4. Torsional velocity spectrum computed from a diesel engine - gearbox - dynamometer test facility, with a resolution of 0.25 Hz.

The torsional spectrum up to 400 Hz shows a number of distinct frequency components, including harmonics of engine firing frequency (fex2), gearbox output shaft frequency (fo) and the fundamental component of the intermediate shaft frequency, fi. The flexible nature of MATLAB code allowed the high resolution spectrum to be computed across the complete frequency band with a number of averages. It would not normally be possible to obtain the number of averages and the frequency resolution together using the standard digital signal analysers currently on the market. However, using the MATLAB signal processing software, the actual frequency resolution and number of averages can be expanded as desired up to the full memory capacity of the computer platform.

5. DISCUSSION & CONCLUSION

This paper has outlined the use of MATLAB software for vibration signal processing. It has been argued that the interactive nature, extensibility and multi platform capability of MATLAB along with the ability to link in existing code, the use of a standardised data format, the range of built in functions and the graphics capability all make for a very productive software environment for the development of vibration signal processing software. Three vibration analysis examples based on data measured from rotating machinery have been outlined and portions of the actual MATLAB code have been shown to illustrate its succinct nature. It is envisaged that the industrial application of MATLAB should be particularly useful in solving the more complex vibration condition monitoring problems where the traditional black box approach does not provide the required flexibility.

ACKNOWLEDGMENTS

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RECENT DEVELOPMENTS IN AUSTRALIAN OCCUPATIONAL NOISE POLICY

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[Note: Statements of official policy are indicated as such. Opinions expressed are those of the writer.]

ABSTRACT: This paper outlines some recent developments in Australian occupational noise policy as indicated in publications of the National Occupational Health and Safety Commission and Australian occupational noise regulations. There has been a gradual change in emphasis over the last twenty years from hearing conservation programs, aimed primarily at protecting exposed workers from hazardous noise, to systematic noise management programs, aimed primarily at achieving reductions in workplace noise.

1. INTRODUCTION

It is a little over 20 years since the National Health and Medical Research Council (NHMRC) first published its Model Regulations for Hearing Conservation [1]. Although the Regulations were purely advisory in nature, their publication prompted the development of actual hearing conservation regulations in the States and Territories over the following decade.

Responsibility for setting occupational health standards passed from the NHMRC to the National Occupational Health and Safety Commission when the Commission was established in 1985.

Occupational noise was one of the Commission's early priorities and it commenced a review of the matter in 1986. A discussion paper canvassing options for a national exposure standard for occupational noise and seeking comment on a draft code of practice for noise management at work was released in 1989. Following analysis of public comment on the discussion paper and extensive consultation with governments, employer and union bodies, the Commission formally declared the *National Standard for Occupational Noise in 1992 and the National Code of Practice for Noise Management and Protection of Hearing at Work in 1993.*

The *Standard and Code* were published in booklet form [2] by Worksafe Australia, the operating arm of the National Occupational Health and Safety Commission, in September 1993.

Like the original NHMRC Model Regulations, *National Standards and National Codes of Practice* declared by the National Commission are advisory documents. Their application in any particular jurisdiction is the prerogative of that jurisdiction. So far, two State and the two Territory governments have incorporated the National Standard in regulations and other jurisdictions are considering the matter (see Table 1 for further details).

Table 1. Adoption of the National Noise Standard and Code in Australian jurisdictions at December, 1994.

Jurisdiction	Current Regulations* (see note below)	Adopted National Exposure Standard?	Adopted National Code of Practice?	Comments
ACT	*Inspection of Machinery Regulations*	Yes	Yes	Current Regulations to be replaced with regulations based on National Code.
COMMON-WEALTH (apply only to C'wealth	Under development	Expected	Expected	Regulations expected 1995
NSW	*Factories (Health and Safety—Hearing Conservation) Regulation, 1979*	Under considera-tion	Under consideration	
NT	*Work Health (Occupational Health and Safety) Regulations 1992*	Yes	Yes	
QLD	*Workplace Health and Safety Regulation 1989, Part 30—Noise*	Yes	The Queensland *Code of Practice for Noise Management at Work* is broadly similar to the *National Code.*	Qld. Code has additional requirements at lower noise levels
SA	*Occupational Health, Safety and Welfare (Industrial Safety) Regulations 1987*	Under considera-tion	Under consideration	Revised Regula-tions expected 1995
TAS	*Industrial Safety, Health and Welfare (Administrative and General) Regulations*	Under considera-tion	Under consideration	
VIC	*Occupational Health and Safety (Noise) Regulations 1992*	Yes	*Victorian Code of Practice for Noise* pre-dates *National Code* and is broadly similar.	Full control hier-archy including engineering con-trols from July 1997
WA	*Occupational Health, Safety and Welfare Regulations 1988*	Under considera-tion	*WA Code of Practice for Noise Control in the Workplace* pre-dates *National Code* and is broadly similar.	

Note: Some jurisdictions have additional noise-related regulations for particular industrial sectors, such as mining and construction.

2. THE NATIONAL STANDARD AND CODE

The National Standard for Occupational Noise is brief and similar in form to other exposure standards for atmospheric contaminants declared by the National Commission. As notified in the Commonwealth Gazette of 26 May, 1993:

"The national standard for exposure to noise in the occupational environment is an eight-hour equivalent continuous A-weighted sound pressure level, $L_{Aeq,8h}$, of 85 dB(A). For peak noise, the national standard is a peak noise level, L_{peak}, of 140 dB(lin)."

"The exposure to noise is taken to be that measured at the employee's ear position without taking into account any protection which may be afforded by personal hearing protectors."

Accompanying interpretation clauses state that $L_{Aeq,8h}$ must be measured in accordance with Australian Standard 1269 and that instruments used to measure L_{peak} must meet the relevant requirements of AS 1259.1.

The statement that noise exposure is to be measured without taking account of hearing protectors makes explicit what is implicit in the procedures specified in AS 1269 for measuring the values of $L_{Aeq,8h}$ and L_{peak}. That is, it makes it clear that the exposure standard refers to the noise in the working environment to which people are exposed, not to the noise 'in the ear' or 'under a hearing protector'. As this is an occasional source of misunderstanding it is useful to have it clarified from the outset.

The *National Code of Practice* outlines acceptable standards of management practice for preventing exposures to noise above the exposure standard and for minimising risks arising from such exposures where it is impracticable to prevent them. The *Code* is discussed in more detail below.

During 1993 an attempt was made by Worksafe staff, in consultation with Commission members, to produce model noise regulations, based on the *National Code of Practice,* which could be used verbatim in all Australian jurisdictions. This attempt was abandoned when it became clear that differences between the enabling Acts and the preferred form of regulations in different jurisdictions would make it virtually impossible for all jurisdictions to agree on the exact wording of model regulations.

The Commission then sought to reach agreement on at least the basic principles for noise regulations. Again in consultation with Commission members, Worksafe staff produced a draft statement of *Common Essential Requirements for Occupational Noise (CERs),* derived from the *National Code of Practice.* The Commission formally considered the CERs at its quarterly meeting in March, 1994, and noted that they were "the basis upon which the States and Territories are implementing the *National Standard for Occupational Noise".*

The CERs, which summarise the key principles of the National Standard and the National Code, are reproduced

COMMON ESSENTIAL REQUIREMENTS FOR OCCUPATIONAL NOISE

1. Without limiting the employer's general duty to protect the health and safety of employees at work, an employer shall, as far as practicable, provide and maintain workplaces, plant and systems of work so that the noise to which an employee is exposed at a workplace does not exceed the exposure standard.

2. An employer at a workplace where the noise to which an employee is exposed exceeds, or is likely to exceed, the exposure standard, shall:

2.1 implement engineering noise controls as far as practicable, to reduce the noise to which the employee is exposed; and

2.2 if the engineering noise controls implemented under 2.1 do not reduce the noise to which the employee is exposed to a level that does not exceed the exposure standard, implement administrative noise controls as far as practicable, to reduce the noise to which the employee is exposed; and

2.3 if engineering noise controls or administrative noise controls implemented under 2.1 and 2.2 do not reduce the noise to which the employee is exposed to a level that does not exceed the exposure standard, and in any case while such controls are being implemented, provide to the employee an appropriate personal hearing protector:

(a) that meets the requirements of Australian Standard 1270 *AcousticsHearing Protectors;* and

(b) that has been selected according to the procedures specified in Australian Standard 1269 *Acoustics Hearing Conservation.*

3. An employer at a workplace where an employee is exposed to noise that exceeds, or is likely to exceed, the exposure standard, shall:

3.1 ensure as far as practicable that administrative and engineering noise control measures are properly implemented and maintained; and

3.2 ensure as far as practicable that personal hearing protectors are properly used, maintained and stored.

4. Employees shall, as far as they are capable:

4.1 comply with noise control measures required by 2.1 and 2.2; and

4.2 use personal hearing protectors required by 2.3.

5. Designers, manufacturers, importers and suppliers of plant that may be used in workplaces and that may emit hazardous noise shall ensure that the plant is designed and constructed so that noise emitted is at the lowest level practicable.

6. Manufacturers, importers and suppliers of plant that may be used in workplaces and that may emit hazardous noise shall, as far as practicable, provide to employers appropriate and adequate information about the noise emitted by the plant and about ways to keep the noise at the lowest level practicable.

below. In view of the drive in Australia towards national uniformity in occupational health and safety regulations, the CERs may be taken to indicate the general direction of occupational noise regulations in Australia.

Employers have a general duty under occupational health and safety law to take reasonable care to avoid exposing employees to unnecessary risks to their health and safety. Clause 1 of the *CERs* expresses a limited aspect of this duty in relation to risks arising from exposure to noise, requiring an employer to aim for workplace noise conditions in which employees are at least not exposed to noise above the exposure standard.

Clause 1, like most other clauses in the *CERs,* is qualified by 'as far as practicable'. The requirement is not to do the impossible, simply the practicable. This opening clause is also a useful reminder to anticipate noise problems when new workplaces or work processes are designed and whenever new plant and machinery are purchased. This connects with responsibilities placed on plant manufacturers and suppliers under Clause 5 to control the noise emission of plant they supply to industry.

Clause 2 and its subsections say what has to be done in situations where employees are already exposed to noise above the exposure standard. The essence of Clause 2 is the requirement to implement the standard 'hierarchy of controls': engineering controls, administrative controls and personal protection, in that order of preference.

Engineering controls and administrative controls are the only ways to reduce 'the noise to which an employee is exposed'. Typically, engineering controls do so by reducing sound pressure level, administrative controls by reducing exposure duration. Reduction of the $L_{Aeq,8h}$ value of the noise to which an employee is exposed is achievable by reduction of sound pressure level, exposure duration, or both. Reduction of L_{peak} is achievable only by reduction of sound pressure level.

Technically speaking, hearing protectors do not 'reduce the noise to which a person is exposed'. By definition, as noted above, the noise to which a person is exposed is the noise in the environment external to any hearing protectors that may be worn and thus cannot be reduced by them. However, hearing protectors are an acceptableæindeed requiredæform of risk control if the noise to which people are exposed still exceeds the exposure standard after all practicable engineering and administrative controls have been implemented (hearing protectors are also required, of course, while the controls are being implemented).

Hearing protectors must be provided in accordance with Australian Standards 1269 and 1270. These standards are referenced to require that the protectors are selected and fitted following standardised procedures (AS 1269), and that they satisfy basic requirements of construction and robustness and have had that their sound attenuation determined according to a standard method (AS 1270).

Clauses 3 and 4 of the *CERs* require the employer to maintain any noise controls installed and to maintain hearing protectors. Employees have complementary duties to use noise controls and personal protectors.

Clause 5 places responsibilities on designers, manufactures, importers and suppliers to ensure plant is designed and constructed so that its noise emission is as low as practicable when properly installed and used.

Clause 6 requires manufacturers, importers and suppliers to provide information about the noise emission of their products, an important step aimed at facilitating the wider adoption of 'buy quiet' programs.

Duties similar to those in Clauses 5 and 6 are now in place in several Australian jurisdictions. They are important because they seek to reduce the flow of noisy equipment into workplaces, in the long run a more fundamental and economical solution to the problems of excessive workplace noise than post-installation retrofitting. In addition, these duties give purchasers the right to expect equipment designers and suppliers to minimise noise emission and to provide noise emission details of their products.

Duties on plant designers and manufacturers are a logical step in the move from an emphasis on protecting exposed individuals from hazardous noise—the conventional 'hearing conservation' approach—to proactive noise management directed towards the achievement, so far as practicable, of an environment free of hazardous noise. While employers are ultimately responsible for controlling noise in working environments under their control, their job will be made much easier in future if equipment designers and manufacturers take their share of responsibility for the noise emitted by products they place on the market.

3. DETAILS OF THE NATIONAL CODE

The *National Code of Practice for Noise Management and Protection of Hearing at Work* deals with many other points not covered explicitly in the CERs:

◆ consultation

The *Code* encourages maximum consultation and cooperation between employers, employees and health and safety representatives in implementing the principles of the *Code.*

◆ noise control planning

Refers to the development of specific noise control policies and plans for the organisation, including coverage of the following issues:

- noise goals for existing work areas
- design goals for new work areas
- selection and purchase of quiet plant
- noise controls in temporary work areas
- implications for contractors
- funding for the noise control program
- periodical review of the noise control program.

◆ information and training

The *Code* advocates the provision of information and training for:

- employees at risk
- their managers and supervisors
- health and safety committees and representatives
- staff responsible for designing work systems and for purchasing potentially noisy plant and hearing protectors,

about:

- the range of health effects of noise
- social handicaps of hearing disabilities
- exposures to noise in their workplace
- general nature of noise control measures
- specific noise control measures where they work
- the organisation's noise control policy and action plan
- arrangements for reporting defects likely to cause excessive noise
- when and how to use and care for personal hearing protectors
- statutory responsibilities of employers and employees.

◆ noise assessments

The *Code* provides general guidance on how to carry out a noise assessment in areas where employees may be exposed to noise exceeding the *National Standard.*

It recommends that the assessment should be reviewed every five years, or earlier where there is any change to plant, the building, working arrangements or workload.

On technical issues of noise measurement and evaluation, this section of the *Code* generally summarises material in AS 1269 and AS 2659.

◆ audiometric testing

The *Code* makes the points that the monitoring of employees' hearing is not in itself a preventive mechanism and that it is relevant only in the context of a comprehensive noise management program. It thus takes a more cautious view of the benefits of audiometry than some of the previous hearing conservation regulations in Australia, reflecting, in my opinion, a more realistic appraisal of the unreliability of audiometric measurement and its lack of sensitivity and specificity as an indicator of program failure.

Nonetheless the position taken in the *Code* is that audiometry 'should be available to any employee likely to be regularly exposed to noise in excess of the national standard'. It is up to the employee to decide whether or not they want to take part.

The technical details and procedures for conducting audiometry and assessing the results follow AS 1269 and guidelines produced by the National Acoustic Laboratories [3].

Results of audiometry are to be given to employees within two months of testing, together with a written explanation of what they mean. To preserve confidentiality, individual results are to be released to other parties only on the written authority of the employee concerned.

Unidentifiable individual results and group data are to be accessible by the employer and the relevant authority.

4. CONCLUSION

The *National Code of Practice for Noise Management and Protection of Hearing at Work,* the Western Australian (4) and Victorian (5) codes of practice which preceded and influenced it, and more recent regulations and codes, devote significantly more attention to the practical details of noise control planning and management than the generation of hearing conservation regulations they are now replacing. This trend is also evident in Worksafe's *Noise Management at Work* information resources [6]. It reflects a paradigm shift, to use a hackneyed but still useful expression, from narrowly-focused hearing conservation to comprehensive noise management.

A major reason for this shift is the mounting evidence that personal hearing protection programs are of limited effectiveness. The intrinsic efficacy of ear plugs and ear muffs falls short of 100% because the anatomy of some wearers is such that it is difficult or impossible for them to achieve an effective acoustical seal. This is especially a problem with earplugs. However, even devices with acceptable efficacy in laboratory tests have limited effectiveness in actual conditions of use. Wearers do not always take the trouble to fit protectors correctly every time they use them, again a significant problem with earplugs. Ensuring that hearing protectors are cared for properly and serviced regularly is also a problem. But the overriding difficulty is that it is virtually impossible to get everyone to wear protectors correctly and consistently every time they should—and in some cases even to get people to wear them at all. The result is that people continue to lose hearing even though conventional hearing conservation programs (i.e. education, personal protection and audiometry) are in place.

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A System For Real Time Measurement of Acoustic Transfer Functions

Note

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This system, the subject of a provisional patent application, was developed for measuring the acoustic impedance spectra and transfer functions of musical instruments and parts thereof [1]. Although it was initially developed as a research tool, we believe that it will benefit the manufacturers of musical instruments by providing a rapid, objective measurement of relevant acoustic properties during and after the construction of the instrument. These properties may be compared with those of a prototype instrument, or one judged to be good by competent players. Such comparison would be useful in quality control for complete instruments, and might be included in the feedback loop in the construction of parts of an instrument. In these situations, real time performance is desirable.

From the point of view of a musical instrument manufacturer, measuring the acoustic response of an instrument is in several ways preferable to measuring its sound. First, the sound of an instrument is dependent on the player - a good player may compensate for the defects of a poor instrument, and a poor player may produce defective sounds from a good instrument. Second, such measurements may be made without the assistance of a competent and patient player. Third, such measurements may be made on parts of instruments or incomplete instruments.

With the exceptions of reeds and lips in wind instruments, and the bow-string interaction in string instruments, most parts of most wind and string instruments behave linearly to a good approximation, so one would expect that most aspects of the acoustic performance of the instrument could be related to appropriate transfer functions, provided that these are known with sufficient detail and precision (see e.g. [2]). Many violin makers make simple measurements of acoustic properties during shaping of the belly and backs of these instruments. Tapping and listening is one test used by most makers, and suspending the components above loudspeakers driven with variable frequency sine waves is another. One manufacturer of brass instruments (Conn) has been making acoustic impedance measurements since 1945 using a swept frequency method [3]. We believe that such objective measurements would become much more widely used if the measurements could be made very quickly and easily, and in the workshop rather than in the laboratory. If a data file were established for the transfer functions of instruments with desirable qualities, instrument makers would be able to compare the measurements of the instruments or parts under construction with those of desirable instruments.

String instruments. In string instruments, the vibrating string drives the bridge, the bridge drives the belly, and the belly interacts with the rest of the body and the enclosed air to radiate sound. For an intact instrument, important transfer functions are the ratio of radiated sound to force applied at the bridge, and the mechanical impedance at the bridge. For the isolated belly of the instrument, the same functions are also important, though in this case we measure them at the position where the bass foot of the bridge would stand. For string instruments, we apply the input signal with an electro-mechanical transducer. Forces are measured with piezo-electric crystals.

Wind instruments. The input impedance is an important transfer function for a wind instrument. Most of the extrema in the magnitude of this spectrum occur at frequencies which

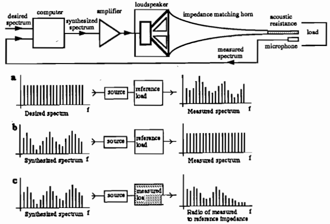

Figure 1 shows schematically the version of the device used for wind instruments, the vocal tract, and acoustic spaces. The frequency dependence of amplifier, horn, microphone etc are measured (a) and used to correct the input spectrum so as to produce a desired output spectrum - in this case flat - into a reference load (b). The same signal is applied to a different load and, providing the source output impedance is much higher than that of the load, the sound spectrum gives the impedance ratio (c). (In the version of the device used for string instruments, a purely mechanical signal is applied by an electro-mechanical driver, usually at the position of the bridge.)

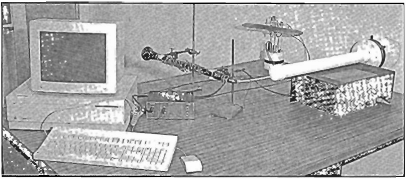

Figure 2. The hardware. At right, the long cylinder is a casing for the exponential horn which is an impedance matching transformer for the acoustic source (see Fig 1). In the background is one version of the electro-mechanical driver which is attached via a quick-release clamp to the belly of a violin.

lie approximately in a harmonic series. When the instrument is played, the reed or the players lips interact with the instrument's bore to produce a quasi-steady oscillation which occurs usually at a frequency which is close to an integral fraction of one or more of these impedance extrema [2,3,4].

Measuring transfer functions and impedance spectra. It is relatively easy to measure sound pressure, mechanical vibrations and forces. For a typical acoustic signal, however, the volume velocity of air is much more difficult to measure accurately. This makes it difficult to measure acoustic impedance directly as the ratio of pressure to volume velocity. This difficulty can however be avoided by supplying the acoustic signal from an ideal current source. When this source is input to two different impedances, the ratio of the measured sound pressure spectra is the ratio of their impedance spectra. A particularly simple case (see Fig 1) occurs when one of the impedances (the reference) is purely resistive and when the measured sound spectrum across the reference is flat. In this case, the measured sound spectrum in the test system is (proportional to) its impedance spectrum.

Broadband measurements. Any measurement of a spectrum takes a finite time and has a finite ratio of signal to noise and therefore yields a finite amount of information. A compromise must therefore be made among time of measurement, sensitivity, frequency range and frequency resolution. In our technique, the frequency range and frequency resolution are chosen first. A finite set of discrete frequencies is chosen and the input signal is synthesized digitally as the sum of a set of sine waves and output via a DAC and an amplifier. Usually several hundred frequencies over the range important to the instrument are chosen.

Correcting for frequency response of the signal source.

When a signal with a given, desired spectrum is synthesized, the frequency responses of the amplifier and the driving apparatus cause a different spectrum to be output. The measurement transducers also have non-flat frequency response. We correct for these responses iteratively. In one application, the reference load is resistive. We measure the output spectrum when the source drives this load and calculate the ratio of measured to input amplitude for all spectral components. We then divide the components of the input spectrum by this ratio, re-scale, and synthesize a corrected spectrum (see Fig 1). Because of non-linear response in some components, this procedure (b) needs to be repeated a few times.

Performance of the device.

The limit to fidelity of the spectrum is the digitization error of the ADC. Other performance parameters are determined by the compromise made among time of measurement, sensitivity, frequency range and frequency resolution. We are currently using the device to study flutes. Sampling the range 200 Hz to 4 kHz at 25 Hz intervals, a measurement time of 0.1 s, and using a 12 bit DAC, the sensitivity is rather better than 1 dB. This is adequate to detect quite subtle changes in the response function of the instrument [1].

Future developments.

We are continuing development of the versions of the device for wind and string instruments, and applying them as research tools to understand the acoustics of musical instruments. Application of the technique to the production of improved musical instruments will require the commercial manufacture of the device, and for this purpose we are seeking a corporate collaborator from the acoustic or electronic instrument industry who is interested in licensing the technique for production.

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Note: Acoustics Into The 21st Century

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What are the requirements to make acoustics a vital force, both at home and overseas, during the next fifteen years? The reply made by the Australian Acoustic Society to a series of questions covering this topic are presented, with the expectation of generating further discussion amongst Society members and thereby creating a broader based response to such challenging questions.

INTRODUCTION

What will be the role of acoustics in fifteen years time? Will environmental noise still be a significant problem in Australian communities? By the 21st century, how can we ensure an acoustic-based innovation will receive funding and a smooth path to the markets of the world? What is potentially the most important area for development within acoustics and how can we ensure it succeeds ?

These are thought-provoking questions – but rather difficult to answer. So often such questions are brushed aside: "we'll think about them later".

Well, later came rather sooner than expected, when the AAS was asked at the end of 1994 to respond to a questionnaire on the future needs of acoustics in Australia.

BACKGROUND: FUTURE NEEDS

"Matching Science and Technology to Future Needs" is the thrust of a study which the Australian Science and Technology Council (ASTEC) initiated [1] in August/September 1994. They seek to establish what Australians think will be the most important issues, problems and priorities facing us until the year 2010, and what role science and technology will play. Responses are being sought from individuals as well as specialised groups such as the Acoustical Society. ASTEC has set up a committee to evaluate and report on the responses. This should lead to an information base which can direct industry and government about the future development and application of science and technology.

Unfortunately, the requested time frame for responses was very short; preferably by October 1994 or if this was too short, then February, 1995. Council of the AAS decided to prepare a response for the latter date, but even then the reply had, of necessity, an input from only a few people, especially as the interval included the much loved "Australian Holiday" time. The resulting response is the compilation of ideas from several Divisions and some individuals and has been sent to ASTEC as requested. However, was it the best response? Does it accurately reflect the overall attitude of AAS members? Do you agree with or violently object to the answers?

Reproduced below are the seven main questions from ASTEC and the responses provided by the Society. Would you have included quite different ideas or examples ? Please read and consider the response and let me know YOUR thoughts on the issues. It is too late to change the present response, however, consideration of the issues may stimulate fresh ideas and help form the basis of how government sees acoustics progressing in the future.

QUESTIONS AND ANSWERS

*1. For members of the Australian Acoustical Society what are the **most promising areas or fields** of research, development or commercialisation where significant achievements are expected over the next 15 years?*

Active control of noise and vibration is seen as the major single area of advancement.

Prediction models for control of noise, especially environmental noise. Applications such as estimating outdoor sound levels around airports, global temperature monitoring by long distance acoustic propagation over oceans.

Refinement of current theoretical modelling approaches; such as boundary element analysis, finite element analysis and wavelet theory, and their application to more complex acoustic systems.

Medical acoustics: effect of noise on humans; both psychological and physiological aspects.

Noise regulations; especially governing Occupational Noise/Control in, say, the mining industry.

Better building construction improved sound isolation and shielding.

Acoustical instrumentation:

- development of medical diagnostic techniques,
- intelligent transducer technology,
- including miniaturisation,
- more efficient sound generating devices,
- speech processing technology.

*2. For your area of expertise, what do you consider will be Australia's **strengths** in the most promising areas or fields of research, development or commercialisation over the next 15 years?*

The expertise and skill of the people and the facilities within Australia, such as Universities, manufacturing and mining industries, provide a strong base for selling to overseas markets, particularly south-east Asia, high quality acoustic products and technology.

Australia can be a leader in setting standards and regulations.

3. *If things went very well, looking at it optimistically, what* ***specific types of significant achievements*** *do you think might be possible in these promising areas or fields over the next 15 years?*

Australia could become the "acoustic centre" of the south-east Asia region.

Australian based companies, involved with acoustic consulting and building products, etc., would expand in Australia and overseas. They would sell to overseas markets Australian intellectual property, technology, training skills and regulation ideas. Specific examples might include; practical applications of active noise control including development of low frequency noise attenuators for vehicles and industry, bionic ears and hearing aids, smart miniature transducers, improved acoustic building materials and designs.

4. *In what ways will these types of significant achievements address* ***important needs*** *in the Australian economy, or contribute to the health and well-being of Australian society over the next 15 years?*

Create an improved lifestyle for Australians through reduction of environmental noise.

Less hearing damage through an improved acoustic environment in residential and industrial areas and in transport. Much of this improvement will be achieved by application of advanced materials and acoustic techniques, especially where noise control was previously impractical.

Improved export market.

Longer operating life of machinery and reduced maintenance costs after application of vibration diagnostic techniques. An example would be quieter mining and processing.

5. *For your area of expertise, what* ***weaknesses or threats*** *do you consider might limit Australia's success in the most promising areas or fields of research, development or commercialisation over the next 15 years?*

University and other research bodies have very restricted funding and there is a poor Government attitude to promoting science.

Noise in the environment is loosing its profile and therefore attracting less funding. Community values are often ignored when other things are assigned higher priorities through political decisions - eg. Sydney airport runway.

Overseas competitor companies will bypass Australia. Cost of manufacture in Australia is relatively high and there is a lack of business development skills. Australia has a small population and industry base and there is a lack of "risk taking" when considering applying new technologies.

6. *Can you identify any* ***special requirements*** *for Australia's success in promising areas or fields of research, development or commercialisation over the next 15 years? eg, requirement for major contributions from multi-disciplinary research or from overseas.*

Industry should contribute more to research and development, with stronger Government support for co-operative research and assistance to industry to understand commercialisation of technology.

Increased tax breaks for organisations which implement new technologies.

Government should promote and sustain bodies like EPA and Universities which are already involved in noise regulations and acoustic research. Funding to such areas should be increased.

Government must ensure companies have the ability to market overseas and there is protection of technology and intellectual property.

7. *Looking at ways research is now carried out, or the results are developed and commercialised, what* ***changes,*** *apart from additional resources, might help ensure optimistic achievements in promising areas or fields are realised over the next 15 years?*

Education of the community, industry and Government about the importance of noise in the environment and what technologies are available to reduce levels - increasing noise consciousness.

Compilation of statistics showing effect of noise.

Closer links between Industry, Government and Universities in the area. Provision of adequate research funding, or tax exemptions, for projects which are likely to lead to commercial success.

Provide a more flexible system in Universities for top researchers to concentrate on research with only minimal teaching and administrative commitments and provide simple paths for interchange of personnel with industry.

WHAT TO DO NEXT

Having read the responses, whether in complete agreement or in total disagreement, please drop me, Charles Don at the address given at the top of this article, a *short* note indicating your thoughts. If you are in dispute, just indicate the question number and point which troubles you and then let me have your ideas. Even if you completely agree, (Is such an unlikely event even remotely possible ?) I would be grateful if you let me, and therefore the Society, know that the response was "correct". No matter what your response, all comments will be given consideration by Council in the future and, if the opportunity arises, incorporated in a new version of future needs.

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Interview

Anita Lawrence

A thumb-nail biography by Dennis Gibbings

I reminisced with Anita in an airy room in her St.Ives home. I recalled that it was fourteen years since we had met as a committee under her chairmanship to plan the technical program for the International Congress on Acoustics in 1980. Much had happened since then, but would she care to go further back still, to the time when she first arrived in Sydney?

Anita Lawrence came to Australia from England in 1946 – about six years late. Her father had reached Sydney in 1940, but by that time the war had made travel difficult, and Anita and her mother spent the war years at their home in Hertfordshire. This was not exactly the safe alternative to wartime travel either, and at 20 miles or so north of London they had their share of the bomb blasts and assorted traumas of wartime Britain. Anita sometimes wonders if it might have been in those years that she acquired the 6 kHz valleys in her audiogram that intrigued her students many years later.

After the war, having matriculated in England, Anita came to Sydney with her mother and enrolled in the School of Architecture at Sydney University. Courses there were not in equilibrium. Ninety of the one hundred first year students were males, most of them supported by C.R.T.S. grants. There were perhaps four lectures a week; for the rest of their time students learned what they could from copying blue prints. Now, copying the Old Masters had been a hallowed means of training artists for centuries, but as a means of training architects it has its limitations, particular if you can't draw, and Anita failed her first year finals.

Friends suggested she take up the Law, but that had no appeal, so she looked for jobs and began to make good her deficiency in drawing by working first as a tracer and later as a draughtsman. It was then that she heard of the establishment of the B.Architecture course at the University of Technology. Here conditions were much less crowded; she was one of only seven starters in the first year of the full-time course. At the end of fifth year, Anita won the University Medal and was granted a bursary that enabled her to embark upon a Masters degree with the prophetic title "Design of Auditoriums with Special Reference to Acoustics".

Some of her time was spent at CSIRO (Highett) with Roy Muncey, and her work included touring Victoria with the Victorian Symphony Orchestra accompanied by a station-wagon load of acoustical measuring gear. The idea was to try to elucidate the design factors in the halls that increased, or

decreased, the pleasure of the players and audience in the music. The life of a professional musician on tour is a pretty wearing one, and Anita wryly suspects that a critical factor not mentioned in the report was the location and quality of the nearest Public House.

CSIRO at the time wished to produce a book to be called "Acoustics in Building", and Anita was asked to be its author. Following this she spent a short time in private practice.

The years 1957 and 1958 were crucial to Anita's subsequent career. In 1957 she married and in 1958 she was appointed to a Lectureship in Building Science at the University of NSW. One of the advantages of Universities as employers is that they have generally recognised the value of having their staff go off from time to time to cultivate fresh areas of knowledge. The traditional name of "Sabbatical Leave" derives of course from the ancient Jewish custom of leaving fields untilled and releasing debtors from their obligations every seven years. But modern usage allows more frequent observance than this, in fact in some cases so frequent that Universities have bowed to societal pressures by disguising it under names like "Special Study Leave". Nevertheless her position with the University has allowed Anita unusual opportunities for contact with the acoustics fraternity overseas, whilst her partnership with Gerry Lawrence, begun in 1957, has given her a mate whose own employment arrangements have allowed him to join her in the major excursions and tolerate the minor ones.

When Anita joined the University in 1958, RA Phillips was in charge of the Building Science program. His interests lay in lighting, so Anita took over acoustics. In 1965 she was asked to devise a Graduate Diploma course, which developed into the MSc (Acoustics). When the Graduate School of the Built Environment was set up, Anita concerned herself almost entirely with post-graduate studies, her undergraduate responsibilities passing to Marion Burgess.

The interest of Anita's department in traffic noise arose somewhat by chance. In compensation for the fact that more predatory projects had siphoned off the funds that should have been spent on building a 'proper' acoustics laboratory, they were given money to fit out the mobile one. They were also able to construct a small house with replaceable facades for investigating the relative soundproofing effectiveness of alternative methods of construction. This proved to be a salutary introduction to the general law that acoustic results are always worse than ideal. It is not much use double-glazing the windows of your dwelling if most of the intrusive sound is entering via the roof - a lesson which Anita fears may be expensively relearned in the wake of the third runway.

When Anita took her first Sabbatical leave in 1965 she travelled across the Pacific by ship to Acapulco, then worked her way across the United States supported by a Carnegie scholarship, ending up at Bolt, Beranek and Newman. Three months in Europe followed, one of the highlights being to see two of the rival models for Sydney Opera House - Cremer's in Berlin and Jordan's in Copenhagen. The resolution of that particular conflict is now, of course, history. A short stay at the Building Research Station in England preceded her return home.

An exhaustive listing of Anita's overseas contacts might become just that, but some years stand out in her memory. In 1982, after extensive travels to acoustic laboratories in Europe, she spent some weeks at the National Research Council in Ottawa with its two Acoustic sections, one in 'Building', the other in 'Physics'. In 1986, she made her first visit to Beijing where she lectured at the Academy of Sciences on Building Acoustics. What they made of it is not altogether certain, but they appeared enthusiastic.

Earlier, in 1977, after an interesting period spent with the Acoustics Section of the Greater London Council, whose work involved implementing compensation schemes for those adversely affected by traffic noise, she spent two months in the Office of Noise Abatement of the U.S. Environment Protection Agency that were something of a revelation, recalling the advice she had been given after her first unhappy contact with Architectural Science. It turned out that the Office was staffed not by Scientists but by Lawyers whose function seems to have been to try to assess the effect of any proposed Federal regulation on every citizen of the U.S.A. Needless to say, not many regulations survived, and neither did the Office.

Since her retirement in 1990, the pace of international travel has not slackened, with Internoise (1990) in Copenhagen and Internoise (1992) in Toronto, where she was one of the three keynote speakers. Internoise (1991) was of course held in Australia. The I.C.A. meeting in Beijing (1992), Internoise (1993) in Leuven, Belgium, and Internoise (1994) in Yokohama were also attended,.

Closer to home, 1980 is remembered as the year the international community came to Australia for I.C.A., for which Anita headed the committee in charge of the technical program. More than a decade earlier she had participated in the establishment and growth of the Australian Acoustical Society. Starting in the 60s Peter Knowland and Vivian Taylor had moved to get a society going and technical meetings began to be held. A constitution was developed and the Society incorporated in 1971. Harold Marshall in the West was persuaded to attach the group he had gathered together and in due course branches were formed in Queensland and South Australia. Anita looks back with some satisfaction on the growth of Acoustics in Australia from a fraternity of largely self-taught practitioners to a profession with recognised standards and training, training in which she herself has had a hand with the publication of three books: "Acoustics in Building" (1962), "Architectural Acoustics" (1970) and "Acoustics of the Built Environment" (1989). The ghosts of the past would not be silenced, even here, and she had to prepare all the illustrations for these volumes herself. Standards Australia has also, she believes, been a valuable forum for technology transfer and she has, over the years, been a member of numerous committees, currently being a member of the Executive Board of Council.

To the question of whether she has ever felt it to be a disadvantage to be both an acoustician and a woman, Anita answers a forthright "No". She has never been a *lone* female acoustician, in any case; there have always been a number of active female colleagues. Sometimes, after it became fashionable to insist that committees couldn't function with out female representation, she had felt that her time and talents were excessively in demand, but that was all.

Asked about the future of noise control, Anita was not inclined to be optimistic. Digitalisation and computerisation had given us a marvellous range of measuring instruments, but she sees the problem of noise pollution being overshadowed by the spectres of air and water pollution, global warming and the thinning of the Ozone Layer. Aircraft and traffic noise are not getting less. Vehicles are becoming larger and more numerous, many even of the smaller vehicles being powered by diesel engines, and regulations are too lenient.

I wondered later whether she had any regrets about devoting her working life to an activity which didn't seem to have realised its early promise. If she had, it didn't show; it had been an exciting and rewarding career. I reflected that it was a pity that the real political world habitually chose so badly from the technologies offered to it.

News...

Report on AAS Council Meetings

The 53rd & 54th Council Meetings were held in Canberra on 9 & 11 November 1994. Nine councillors attended both meetings.

The Chairman of the Council Standing Committee on Membership, Ken Cook, reported that 29 gradings had been made throughout the year. They comprised 16 Members, 1 Associate, 10 Students and 2 Subscribers. The members of the Committee are Ken Cook, John Davy and Bill Davern. All Committee members were re-elected. The Registrar, Ray Piesse, reported that the number of admissions and elevations to the Society in 1994 was 27. This was a substantial improvement on the previous year. The number of elevations to Member grade was 16, which was 10 greater than last year. Current State statistics are:

NSW	176
Vic	117
Qld	49
SA	37
WA	46
TOTAL	425

Dr Norman Carter, has been asked by the International Commission on the Biological Effects of Noise to run the Seventh International Conference on Noise as a Public Health Problem in Australia in 1998. Council discussed the extent to which it feels the Society should be involved with the running of this significant event and has agreed, at this stage, to provide a small financial loan to Dr Carter to enable him to further research options for running the Conference.

Anita Lawrence provided a report on Internoise '94 and I-ICE Meetings and Bob Hooker provided feedback on Westprac V. Ross Palmer put a submission to Council requesting support for the formation of an Acoustical Society in Bangkok and suggested consideration of Bangkok for the 1996 Conference. Any information that might be useful to the new Society in Bangkok, please forward to Dr Pichai Pamanikabud, King Mongkut Institute of Technology, Thornburi, Pracha U -tid Road, Rajchaburana, Bagmod, BANGKOK 10140, tel 66 2 427 0039, fax 66 2 379 7089. It was considered that the holding of the 1996 AAS Conference in Bangkok might disadvantage attendance by some AAS members.

The Australian Foundation for Science recently established a national committee on the Environment and AAS is to prepare a submission to this Committee on the major environmental issues that it would like addressed. Council is also preparing a submission to FASTS which is responding to ASTEC on Matching Science and Technology to Future Needs.

Another important matter considered by Council was the administration of the Society. Requirements of the Articles of Association and the Australian Securities Commission create significant administrative workload and Council is concerned that voluntary officers that change regularly are not in the best interest of members. It is planned to hold a further Council meeting mid year to review the results of several enquiries that are being made on this matter.

The 1995 Conference is being held in Fremantle, Western Australia, 15 - 17 November. The AGM and Council Meetings are planned for that time.

Noela Eddington,
General Secretary

AAS 1995 Conference

Located on the boarder of the ACT, the Eagle Hawk Hill Resort provided pleasant surroundings for the 123 people who registered for the 1994 AAS annual conference. The opening speeches, including a welcoming address by the Minister for Environment, Land Planning and ACT Government, Mr **Bill Wood**, were kept short so that the delegates were not distracted too much from enjoying the Buffet on Wednesday evening. During the following one and a half days there was a succession of interesting papers, sometimes in parallel sessions, covering topics ranging from chicken noise to wet soils, from musical instruments to active control of vibrating rods. A stimulating workshop on road traffic noise descriptors commenced with five notable workers in this field giving, at relatively short notice, their views on the topic. Afterwards, many members of the audience took the opportunity to join the animated discussion, in what proved to be one of the highlights of the conference. For many the gem of the activities would have been the brief, but necessary, Annual General Meeting of the Society held at 6 pm, however, others may have felt that the Conference Dinner, with its Australian bush flavour, was more to their taste. The dinner was the setting for the Excellence in Acoustics Award while the closing session prior to Friday lunch was preceded by the presentation of the President's Prize. This year it was awarded to **C.Field** and **F.R.Fricke** for a paper on optimisation of building ventilation opening size in a noisy environment (included in this issue). In addition to the conference papers, a display of technical equipment attracted considerable interest while comfortable chairs in the foyer provided the focus for many stimulating discussions - and a few short naps, perhaps from those who had over-indulged the night before. Overall, the conference was a great success and a credit to all involved in its organisation, especially **Marion Burgess** and **Stephen Samuels**.

Proceedings are available from the Society, cost $50, inc postage (A$60 for overseas air mail) from Australian Acoustical Society (NSW Division), Private Bag 1, Darlinghurst, NSW 2010.

Charles Don

Charles Don, Vice President, presenting President's Prize to Chris Field for paper by Field and Fricke.

Excellence in Acoustics Awards, 1994

The Society's Excellence in Acoustics Awards Scheme was run during 1994, for the first time on a national basis. Previously the Scheme had been a biennial event of the NSW Division. Henceforth the Awards will continue as a biennial, national scheme.

Awards are made to encourage excellence in the research, design and execution of acoustics and vibration related projects. The works must have been carried out in design, study or execution in Australia. An additional objective of the Awards is to assist in promoting community awareness of the achievements of those involved in the various fields of acoustics.

Two broad entry categories were established and these covered acoustical design projects and acoustical reports, procedures and systems. Although the scheme was advertised extensively, only two entries were received in the first category along with four entries in the second. Each entry was independently assessed by three judges. A judging panel of nine was assembled, with each judge assessing two entries. Assessment was made against a series of carefully evolved criteria which, in general terms, included the following.

- The novelty of the project in the extent to which it advanced acoustic knowledge and/or application.
- The extent to which the project achieved its stated objectives.
- The significance to the community of the outcomes of the project.
- The quality of presentation.

In two cases judges also made site inspections to assist in making their assessments.

Subsequently, further independent collation and analysis of all the judges' assessments were undertaken by the Excellence Awards Organising Committee. It is of some interest to note that there was a very high degree of consistency between the assessments. In other words, there was considerable consensus about all entries.

The following six entries were received:

Acoustical Design

Sutherland Centre, St Catherine's School, Waverley

Sydney Harbour Tunnel ventilation noise control

Reports, Systems & Procedures

Exposure of the Australian population to road traffic noise

Sydney airport noise management plan

Noise source identification of a CM25-8 locomotive

Noise assessment of the M5 East Motorway

Overall, the judges' opinions were that all entries were of good quality and that each was suitable for inclusion in the assessment process. However the clear consensus of the judges was that none of the entries could be assessed as excellent. Nevertheless two of the entries were assessed as being of a high standard. On this basis, no Awards for Excellence were made. High Commendations were made to the following two entries:

A/Prof A L Brown, Brisbane, Qld
Exposure of the Australian population to road traffic noise

Mitchell McCotter, Sydney, NSW
Sydney airport noise management plan

Both High Commendation certificates were formally presented to the recipients by AAS Vice President Charles Don during the official dinner of the 1994 Annual Conference. The Society's congratulations are extended to both recipients and thanks to all entrants for their support of and interest in the Awards scheme. A warm invitation is made to all to consider participating in the next, 1996, Awards scheme. This will be organised by Queensland Division with presentations again scheduled during the Annual Conference. Finally, the Society is greatly indebted to the 1994 judges and Awards Committee members.

Stephen Samuels

Charles Don (c) presenting Excellence in Acoustics Awards to Lex Brown (l) and Rob Bullen (r)

International Conference on Underwater Acoustics: Acoustic Imaging and Remote Sensing

This, the third such conference convened by the Australian Acoustical Society on underwater acoustics, was held at the University of New South Wales in December. The conference was well supported by both the defence, industries and academia, there being 110 registered delegates and 57 presentations scheduled during the two and a half days. It was co-sponsored by the Australian Academy of Science and GEC-Marconi. Highlights of the conference were the list of eminent overseas speakers and the high quality of the papers presented by the local contingent.

The opening address to the conference delivered by Prof. A.C. Kibblewhite of Auckland University gave the development of underwater acoustics in the Southern Hemisphere. This was followed by 6 papers on different aspects of underwater noise, its characteristics and sources, particularly sea animal and fish noises. A subsequent session of 4 papers on fisheries, the exploitation of the marine bio-mass using acoustic technologies such as imaging and remote sensing added a useful appreciation of some of the commercial aspects of the conference.

Acoustic imaging techniques are not limited to the marine environment, as illustrated by presentations on medical imaging (6 papers) and on ultrasonic imaging (2 papers). M.J.Buckingham of SCRIPPS (San Diego) introduced the main session on underwater imaging and discussed the concept of "acoustic daylight" and its development in acoustic imaging. In the field of imaging and classification of the acoustic properties of the sea floor, a series of three papers by M.D.Richardson of the US Naval Research Laboratory indicated the wide range and scope of projects under development in the US. The more controversial and commercially successful "Roxann" system of classifying these properties was then discussed by F. Olgivie of Marine Micro Systems, Aberdeen, Scotland. However for in depth classification of the seabed, a geo-sounding or low frequency system is required and this was expanded on by Prof. S.Y.Zhang of Academia Sinica, Shanghai. These invited papers were followed by 9 papers specialising on seabed properties.

The sessions on remote sensing were introduced by a plenary lecture on "Global acoustic propagation" by W.A.Kuperman of SCRIPPS. The involvement and cooperative efforts of the many Australian and New Zealand workers in this field with their northern hemisphere colleagues was indicated by a diverse series of 11 papers such as the acoustic detection of supercooled Antarctic water and the verification of the nuclear test ban treaty.

An enjoyable event was the Conference Dinner Cruise on Sydney Harbour, which was combined with the Annual End of Year Function for the N.S.W. Division and gave many of the local acousticians opportunity to meet our overseas delegates.

The Society wishes to express its thanks for the support given by the organisations which supported the Conference through sponsorships and advertisements in the Proceedings. The Conference ended with a plea for more frequent gatherings in underwater acoustics.

Proceedings (extended abstracts) are available from the Society, cost $40, inc postage (A$50 for overseas air mail) from Australian Acoustical Society (NSW Division), Private Bag 1, Darlinghurst, NSW 2010.

John Dunlop

Visit to ABC Centre

The final technical meeting for 1994 of the Victorian Division was a combined one with the Audio Engineering Society, and was a site visit to the new ABC Southbank Centre. About 75 people attended, of whom 41 were AAS members. The introductory remarks to the whole group to describe the scope and nature of the new building and the activities regularly carried out within it, were followed by a tour of inspection. Features of special acoustic interest included the "virtual doors" leading into each broadcasting or recording studio, the studio "Schroeders" facilities, and the acoustic and vibration isolation features of the Centre's emergency electric power generator.

The "virtual doors" into the studios, making a physical door unnecessary, comprised a curved passageway acoustically treated to provide a high degree of sound absorption, and were found to be most effective in practice, the advantage being that those in the studio were not completely cut off from the neighbouring spaces, and that those entering or leaving the studio during a broadcast or recording session could not add extraneous noise through the banging of a door. The "Schroeders" facilities, a substitute for acoustic absorption, consisted of a special shaping of parts of a studio ceiling or wall to aim the reflected sound in desired directions. The acoustic shrouding and resilient mountings of the engine-driven emergency electric power generator were found to be the most effective in preventing its noise and vibration from being transmitted to the surrounding space and supporting building structure. In all, this visit proved to be a most interesting evening.

Louis Fouvy

Information in Music

The first meeting of the ACT group for 1995 was held jointly with the Australian Institute of Physics. The talk was given by **Joe Wolfe** of the Musical Acoustics Group, University of New South Wales with the title: "The creation and analysis of information in music - from ideas to acoustics and back again". About 50 people attended, including several musicians as well as acousticians and physicists.

Joe's talk traced the "signal" of a piece of music from its genesis as an idea or motif in the mind of a composer, through the stages of melody, development, harmonisation, orchestration, and concert performance. At all stages the information content and transmission rates were estimated, the coding was described, and the algorithms employed to generate each new version were discussed from both musical and physical viewpoint.

The second half of the talk followed the information-rich signal which enters the ear through the stages of frequency analysis, note and timbre recognition, and higher stages of analysis which, in some listeners at least, reverse the stages of composition.

Finally these ideas were used to compare music and speech and to support some arguments about the possible reasons for, and the possible origin of, the phenomenon of musical communication.

This interesting presentation sparked considerable discussion which continued during the dinner held at a nearby Club.

Environment Issues

The National Committee on the Environment of the Australian Academy of Science is to investigate major environmental issues. The Society has been asked to provide a list of issues for consideration and (hopefully) action by this committee. The Academy has an important profile and provides a good opportunity for addressing environmental issues that the members of the AAS consider to be important on a national basis.

At the last Council Meeting of the AAS, Marion Burgess and Lex Brown were given the responsibility for preparing a submission on the major issues with which the AAS would like the Academy to be involved. Any members of the Society who have issues for this submission are invited to pass the details onto Marion (tel 06 268 8241, fax 06 268 8276, email m-burgess@adfa.oz.au)

Fellowships and Awards

The Australian Academy of Science has associations with international organisations which provide grants in various forms for scientific exchanges. Some are for short visits while others provide financial assistance over longer time periods. The grants available for 1996 include visits to France, UK, Korea, Taiwan, China and Japan. Further information and application forms can be obtained from International Exchanges, Australian Academy of Science, GPO Box 783, Canberra ACT 2601 or tel (06) 247 3966.

STANDARDS AUSTRALIA UPDATE

There are several major projects and revisions are being undertaken by Standards Australia in the field of acoustics, the following gives a brief summary of the progress achieved over the last year.

The revision of AS 1269 1989: Acoustics Hearing Conservation is progressing slowly, but the Public Comment Drafts should be available later this year. The revised Standard is to be split into the following five Parts:

Part 0: Introduction.
Part 1: Measurement and assessment.
Part 2: Noise reduction management.
Part 3: Selection, use and maintenance of hearing protection devices.
Part 4: Auditory assessment.

The major change to the Standard is the expansion of the noise management section, which it is envisaged will provide strategies for a noise reduction program. This is due to the emphasis of hearing conservation in recent years shifting away from the use of personal hearing protection towards minimising noise exposure through noise reduction management and engineering noise control. The other sections are also being updated to reflect changes in technology and, where applicable, to follow measurement techniques, guidance and criteria given in relevant International Standards.

The revision of AS 1055 1989: Description and measurement of environmental noise and the equivalent New Zealand Standards, NZS 6801 1991: Measurement of sound and NZS 6802 1991: Assessment of environmental noise is proceeding and again it is thought that Public Comment Drafts will be available some time in 1995.

A Public Comment Draft providing techniques for the measurement of impulsive noise such as that produced by explosions, small and large calibre weapons and cartridge operated nailing machines should also be available later this year. It is based on ISO/DIS 10843: Acoustics Methods for the physical measurement of single impulses or bursts of noise (Explosive noise).

Grant Cooper,
Executive Officer

Standards Australia Email

The Sydney and Melbourne Information Centres of Standards Australia can now receive requests for information from members via Internet. The addresses are for Sydney Centre sic@saa.sa.telememo.au and for Melbourne mic@saa.sa.telememo.au. The Sydney Information Centre also provides a bulletin board on AUSTEL on the ETSI and ITU publications.

Multitechnics Standards Board

In November 1994, Standards Australia issued a strategic plan for a Joint Multitechnics Standards Board. The Board will cover those areas outside the Building and Electrical sectors, and its coverage will include quality, occupational health and safety, and environment. The Board will direct the Standards process and establish objectives, assess performance of committees and staff, and explore opportunities for international and regional rationalisation. Anita Lawrence is a member of the Board.

Costs of Standards

Of interest to those who consider that Australian Standards are expensive will be an item on comparative costs of national and international Standards which was included in Standards Australia's publication Consensus for October 1994. Expressed in Australian dollars, the price of a typical 20 page standard is $30 in Australia and New Zealand, $40 from IEC, $55 in the UK and from ISO, $60 in Japan, $70 in France and $100 in Germany.

FASTS Changes

The Federation of Australian Scientific and Technological Societies (FASTS), of which the AAS is a member, has been going through a difficult time. However recently there have been substantial changes and significant progress has been made as FASTS enters 1995. At the last Board meeting, two new members were elected to the executive: Joe Baker as the President elect and Marion Burgess, from the AAS, as Treasurer. This means that the AAS now has the opportunity to play a significant role in the activities, priorities and policies for FASTS.

The new Executive Director, Toss Gasgoine, commenced in early March and has already produced a news letter and arranged for the release of the FASTS policy documents. These were discussed at the forum in late 1994 and their release will be a major milestone for FASTS and with great potential for impact during an important pre-election year.

Bilsom Seminars

A series of free half day seminars are to be held by Bilsom at venues around Australia. The aim of these seminars is to provide information for industry on the latest developments in hearing conservation products and services. Seminar dates: Brisbane May 2, Sydney May 4, Melbourne May 8, Adelaide May 10 and Perth May 11. For more information contact Bilsom tel (02) 450 1544 or fax (02) 486 3319.

Proceedings Available

The Proceedings of the 3rd International Congress on Air and Structure Borne Sound and Vibration are now available. This congress was held in Montreal, Canada June 13 to 15, 1994 and the three volume proceedings include 264 papers. The six keynote papers are: Methods to reduce computing time in structural acoustics predictions by Guyader; Acoustically induced structural vibration and fatigue by Norton; Human response to sound and implications to safety by Hetu; Wavelet theory by Newland, Aeroacoustics of helicopter rotors by Heller and Design of active control systems by Fuller.

The proceedings are available from International Scientific Publications, PO Box 13, Auburn AL 36831, USA for US$135 plus US$40 for overseas airmail.

Email Digest

The International Sound and Vibration (IS&V) Digest is available for no cost on email to anyone interested. Currently it is distributed to 1198 recipients around the world. Malcolm Crocker is the Editor in Chief and the 18 member Editorial Board comprises members from over 12 countries, including Colin Hansen and Michael Norton from Aust. All are invited to submit material for the Digest as the aim is to make the Digest truly international (the next issue will include an item on the AAS).

The content of the recent Vol 1, No 3 includes: Overview of the Boundary Element Method, Overview of Active Noise Control Systems, East-European Acoustical Association, Penn State Center for Acoustics and Vibration, Conferences, Short Courses, Reader Questions, Book Reviews.

To request addition to the mailing list or to send a submission for the Digest e-mail to yanas@eng.auburn.edu.

Sound Award

The 1994 USA Annual Discover Awards for Technological Innovation were presented by Vice President Al Gore. The winner in the Sound Technology category was the NoiseBuster from Noise Cancellation Technologies (NCT) which uses active noise control in a small headset. This unit was reviewed in Acoustics Australia **22**, 2, 56-57 and is available from Dick Smith Electronic Stores. Further information on NCT products can be obtained from ICP Pty Ltd, Tel (03) 602 4047, Fax (03) 602 4076.

Metacoustics Move

After yet another re-organisation in CSIRO two years ago, the Acoustic Emission/Microseismic Department of CSIRO which was located at Lucas Heights was privatised. Metacoustics Pty. Ltd. rose from the blood, sweat and tears and the CSIRO equipment and most of the staff transferred to Metacoustics which was located at Castle Hill in Sydney. Now two years later, Metacoustics has moved into a new larger and customised laboratory at 17 Chicago Avenue in Blacktown, NSW and expanded the company's activities at the same time. Dr. Bob Harris and Brian Wood who were the leaders of the CSIRO team are still together at Metacoustics. The staff of Metacoustics are involved in basic research, applied research and application and provide a complete service which includes both advising and actual testing of large and small projects. The fields of activity include: acoustics, acoustic emission, metallurgy and structural integrity investigations. Contact details: PO Box 6042, Blacktown 2148, tel 02 831 7535 fax 02 831 7626

ROCLA Move

The Sales, Administration and Accounts of Rocla Composite Products are now located at 73-105 Frankston-Dandenong Rd, Dandenong, Vic 3175. Postal address is Private Bag 1448, Dandenong South B.C., Vic 3164. Tel (03) 767 4574, fax (03) 791 2781.

B&K Quality Management

Following an audit of its quality system in October 1994, Bruel and Kjaer has been recommended by NATA to be certified to the Australian and New Zealand Standard AS3902-1987/ISO 9002. At the same time, the parent company in Denmark has been recommended to be certified to ISO 9001.

Consultant Quality Management

Acoustics Consultants Richard Heggie Associates has recently received full certification of its Quality System by Standards Australia Quality Assurance Services.

The company has based its quality system on the requirements of Australian Standard 3901, as it includes the important element of Design and Development. "Design tasks are essential in the services provided by acoustical consultants", Mr Heggie said. "Quality of design ensures that advice given to clients is reliable, and meets project needs with practical and cost-effective solutions. Certification is really only the first step, and it is important that the Quality System not be regarded as some separate entity, set apart from the company's normal operations. By implementing responses to internal auditing and more general reviews, the system is continually improving the quality and efficiency of the services we provide"

ERM Mitchell McCotter

In September 1994, the Sydney-based consulting firm Mitchell McCotter became a member of the Environmental Resources Management (ERM) Group of companies, a world-wide consulting organisation with over 2,500 staff in 21 countries. The company will continue to operate very much as before, with the same principals and professional staff, but it will be strengthened by the expertise available form the ERM Group. Further information: ERM Mitchell McCotter Pty Ltd, PO Box 943, Crows Nest, NSW 2065. Tel (02) 906 1666, Fax (02) 906 5375.

Ultrasound Bioeffects and Biophysics

In response to the use of higher acoustic output levels, the American Institute of Ultrasound in Medicine (AIUM) has announced the publication of "Medical Ultrasound Safety", an essential reference source to ensure patient safety and operator knowledge. Information is presented in easy-to-read question and answer format. The book includes 40 pages of text and is available to AIUM members for US$10, and to non-members for US$19.

Further information: AIUM Publications Dept., 14750 Sweitzer Lane, Suite 100, Laurel, Maryland 20707-5906, USA. Tel +1 301 498 4100

ASSOCIATION OF AUSTRALIAN ACOUSTICAL CONSULTANTS

The AAAC was formed in 1976 to advance the fledgling acoustical consulting industry and to safeguard the interests of the clients and public served by acoustical consultants. Some say that acoustical consultants are rather rare birds. In 1976 they were even rarer. The main driving force was the late Ron Car of Car & Wilkinson fame, and then of Car Marshall Day Acoustics Pty Ltd. Among the foundation members were the renowned and inimitable Peter Knowland and that stalwart of long lonely nights spent with a cold and heavy B&K2203 sound level meter, Mr Jim Madden of James Madden & Associates. The late Dr Ron Barden also contributed his not inconsiderable skills and influence to the formation of the AAAC.

Membership of the AAAC is open to all Australian acoustical consulting firms, but is restricted to those whose organisation is completely independent from other commercial or consulting interests which could compromise their integrity. AAAC members are specialist acoustical consultants, whose Principal must have formal educational qualifications at a degree level and be a Member of the Australian Acoustical Society. Their experience must cover a broad range of acoustical areas including environmental noise and vibration assessment and control, architectural acoustics, occupational hearing protection, occupational noise measurement and control, road traffic noise control, aircraft and train noise intrusion control, etc.

One of the Objectives of the AAAC is to cooperate and liaise with Authorities and Associations so as to contribute to and maintain acoustical standards, laws and regulations. In this regard the AAAC is represented on a number of Committees working towards new or improved standards of noise and vibration control. We are currently involved in a review of the Building Code of Australia and the NSW Roads & Traffic Authority review of their Traffic Noise Control Guidelines. We are also represented on a number of Australian Standards acoustics committees.

Athol Day,
Hon Sec

This is the first of a series of items from the members of the AAAC

New Products...

ACU-VIB ELECTRONICS

Portable Analyzer

The SVAN 910A analyzer can be used for a very wide range of practical applications, from environmental measurements, to machine health monitoring in industry, to sophisticated applications in the laboratory. Features include microphone, accelerometer and direct inputs; 90 dB dynamic range; FFT analysis up to 40 kHz (25.6 kHz real time); 1/1 and 1/3 octave digital filters; linear, A, C, and "human response to vibration" weighting filters; RS232C, IEEE488 and Centronics interfaces, and easy operation due to menu control. Complies with IEC 651 and IEC 804 Type 1, ISO 2631, ISO 5349 and EEC 86/188. Weight with batteries 6 kg.

Handheld Analyzer

The SVAN 912 provides sound, vibration and voltage measurement. Features include 80 dB dynamic range, FFT analysis up to 25.6 kHz (6.4 kHz real time), 1/1 and 1/3 octave digital filters; linear, A, C, and "human response to vibration" weighting filters and G infrasound filter; RS232C interface and easy operation due to menu control. Complies with IEC 651 and IEC 804 Type 1, ISO 2631, ISO 5349 and EEC 86/188. Weight with batteries 1.8 kg.

Further information: Acu-Vib Electronics, PO Box W16, Wareemba, NSW 2046. Tel/Fax (02) 819 6398, Tel 018 470 179.

VIPAC

Sound Level Meters

Larson-Davis has released new Models 712, 720, 812, and 820 sound level meters, continuing a tradition of adaptability to a variety of measurement applications. For the evaluation of hearing protection devices, this range offers unique C minus A analysis capability. This feature sequentially measures a C-weighted Leq, then an A-weighted Leq, and computes the result of subtracting the LeqA from the LeqC. The sound level meters come standard with extensive "on-board" non-volatile memory. Data can be acquired and stored in the field and later transferred to a PC for further analysis, or printed directly to a serial printer in tabular and graphic formats. An extensive range of software is available to complement the sound level meters.

Dynamic Data Visualisation

Index Data Systems has created the fastest, easiest way to obtain answers from multi-channel sound and vibration analysis with the introduction of ID software. It features data acquisition, data processing, dynamic data display and report generation elements and takes full advantage of the power and flexibility of the Microsoft Windows environment. Ease of use was one of the principal design criteria, and simple point and click functionality is maintained throughout. System requirements are MS-DOS 5.0 or later, Windows 3.1 or later, 386 DX 20 Mhz or better, a graphics controller supporting 256 or more colours, 12-15 MB disk space, at least one floppy drive and a mouse or other pointing device.

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

ETMC

Real Time Analyser

The Norsonic, RTA 840, is a dual channel, portable 1 and 1/3 octave analyser which combines the power of a laboratory analyser with the flexibility of a battery operated field unit. As well as fast, slow and impulse time constants, it has floppy disc drive and various interfaces.

Further information: ETMC Technologies,3 Montague Street, Balmain NSW 2041. Tel. (02) 555 1225, Fax. (02) 810 4022

New Members...

The following are new members of the Society, or members whose grading has changed:

Queensland
Member: Mr B Thorne, Mr P C Yallamas
Associate: Mr B A Whittle
South Australia
Member: Mr B Cazzolato
Subscriber: Mr P Dewing
Student: Mrs X Pan
Victoria
Student: Mr A Mills, Mr R R Nicholson
Western Australia
Member: Mr D Lloyd
Subscriber: Mr M D Penketh

Publications by Australians...

The following listing of publications by Australian authors is provided in order to encourage communications among those working in the various fields of acoustics.

Remote excitation and sensing of mechanical resonances in structures using laser diodes and an optical fibre interferometer, Philp, W.R. (Vic Univ Tech); Booth, D.J. *Measurement Science & Technology v 5 n 6 1994.p 731-735*

Analytical and numerical study of the forced vibration of a spherical cavity. Forbes, L.K. (U Qld) *JSV v 172 n 4 1994.p 471-489*

Effect of transfer function estimation errors on the filtered-X LMS algorithm. Snyder, Scott D. (U Adel); Hansen, Colin H., *IEEE Transactions on Signal Processing v 42 n 4 1994.p 950-953*

Free vibration of laminated conical shells including transverse shear deformation. Tong, Liyong (CRC Aerospace Structures) *Int J Solids and Structures v 31 n 4 1994.p 443-4456*

Ultrahigh sensitivity sapphire transducer for vibration measurements. Peng, H. (UWA); Blair, D.G.; Ivanov, E., J Physics D: *Applied Physics v 27 n 6 1994.p 1150-1155*

Vibration and jarring as a cause of back injury in the NSW coal mining industry. Cross, Jean (UNSW); Walters, Megan, *Safety Science v 17 n 4 1994.p 269-274*

Shotshell primer impulse sources. Don, C.G. (Monash Uni); Cramond, A.J.; McLeod, I.D.; Swenson, G.G., *App Acoust v 42 n 1 1994.p 85-93*

Stability and bifurcation of unbalanced response of a squeeze film damped flexible rotor. Zhao, J.Y. (Aust Defence Force Acad); Linnett, I.W.; McLean, L.J., *J Tribology, Transactions of the ASME v 116 n 2 1994. p 361-368*

Inverse eigenvalue problem for a modified vibrating system. Ram, Yitshak M. (U Adel) SIAM *J Applied Mathematics v 53 n 6 1993.p 1762-1775*

Experiences of a building services acoustic engineer. Palmer, Ross H. (Palmer Acoust, Brisb), *A Refrig, Air Cond & Heat v 47 n 8 1993.p 29-32*

Effect of end conditions on the active control of beam vibration. Pan, X. (U Adel); Hansen, C.H., *JSV v 168 n 3 1993.p 429-448*

Inverse mode problems for the discrete model of a vibrating beam. Ram, Y.M. (U Adel), *JSV v 169 n 2 1994.p 239-252*

Constructing a finite element model of a vibratory rod from eigendata. Ram, Y.M. (U Adel); Gladwell, G.M.L., *JSV v 169 n 2 1994.p 229-237*

Field study of the effects of traffic noise on heart rate and cardiac arrhythmia during sleep. Carter, N.L. (NAL); Ingham, P.; Tran, K.; Hunyor, S.N., *JSV v 169 n 2 1994.p 211-227*

Vibration of triangular Mindlin plates subject to isotropic in-plane stresses. Xiang, Y. (U Qld); Liew, K.M.; Kitipornchai, S.; Wang, C.M., *J Vib & Acous, Transactions of the ASME v 116 n 1 1994.p 61-66*

Three-dimensional simulation of stress around inclusions in viscoelastic fluids. Wendlandt, B. (DSTO), *JSV v 168 n 1 1993.p 141-156*

Effects of spurious modes in resonance cavities. Tobar, Michael E. (UWA), J Physics D: *Applied Physics v 26 n 11 1993.p 2022-2027*

Tests on a low-frequency inverted pendulum system. Pinoli, M. (UWA); Blair, D.G.; Ju, L., *Meas Science & Tech v 4 n 9 1993.p 995-999*

Noise generated by a turbulent jet interacting with a rigid plate. Davis, M.R. (UTas); Pan, N.H., *JSV v 167 n 1 1993.p 165-181*

Coupling of vortex shedding with the fundamental resonant mode of a resonator tube. Hourigan, K. (CSIRO); Thompson, M.C.; Brocher, E.; Andrianantoandro, A., *Noise Control Eng J v 41 n 2 1993.p 331-337*

Development of a flush mounted microphone turbulence screen for use in a power station chimney flue. Davy, John L. (CSIRO); Dunn, Ian P., *Noise Control Eng J v 41 n 2 1993.p 313-322*

Vibration signature based condition monitoring of bowl-roller coal pulverizers. Nathan, R.J. (State Energy Com WA); Norton, M.P. *J of Vib & Acoust, Transactions of the ASME v 115 n 4 1993.p 452-462*

Axisymmetric model of a moving-coil loudspeaker. Murphy, David J. (Regency Inst of Voc Ed) *J Audio Eng Soc v 41 n 9 1993.p 679-690*

Effect of temperature on the natural frequencies and acoustically induced strains in CFRP plate. Galea , S.C.P. (DSTO); White, R.G. *JSV v 164 n 3 1993.p 399-424*

Sound transmission loss measurements using the sound intensity technique Part 1: The effects of reverberation time. Lai, Joseph C.S. (Aust Defence Force Acad); Qi, Dan, *App Acoust v 40 n 4 1993.p 311-324*

Effect of error sensor location and type on the active control of beam vibration. Pan, X. (U Adel); Hansen, C.H., *JSV v 165 n 3 1993.p 497-510*

Acoustic sources in a tripped flow past a resonator tube. Thompson, M.C. (CSIRO); Hourigan, K.; Welsh, M.C.; Brocher, E. *AIAA Journal v 30 n 6 1992.p 1484-1491*

Explicit formulas for correcting finite-element predictions of natural frequencies. Xie, Y.M. (U Syd); Steven, G.P. *Comm in Numerical Methods in Eng v 9 n 8 1993.p 671-680*

Effect of fiberglass density and flow resistance on sound transmission loss of cavity plasterboard walls. Narang, P.P. (CSIRO), *Noise Control Eng J v 40 n 3 1993.p 215-220*

Theory and experiment on a method for on-site identification of configurations of multi-bearing rotor systems. Krodkiewski, J.M. (U Melb); Ding, J., *JSV v 164 n 2 1993.p 281-293*

Inclusion of static indetermination in the mathematical model for non-linear dynamic analyses of multi-bearing rotor system. Ding, J. (U Melb); Krodkiewski, J.M., *JSV v 164 n 2 1993.p 267-280*

Active control of panel vibrations with piezoelectric actuators. D'Cruz, Jonathan (DSTO), *J Intelligent Material Systems & Struct v 4 n 3 1993.p 398-402*

Books...

Environmental Noise Manual

NSW EPA

EPA, 1994, loose leaf in binder, ISBN 0 7310 1230 5. Available from: Gov Information Service, PO Box 258, Regents Park NSW 2143 or Tel (02) 795 5000 for details of over counter purchase. Price $70 plus $15 post and packing.

The NSW Environmental Protection Authority (EPA) has recently released a revised version of the Noise Control Manual. The original manual was first produced in 1985 and over the years there have been occasional amendments. The manual has been regularly used by all of those involved with environmental noise issues. It has even been a valuable reference for those in others areas of Australia as it has sections dealing with many different types of noise.

The new 1994 edition maintains the same production style with loose pages in a ring binder. The main changes to the manual are in the sections on legislation and responsibility following the introduction of the Protection of the Environment Administration Act of 1991. This led to the replacement of the State Pollution Control Commission with the EPA. An other noticeable change is the increase in penalties and fines with many increased tenfold. The section on Noise Measuring Equipment, under Reference Material, has also wisely been removed as there have been substantial changes in the type of equipment used for noise monitoring.

The bulk of the manual is essentially unchanged. It is stated that "the EPA intends to progressively review and update the noise control guidelines in the Manual to ensure that they maintain relevance to contemporary society". However it is surprising that with the release of this new edition, little opportunity was taken to update the content which is not specifically related to legislation. For example in the section on assessment procedures there is no mention of noise loggers, which are now used extensively for environmental noise assessment, yet there is still an entire chapter on the procedure for use of a tape recorder. Perhaps even more serious is the failure to update the list of relevant Australian Standards - it still lists the 1974 version of AS 1055.

For those involved in environmental noise assessment and who do not have a copy of the original Noise Control Manual, purchase is recommended. It is certainly a valuable reference and the production style allows for easy insertion of future updates. For those who already have a copy of the old version (with the subsequent amendments) and do not need to regularly refer to the legislation sections, purchase of the revised edition may not be warranted.

Marion Burgess

Compendium Workers Compensation Statistics, 1991-92

Worksafe Australia

AGPS, 1994, soft covers, 98 pp, ISBN 0 664 33540 8. Available from: Comm. Government Bookshops or Worksafe Aust GPO Box 58, Sydney 2001, Tel (02) 565 9555, Fax (02) 565 9202. Price $11.95.

This is the first listing of comparable data from around Australia on compensated occupational injuries and diseases. At the time of its release the Minister, Gary Johns said that "with uniform data collection for workers' compensation across State borders, we can, for the first time, compare health and safety issues at Federal, State and Territory Government levels."

Following the Introduction and Explanatory Notes in part A, the Compendium contains the comparative statistics in four main groupings. Part B contains the statistics for fatalities. Part C compares the new workers compensation case by industry and part D by occupation. The last part is by duration of absence and this is followed by appendices.

Information on hearing loss is included in parts C and D. Taking an example from Part C for the industry area mining, the number, incidence and frequency of all compensational cases is provided by juristriction. Then the information on the types of occurrence for the combined juristrictions is provided in the form of pie charts for nature, bodily location, mechanism and breakdown agency. So for the new cases in the mining industry in 1991-92, 18% were for deafness which is second only to 42% for sprains and strains. In terms of bodily location, 22% of the claims were in the head region. The categories for "breakdown agency" include mobile plant, powered tools, fixed plant etc so it is not possible to directly compare these with the deafness data. Comparing across industries, it can be seen that the deafness claims were 7% in the construction industry while they did not score on the pie chart for the communication industry. Part D presents the information in a similar manner but in terms of occupation, ie trades person, clerk etc.

While there are obviously differences between the compensation systems in the various States and Territories, this is an excellent start in the comparison of available data. The compendium would be of value to those involved with workers' compensation claims, those identifying occupations and industries which require more noise control considerations and for those developing policies and strategies for dealing with workers' compensation.

Marion Burgess

Marion Burgess has been involved with noise control issues for many years and is currently employed as a research officer in the Acoustics and Vibration Centre at the Australian Defence Force Academy, ACT.

Wave Scattering from Rough Surfaces

Alexander G. Voronovich

Springer Verlag, 1994, 228 pp, hard covers, ISBN 3 540 57439 5, Aust Distributor: DA information Services, PO Box 163, Mitcham, Vic 3132, Tel (03) 873 4411, Fax (03) 873 5679. Price A$ 131.25.

This book covers a large field, is strong on derivations and understanding of the mathematics, but somewhat light on presenting results. The title page mentions that the book contains 22 Figures. Of these, 9 present results, and these are all in the one chapter (No. 6). The English tends to be somewhat stilted. The description on page 58 that a variable "...changes monotonously along the lines..." would be the most humorous of much awkwardness in translation. I often had to read a sentence twice to be satisfied that I had picked up the message. On average there is a typographical error every few pages. Most of these are trivial misspellings, but several of them are irritating misreporting of numbers. Further use should be made of headings within sections, to distinguish between scalar and vector analyses, or between electromagnetic and scalar analyses. Many readers not interested in the more complex treatments will have to scan them with an alert eye to catch when the book returns to the scalar scenario.

The Introduction gives a good bird's-eye view of the field of scattering from rough surfaces. It notifies the reader of the author preferences and presents a summary of the book's contents.

Chapter 2 on the Scattering Amplitude and its Properties is heavy going and pages 21 to 33 are better left until referred to during later chapters. As the equation to be solved in 2.2 is the Helmholtz integral equation, it is better to read 3.1 between 2.1 and 2.2. The definitions of the single-argument Green's function G0(R) [as the incident field from a single source] and the double-argument Green's function, G(R, R0) [as the sum of the incident and scattered fields for the case of a single source] need to be explained descriptively. The dimension of the field seems to vary: at p.12 it is a velocity potential, but between pages 17 and 20 its dimension fluctuates between reciprocal length and the square root of length. The unconventional definitions of Scattering Strength on p 40-41 are better glossed over.

Chapter 3 treats the Helmholtz Formula and Rayleigh Hypothesis (two quite independent concepts). An odd convention is followed in that R* is defined as the "observation point", and yet the argument of the single-argument Green's function is given as R - R*, where R is a point on the rough surface. Section 3.1 gives detailed accounts on solving inhomogeneous equations that are usually found in texts on differential equations rather than scattering. However the approach is fresh and worth reading for those interested in derivations. The objective of the final few pages of 3.1 is not stated; it seems from later comments that the objective is to find, for the Dirichlet problem, an intermediary function (nu) related to the field, for which an implicit integral equation can be written that does not involve derivatives of that function (presumably so that it may be solved by iteration). It would be helpful if there were descriptive discussions of this issue, as well as, for example, if the function F is arbitrary, why Eqs. (3.1.37) and (3.1.40) are inconsistent [in the case of the Neumann (immobile surface) problem].Sections 3.2 to 3.4 on the Rayleigh Hypothesis contain an interesting and detailed analysis of the limits of applicability of the Rayleigh Hypothesis (even though the sentence that carries over from p. 56 to p. 57 has some words missing).

In Chapter 4 on the Small Pertubation Method, a series is sometimes described as a power series and sometimes as an asymptotic series (it cannot be both). In 4.1 on the Dirichlet Problem (pressure release) is a derivation of an interesting expression, Eq. (4.1.22), for the mean reflectivity of a rough surface in terms of a weighted integral of the roughness spectrum. This useful expression has been overlooked by some texts, although it has appeared in well-regarded journal papers. The conclusion of this section is that, for the Dirichlet problem, the Rayleigh and small perturbation methods are equivalent.

Chapter 5 is on the Kirchhoff Approximation and the Helmholtz integral equation is again presented, although in a slightly different form that is equivalent to the previous expression under certain conditions. The explanation of these conditions is rather abstract and lacking in geometrical concepts. The remainder of 5.1 considers the field "scattered" (reflected) by a smooth sloping plane (although since there is just a point source, it is unclear why the plane cannot be treated as horizontal). Section 5.2 is on the Kirchhoff approximation for a rough surface, and as in Chapter 3, the treatment again uses an intermediary function.

Chapter 6 covers the following "non-classical" approaches: Small slope approximation, Phase perturbation technique, Phase operator method for Dirichlet problem, the Meecham - Lysanov approach, and the relation between Bahar's full-wave approach and the small slope approximation. This chapter contains interesting diagrams showing the domains of accuracy for the various approximations, including Perturbation and Kirchhoff.

Chapter 7 deals with a homogeneous waveguide bounded above by a rough boundary and below by an upward-refracting half-space. In spite of my interest in this topic, I found this chapter heavy going. Some more diagrams and descriptions of the purpose and significance of the analysis would improve its usefulness.

The References are satisfactory, except that the English translations of many Russian articles are overlooked. The Index is satisfactory, except that I looked up Reflection under "R" to no avail. It was instead under "M" as "Mean reflection coefficient".

Marshall Hall

Marshall Hall is a Principal Research Scientist at the Sydney branch of the Maritime Operations Division of DSTO, heading up the Propagation and Scattering section. His current interests are in developing a useful and accurate model of surface scattering, and in finding an efficient way to incorporate the important acoustic properties of the seabed into a practical database.

Noise and Vibration Control in Vehicles

N.I.Ivanov and M.J.Crocker (Editors)

Interpublish, Russia, 1994, pp352, hard covers, ISBN 5 7325 0090 1. Distributor: International Scientific Publications, PO Box 13 Auburn AL 36831 USA. Price US$80 (includes airmail).

The editors have put together 13 Chapters by 11 authors and the book presents an overview of the procedures for recognising and controlling noise in cars, trucks, tractors and other heavy duty vehicles. The emphasis is on noise shielding and muffling. It is in a summary form which would not be suitable for a teaching text. The strength lies in the worked examples, in setting realistic limits on the effectiveness of the methods described, and in the many Graphs and Tables. It is therefore a reference book for the practicing Engineer or Consultant. Although the theoretical principles are presented with explanations of all of the parameters involved, the derivations are omitted, and the majority of the references quoted are unfortunately in Russian.

The overall picture of a complex subject is built up logically from chapter to chapter. There are three main sections, as follows:

1) The general Problem of Noise in Vehicles. A very brief introduction to some basic principles is followed by Chapter 2 on Noise Generation and Vehicle Noise Estimation. This is a densely packed resume of the contributing factors, often rolled into long theoretical compilations suitable only for computer usage. Worked examples and Tables of data clarify the processes. Chapter 3 deals with the approaches to noise control, and is largely concerned with the practical effectiveness of enclosures.

2) Noise and Vibration Control Methods. Chapters 4 and 5 deal with the theoretical approach to designing effective noise barriers and vibration isolators respectively. These are overviews from work presented more completely in other texts, but here usefully specialised to the problems and dimensions encountered in vehicles. Chapter 6 on vibration damping is very brief, and would be better pursued in other texts.

3) Noise Control Measures. Chapters 7 and 8 deal with the practicalities of cabin and engine enclosure designs. The consequences of the penetrations required for access and for cooling are well covered. Chapter 9, on the design of acoustic baffles and shields, is applicable to open style vehicles such as Tractors. Chapter 10 provides a comprehensive and well written coverage of Intake and Exhaust Muffler design. This chapter alone would make the book valuable to those concerned with this aspect. Finally, there is a chapter dealing with the Russian Standards and Regulations for Interior and Exterior noise, which have recently moved into line with the EEC Methods and Limits. There are two chapters dealing with the problems specifically associated with Tractors and with Transportation and Construction Vehicles.

Not covered in the book are Road noise and Suspensions, Drivelines and Wind noise. The Contents are detailed at the rear, but there is no itemised Index. This is a pity, as there is much of value which is not apparent from the Contents. The book should nevertheless be of particular interest to those concerned with vehicular noise. It is a distillation from a wide range of theory and practice of many aspects which are applicable to the control of noise and vibration in vehicles. Some tolerance is required for the differing styles of the various authors, an unevenness of presentation and typographical errors in this translation.

Jim Menadue

Jim Menadue is a Noise and Vibration Engineer with 10 years experience at General Motors Holdens in Melbourne, where he specialises in new model family car development.

Letters...

Building Code

We at the Australian Building Code Board (ABCB) Directorate are aware that there is some concern regarding the current provisions for sound and impact isolation between sole occupancy units in the Building Code of Australia. The ABCB has commenced a program to restructure the BCA so that it is more of a performance based document with deemed-to-comply provisions. This restructuring could also highlight some areas where changes are needed and so this may be an opportune time to review the current provisions.

Of course, any proposed changes would need to be justified, not just in terms of the increased amenity, but also in the additional cost to the community. We welcome comments from readers of the Journal who have had difficulties with either the current ratings in Part F5, the construction provisions of Specification F5.2 or the impact test of Specification F5.5. These comments should be forwarded to:

John Kennedy, ABCB Directorate, GPO Box 9839, CANBERRA ACT 2601 Tel 06 276 1000 Fax 06 276 2281

Ukraine Exchange

I am writing to you to present the only Department of Acoustics in the Ukraine, in the hope that Australian scientists in the field of acoustics might be interested in the possibility of cooperation with our Institute. The Department of Acoustics in the Kiev Polytechnic Institute has been in existence for over fifty years. We prepare specialists in the following branches of acoustics: Acoustic Ecology (protection from noise and vibration), Vibroacoustic Diagnostics, Electroacoustics, Medical Acoustics, Ultrasonic Techniques, and Underwater Acoustics. There are 400 students studying in the Department, which has a staff of 5 Professors and 14 Readers. The Department carries out research in vibration acoustics, applied mechanics, and ultrasonics. We maintain collaborations with educational institutions in Germany, England, Italy, Poland and the USA, and we would like to establish similar relations with Australia. Within the framework of such a cooperation we envision - exchange of scientific and technical data - exchange of scientific workers to deliver lectures and undertake research - joint scientific projects. I would be happy to discuss these possibilities with interested individuals or organisations.

Professor V. Didkovsky KPI Chair of Acoustics Kiev Polytechnical Institute Prospect Pobedy 37 Kiev, 252056, Ukraine

Rowing Noise

In 1993, the co-operative management of the Brisbane River Catchment became a reality with the formation of the Brisbane River Management Group (BRMG). The BRMG focuses co-operative management by State and Local Government agencies and the community of the Brisbane River catchment area. Initially, the BRMG set up five working groups, one of which was the Noise Pollution and Abatement Working Group. This Working Group has now formed a Community Advisory Panel on the specific issue of rowing noise. As part of its research into rowing noise on the Brisbane River and its effect on the community, the Community Advisory Panel is gathering information on options for abatement and control of this major source of annoyance for Brisbane River residents. The Panel would welcome any information or advice from members of the Australian Acoustical Society on this matter. If you can provide any assistance, please contact:

Cherie Beaumont, Communication and Education Officer, BRMG Secretariat, P.O. Box 155, Brisbane Albert Street, 4002 tel (07) 227 8264 or fax (07) 225 1501.

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Diary...

CONFERENCES and SEMINARS

* Indicates an Australian Activity

1995

May 9-11, LIVERPOOL
Environmental Noise and Vibration
Details: Institute of Acoustics, Agriculture House, 5 Holywell Hill, St Albans, Herts AL1 1EU, UK. Tel +44 727 848195, Fax +44 727 850553

May 15-18, TRAVERSE CITY
SAE Noise and Vibration Conf
Details: Mone Asensio, SAE Int, 3001 West Big Beaver Rd, Troy, Michigan USA. Tel +1 313 649 0420

May 31 - June 4, WASHINGTON
129th Meeting Acoustical Soc. America
Details: ASA, 500 Sunnyside Boulevard, Woodbury, NY 11797, USA. Tel +1 516 576 2360, Fax +1 516 349 7669

June 12-16, ABERDEEN
Symp on Fisheries and Plankton Acoustics
Details: John Simmonds, Marine Laboratory, PO Box 101, Victoria Road, Aberdeen AB9 8DB, Scotland. Fax +44 224 295511

June 20-22, WARSAW
Noise Control 95: Noise - a civilization hazard
Details: Noise Control 95 Organizing Committee, Central Institute for Labour Protection, Czerniakowska 16, 00-701 Warsaw, Poland. Fax +482 623 36 95

June 26-30, TRONDHEIM
15th International Congress on Acoustics
Details: ICA'95, SEVU Congress Department, N-7034, Trondheim, Norway. Fax +47 7359 5150, email ica95@sevu.unit.no

July 2 - 6, PARIS
Int Symp on Musical Acoustics
Details: ISMA'95 Secretariat, c/o Rene Causse, IRCAM, 1 Place Igor Stravinsky, 75004 Paris FRANCE. Tel (331) 44 78 47 60, Fax (331) 42 77 29 47, email: isma@ircam.fr

July 6-8, NEWPORT BEACH, CALIF
Active 95: Int Symp on Active Control
Details: Noise Control Foundation, PO Box 2469 Arlington Branch, Poughkeepsie, NY 12603 USA. Tel +1 914 462 4006, Fax +1 914 463 0201

July 10-12, NEWPORT BEACH, CALIF
INTERNOISE 95
Details: INCE/USA, PO Box 3206 Arlington Branch, Poughkeepsie, NY 12603 USA. Fax +1 914 473 9325

August 1-9, STOCKHOLM
Int Congress Phonetic Sciences
Details: ICPhS, Dept Linguistics, Stockholm Uni, 106 91 Stockholm, Sweden. Fax +46 816 2347

August 16-18, AUCKLAND
Conference of NZ Acoustical Society
Details: Secretary, PO Box 1181, Auckland, NZ. Fax +64 9 6233248

September 3-7, BERLIN
1995 World Congress on Ultrasound
Details: J. Herbertz, WCU 95 Secretariat, Gerhard-Mercator-Universitat, 4708 Duisburg, Germany

September 19-22, BRISBANE
* Asian Pacific Conference on Occupational Health and Safety: Education and Training.
Details: OH&S Conference, PO Box 515, Sunnybank, Qld 4109. Tel (076) 312 438, Fax (076) 345 4892

October 9-11, SYDNEY
* Airports 95. Airport Engineering: Innovation, Best Practice & Environment.
Details: Convention Manager, Airports 95, AE Conventions Pty Ltd, PO Box E181, Queen Victoria Terrace, ACT 2600

November 8-10, MELBOURNE
* cm² Forum on Condition Monitoring
Details: Dept Mech Eng, Monash Uni, Clayton, Vic 3168, Tel (03) 905 5699, Fax (03) 905 5726

November 15-17, FREMANTLE
* AAS Annual Conference 1995
"Acoustics Applied"
Details: Dr G Yates, Dept Physiology, Uni WA, Hackett Drive, Crawley, WA 6009. Tel (09) 380 3321, Fax (09) 380 1025,
email gyates@uniwa.edu.au

November 27-Dec 1, KUALA LUMPUR
Asia-Pacific Vibration Conference
Details: Joseph Mathews, Dept Mech Eng, Monash Uni, Wellington Rd, Clayton VIC 3168 Tel +613 905 3554, Fax +613 905 5726,
email: mathews@eng2.eng.monash,edu,au

November 27 - December 1, ST LOUIS
130th Meeting Acoustical Soc of America
Details: ASA, 500 Sunnyside Boulevard, Woodbury, NY 11797, USA. Tel +1 516 576 2360, Fax +1 516 349 7669

December 4-7, HONG KONG
SDVNC 95 Int Conf Structural Dynamics, Vibration, Noise & Control
Details: Prof De Mao Zhu, Nanjing Uni Aeronautics and Astronautics, Nanjing, Tiangsu 210016, China, Tel +86 25 449 2492, Fax +86 25 449 8069

1996

February 19-21, MELBOURNE
*Australasian Cong. on Applied Mechanics
Details: AE Conventions (ACAM 96), PO Box E181, Queen Victoria Terrace, ACT 2600. Tel (06) 270 6562, Fax (06) 273 2918

April 1-4, ANTWERP
Forum Acusticum 96
1st Conv. European Acoustics Assoc.
Details: Forum Acusticum, Technological Institute KVIV, Desguinlei 214, B-2018, Antwerpen, Belgium, Tel +32 3 216 0996, Fax +32 3 216 0689

May (tentative), MICHIGAN
Joint meeting Catgut Acoustical Society & Michigan Violinmakers Assoc.
Details: Catgut Acoustical Soc. Inc., 112 Essex Ave, Montclair, New Jersey 07042, USA. Fax +1 201 744 9197

June 24-28, HERAKLION, CRETE
European Conf on Underwater Acoustics
Details: Secretariat, 3rd European Conference on Underwater Acoustics, Institute Applied Computational Mathematics, PO Box 1527, 711 10, Heraklion, Crete, Greece. Tel +30 81 210034, Fax +30 81 238868, email conference@iesl.forth.gr

July 30-August 2, LIVERPOOL
INTERNOISE 96
Details: Institute of Acoustics, Agriculture House, 5 Holywell Hill, St Albans, Herts AL1 1EU, UK. Tel +44 727 848195, Fax +44 727 850553

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COURSES

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

1995

November CANBERRA
Basics of Underwater Acoustics
Details: Acoustics & Vibration Centre, ADFA, Canberra, ACT 2600. Tel (06) 268 8241, Fax (06) 268 8276
email: m-burgess@adfa.oz.au

November CANBERRA
Basics of Noise & Vibration Control
Details: Acoustics & Vibration Centre, ADFA, Canberra, ACT 2600. Tel (06) 268 8241, Fax (06) 268 8276
email: m-burgess@adfa.oz.au