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Contributions and letters to:
The Editor, 4 Oakland Vale, New Brighton, Wallasey CH45 1LQ
Tel 0151 638 0181 Fax 0151 638 0281
e-mail roy@cmrl.demon.co.uk

Books for review to:
S Peliza MIOA, Acoustic Consultants Ltd, Raleigh House, Wellsway, Keynsham, Bristol BS31 1HS

Information on new products to:
J W Sargent MIOA, Oak Tree House, 26 Stratford Way, Watford WD1 3DJ

Advertising:
Keith Rose FIOA, Beamans, Chale Street, Chale Green, Nr Ventnor, Isle of Wight PO38 2JQ Tel 01983 551340 Fax 01983 551341

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The Institute of Acoustics, 77A St Peter's Street, St Albans, Herts. AL1 3BN
Tel 01727 848195 Fax 01727 850553
e-mail ioa@ioa.org.uk Web site http://www.ioa.org.uk

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contents

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Dear Members

Christmas and the New Year are upon us again, and as 2000 closes we can look back at several changes in the Institute's affairs which have taken place over the last few months. What Council hopes and trusts is that the changes put us on a secure footing for the next few years and ensure a renewed vigour in some key areas of our activities.

Firstly, you have been hearing about the changes in the publications area. These kick off with the new style Bulletin in the new year. We have been very lucky in securing the services of John Tyler to guide the editorship of the Bulletin through the transition period. Ian Bennett has just been appointed Editor from the new year – and John Miller, as Chairman of the Institute's Publications Committee, has written a piece elsewhere in this issue of the Bulletin covering the changes.

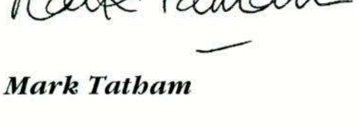
Secondly, from January we shall have our new Education Manager in place. Peter Wheeler takes up the challenge to take our education activities forward into new areas. He will be working closely with the Education Committee, chaired by Mike Fillery, to ensure that the tremendous educational assets the Institute has continue to be a corner-stone of our services to the profession. Over the next few years there is an opportunity to implement some of the ideas and recommendations outlined in last year's Education Report commissioned by Council. Peter Wheeler is currently Manager of the European Acoustics Association, and of course, was recently the Institute's President.

Both these appointments constitute a structural change for the Institute. We are moving toward a situation where the interests of our members and fellows are served as part of central management by professionals whose job it is to implement Council's policies. Specialist policy, of course, is developed by the individual Council committees – in this case Publications and Education – but once adopted by Council we can now look forward to a new professional momentum for carrying the policy forward.

Finally, and temporarily I trust, we have given notice of withdrawal from the European Acoustics Association. The reasons for this are complex – and I have written a note about the situation elsewhere in this issue of Acoustics Bulletin.

With very best wishes for Christmas and the New Year.

Sincerely,



Mark Tatham

VIBRATION PROPAGATION FROM A TRAIN TUNNEL: MEASUREMENTS TO VALIDATE A NUMERICAL MODEL

Rupert Thornely-Taylor FIOA

Introduction

To connect the passenger rail service to and from the Öresund Link with the rail system north of Malmö Central Station, a tunnel is to be excavated below the central regions of the city. The tunnel, which is called the City-tunneln, will be completed as two separate full-face bored tunnels in limestone rock. The general geography is set out in Figure 1.

Conventional cast-in-situ concrete tunnels and ramps, constructed in open cuts, will connect the portals in the north and south. A new subterranean station, Triangeln, will be constructed in the section of the tunnel that is to be full-face bored. Citytunneln will pass under existing buildings that are currently used as homes, hospitals, offices, schools, etc.

A study is being carried out on behalf of City-tunnelkonsortiet in Malmö to predict vibration from the operation of Citytunneln. This is being done using a numerical finite difference model. The study has been made by the joint venture KCM (Kjessler and Mannerstråle AB, Carl Bro A/S and Maunsell Ltd) with Rupert Taylor Ltd as subconsultants.

The accurate prediction of ground-borne noise and vibration from underground railways is a complex task. Whereas in airborne acoustics comparatively simple mathematical procedures may be used to process readily available source data (or readily measurable data), taking account of well-known effects such as noise barrier attenuation, transmission loss of acoustical elements, reverberation and similar concepts, the nearest analogies to these items in the prediction of ground-borne noise are many times more complex. Not only is there no simple equivalent to sound power level, because the source impedance is an unknown (in contrast to the position with air as a medium), but the method of propagation involves several different co-existing wave types whose behaviour, except in restricted cases not found in real life, can only be approximated algebraically. Propagation through layered or anisotropic media makes matters even more complex.

A useful approach to the difficulties identified is to seek to reproduce, in the time domain, the actual dynamic behaviour of all the elements of the system using finite-difference methods. The finite difference concept is fundamentally simple although the implementation in cases other than homogeneous isotropic media is less so.

Fig. 1. Citytunneln will pass below Malmö City and connect Malmö central station with Öresund bridge

This article describes a finite difference model for predicting ground-borne propagation of vibration at acoustic frequencies, and compares the predictions with measured results. The finite difference model is known as *FINDWAVE®* and is proprietary to Rupert Taylor Ltd.

The model has been validated by applying it to a tunnel on the Copenhagen metro, and comparing the results with field measurements carried out in the tunnel and in a building above, Building 202 in the Serum Institut. The modelling has been carried out by the present author. The measurements in the Copenhagen Metro (Comet) tunnel were carried out by Acoustica Carl Bro A/S, Jørgen Tornhøj Christensen.

Measurements

In order to verify the predictive numerical model for the propagation of vibration in the Malmö City Tunnel, verification measurements in the Copenhagen Metro Tunnel have been carried out. The transmission loss from the tunnel floor to the building and ground above has been measured as the reduction in vibration velocity level in the tunnel to the measured levels above.

The exciter and ancilliary equipment is as shown in Figure 2.

Furthermore, the point impedance for the tunnel floor has been measured. The impedance is defined as the ratio between the applied force at the excitation point and the measured velocity at the excitation point.

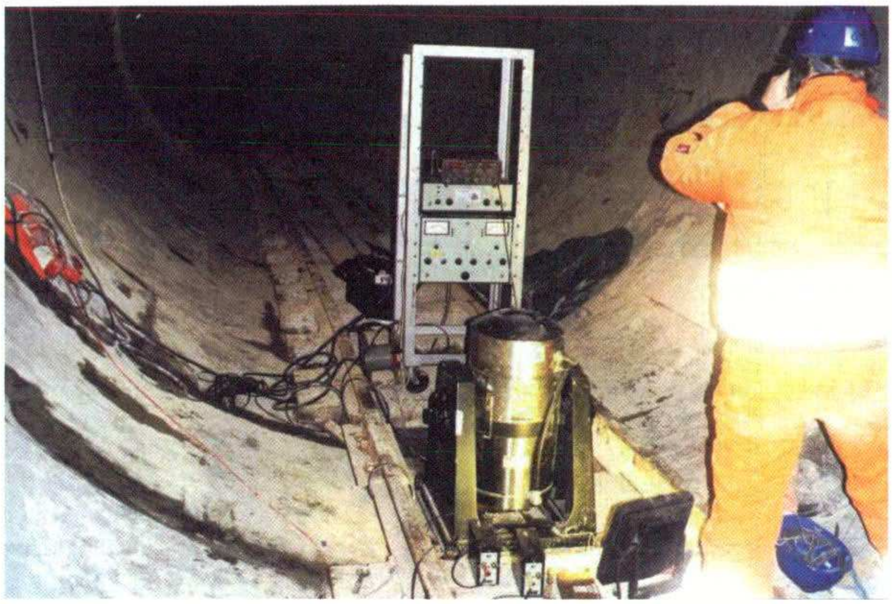


Fig. 2. The vibration exciting equipment

Data

The data used in the model study were as follows:

Test location: Chainage 20550 in tunnel 'Betty'

Tunnel diameter: 5.45 m external 4.90 m internal

Tunnel depth: Top of crown 13.075 m below ground level

Soil properties were provided by Maunsell as their interpretation of borehole results obtained by Rambøll and Carl Bro at the Seruminstitut. Data concerning soil loss factor were provided by KM. They were evaluated from measurements of ground vibration response at 20, 40, 57 and 80 m distance from the ground level centreline of the tunnel.

Excitation in the model was at the base of the tunnel in the vertical direction. The excitation signal produces a continuous spectrum, which can be used to compare the predicted results with the discrete frequency measurements carried out. Because of the nature of the model grid, it was necessary to excite four points on the edges of a cell representing the tunnel floor around the centreline. This will produce a slightly different driving point impedance compared with the measurements, in which the excitation took place at a point.

The model was in two parts, in order to allow for the fact that Building 202 is not aligned with the tunnel (its long axis is at approximately 45° to the tunnel). The first part of the model investigated was a 50 m cube, consisting of the tunnel and the soil, with the tunnel running parallel with the *k* axis.

The second part was similar to the first, with Building 202 added, also with its long axis parallel with the *k* axis. The first part of the model was interfaced to the second part by interpolating the displacement for each of the lowest layer of cells in the second part, after rotating by 45°, at an interface level immediately above the tunnel crown. Each part has vibration absorbing boundaries.

The model was run for 0.9216 s (ie a total of 16384 times in steps of 112.5 μs) and the time history at the tunnel floor, wall and crown, at the three measurement locations, in each case in the *i*, *j*, and *k* directions.

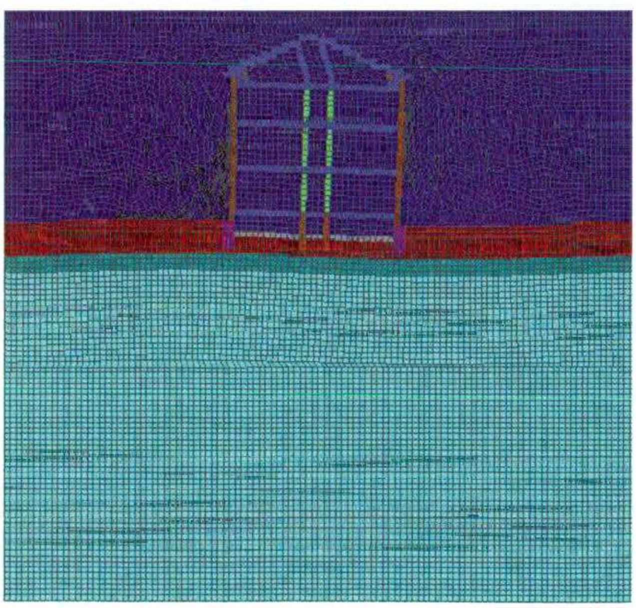


Fig. 3 Instantaneous cross-section through the building model

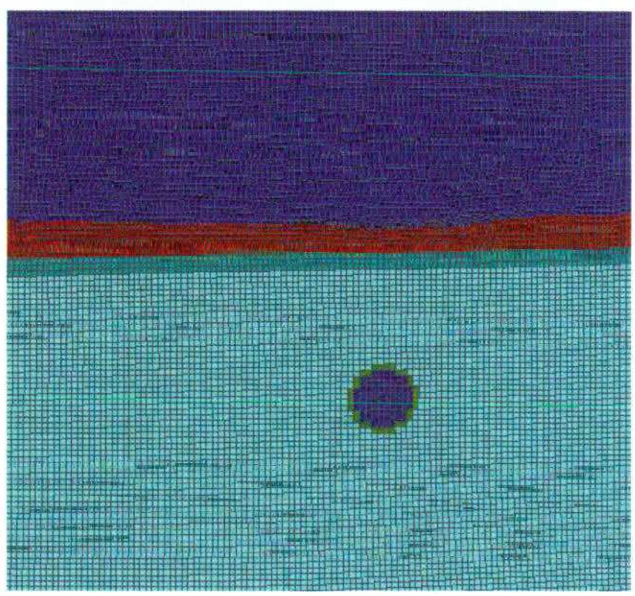


Fig. 4 Instantaneous cross-section through the soil model

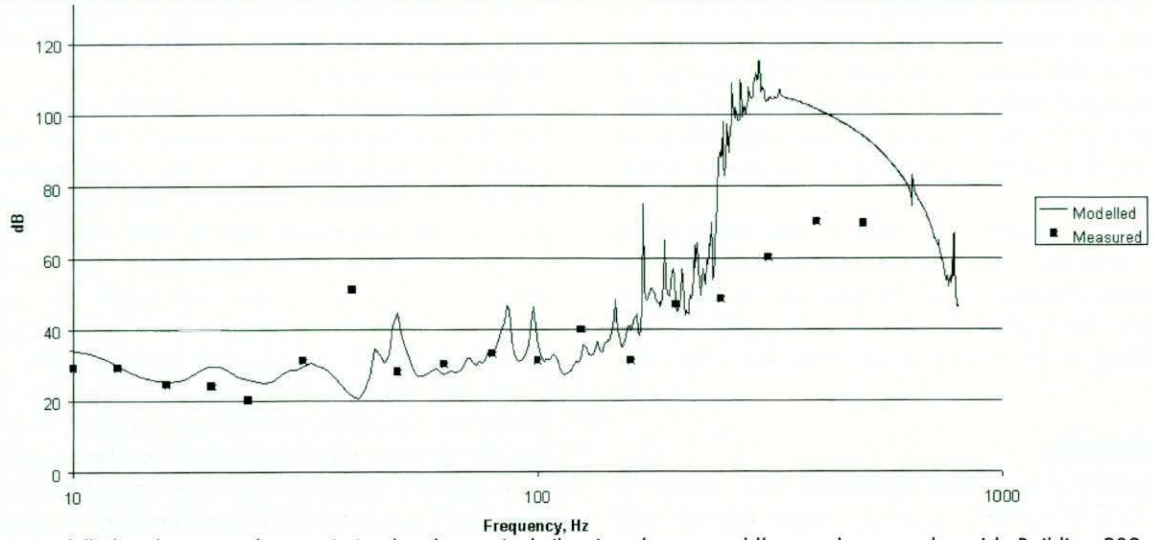


Fig. 5. Modelled and measured transmission loss for vertical vibrations from tunnel floor to the ground outside Building 202

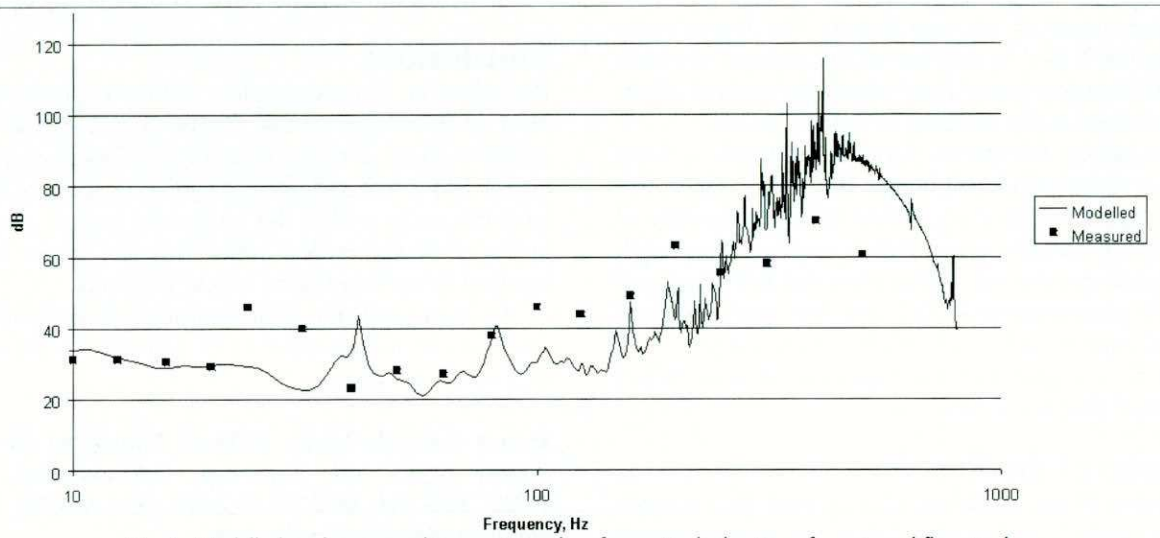


Fig. 6. Modelled and measured transmission loss for vertical vibrations from tunnel floor to the floor in room 25 in the basement of Building 202

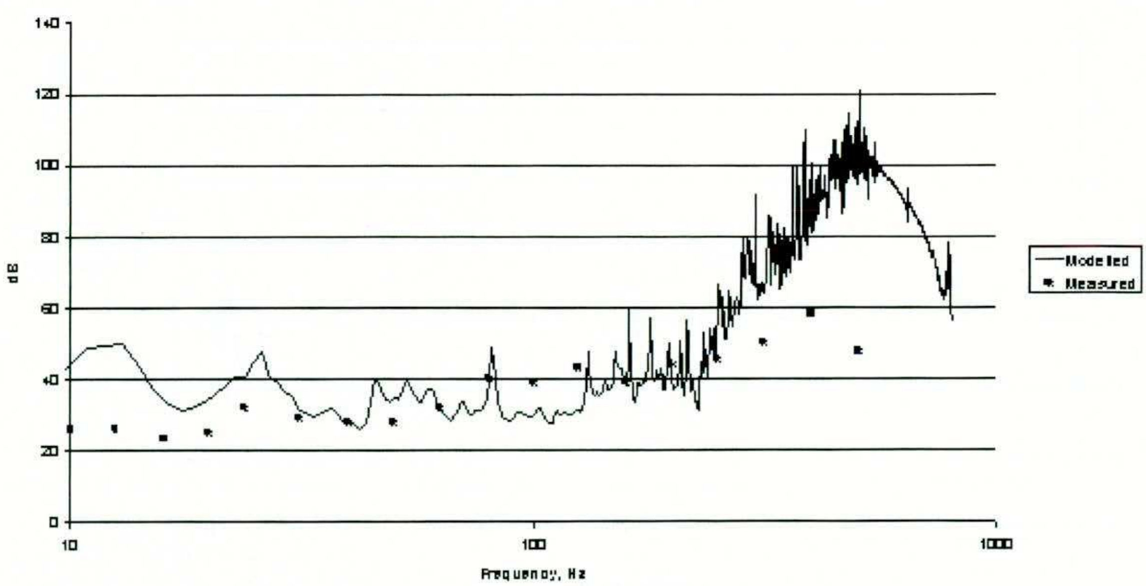


Fig. 7. Modelled and measured transmission loss for vertical vibrations from tunnel floor to the floor in room 3 in the basement of Building 202

The *i* and *j* results for Building 202 were in directions aligned with the building axis, and were subsequently recomputed in the frame of reference of the tunnel, so that *i* is horizontal (lateral to the tunnel axis) and *j* is longitudinal (along the tunnel axis). Screen captures of an instant during the model run (model 1) are shown in Figures 3 and 4.

The model represents the material loss factor of the soil in a manner that produces a constant rate of attenuation per metre distance, at all frequencies, ie by setting the loss factor for a given frequency such as 80 Hz, and then adjusting it in inverse proportion for other frequencies.

Model Results

Three examples of frequency transforms are shown in Figures 5 to 7. The valid frequency range extends only up to 300 Hz. For the measurements in and outside Building 202, the single-frequency results obtained during the measurements are also shown. The transmission loss in Figures 5 to 7 is defined as the vertical vibration velocity level on the tunnel floor minus the vertical vibration velocity level in the building or in the ground.

The frequency transforms have been made without Hanning or other time-weighting. The valid upper frequency is approximately equivalent to the frequency at which a cell dimension is equal to a quarter wavelength in the medium concerned. In this case, for the upper soil layer it is approximately 725 Hz for compressional waves and approximately 320 Hz for shear waves.

Figure 8 is a graph of the measured and modelled impedance of the tunnel floor.

Discussion of the Results

It is a feature of the modelled spectra that they contain significant peaks and troughs. Since the measurements were made at discrete frequencies, small frequency variation in the model spectra can lead to large differences in the discrete values.

For Citytunneln, $^1/_3$ octave bands will be reported. For the verification measurements in the Metro they would be misleading, since the measurements were made using discrete frequencies, and therefore the comparison between measurements and model results must be done using the same bandwidth. The measurements used an infinitely narrow bandwidth (ie single frequency). The model should use the narrowest practicable bandwidth, which in this case is just over 1 Hz.

As the model results show, the spectrum is peaky. Given the inevitable small frequency error in the model, we do not know whether the field excitation was actually on a peak or not, and it is more helpful to show a narrow band spectrum for the model, for comparison with the discrete frequency results of the measurements. Then the influence of frequency error can be easily seen.

Conclusions

The vibration from operating railways usually contains most of its energy in the 50 Hz to 100 Hz range. The model in these circumstances of the Copenhagen Comet tunnel has predicted the transmission loss to the three locations quite well in this frequency region, particularly in the vertical direction which has the largest effect on levels of re-radiated noise inside buildings.

An overprediction of transmission loss would tend to result in an underprediction of vibration levels in buildings, and *vice-versa*.

Rupert Thornely-Taylor FIOA is Managing Director of Rupert Taylor Ltd, Fairwarp, Uckfield, East Sussex TN22 3BG Tel: 01825 712435 Fax: 01825 712542 email: rmtt@ruperttaylor.com ❖

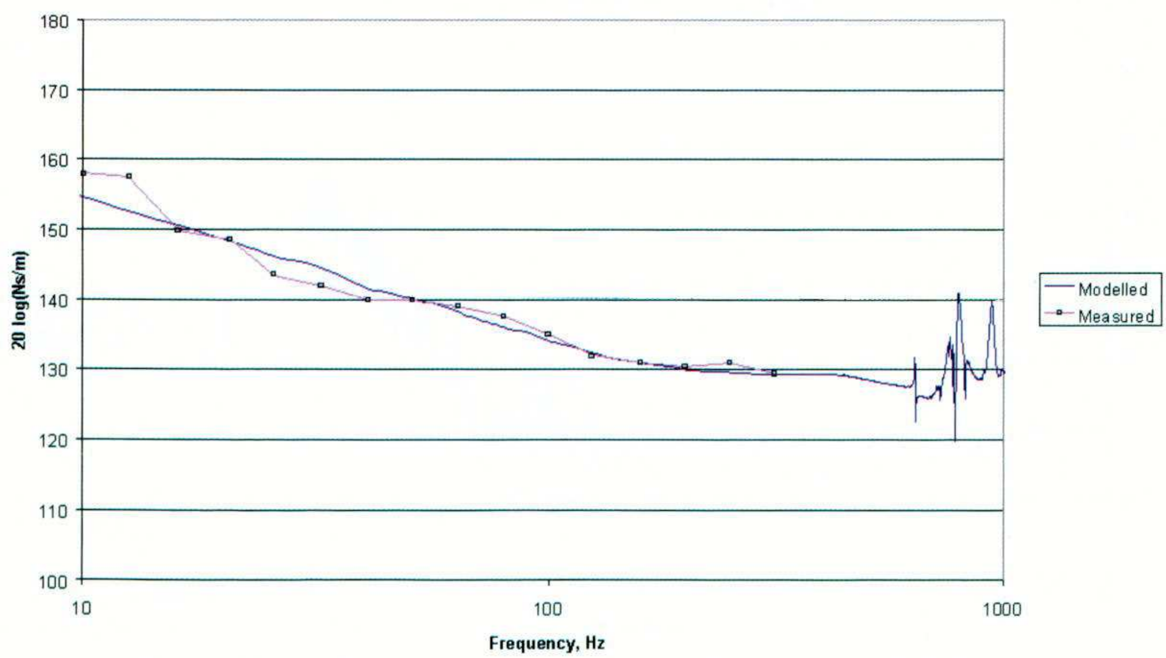


Fig. 8. The measured and modelled impedance of the tunnel floor.

ACOUSTIC APPLICATIONS OF PHASED ARRAY TECHNOLOGY

Charles W Danforth

Introduction

The angular resolution (beam width) of a detector is proportional to the wavelength divided by the aperture diameter. Hence, for longer wavelengths, a different technology must be used for higher resolution. Phased arrays synthesize larger apertures from an array of elements. The basic theory is explained with 2-element arrays and then expanded with an N-element linear array. Beam-steering and nulling are briefly discussed. This technology is widely used in radar and radio-astronomy, however, in this article, a number of acoustic applications of phased arrays including side-scan sonar, passive sea floor detectors, and towed arrays are presented.

Aperture Theory

The High-School Approach

Optical telescopes yield beautiful, crisp images for one basic reason; the wavelength of light they deal with is tiny compared to the diameter of the aperture it must pass through (the main lens/mirror of the device). However, when longer wavelengths are used, resolution becomes increasingly worse. The angular resolution theta is written

$$\theta = \frac{1.22\lambda}{D} \qquad \text{Eq 1}$$

where D is the diameter of the aperture and lambda is the wavelength of light being considered. The 1.22 factor arises from the circular aperture and will be explained shortly.

The Fourier Approach

If we consider a point source represented by a Dirac delta function delta(x,y) and view it through a circular aperture of radius a, f(x,y), the observed pattern will be the square of the Hankel transform of the convolution of the source and aperture functions or

$$f(x,y) = \left(\pi a^2\right)^{-1} \mathrm{rect}\left(\frac{r}{2a}\right)$$

$$h(r) = \left(\pi a^2\right)^{-1} \mathrm{rect}\left(\frac{r}{2a}\right) * \delta(r) \qquad \text{Eq 2}$$

$$\begin{aligned} H(q) &= \mathrm{FT}(h(r)) \\ &= FT\left(\left(\pi a^2\right)^{-1} \mathrm{rect}\left(\frac{r}{2a}\right)\right) * FT(\delta(r)) \\ &= \left(\frac{4}{\pi}\right) \mathrm{jinc}(2aq) = \left(\frac{4}{\pi}\right) \frac{J_1(2\pi a q)}{aq} \end{aligned} \qquad \text{Eq 3}$$

The observed intensity at the detector is then $(H(q))^2$ as represented in Figure 1. The location of the first minimum is ± 0.61 from the axis, half the 1.22 seen in Equation 1. This is the beam width so important for radio astronomy, radar, sonar, and other applications. Notice that the strength of the side lobes decreases with angle.

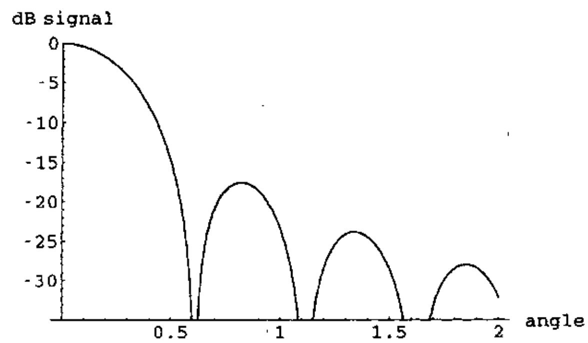


Fig. 1. Aperture function from a uniform pinhole

Obtaining Better Resolution

From Equation 1, we see that optical images with one arc-second resolution/beam width are possible using a 10 cm perfect telescope. However, the same resolution with microwaves would require a telescope 250 m across, something very difficult to engineer. There is a better way to improve resolution.

Phased Arrays

Phased arrays get around the beam width limit by using several small apertures to achieve the same result as one large aperture. The most dramatic example of this may be the Very Long Baseline Interferometer, a series of 25 m radio telescopes spaced all over the earth operating at radio wavelengths. By themselves they sport mediocre beam widths insufficient for scientific studies. But when linked together as an array the size of earth, they have a beam width of milliarcseconds, far better than any current optical instrument.

Before we explore the workings of a phased array, it should be noted that the equations and science here make no distinction between receiving and transmitting devices. For instance, radio telescopes can operate to detect signals from the sky or to broadcast terrestrial messages. While the mechanics of the actual transmitters and receivers may differ, the science here is the same.

2-Element Array

Let us examine the simplest case of a 2-element array.

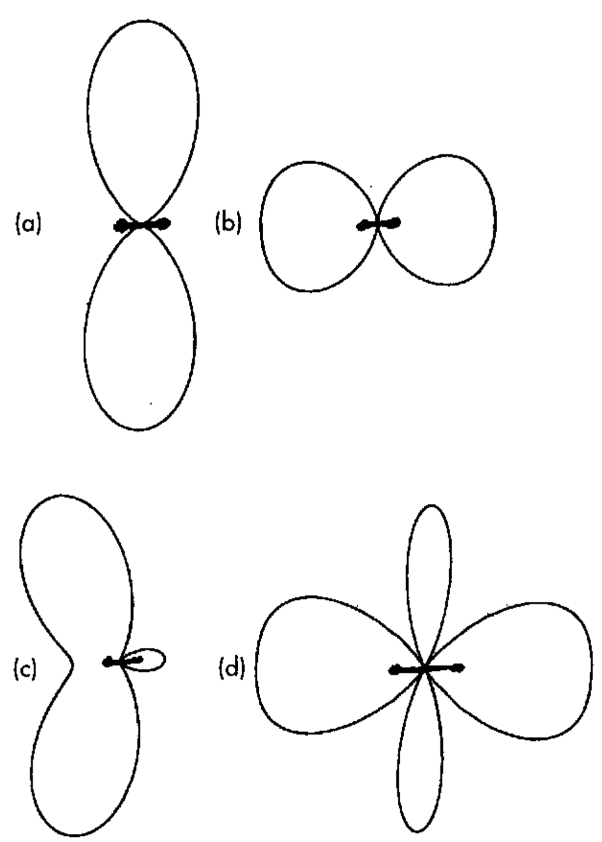


Fig. 2. Power patterns from a two-element array
(a) broadside, (b) endfire, (c) arbitrary phase,
(d) full-wavelength spacing

Assume we are dealing with devices much smaller than the wavelength of interest and that each broadcasts isotropically. Let us also assume that all measurements are made in the far-field. The power radiated at a given angular position is the square of the sum of the fields put out by the two elements.

$$E(\theta) = \exp\left(i\pi\frac{d}{\lambda}\cos\theta + \delta\right) + \exp\left(-i\pi\frac{d}{\lambda}\cos\theta + \delta\right) \qquad \text{Eq 4}$$

$$I(\theta) = E(\theta)^2 = \cos\left(\pi\frac{d}{\lambda}\cos\theta + \delta\right)^2 \qquad \text{Eq 5}$$

where theta is the viewing angle with respect to the array axis, d is the separation between the array elements, and delta is the relative phase of the two emitters. Equation 4 generates an intensity pattern with two lobes, the main lobe and back lobe. By varying the element separation and phase, a number of interesting patterns can be produced (Figure 2). The case where the main lobe projects perpendicular to the line between the elements is known as broadside whereas the on-axis case is referred to as endfire. It should be noted that the beam produced by a linear array (of which two elements is the simplest case) is a conical one. The actual radiation pattern in 3-dimensional space is the solid of rotation.

N-Element Array

Now let us generalize to a linear array of N elements all spaced d/λ apart (Figure 3). One way to quantify this array is as a series of 2-element arrays (1,2) + (1,3) + ... + (1,N) and sum the output (Kraus 1988).

$$E(\theta) = \sum_{n=0}^{N-1} \exp\left(in\frac{2\pi d}{\lambda}\cos\theta + in\delta\right) \qquad \text{Eq 6}$$

With N = 2, Equation 6 reduces to Equation 4. The more elements used, the sharper the main beam and back lobe will be. The usual games may be played with the array spacing.

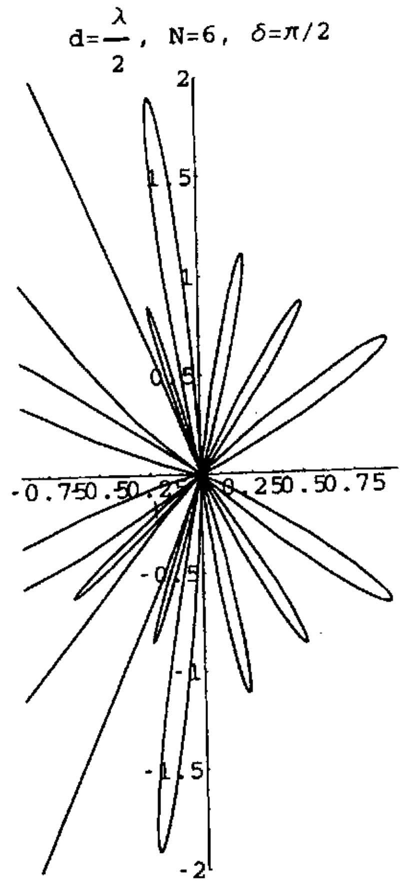


Fig. 3. Power pattern from a 7-element evenly spaced, unshaded array set at phase π/2.

Two-Dimensional Arrays

Extending the above analysis to multi-dimensional arrays is simple in concept. While a linear array produces a narrow fan beam of radiation, a plane array can be created to emit a thin pencil beam.

Arrays of Arbitrary Arrangement

In practice, arrays are often placed in more complicated arrangements. Arrays may be multi-dimensional. Some may feature irregular element separation. The mathematics for arbitrary arrangements becomes complicated quickly and won't be dealt with here. Suffice it to say that with careful numerical modeling, arrays can be designed to fulfill a wide variety of purposes. Upcoming sections will focus on some applications of acoustic arrays.

Aperture Shading

Recalling the Fourier approach used above, we used a 'square' aperture with equal transmission at all points for our calculations. If instead the transmission varied over the surface of the aperture, the Fourier transform, and hence the shape of the beam would be different.

Several outcomes can be obtained by skillful aperture shading. First let us examine an aperture where the transmission is 'shaded' by a Gaussian function.

$$f(x,y) = e^{-\pi r^2} * \mathrm{rect}(r)$$

$$h(r) = e^{-\pi r^2} * \mathrm{rect}(r)$$

$$H(q) = e^{-\pi q^2}\ \mathrm{jinc}(q) \qquad \text{Eq 7}$$

This pattern has about the same beam width as that seen in Equation 2. The one striking difference is that the side lobes are roughly 16 decibels lower. Secondly, let us examine an aperture shaded such that it becomes a narrow annulus.

$$f(x,y) = \mathrm{rect}\left(\frac{r}{2}\right) * \frac{1}{2}\delta(r-1)$$

$$H(q) = \pi J_0(2\pi q) \qquad \text{Eq 8}$$

This main beam is only 2/3 the width of the unshaded aperture but the main lobe is a full 10 decibels lower while the side lobes remain more or less unaffected (Figure 4).

Applying this technique to phased arrays involves simply giving more or less weight to individual elements. In applications where there is plenty of signal and better resolution or lower side lobes are required, shading may be a good option.

Beam Steering

Notice that by changing delta in Equation 6, the main lobe and backlobe both shift one direction or the other (Figures 2, 3). This represents one of the most significant advances over fixed detectors: fast beam steering. With a single dish antenna, to change the direction, motors and mechanical devices must physically turn the hardware. With arrays, the same effect can be obtained by changing the relative phases of the different elements. This results in a lighter structure with a response time limited by electronic rather than mechanical factors.

The downside is that adjusting the phases is nearly always more difficult than rotating the detector. The methods of phase adjustment vary depending on the medium and the frequency being used. Optical devices can be phase-delayed by using mechanical or electronic delay lines or by passing the beams through regions of adjustable index of refraction. Acoustic devices and some lower frequency electromagnetic devices operate at low enough frequencies that each element can be individually driven and the phases adjusted by software.

Noise Cancellation With Nulls

In all previous examples, all array elements have had a consistant phase relationship with their neighbours. However, just as shading offers many options in beamforming, null steering allows sources of noise to be filtered out. The principle of null steering is that the beam is shaped such that a source of noise coincides with a direction of very low power/sensitivity in the beam. The full-blown mechanics of detailed beamforming is beyond the scope of this article, however, a simple example of null steering presented by Lombardo *et al* (1993) may be illustrative.

In their experiment, Lombardo *et al* used an acoustic twin-line towed sonar array. It was composed of two 5 km strings of hydrophones separated by a distance comparable to the wavelength of the energy being studied (the low frequency sounds of submarines, in this case). With the large number of elements in each string, the mainlobe was quite sharp and could be pointed by either steering the towing ship or adjusting the phases. Unfortunately, a source located in the left beam was indistinguishable from that in the right beam.

To solve this left-right ambiguity, the line separation distance was adjusted such that $d = \lambda/4$. Signals arriving from the right would reach the left line a time $+\pi/4$ out of phase with the right line. Signals arriving from the left would reach the left line $-\pi/4$ out of phase with those from the right. When the $-\pi/4$ phase is added to the data from the left line, the mainlobe will be brought into phase, while the backlobe data will sum to zero. There is slight degredation in the mainlobe strength, but the backlobe drops to − 100 dB (Figure 5).

Acoustic Arrays

The basic sonar system is fairly straightforward. A projector is used to emit a pulse of sound energy. The accoustic waves travel outward and rebound to varying degrees from objects in the field. The reflected wave is then picked up by a hydrophone. Modern sonar systems use piezo-electric or magnetostrictive components both to produce the ping and measure the very small pressure variations associated with the return. They can be man-

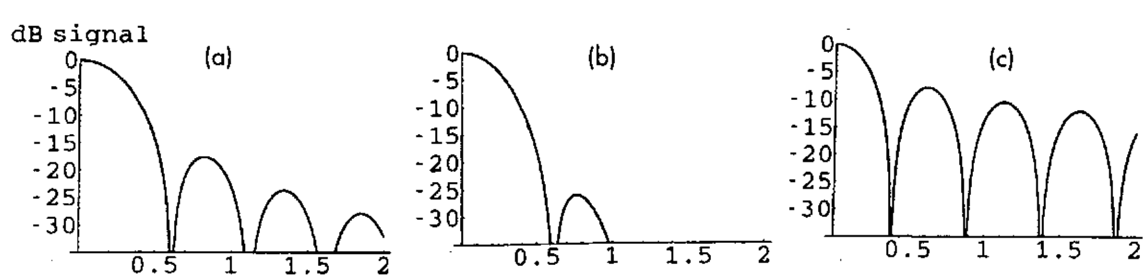


Fig. 4. Power patterns for (a) unshaded aperture, (b) Gaussian shaded aperture, (c) annulus shaded aperture

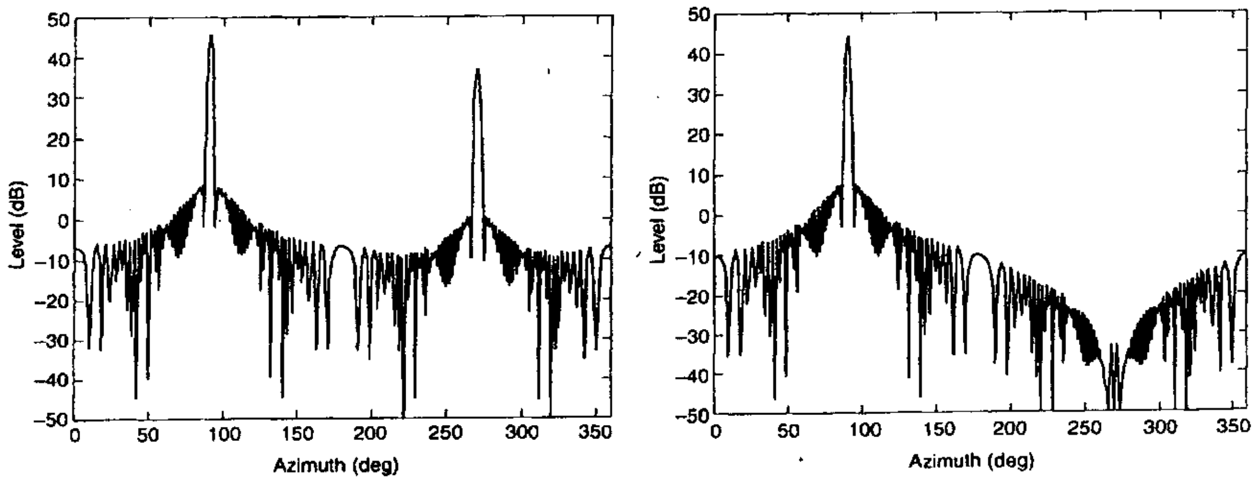


Fig. 5. An example of nulling. Before: main lobe and back lobe are of comparable strength. After: back lobe drops by 100 dB (Lombardo *et al* 1993)

ufactured in many ways, but most are made from relatively cheap ceramic materials (Urick, 1983). This is referred to as active sonar. Passive sonar is simply the receiving half of the active system.

Even from a very simple one-component echo sounder system such as this, a number of data can be found. From the time delay between transmission and detection, the distance to the reflecting object (henceforth the target) can be found given the velocity of sound in the medium (more on this later). The frequency shift of the returned signal can be used to determine the radial velocity of the target. Thirdly, the strength of the returned signal can help guess the properties of the target. Larger cross-sections will yeild larger returns, however, different materials will reflect differently. Orientation of target surfaces also matter.

Speed of Sound

One feature unique to sonar applications is the high variability of sound speed in a medium. In water, the primary arena for sonar, the sound propagation speed is a function of temperature, pressure and chemical composition (in this case, salinity) (Coates, 1989). Thus in a real body of water, the speed profile varies with seasonal changes and currents. A typical deep-water profile is shown in Figure 6.

A consequence of this feature is that sound rays (the path locally normal to the wave fronts) will refract and bend with depth. In the limit where the water depth is small compared to the horizontal distance, grazing rays will reflect and refract. This phenomenon can be exploited in several ways. Rays from a source located in the surface layer (down to perhaps 100 m) will refract downward into the deep water whereupon they will be refocussed upward. These convergence zones form concentric rings around the horizontal location of the source (Lombardo *et al* 1993) (Figure 7a). Hydrophones placed on the surface at these regions will hear a much stronger signal than those placed in the 'dead zones' between.

For sources at greater depth, upward-heading rays may refract downward and never actually reach the surface (Figure 7b). Military submarines utilize this phenomenon by cruising below the thermocline, the depth where the sound speed reaches a minimum, thus hiding their acoustic trace from surface ships. Sub-hunting surface craft counter this by deploying deep-running passive arrays

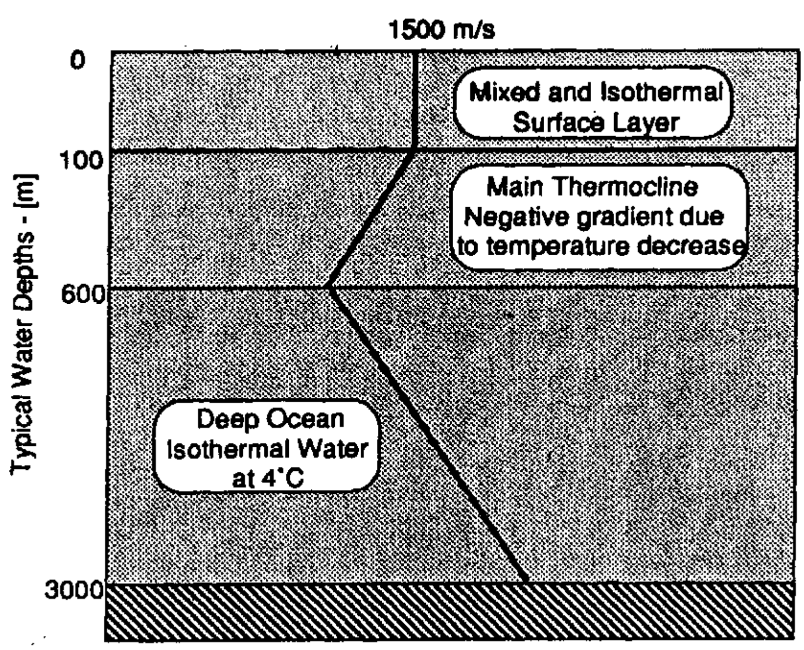


Fig. 6. Sound speed in ocean water (Coates 89)

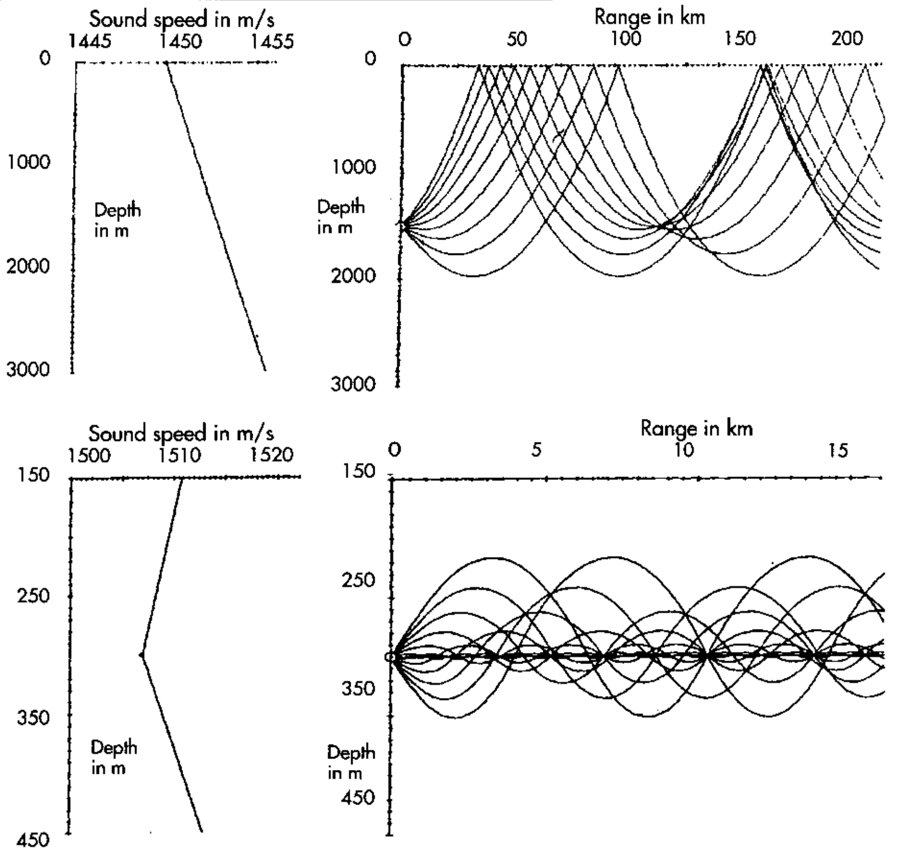


Fig. 7a,b. Ray traces of sound above and below the thermocline (Coates 1989)

(Lombardo *et al* 1993) or by using data from sea-bed arrays (Davis *et al* 1997).

Applications of Acoustic Arrays

Sonar technology and phased array technology can and have been quite successfully merged with very impressive results (Lombardo *et al* 1993; Boyles & Biondo 1993; etc). A few of the multitude of sonar array applications include passive 'listening' arrays for submarine detection. Marine biologists use similar arrays in tracking animal life such as whales. Geologists are able to detect submarine movement of magma and seabed materials. Oceanographers make extensive use of both vertical and horizontal seafloor arrays to study surface waves (Davis *et al* 1997), acoustic propagation velocity in various shallow-water areas (Boyles & Biondo 1993), high-resolution mapping of the ocean floor, and seasonal temperature changes.

Side-Scan Sonar Imaging

Certainly one of the more profitable areas of underwater acoustics, side-scan sonar is one with numerous applications. This technology is frequently used by archeologists, geologists, prospectors and developers, not to mention search-and-rescue teams and practically anyone else who wants to explore the sea-floor. Indeed, high quality side-scan units are commercially available now for a modest price to practically anyone.

The typical side-scan sonar is a short array (typically 50 wavelengths long) encased in a towfish which is a torpedo-shaped object towed underwater behind a ship. It typically operates in the hundreds of kilohertz range providing good azimuthal and range measurements. The high frequency limits it to operating in fairly shallow water typically a hundred meters (Figure 8).

As the towfish is pulled through the water, it emits a sonar pulse in a fan-pattern covering a line of seabed. The strength of the return plotted against the delay can then be interpreted as a the illumination of a source as a function of distance. Subsequent pulses give the next lines in what builds to a 3-dimensional image. While this data seems very arcane, it is a representation the human brain is extremely good at interpretting. Strong signals belie something strongly 'illuminated' while areas of little or no signal are 'shadows'. Figure 9 shows a particularly good example of these images.

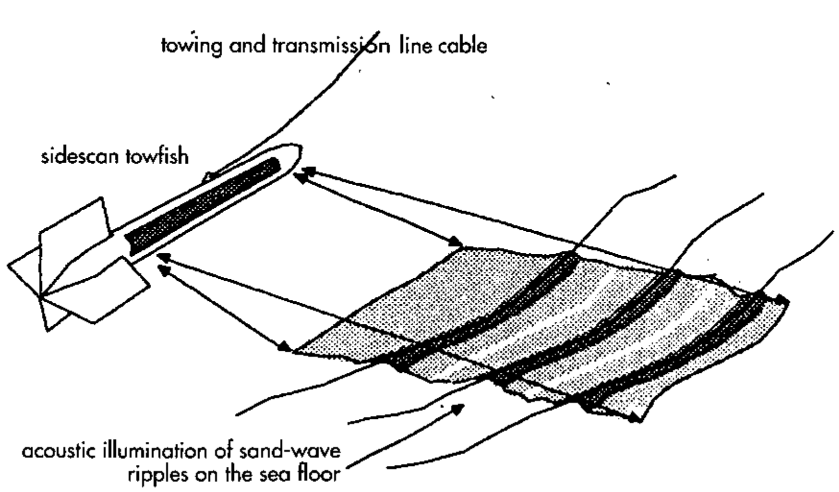


Fig. 8. Side-scan sonar system. The towfish is typically a meter or so long (Coates 1989)

Passive Listening Arrays

The world's naval industries are constantly engaged in a race to make their submarines stealthier and develop better methods of detecting enemy vessels.

Davis *et al* (1997) advanced the cause by using a passive, two-dimensional array placed on the ocean floor, connected by fiberoptics to a central telemetry station. This device successfully measured ambient sound in the frequency range 0.01 to 6000 Hz and detected passing ships. Similar arrays feature the ability to monitor the height of surface waves (the height

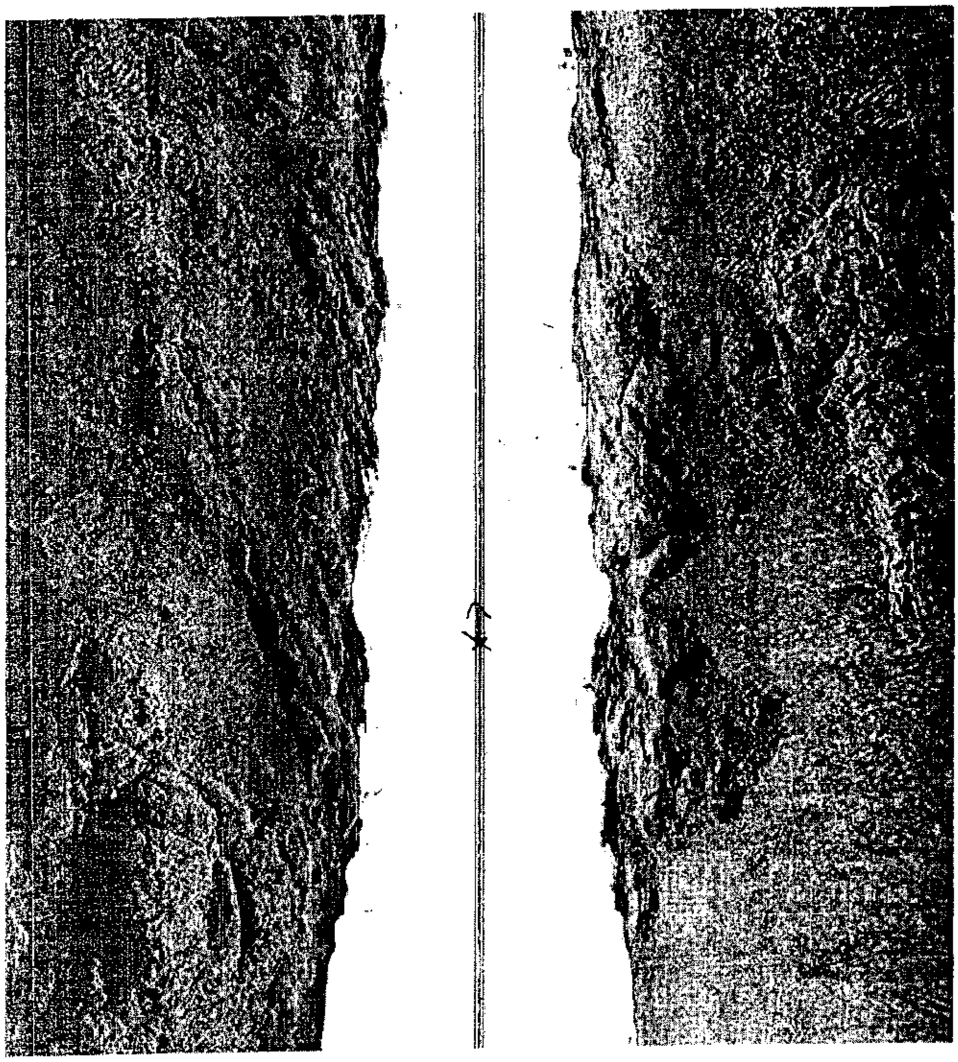


Fig. 9. Side-scan sonar image of seafloor geology (KleinSonar,1997)

variation of the water causes pressure fluctuations in the depths) and to monitor local marine life.

A different approach to the same challenge was developed by Lombardo *et al* (1993) with their twin-line towed array. This 5 km twin-line array was towed behind a ship in the deep waters south of Hawaii and using careful beamsteering and nulling (Figure 5), they were able to scan the acoustic environment and resolve individual surface ships many hundreds of kilometers distant.

Air-Based Acoustic Arrays

It is no surprise that practically all acoustic arrays operate underwater. There are several reasons for this. Gasses are not good conductors of acoustic energy unlike denser media. The temperature variations in the air are more extreme and faster varying than those in water leading to less well understood refraction systems. Finally, other sensing systems, such as radar and simple visual observation, can operate in air while they are hampered in marine environments.

An interesting non-marine application of passive accoustic arrays is found in a series of military listening posts scattered across the American Southwest (Hoffman 1996). Originally intended to detect the extremely low freqency acoustic (infrasound) signatures of atomic weapon tests, it has proven useful in tracking large meteorites entering Earth's atmosphere.

Acknowledgments

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Charles W Danforth is in the Department of Physics and Astronomy at Johns Hopkins University, Maryland, USA

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ACOUSTICS AND NEW STYLES OF WORSHIP

Robin Mark MIOA

Introduction

New styles of church worship have been gaining popularity in recent years [1]. These generally involve firstly an increased and more varied degree of musical participation by the congregation and secondly a greater diversity in the uses to which church buildings are put. These factors carry implications for acoustical design. One issue to taken into account is the fact that the significant sources of sound may no longer be taken as located only with the minister or priest conducting the service. This gives rise to interesting design problems both in respect of new buildings but, perhaps more significantly, in buildings designed and constructed in earlier times when the perceived function of the spaces and the type of sounds created, was more limited. New churches are in many cases perceived as quintessentially multi-purpose spaces; more and more existing churches have moved in that direction.

Evidence of a widening awareness of relevant acoustic issues emerged at a large (2,500 delegates) conference on church music and worship [2] run by one of the major Christian music publishing companies in the UK. As a conference speaker I was asked to conduct a small workshop on 'The Acoustics of Churches' for delegates and was surprised at the intense interest shown in the topic.

Changing Patterns of Worship

The following is a resumé of the main ways in which changing patterns of church worship impact upon the acoustic requirements of the spaces.

Music

A modern service will have generally dispensed with the pipe or electric air driven organ, or have limited its use, and replaced the musical accompaniment with a 'worship band'. This will often include drum kits and percussion, electronic keyboards, electro-acoustic and electric guitars, an assortment of vocalists and a range of acoustic and classical instruments generally comprising whatever skills are available in the church at that time. To accommodate this alternative accompaniment there will almost certainly be a PA system desired or provided, which, for a moderate sized fellowship, can be of the order of 3 – 5 kW [3]. The church may have a choir.

Congregational Participation

The involvement of the congregation with its collected singing of songs of various forms and types – from ancient and modern hymnody with fixed steady rhythm and pattern through rock music, brit-pop, and Caribbean influences to Celtic song style – is critical to the ambience of the modern church. Such elements of the services will often extend to 30 or 40 minutes of continual music and singing. There is a need to enhance the 'ensemble' of the acoustics in the congregation, whilst preserving the clarity of the musicians' source sound. The congregation will need the audible sense of corporate raised voices surrounding them as individuals whilst clearly hearing the musicians leading from the front. So, within the body of the church, we require a perhaps more 'chorale' environment.

Preaching

One further element is the role of the speaker. Many present-day church speakers are drawn from lay-workers who may have had little formal instruction in public speaking. The traditional church seminaries and colleges formerly would have encouraged and instructed on diction, pause, clarity and pronunciation techniques to accommodate some of the long reverberations common to the traditional church but this seems no longer to be the case. Thus a quality conference environment with low reverberation is required when this portion of the service is reached.

In our experience, of the two factors that primarily determine speech intelligibility in a space, namely background noise level and reverberation time, the former has generally been sufficiently low as to justify an emphasis on adjustments to the latter.

Other Issues Impacting on Acoustic Design

There are a number of points that may need to be taken into consideration and these are listed below.

The receiver and the source are co-located in some usage patterns, the design implication being that the singer in the congregation requires sufficient acoustic response from the room to feel part of the worship experience. A parallel issue is that instrumentalists need adequate audibility of the sounds produced by themselves and others.

The performers, generally good amateurs, need a strong degree of audibility and sense of envelopment.

The congregation will certainly need the necessary clarity to enable them to participate in the singing although this would not normally stretch as far as a desire for concert hall experience of envelopment, intimacy or even reverberant response. Once singing, the congregation's individual members need to feel part of the corporate expression but the performers at the front need not necessarily be assailed by the congregation's sound.

Finally for speech during the sermon, the clarity of the single voice has to be important.

There are also aspects of design that can be traced to the fact that it is rarely possible nowadays to preserve and maintain a building purely for worship for a short time each week and much diversification of use is in evidence. Whilst a normal multi-use facility may be restructured, reset and even possibly have its reverberation time altered by movable panels and surface treatments, the church must still be able to perform its multiple functions inside the 1 or 2 hour timespan of its normal service and this appears to be a major cause of the problems.

The Lessons of Experience

Our experience has shown, unsurprisingly perhaps, that it is almost impossible to satisfy all the needs of each user of this space and we are constantly reviewing our experience and varying our design guidelines. Regarding the acquisition of experience we are fortunate that at present our role mainly involves remedial tasks and so the effects of the various design changes can be noted.

In view of potential conflicts among the requirements raised above, it is important to embark upon a design project with a clear idea of priorities, that is to say making decisions about which aspects of church life it is most important to direct the basic acoustic design towards. In many situations this will probably be focused on congregational participation and the effect of this leads to a tendency to push the desired RT upwards to 3 or 3.5 s.

We have found that an RT in the medium frequencies of about 2 s, for example, such as would be appropriate for concert hall usage, is often a little low and results in a somewhat unresponsive and unsatisfactory environment (assuming for the purpose of this article that medium frequency response is an appropriate design guide). A reverberation time of 3 to 3.5 seconds would be excessive for PA systems and probably cause some difficulty for the rapid speech of the sermon deliverer. As a result of this our current thoughts are something of the order of 2.3 – 2.5 s when occupied as a good compromise. Michael Barron [4] refers to the optimum area for a choir of 0.5 m^2 which, coupled with the acceptable reverberation time, would give an appropriate ensemble. This quantity is the first consideration in designing for a choir who may be performing for an audience of up to 2500 listeners. Although the end purpose is different, this basic design tool may be sufficient to generate the proper room or 'congregational zone' volume. However the effects on speech and band PA need to be taken into account.

With regard to the acoustic comfort of the band, it is relevant that the band is almost always 'miked' to the PA system, even with orchestral instruments. This allows the use of fold-back PA loudspeakers to generate the necessary audibility for the individual instruments.

The musicians would probably benefit from a zone around them that is treated with a measure of local absorption to control the degree to which reflections from fold-back loudspeakers reach the congregation; this makes it a little like the dead end/live end studio technique for recording spaces. This approach actually enhances instrument clarity. We would probably treat locations where acoustic instruments may need some strong reflections, or where strong source levels need to be reduced, with screens. It is a common sight in modern churches to see the drummer hidden behind studio style perspex screens in order that his or her output may be adequately controlled.

Finally for speech during the sermon, the clarity of the single voice would seem to demand a lower room reverberation, and, for the larger building a short distance from speaker to receiver and an absence of any serious echo effects or long sound path lengths. Interestingly enough, some sense of echo in churches does not seem to cause the same problems as inadequacies in the balance between volume and reverberation. An apparent solution, really as a compromise between the speaking ability of the orator versus the room acoustic, is to design the PA system to use a smaller range of loudspeakers distributing lower power sound direct to the congregation. An acoustic design alternative may be to construct the church in a very wide fan shape, reducing the distances between source and receiver whilst maintaining the room volume essential for the corporate worship. This would be unsatisfactory for a performance space but, regarding the hierarchy of needs for a church, would seem to work moderately well.

The Metropolitan Church (Figure 1), a design based on some North American examples, applied this theory with moderately good results even though the very large congregation size (3,500 seats) introduced a number of problems. We found that the more obscure acoustic flaws such as flutter echoes and standing waves are not an issue for most spaces if the preferred desirability of reasonable quality band sound, good interactive community singing and moderate speaker clarity can be obtained.

The shape of church spaces is another ingredient in the acoustic design process. Choices in the shape of churches has traditionally had much to do with spiritual criteria and glorifying a deity rather than any acoustic requirement. The major task facing the church designer now is one of trying to use the shape of the church to harmonise provision for the various possible uses. Architects, free from the need to stick with the traditional shapes

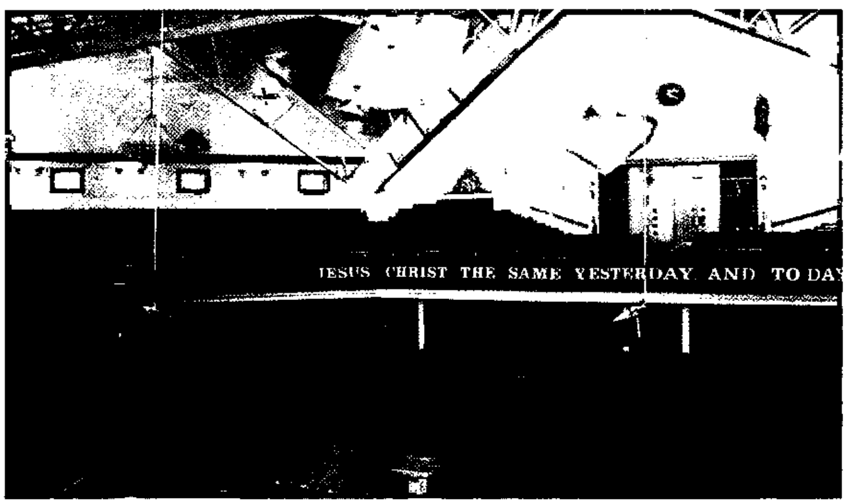

Fig. 1. Metropolitan Church, Belfast

Frequency band (Hz)	63	125	250	500	1k	2k	4k	8k
Parish Church Hall	3.0	3.0	3.0	3.1	2.9	2.5	2.1	1.8
Downpatrick Cathedral	3.3	3.1	3.0	3.0	3.0	2.9	2.8	2.5

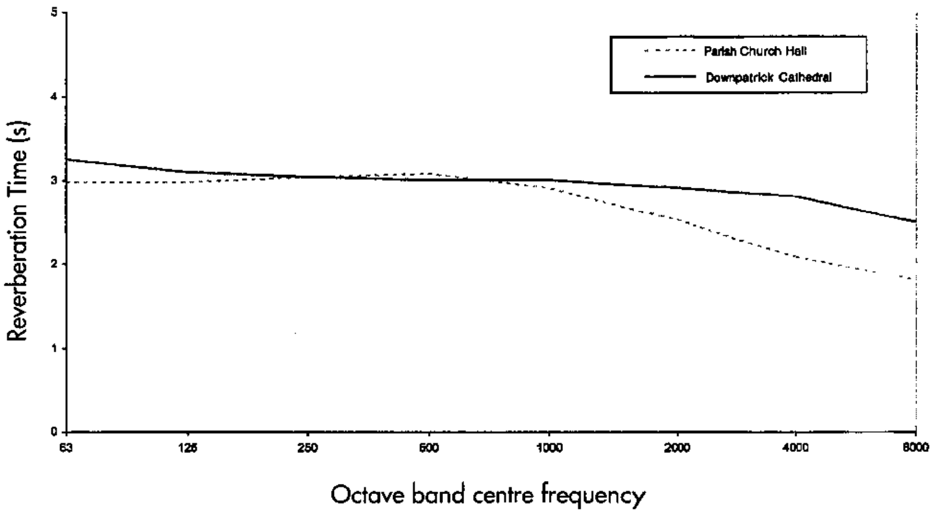

Fig. 2. Comparison of the Reverberation Times – New and Old Church

and requirements of previous generations, are experimenting and constructing shapes which to the acoustical consultant would look rather problematical. Two recent commissions have found this consultancy struggling with the implications of a circular and elliptical shaped church sanctuary. The circular church [5], now complete, has a beautiful ethereal acoustic which, for private prayers and normal daily mass, creates a striking ambience. However the speech reinforcement system is finding it difficult to cope with the sermons delivered by the priest and some parishioners have expressed their dissatisfaction. The existing PA system was installed as a separate part of the contract and the location, type and directivity of the selected loudspeakers are not satisfactory. It is expected that the problems will be addressed by a redesign of this system. So, in essence, we have a shape which for other acoustic purposes would have been rejected at the early design stage, presenting an acceptable environment for this particular use.

A previous refurbishment commission involved trying to deal with the focusing effect of two overhead plasterboard 'domes' designed by an interior designer using the floor as the focal point of the reflecting surfaces. One of these was centred directly above the altar where the parish priest suffered the effects of this focusing as he ministered. The congregation, unaware of his acoustic discomfort, insisted on retaining the features as they appreciated the decorative effect which altered the otherwise bland look of a rectangular building. The priest's 'zone' was eventually treated to minimise reflections and a satisfactory outcome resulted.

It should not be taken for granted that any church shape can be made acceptable, but simply that once the hierarchy of design requirements changes, then the critical acoustic design factors will change also.

Additional Examples

Two recent projects of this consultancy illuminate the sort of problems encountered.

Firstly there is the historical St Patrick's Church of Ireland in Downpatrick, Co Down, the ecclesiastical site of an ancient Christian settlement and mission church and the site of St Patrick's grave. Problems arose with the clarity of the loudspeaker system installed in the church and the general acoustic ambience which was deemed too 'lively'. In fact the reverberation time was of the order of 3.5 seconds (see Figure 2). There was a choice between, on the one hand, ruining the internal architecture through the incorporation of various absorbent surface treatments and, on the other, convincing the church committee that there were other possible means by which the problem could be addressed. As evidence of the importance placed on potential improvements, there was a general inclination to accept whatever changes to the internal fabric as were found necessary; in the event it happily proved possible to retain the character of the church.

The second example is a church building of recently design and construction for which the reverberation plot is also shown in Figure 2. Since for many hundreds of years a cathedral was deemed an appropriate space in which to conduct worship (and incidentally is still a fine acoustic space for chorale pieces) it was not unrea-

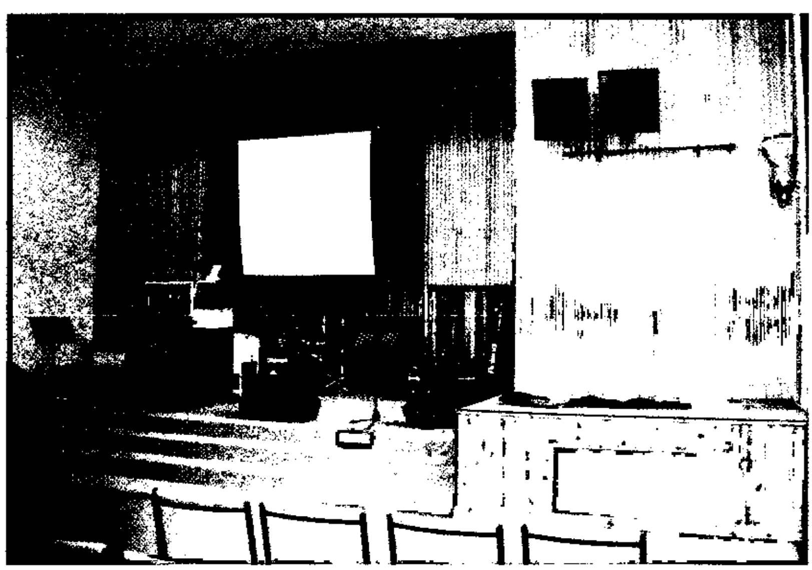

Fig. 3. Christian Fellowship Church, Belfast

sonable to conclude that the new church would present an appropriate acoustic space. However this is an example of a space where the acoustic qualities have been found with time to be unsuitable for for its dominant use.

Figure 3 shows the interior of Christian Fellowship Church in Belfast. The two raised platforms on either side of the main band area and lectern house two 1 kW subbass loudspeakers of dimensions around 2m x 1m x 1m depth. An L-Acoustic system having replaced a cluster system by Electro-Voice which was deemed unsatisfactory in terms of directivity, a Soundcraft 24 desk controls the system with a Behringer delay arrangement within the amplifiers.

Another major challenge was for a church with a low ceiling [6] which, on refurbishment, gave a volume of around 4 m^3 per person. The church had had a history of acoustical problems which advisers had attempted to solve by absorbent panelling and ceilings. As a consequence the music band was clearly audible but the congregation were unhappy with the 'feel' of the space. This also exposed some problems associated with echoes or 'long delayed reflections [7].

Clearly audible echoes generated by the few hard surfaces remaining disturbed some of the speakers. The solution, which appears to have been well received, was to enhance the reflections of surfaces around the congregation to increase the reverberation, whilst deadening the area around the performers. The performers' space, whilst not a stage or orchestral platform as such, was designed as a small highly absorbent performance zone where sound reinforcement fold-back speakers were relied upon to give the necessary ensemble. The rear surfaces of the Church (glazed) had the facility for curtains to be drawn, thus keeping with the character of a worship space and avoiding echo effects. This method combined with the careful design of the PA system, seems to have created a reasonable environment

This problem of balancing multiple needs also arose in the new church construction of a large modern facility, with which we were not initially directly involved. In a space of some 20,000 m^3, the PA consultant requested a reverberation time of under one second in order to provide the optimum performance from the sound system. The acoustic consultant wished to pursue longer 'singer friendly' reverberations. A difficult compromise was eventually reached.

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Robin Mark MIOA is Principal Consultant with F R Mark & Associates, 346a Beersbridge Road, Belfast BT5 5DY ❖

OFFSHORE ACOUSTICS AT ACOUSTIC TECHNOLOGY LIMITED

Chris Saunders and Dick Wood FIOA

Two important commodities which are obtained from the ocean are energy (in the form of oil and gas) and food (fish). The winning of both of these commodities has acoustical implications. Acoustic Technology Limited (ATL) has been active in the offshore oil and gas industry since its early developments in the North Sea in the 1970s. More recently ATL has built up considerable expertise in helping to develop quiet ocean-going vessels for use in fishery research. The following article gives two examples of the type of projects undertaken by ATL in these areas and some of the tools used for problem solving.

Offshore Platform – Burner Noise Investigation

ATL was contracted by a major offshore operator to undertake noise management activities on one of its installations, which included the prediction of personal noise exposure based on measured noise level data and work pattern information. The installation involved was a satellite platform which essentially means that it normally operates unmanned. However, satellite crews shuttle to the platform on a rotational basis, to carry out essential repairs and continuous maintenance. During the noise survey of the platform, it became apparent that the TEG (tri-ethylene glycol) system was likely to be a significant contributor to the personal noise exposure calculations. Noise levels locally to the unit were in excess of 112 dBA and due to the confined nature of the platform, the TEG unit was the dominant source of noise over the whole platform. Given the tonal nature of the TEG unit (high annoyance factor) and high noise levels, ATL advised the operator of options for noise source reduction.

TEG is used by the oil and gas industry to remove unwanted moisture from well gas. In basic terms the well gas and TEG are mixed together and the TEG absorbs unwanted moisture in the gas, the TEG is then passed into a reboiler system (including burner) where the TEG is heated and the water separates from the TEG and evaporates. The TEG can then be re-used to dry further gas.

Noise measurements were taken around the TEG burner/boiler unit under various operating conditions (burner fuel gas to air ratios). The results indicated that when fuel gas valve settings were open less than 15%, overall noise levels around the unit were approximately 85 dBA. Above the 15% valve setting, noise levels increased rapidly to approximately 112 dBA at a 20% valve setting and stayed at this level until the fuel gas valve was fully opened. The majority of the noise was being radiated from the burner exhaust ducting and in-duct narrow band measurements indicated significant tonal contributions at 130 Hz, 190 Hz, 260 Hz and 380 Hz. These are presented in Figure 1.

Although offshore measurements had indicated that the majority of noise was radiated from the exhaust duct, the source of the tonal excitation was uncertain. Therefore, finite element (FE) modelling of the TEG package burner system (which was considered the most likely suspect) was undertaken by ATL using the FE package ANSYS. Detailed drawings of the system and gas properties were obtained from the operator and the burner manufacturer, such that the FE model from the air intake to the exhaust gas openings could be modelled. The finite element model of the system is presented in Figure 2.

A modal analysis of the finite element model was carried out over the frequency ranges of concern, primarily 130 Hz, 190 Hz, 260 Hz and 380 Hz. The results obtained predicted modal responses of the system at each of these frequencies indicating that system acoustic resonances were the most likely cause of the excessive tones. Figure 3 shows the predicted acoustic resonance of the 20" and 6" x 6" firetubes at 130 Hz.

Given that ANSYS had shown that the system resonances were due to planar acoustic propagation and not due to system cross modes, it was possible to analyse the TEG burner system using the fluid simulation package PULS. Since the resonances predicted by ANSYS

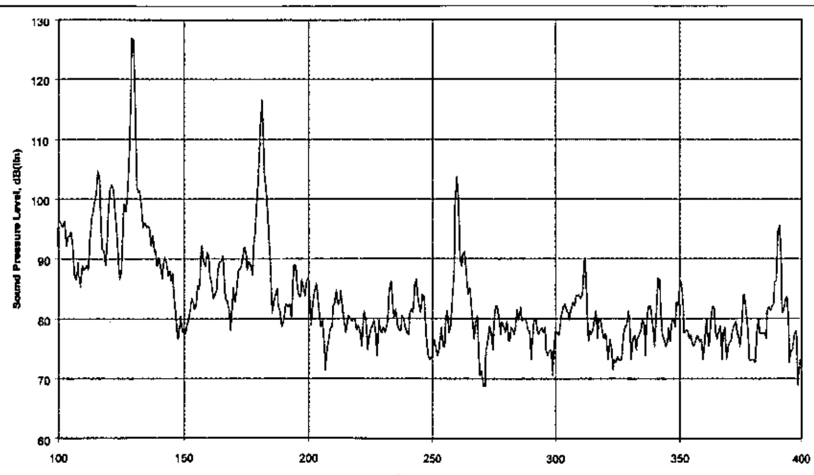

Fig. 1. Measured Sound Pressure Level, Inside TEG Burner Exhaust Ducting

Fig. 2. Plot of ANSYS Model Showing Air Intake / Exhaust Ducting, Exhaust Plenum Chamber, Main 20" Firetubes and 6x6" Exhaust Firetubes.

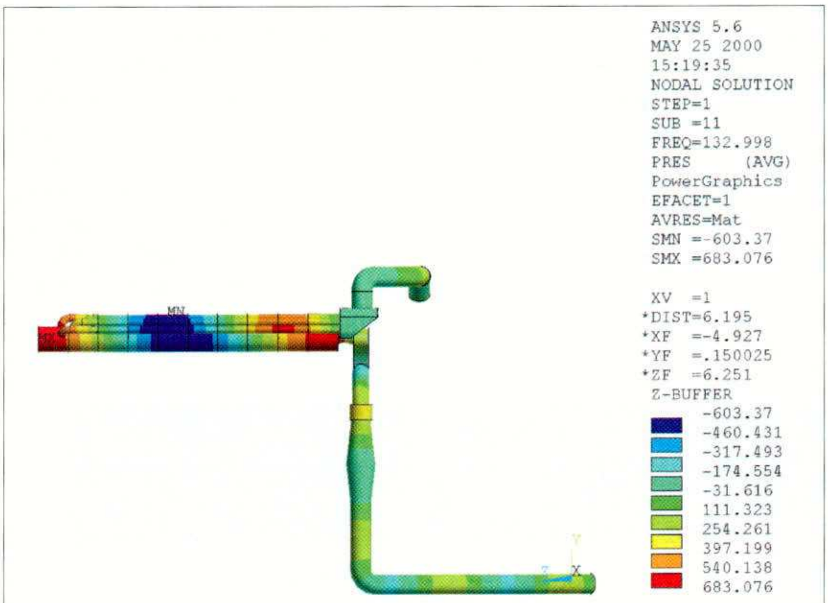

Fig. 3. Plot of predicted ANSYS results at 133Hz (Resonance of Combustion Chamber)

related to downstream of the burner jet, the PULS model did not include the air intake system. Figure 4 shows the PULS model used in the analysis.

PULS predicted the acoustical responses of the system, which were indicative of the resonances predicted by ANSYS, however PULS also enabled the prediction of in-duct pressure levels. Therefore, for each acoustic resonance, peak pressure levels were noted in the system such that they could be compared to the post-modified pressure levels to determine likely reductions in sound pressure level.

Figures 5a-5d show the predicted results of PULS at the critical frequencies.

It had been determined that the TEG burner system's acoustical resonances coincided with the dominant tones measured offshore. It was still unclear, however, as to why the system should generate high noise levels at these frequencies. It was hypothesised that the mechanism was as follows. Upon ignition of the burner flame, combustion noise, which essentially is broadband in nature, starts to drive the acoustic resonances of the burner system. This results in small pressure pulsations that in turn drive the flame source and cause the flame to pulsate at the TEG burner system resonant frequencies. This in turn generates a feedback mechanism where the flame, which is pulsating at the frequencies of concern, starts to drive the system resonances harder.

The question therefore was how best to disrupt the system resonances and stop the flame pulsation and acoustic resonances from coupling. The solution was to insert four orifice plates (one for each frequency) into the 20" firetube at locations corresponding to their resonance pressure minima. This, in effect, introduces discrete impedance changes along the propagation path to disrupt the plane wave propagation. The level of reduction achievable is dependant on the size of the orifice plate used as the larger the change in cross sectional area, the greater the change in acoustic impedance. However, in practice the size of orifice plate allowable is dependent on the existing system arrangement and allowable pressure drops. Based upon these limitations, ATL predicted a reduction in average overall sound pressure level around the unit of 17–20 dBA; further reductions up to 40 dBA were predicted as being possible with the use of smaller bore orifice plates.

Preliminary results from offshore suggest that the modifications have been successful acoustically, with full commissioning due in the near future after issues relating to the thermal impact of installing the baffle plates have been resolved.

The next section describes a project where very detailed check-out measurements have been undertaken, and where failure to comply with the required noise limits would have incurred large financial penalties for ATL's client.

Fisheries Research Vessel FRV 'Scotia'

This fisheries research vessel (FRV) was developed for the Scottish Office Agriculture and Fisheries Department to undertake survey and sample trawling work. ATL was contracted by the successful shipyard to carry out all necessary project work relating to noise and vibration from design specifications through to vessel sea trials. The work was carried out from mid 1996 to early in 1998 when the noise ranging trials were conducted and the vessel accepted. The vessel is illustrated in Figure 6.

Part of the contractual obligations on the shipyard was an extremely onerous requirement on underwater

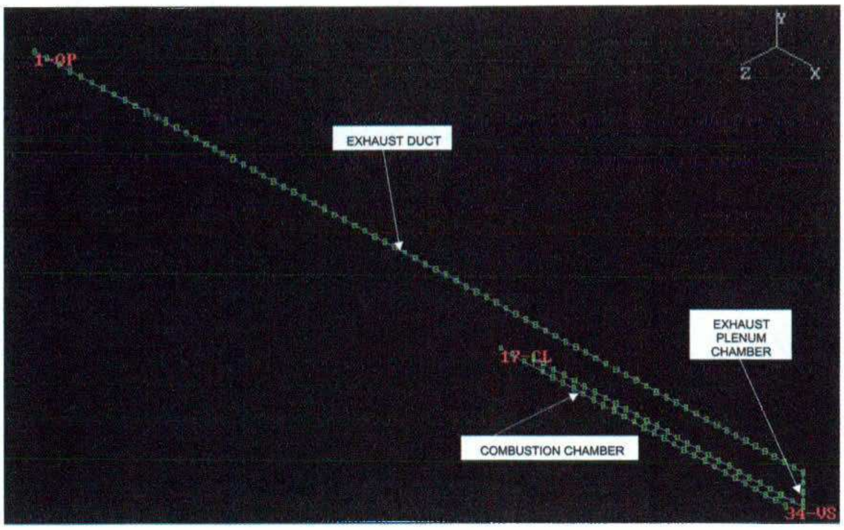

Fig. 4. Plot of the PULS model showing boundary conditions (VS = velocity source, CL = closed end, OP = open end)

radiated noise (URN). This required that the vessel conform to a URN signature from 1 Hz to 100 kHz with the added complication that if there was an excess of more than 3 dB, anywhere within the spectrum, then the vessel reject clause would apply. It was therefore imperative that the shipyard should address this issue with great care as failure to do so would result in very severe commercial penalties.

Before moving onto the means of achieving these requirements, it is worthwhile discussing in outline why there are such stringent limits. The URN limits are based on two different criteria over different parts of the frequency range. At low frequencies (up to 1 or 2 kHz) there is a fish 'hearing' issue, whilst at high frequency (above about 10 kHz) there is an onboard acoustic equipment issue.

It is evident from research work over many decades that fish can detect noise from shipping over long distances when ambient levels are low, but are unlikely to react and move away unless the noise level is quite high. There is substantial evidence to support the statement that fish display avoidance when noise levels exceed their threshold of hearing by more than 30 dB. Clearly such an effect will distort fish stock evaluations whether carried by sample trawling or by acoustic equipment. It is therefore very important to minimise 'fish scaring' around vessels that are researching fish in their natural environment.

The sensitivity of fish depends to a large extent on the species involved and their size, and is a complex field. A summary of the fish hearing is set forward by the International Council for the Exploration of the Sea (ICES) in their report no. 209. This document not only summarises fish hearing but also discusses onboard acoustic systems and sets forward guideline URN limits for research vessels based on the above, as well as practical considerations. This culminated in URN limits for fisheries research vessels being set such that fish scaring does not occur

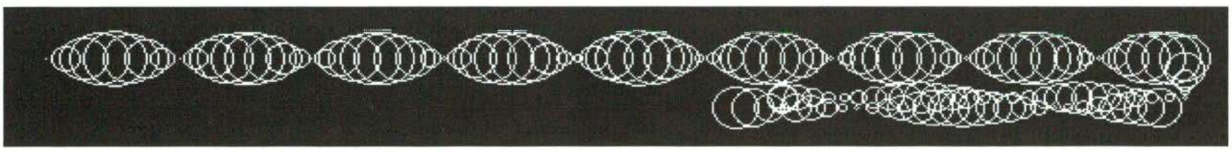

Fig. 5a. Plot of Predicted PULS Results at 132Hz (Resonance of Combustion Chamber & Exhaust Ducting)

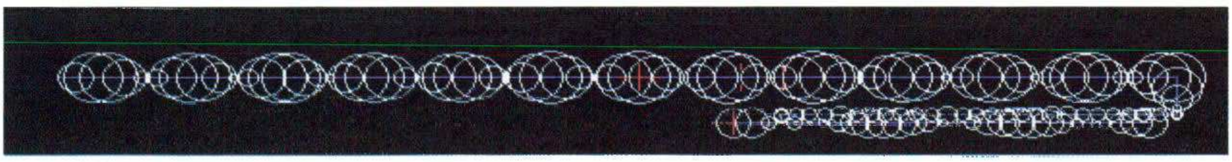

Fig. 5b. Plot of Predicted PULS Results at 191Hz (Resonance of Combustion Chamber & Exhaust Ducting)

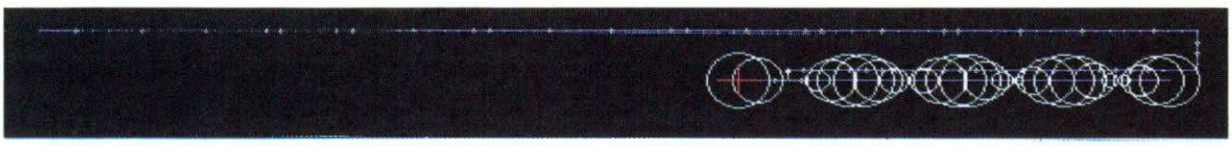

Fig. 5c. Fig. 5c. Plot of Predicted PULS Results at 260Hz (Resonance of Combustion Chamber)

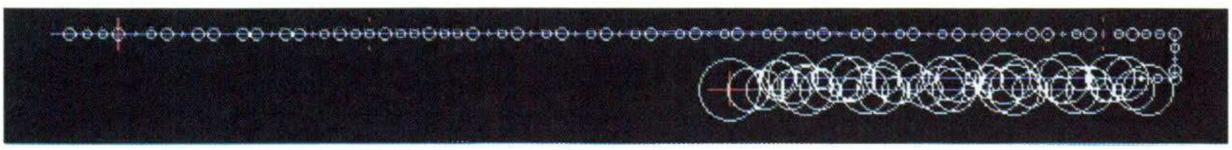

Fig. 5d. Plot of Predicted PULS Results at 380Hz (Resonance of Combustion Chamber)

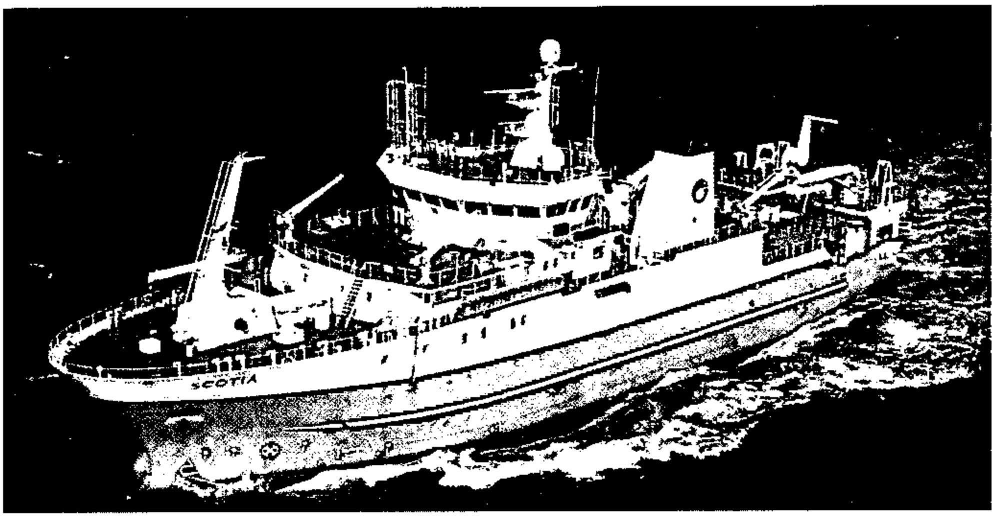

Fig. 6. Illustration of FRV "Scotia" whilst in service (1998)

within 10–20 m of the vessel.

Acoustic echo sounders used for evaluating fish stocks are required to detect from single small organisms to large schools of fish. This means that the systems have both a high sensitivity and a large dynamic range. The acoustic systems onboard a vessel will operate at various frequencies dependent on their specific functionality but typical systems have operating frequencies which range from 12 kHz up to 200 kHz. At the top end of this frequency range, the vessel radiated noise is usually quite low and natural effects, such as light rain falling onto the sea, can swamp any vessel radiated noise. At lower operating frequencies (such as the commonly used 12/18/38 kHz systems) vessel radiated noise is far more important – with the most common significant source of acoustic energy being the propeller (particularly when cavitating). It should be appreciated that other flow noise generated sources (such as hull apertures, sea water cooling system intakes etc) can also become significant.

Shipyards rarely have sufficient in-house expertise to assess the risks of meeting given URN limits as these are a function of numerous different structural and machinery parameters. To achieve ICES 209 URN requirements is likely to enforce a number of engineering decisions up front, such as:

- the selection of a diesel electric propulsion system (ie diesel generators which are mechanically separate from the electric propulsion motor and a fixed pitch propeller);
- the selection of a rafted (ie double isolated) arrangement for the diesel generators which controls

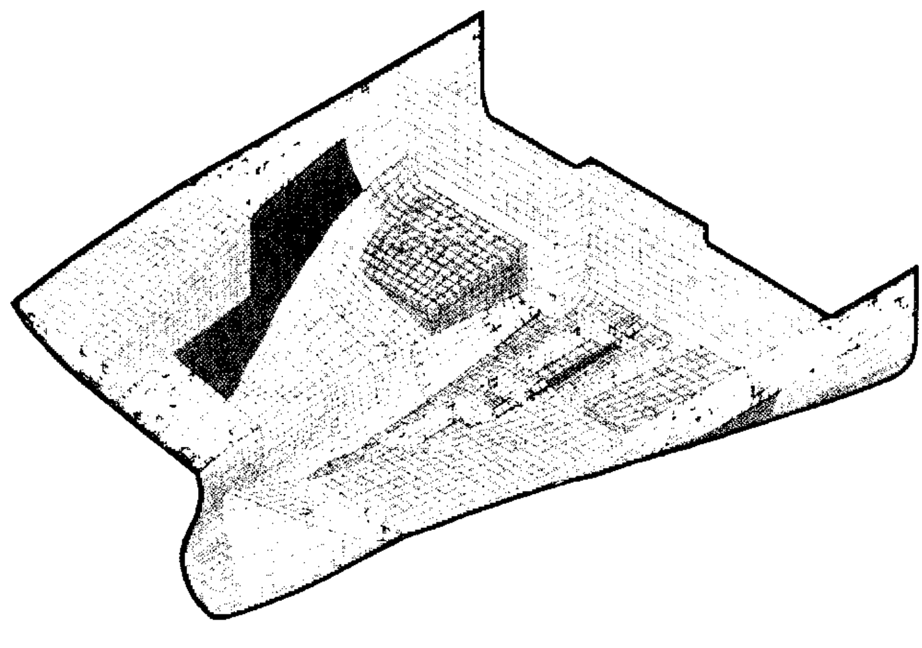

Fig. 7. Finite Element Model of Propulsion Motor Room Steelwork of FRV "Scotia"

the high frequency energy transmitted from the diesels;

- the selection (based on current technology) of a DC propulsion motor with a supply system comprising a 12 pulse thyristor control system and ancillary smoothing circuit;
- the selection of a propeller with a large number of blades (usually 5) which are highly skewed to minimise the generated pressure pulses and have anti-singing edges;
- the use of specialised materials to control airborne excited underwater noise (ie a composite construction which comprises constrained layer damping material, acoustic barrier material and sound absorptive material);
- the use of extensional and constrained layer damping systems in relevant areas of the vessel; and
- the selection of intrinsically balanced low signature ancillary equipment which is mounted on high performance isolation systems.

Whilst this is the starting 'shopping list', there are then a large number of ancillary requirements necessary to ensure that the design is successful. These include the optimisation of raft and major seating design (by means of finite element analysis), the appraisal of vessel whole body modes (hull girder analysis) and associated remedial actions. By way of example, Figure 7 sets forward a review of the finite element model of the propulsion motor room steelwork. This model was developed to check that the propulsion motor seatings were acceptable dynamically.

In the case of *Scotia*, one of the most difficult parts of the project was to feed vibration data from the test-bed to the vessel. This was accomplished by measuring not only vibration levels on the operating equipment on the test bed whilst on-load, but also the test bed mechanical strength (via mobility/accelerance levels). This data was initially transferred onto the vessel via the finite element model (at low frequency) and then, after seatings were fabricated, via the results of their *in-situ* accelerances/mobilities. In this way early warnings could be established of performance shortfalls enabling seatings to be modified before equipment was installed and commissioned.

There was heavy involvement by ATL throughout this project as input was required for machinery selection, raft design, seating design, sound insulation constructions, floating floors, damping measures etc. The outcome was that *Scotia* met the required URN signature at the first ranging trials, much to the relief of the shipyard (and its consultant!).

Whilst the shipyard was delighted that the vessel had *just* met the specified limit (ie excessive costs had not been incurred during the vessel build), it was evident that the small safeguard margins adopted during the course of the project had been eroded by the time of vessel completion. The data from this and following research vessel projects have been fed into refining the URN model developed by ATL. This enables us to provide detailed engineering support for shipyards as URN limits are becoming increasingly common (and tight) on this class of vessel.

A by-product of this intense engineering effort is that *onboard* noise levels on this type of vessel are extremely low. On *Scotia*, onboard noise levels in accommodation areas ranged from 37 to 52 dBA with the vessel at full speed during its acceptance trials (the highest level being monitored over the engine room). The final noise levels will have been even lower as many areas were not fully finished at the time of the survey. This means that the onboard environment is extremely pleasant for scientists who are not usually experienced sailors and appreciate a quiet working platform for their research work. The vessel has left port on many occasions without the occupants (the author being one of those) being aware that the vessel was underway!

Chris Saunders and Dick Wood are Consulting Engineer and Principal Consultant with the company, respectively.

Acoustic Technology Limited, part of the ATL Consulting Group, is one of the longest established acoustical consultancies in the UK. The company was founded in 1969 and is based in Southampton, with a similar size office in Aberdeen. ❖

EUROPEAN ACOUSTICS ASSOCIATION

Statement by the President of IOA

On 7th November, the Institute gave the required year's formal notice to the Manager of the European Acoustics Association that it will be terminating its membership from 1st December 2001.

For several years now Council has been conscious of a steadily growing financial risk associated with membership of the Association. The EAA is a European Economic Interest Grouping (EEIG) of most of the acoustics societies of Europe, including those from some countries not currently members of the European Union. As such there is no formal limit in financial liability to members which could be seen to correspond with, say, the Institute's own formal status as a Company Limited by Guarantee.

Over the past couple of years it has become apparent that some very real financial risks have been accumulating. For example, it is our opinion that it is by no means certain that the EAA's adopted journal, Acta Acustica (which is the property of the German publishers Hirzel), can continue securely into a further contractual period, due to start on 1st January. This situation has arisen partly because not every society is able to guarantee a continuing circulation which will keep the price to a reasonable level, and partly because the transition to an electronic format for the journal entails a rethink of its financial and editorial structure. I should add that not every society agrees with our opinion.

Over the course of the last couple of years, under the leadership of Ian Campbell as our representative on the EAA's Risk Committee, the Association has been persuaded of our viewpoint that an alternative to the EEIG status should be sought with a view to introducing strict limits on individual members' liabilities. This is particularly important to the Institute of Acoustics, the German DEGA and the French SFA, because, as the largest and most financially stable of the societies, we would collectively bear the brunt of any financial disaster. Of the three, our own Institute is itself particularly vulnerable since our reserves exceed those of the other two.

At the August meeting in Nice of the EAA Board (comprising the Presidents of all the Member Societies) I put forward on behalf of the Institute the proposal that EAA should be reconstituted either as a UK Company Limited by Guarantee or as a European 'Association' (roughly equivalent) as a matter of urgency, and certainly before the proposed three-year renewal of the Acta Acustica contract. The proposal was carried, and a deadline of 31st October was set. However, our own Council decided that we would take steps to minimise any continuing liability if this deadline were not met by giving notice immediately thereafter of our withdrawal. The deadline was not met, and I duly gave the notice on behalf of the Institute.

Currently the EAA is voting whether or not to become a UK Company Limited by Guarantee or a European Association incorporated in Spain. So there is welcome movement toward implementing the Nice resolution and we look forward to a swift enactment of the decision.

It is very important for our own Membership and that of the other Acoustics Societies of a wider Europe to be fully aware that IOA Council strongly endorses the principles and aspirations of the European Acoustics Association. It would be as absurd to contemplate a breakup of EAA as it would to contemplate EAA without our own participation. There are enormous benefits to be had for all, including our own individual members, from this collaboration. But Council decided that for the moment the financial risk was becoming too great.

I personally hope that we shall shortly be in a position to withdraw our notice of termination of membership. I feel that the EAA, in its new form, will have a great future. We shall be making very clear proposals concerning how the Association might develop - in particular we shall be emphasising the development and strengthening of services (as opposed to 'products') for our membership. You can imagine many areas from information services covering the different customs and local laws of the societies' member states, to a service designed to facilitate opportunities for grants and guidance from the Commission itself, through to a 'dating agency' designed to enable consultancies and small businesses to come together to collaborate across Europe. My own belief is that financial security and minimisation of risk will enable us to move forward to achieve far more as a group of societies than we might be able to do as individuals.

Mark Tatham
IOA President

Institute of Acoustics, 77A St Peter's Street, St Albans, Herts AL1 3BN
Tel 01727 848195 Fax 01727 850553 email ioa@ioa.org.uk Registered Charity No 267026

WORKSHOP NOTICE

Half-Day Workshop

(Organised by the Building Acoustics Group)

APPROVED DOCUMENT E OF THE BUILDING REGULATIONS

1pm, Wednesday 31 January 2001

Building Research Establishment, Garston, Watford

A major revision is taking place of the Approved Document E of the Building Regulations which will shortly be made available for public comment. This document will affect England and Wales and thus for the first time harmonises the regulations.

The Institute of Acoustics and the Building Research Establishment will hold a joint half-day meeting to review this document and to provide an opportunity for discussion.

The meeting will be chaired by Professor R J M Craik as Chairman of the Building Acoustics Group and speakers will include Dr L C Fothergill of the DETR and representatives of the BRE who were involved in providing technical assistance and support.

The meeting will consist of a series of short presentations followed by discussion.

Approved Document E - Wednesday 31 January 2001

Name:

Address:

Tel: Fax: email:

Please register me as a delegate. Cancellations are payable in full.

- ☐ Fee for Authors & Members £50 + VAT = £58.75
- ☐ Fee for all others £60 + VAT = £70.50
- ☐ I enclose cheque/credit card details for the full amount.

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MEETING NOTICE

One-day Meeting

Measurement and Instrumentation Group

To Verify or Not to Verify That is the Question

14 February 2001, Royal Society, London

As the concepts of legal metrology become more accepted the pattern evaluation of new designs of instruments by their manufacturers along with the routine periodic verification of their performance by users are becoming routine. There is now considerable experience of the application of the British Standard BS-7580 with a number of Calibration Laboratories offering the tests it sets out; in addition there is the overlay of UKAS accreditation. This meeting forms part of the consultation exercise by the IOA to feed opinions to the UK members of the International Standards Committees responsible for new Standards that could well considerably strengthen the type approval and calibration requirements. The meeting will therefore be of interest to all users of acoustic instrumentation for legal or commercial measurements who will have to manage the logistical and cost implications of the proposed new requirements.

Programme

9.00 Registration
10.00 Welcome
Uncertainty Budgets; Are We Sure We Understand Them? *Richard Tyler FIOA, AVI Ltd*
Standards for Sound Level Meters and Sound Calibrators, the Current Status *Sue Dowson, National Physical Laboratory*
Management of the Verification Process *Tim South MIOA, Leeds Metropolitan University*
Beyond Verification - The Role of Measurement Uncertainties in Noise Measurements *Geoff Kerry FIOA and Nick Craven, Salford University*
A System for the Verification of Interfaceable Sound Level Meters *Nigel Milton, National Physical Laboratory*
Implementation of Pattern Evaluation and Verification Requirements *Thor Carlsen, Norsonic AS*
Is There a Need to Verify Sound Level Meters When New? *Liz Brueck MIOA, Health and Safety Laboratory*
The Consultants Perspective *Jim Connors MIOA, Association of Noise Consultants*
Self-Verifying Instrumentation; If Possible, Is It a Manufacturer's Nightmare or a Competitive Advantage? *Richard A Collman MIOA, Acoustical Control Engineers and Bellair Research Ltd*

TO VERIFY OR NOT TO VERIFY THAT IS THE QUESTION
Name
Address

Tel: Fax: email

☐ Please register me as a delegate ☐ Fee for Members £95 + VAT = £111.63 ☐ Fee for Non-Members £125 + VAT = £146.88 I enclose a cheque/credit card details for the full amount. Please give a purchase order number if you wish to be invoiced. Cancellations are payable in full.

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MEMBERSHIP

The following were elected to the grades shown at the Council meeting on 7 December 2000

Fellow
Knowles, I C

Member
Bailey, M S
De Salis, M H
Fraser, S F
Goddard, H M
Holmes, J W
Howe, D G
Jones, W D
Leach, S C
Lewis, S P
Locke, A J S
Maidment, R J
McCaul, D J
Morgan, S
Moyes, S A
Searson, K V
Sugimoto, R
Swan, S J
Tam, K T
Urbanski, I D
Wang, Q

Associate Member
Allen, D
Athol, S C
Bacon, M R H
Barlow, R J
Barrett, H
Bougdah, H N D
Bradfield, M J
Bradley, N
Bradley, P B
Burns, G
Campbell, J
Cant, R S
Clarke, A S
Clow, S
Colebrook, J J
Coleman, B
Collinson, E J
Cope, S L
Corr, J A
Critchlow, R A
Curran, A S
Dagger, G F W
Davies, J B
Davis, L
Dillon, M R
Dixon, J R
Eagleton, S T
Ekici, I
Finlay, H L
Franklin, A
Greasly, M
Greenham, E G
Haire, A
Hamilton, A
Hawkes, K L
Henson, J
Hoey, P
Hurst, C J
Jane, R
Jouan, S
Kennedy, J W C
Kidby, A
Leach, M
Levett, S
Lewis, T W
Mann, N
Mansfield, R E R
Moore, G J
Naisbitt, N J
Neagle, P
Nightingale, T E
Philcox, K P
Pugsley, A N
Puigdefabregas, E
Revie, C
Riley, N R
Ryall, L
Sewell, C
Simpson, J C
Stacey, A N
Starsmore, S J
Stedman, G M
Street, T A
Talbot, S J
Taylor, N
Tilbury, R
Waterfield, R J
Watson, R
Watts, M J
White, G R
Withall, G K
Wood, S J
Wootton, R
Wrayford, A E J
Young, G M

Associate
Daniels, D
Mather, L

Student
Aliberti, G
Carrilho, J A D
De Stefano, A
Karatsovis, C
Macgillivray, T J
Mohammad, J I
Papadopoulos, T

EDUCATION

Certificate of Competence in Workplace Noise Assessment

The following were successful in the October 2000 examination

Bristol
Busse, M J
Gray, M R
Hill, T C
Peers, J I
Phillips, D W

Colchester
Collins, S
Cowley, A J
Horgan, D
Martin, R
Morris, P
Ross, J
Watton, P J
Woods, K

EEF Sheffield
Amos, M A
Chandler, C J
Cook, I C
Dark, W K
Ducie, D B
Howes, S J
Leaning, J C
Smillie, P
Tillett, S
Topliss, S A

Leeds
Halliday, G F

Loughborough
Boylan, G C A
Card, M E
Carter, J
Cowen, B
Cozens, V S A
Donnelly, P F
Ferguson, P E
Gandor-Graham, U
Graddon, J H
Harvey, B L
Harris, G
Mennie, D
Morris, K S
Reid, L T

Ulster
Baxter, J
Bradley, J G
Clancy, J
Gavin, J
Hanna, S M
Mawn, G

Certificate of Competence in Environmental Noise Measurement

The following were successful in the October 2000 examination

Birmingham
Ankers, W B
Anspoks, V P
Beale, S L
Bond, A G
Bray, K L
Chamberlian, S A
Dhammi, C
Gillard-Eastop, S T
Griffiths, E F
Jacobi, D L
King, R P
Laughland, E M
Martin, J
McNally, V E
Semple, A J
Shutt, M
Small, A J
Watkiss, J
Wilson, S L
Woodland, V L
Yarnold, C F S

Bristol
Bowen, M J
Chia, C
Hughes, J
Massie, J C
Peters, C J
Plant, P

Colchester
Arter, S J
Collins, S
Denford, A M
Jones, E G
Logan-Taylor, C
McIlwain, P J
Oldfield, L
Plume, R C
Stroud, P J
Thompson, M

Derby
Coles, A
Ford, M F
Hall, S M
Humphreys, C C
Mantas, R R
Plant, A J
Scott, J
Shores, V

Leeds
Bailey, M J
Lamle, P A
Rothery, J R R

Liverpool
Armstrong, M A
Farrell, R A
Kearney, C P J
King-Hele, D J
Leedam, P
Parnell, A
Ravetta, V C
Reid, C M
Wilson, D

NESCOT
Barnes, J J
Berry, A
Buckland, R J
Charles, R P
Evershed, V
McDonald, P
Nkere, E
Sokoya, O O

Ulster
Power, P

EU AND USA ARGUING OVER HUSH-KITS

Geoff Leventhall FIOA

America and the European Union are in the midst of a fierce and wordy dispute over hush-kitted aircraft. The origins of the problem lie in a position taken up by the EU in November 1998 (Common Position (EC) No.66/98), which would effectively ban these aircraft from using European airports.

The Main Points of the Ban

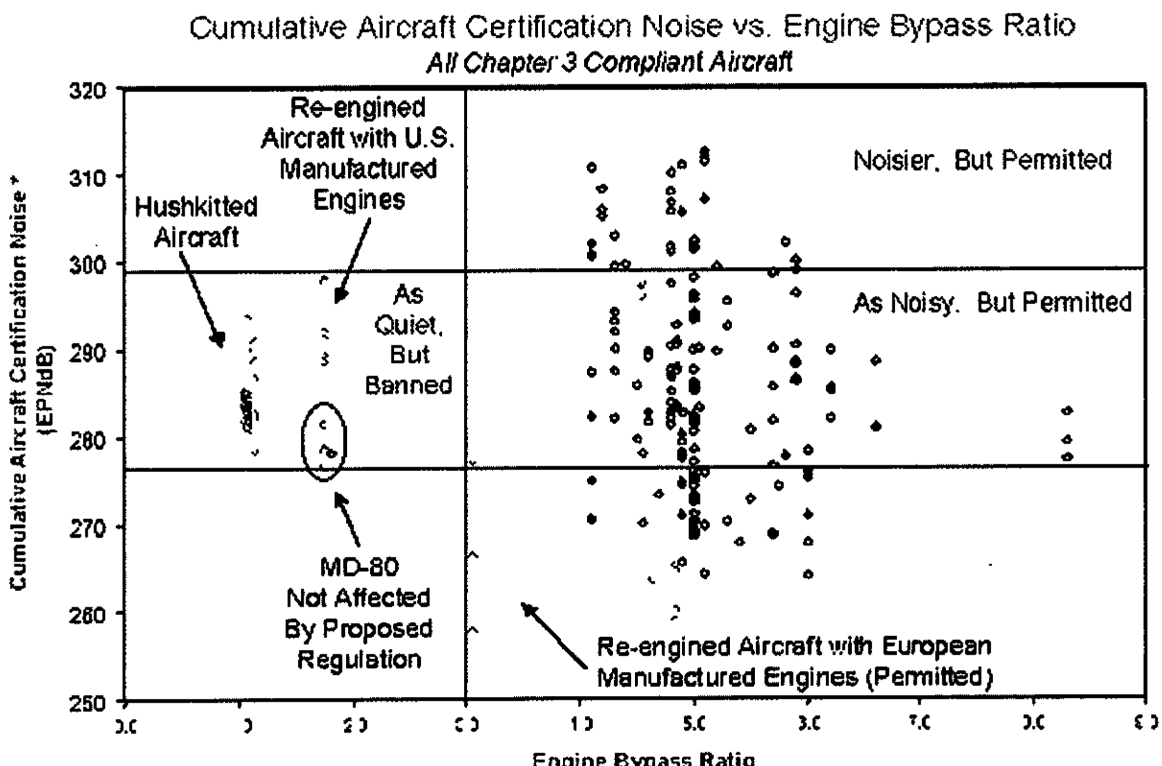
The ban is a non-addition rule, which states that, after a specified date, further hush-kitted aircraft cannot be added to the registers of EU member states. Its main purpose is to freeze the present situation in order to prevent companies expanding their activities within the EU by using increasing numbers of such aircraft. The cut-off date was originally set at 1st April 1999, but delayed for a year in response to protests from the USA. The ban came into effect on 4th May 2000.

The EU Position

The EU recognises the growing environmental constraints on airports and that the use of quieter aircraft leads to enhanced use of available capacity. Older aircraft, originally certified to Chapter 2 standard, but now carrying hush-kit fixes to reduce their noise to Chapter 3, have a poorer mass for mass performance than later aircraft, create greater gaseous emissions and have greater fuel burn. These older planes also suffer load and other operational restrictions in order to meet the newer standards and are noisier than new-design Chapter 3 aircraft. The EU regards them as 'recertificated'. However, older aircraft, which have been re-engined, with engines having a by-pass ratio greater than three, are permitted. The crunch is that by May 2002, recertificated planes registered outside the EU will not be allowed to fly into the EU unless they were EU registered by May 4th 2000. The planes concerned are typically the older B-727, B-737 and DC-9.

The US Position

The US is angry about the EU decision, because America controls the hush-kit industry and is also a popular source of second hand aircraft. 'Europe is the single largest export market for US aerospace producers – this hush-kit regulation, which is based on design rather than a per-



* summation of aircraft noise at three noise certification measuring points: sideline, takeoff, approach

Fig. 1. Discriminating between aircraft on the basis of engine by-pass ratio is not an effective means of reducing noise

formance standard cannot be allowed to stand' said US Commerce Secretary William Daley as he waved the flag to demonstrate a stand for 'the principle of uniform global aviation standards and the need to safeguard against regulatory measures that discriminate against free and fair trade'.

Work It Out Together?

Earlier compromise attempts had failed as each side dug in. At one stage it was agreed that the EU would suspend its Regulation, whilst the US backed-off from taking a threatened action through ICAO (International Civil Aviation Organisation), a UN sponsored body. This would have given a breathing space whilst a new noise standard was worked out. However, US industry, which is wary of the impact of an improved noise standard and also feared that the ban would be a stigma on hush-kits, lobbied their Government to reject the compromise. So the negotiations between US Under Secretary for Commerce David Aaron and EU Transportation Commissioner Loyola de Palacio, failed at the final stage and, on March 13th this year, Palacio advised the European Parliament that she could not recommend suspending the hush-kit regulation, describing US proposals for a compromise as 'neither balanced nor reasonable'. On March 14th the US Government formally lodged the complaint with ICAO, requesting that it resolve the problem. The US is driven by the fact that aerospace is one of the nation's largest industry sectors, contributing about $40 billion surplus to the US trade balance in 1999.

Aaron claimed that the stumbling block had been the primary EU requirement that the US must not file the complaint to ICAO, rather than to file and then suspend it, as the US had offered. Both sides could then have worked together with ICAO to develop a new global noise standard. However, since the EU was holding the hush-kit ban over the heads of the Americans, they in turn wanted to have the complaint to ICAO to hold over Europe. Such are the skills of levelling-up on negotiating positions!

Some unexpected support for the EU standpoint comes from the North American Airports Council International (ACI-NA). They oppose the ban, but their President, David Plavin, has expressed a view that older planes with hush-kitted engines 'stick out like a sore thumb'. The ACI-NA recommends that there should be a relatively rapid phase out of, for example, aircraft within 5 dB of the Chapter 3 limit, which should disappear from service within five years.

Perhaps this points the way to a compromise on the hush-kit problem.

But of course, removing one hush-kitted aircraft from the mix makes space in the noise agenda for several quieter aircraft, so that residents around airports may have only marginal benefit.

The Hush-Kit Industry

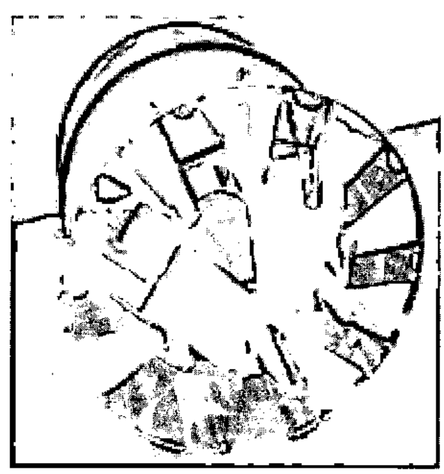
In August 1999 US Transportation Secretary, Rodney E Slater, was reporting to Congress that the US commercial aircraft fleet is the quietest in history. The Airport Noise and Capacity Act of 1990 required that all civil aircraft over 75,000 pounds reach 'Chapter 3' by January 2000. The FAA has shown that roughly five Chapter 3 aircraft equal the total noise level of one Chapter 2 aircraft. The 1990 Act affected about 7500 aircraft and by the end of 1998 over 75% of these had complied with Chapter 3 levels. This compliance is achieved largely by operators installing those FAA certified Chapter 3 hush-kits at the heart of this transatlantic dispute and which will be banned from European airports.

Hush-kit development was progressed, amongst others, by the courier company FedEx, which is the world's largest operator of B-727s. As of October 2000, FedEx Aviation Services has had orders for 740 Chapter 3 aircraft conversions, at around $2 million a time.

The hush-kit regulation hits US exports, since older aircraft are sold off to small European air carriers. Aaron asserted that the US aviation industry had already lost an estimated $2 billion in forgone revenue. A new Irish airline, Omega Air, was planning to buy nearly a billion dollars of older US aircraft and accessories in order to start a low cost airline within Europe, but the banks refused to finance the deal, worried by doubts over the future use of these aircraft. So Omega Air is currently working its way through the European Court with a complaint against the ban!

It is not only the aircraft companies who are angry. Sonny Hall, trades union leader for transportation workers proclaims that 'The ban on hush-kits......puts the US aviation industry at a competitive disadvantage and poses a major threat to aviation workers'. By taking this action, 'the Europeans have made their anti-US intentions clear. Transportation labour wholeheartedly supports the Administration's action, which sends a strong message that the United States does not intend to sit idly by and allow this poorly-veiled economic assault to adversely impact the US aviation industry and its employees'

David Aaron was furious about 'unilateral and discriminatory action......against our equipment'. He stated that to discriminate against aircraft on the grounds of by-pass ratio alone is unjustified and he uses a plot of cumu-



Hush-kit

lative EPNdB against engine by-pass ratio to illustrate this (Figure 1). He claimed that hush-kitted aircraft are to be banned even though they are as quiet as permitted ones, drawing attention to the cut-off line at a by-pass ratio of three and to the European re-engined aircraft, which just squeeze in, whilst it is only US ones which are out! He saw a pro-European conspiracy in this and hinted at retaliation against Concorde and the new Airbus.

However, Figure 1 does not include aircraft weight, although higher bypass ratios are associated with larger aircraft. The Chapter 3 (Stage 3) limits, including weight, are given in Figures 2a,b&c for Takeoff, Sideline and Landing respectively, whilst Figure 3 shows the Certification measurement positions.

The threat to Concorde, although subsequently overtaken by events, was a very real one. Concorde, which does not meet current ICAO noise standards, was granted special noise wavers nearly 30 years ago, but in March 1999 the US House of Representatives passed enabling legislation to ban Concorde from US airports if the EU went ahead with its Chapter 3 plans. Representative James Oberstar, who sponsored the Bill, claims that the resale of over 1500 used US aircraft with hush-kitted engines is at stake, amounting to nearly a billion dollars in potential sales.

Passing the Blame

The EU asserts that the root of the problem was the US reluctance to move on from the 1977 Chapter 3 aircraft noise standard, claiming that the US blocked all progress within the ICAO Committee on Aviation Environmental Protection throughout most of the 1990s. As a result, the EU was forced to introduce its own regulations, the hush-kit ban, in order to control the noisiest aircraft. The EU is sticking with this, despite the USA changing its position on Chapter 4, and the FAA now claiming a prominent part in the developments. One big problem with the progression through the 'Chapters' for aircraft noise limits, is that these follow developments in engine noise reduction, rather than driving them. So whatever the Chapter 4 limits turn out to be, and we should know them by Autumn 2001, they will already be met by modern designs, probably with decibels in hand. The Chapter 4 limits will ensure that all newly certificated aircraft meet the standard, whilst leaving existing ones to live out their commercial lifespan of around 30 years. There is a time lag of around 10 years or more between the introduction of a new ICAO noise limit and a real effect on noise levels.

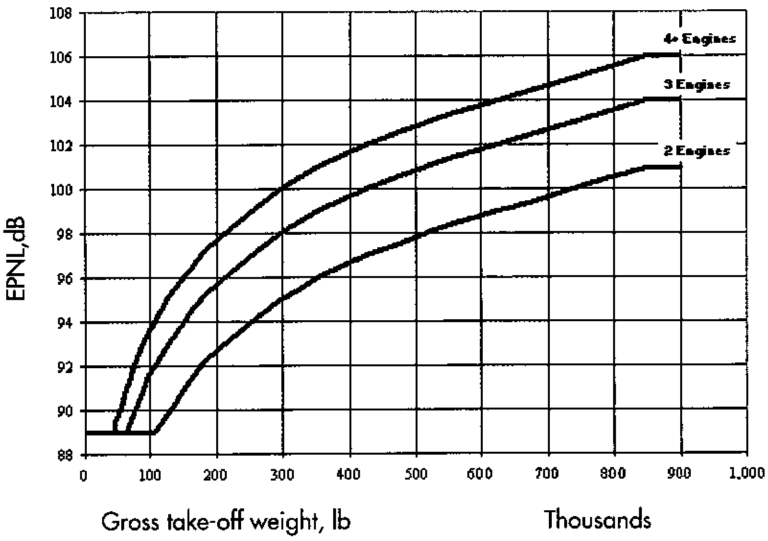


Fig. 2a. Takeoff noise limits

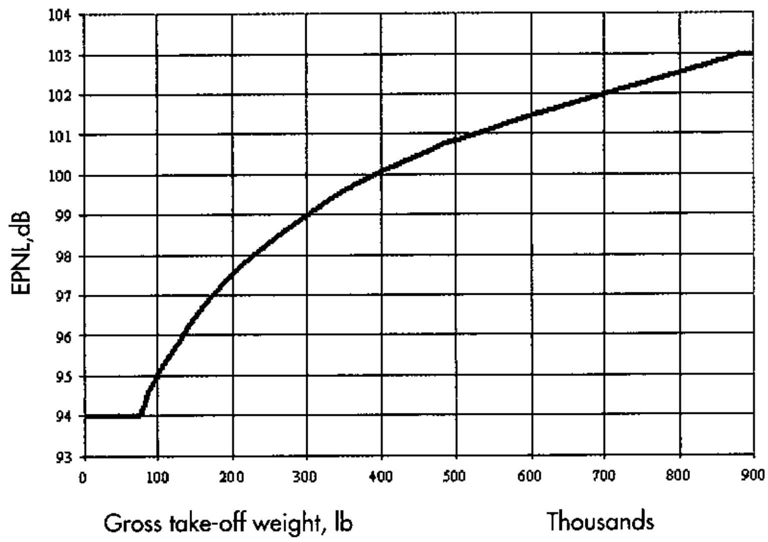


Fig. 2b. Sideline noise limits

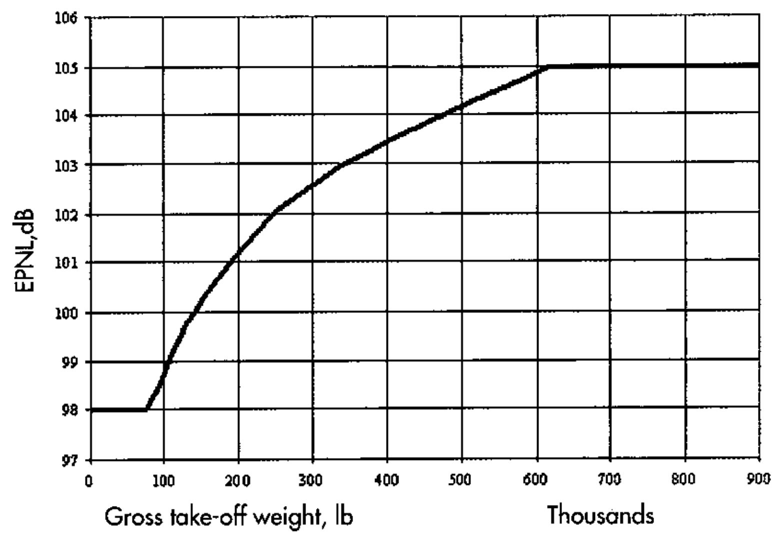


Fig. 2c. Landing noise limits

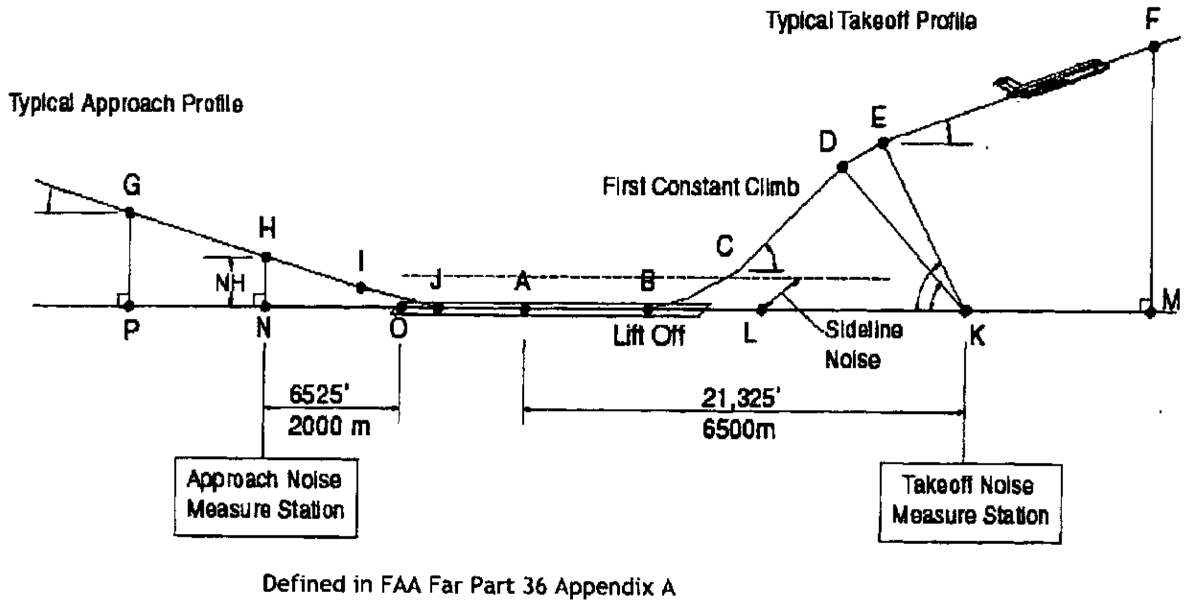


Fig. 3. Measurement points for aircraft noise certification
G = Start of certification approach path H = Directly above the approach noise measurement station
A = Start of roll-off B = Lift-off C = Start of first constant climb D = Start of thrust reduction
E = Start of second constant climb F = End of certification flight path

Chapter 4 Limits

ICAO believes that, if the momentum which led up to Chapter 3 regulation is lost, stability will be undermined within the operating environment of the aircraft industry. Thus there has been some pressure to progress agreement. Firstly, harmony must be achieved on the new noise standard. Then there has to be accord on how to implement the standard, remembering that a commercial aircraft has a life of around 30 years. A range of new noise standards has been defined and possible transition strategies for implementation of these are under evaluation. A key activity has been a cost benefit analysis of the various options, in order to provide decision makers with information on relative merits, so leading up to a final recommendation to ICAO.

The new standard is expected to be approved by ICAO Council in 2001 and international agreement on the transition strategy will follow at the ICAO 33rd Assembly in September 2001.

In October 1999, the Working Group reached agreement on four noise stringency options with respect to the current Chapter 3 aircraft noise, for the sideline, approach and takeoff measurement points of the certification procedure.

1. A traditional option with specified reductions at each measurement point.
2. A cumulative option requiring a total reduction of 8 dBA.
3. A cumulative option requiring a total reduction of 11 dBA.
4. A cumulative option requiring a total reduction of 14 dBA.

A cumulative option permits different reductions at the three measurement points, where a low reduction at one is compensated by a higher reduction at another. Thus, a cumulative reduction of 8 dBA requires an average reduction of nearly 3 dBA at each point.

It is confidently expected that in mid-2001 ICAO will have finalised its more stringent noise certification for large jet aircraft at somewhere in the range of a cumulative reduction from 8 dBA to 14 dBA. However, it won't all happen immediately! The transition strategies range from slow to fast. A fast single-step phase-out is most likely for the lower standards (8 or 11 dBA reduction). This could, for example, go into effect for new designs in 2002, acting in conjunction with a seven year phase-out beginning in 2006 and ending in 2013. A slow two-step phase-out would be completed in 2020.

There is no doubt that, in 20 years time, aircraft will be quieter. But will there be a reduction in total aircraft noise? Current aircraft noise exposure criteria rely heavily on period equivalent levels, for example 16 hour L_{Aeq}. If a reduction of 3 dB at each monitoring point merely means that operators are free to double the number of flights, there is little relief for communities near airports. Runway and passenger limitations at major airports put pressure on the spare capacity of secondary airports round busy hubs and conurbations such as London, New York, Amsterdam or Paris. A lower noise level per event may be used as a reason to succumb to this pressure.

ICAO's work on reducing the levels of separate events must be accompanied by a reduction in the permitted community exposure. This is a matter for the politicians, but continued campaigning on environmental issues might be necessary to help guide their thinking.

Geoff Leventhall FIOA is a former President of the Institute and a noise and vibration consultant. This paper is based on several articles he has written for Noise and Vibration Worldwide, MultiScience Publishing Co. ❖

APPLICATIONS OF LASER DOPPLER VIBROMETRY

Tony Jones FIOA

The Operating Principle

The basic principle underpinning laser doppler vibrometry (LDV) is the well-known Doppler effect. A coherent laser beam is projected on to the surface under investigation and light scattered back from the surface is shifted in frequency by an amount proportional to the velocity of the surface. The instrument measures this frequency shift to produce an instantaneous velocity signal which can subsequently be analyzed. By using scanning mirrors, a single point vibrometer can be used to scan across a surface, gathering multi-point data from large vibrating objects.

The heart of the instrument is the classical Michelson interferometer (Figure 1) in which a laser beam is divided into a reference beam and a signal beam. The signal beam is directed onto a vibrating surface and a back-reflected beam is recombined with the internal reference beam. When the test surface moves, the path difference between the reference and signal beam changes, resulting in intensity modulation of the recombined beam due to interference between the two components. One complete cycle of intensity modulation corresponds to a surface movement of 0.316 μm, half the wavelength of the helium neon laser source. Therefore the frequency (F_d) of intensity modulation corresponding to a surface velocity (v) is given by $F_d = 2v/\text{wavelength}$. F_d is the Doppler frequency associated with a surface velocity (v).

The main operational interest lies in the fact that it is a non-contact technique, avoiding problems associated with the mass loading of light structures that could be a problem with conventional accelerometers. Equally the ability to scan a surface to determine a vibration profile is a particularly valuable one in suitable circumstances.

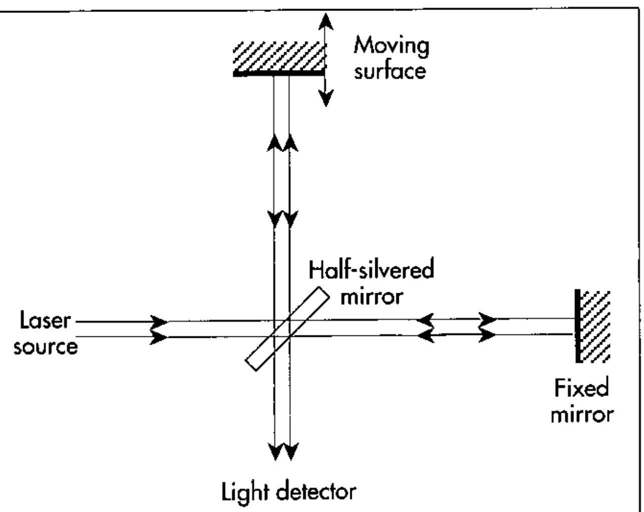


Fig. 1. Simplified diagram of a Michelson interferometer showing the light paths with a moving reflector

Examples of Unusual Applications

Biological

Ronald Miles of the Watson School of Engineering and Applied Science at SUNY-Binghamton, for example, has used scanning laser doppler vibrometry in collaboration with biologists at Cornell to explore the extraordinary hearing mechanism of a parasitic fly called Ormia ochracea. The fly's ears were found to be under its head and that the female's hearing was well tuned to the song of the male cricket, its host for reproductive purposes.

Working on a vibration isolation table, Professor Miles found that, unlike any other known hearing system, the fly's ability to localize sound is accomplished by a clever mechanical device that preprocesses the sound before it gets to the central nervous system. Its hearing organ uses a stiff, mechanical connection between the eardrums while animals normally have ears as widely separated as possible. It was shown that the mechanical interaural coupling was responsible for the highly accurate directional sensitivity of the fly's hearing.

Single point vibrometers have aided the study of the human ear. The vibration patterns of the middle ear can be visualised and the frequency response characteristics determined. The information provided makes it possible for a biomedical engineer to design a transducer that can enhance the vibrations of the middle ear and deliver an improved signal to the inner ear.

Non-destructive Testing

LDV can be used in an advanced mode in conjunction with ultrasonic methods in non-destructive testing applications. The latter techniques encounter problems when applied, for example, to concrete. The inhomogeneities in concrete attenuate the propagating ultrasonic signal and also lead to strong coherent noise that can totally mask even large backwall echo.

Scanning LDV can be used to detect ultrasonic vibration over the surface of the concrete and means have been developed to improve the signal to noise ratio.

Loudspeaker Development

This technology has proved valuable in studying the detailed movement of loudspeaker cones, particularly for studio monitor development.

Equipment Companies

The major players are Ometron, now marketed worldwide by Brüel & Kjær, e-mail info@bkgb.co.uk and Polytec, marketed in the UK by Lambda Photometrics, Lambda House, Batford Mill, Harpenden, Herts AL5 5BZ e-mail info@lambdaphoto.co.uk. Further information may be obtained from these companies.

Dr A J Jones FIOA is Managing Director of Acoustical Investigation and Research Organisation Ltd ❖

AUTUMN CONFERENCE 2000 – INDUSTRIAL NOISE

Stratford upon Avon, 10 – 11 November 2000

Stratford Conferences 2000

Another year has passed and the IOA were again at Stratford upon Avon in November for the IOA Autumn and Reproduced Sound conferences. Fortunately for the delegates and others and compared with other, less fortunate, parts of the country this autumn, the flood control system in Stratford ensured a safe and dry conference venue. The Stratford Victoria maintained its high standard of accommodation and catering and provided a comfortable base for the proceedings.

The report on the Industrial Noise conference is presented in this issue of the *Acoustics Bulletin* while that on the Reproduced Sound 16 conference will appear in the first, redesigned, issue of 2001.

Thanks are due to the Chairmen who provided notes on their sessions to assist in the compilation of the conference reports. As is usual with these reports, because of space limitations, each paper is described only briefly to give readers an idea of the subject matter. As always, if anyone wants or needs fuller information, IOA headquarters in St Albans can be approached for the purchase of a copy of the full proceedings or a photocopy of particular papers.

The reformed Industrial Noise Group Committee celebrated the end of its first full year of existence by hosting the Autumn conference. The result was a lively event where every paper produced questions and contributions from the audience.

The highlights included a keynote paper from Eric Tromp of Shell Global Solutions, an entertaining practical session by David Bull and presentation of the Tyndall Medal to Professor Y W Lam and the R W B Stephens Medal to Professor D C Hothersall followed by their award lectures. The citations are published elsewhere in this issue.

Thanks are due to the exhibitors: Acsoft, Brüel & Kjær, Rockfon, Casella CEL, ISVR and 3M. Their stands and pre-dinner reception created a lot of interest.

At 11am on Saturday the 11th the conference paused the proceedings to observe the Remembrance Day silence.

Medal Lectures

Tyndall Medal

The modelling of noise from industrial buildings – from inside to outside (Professor Y W Lam, University of Salford)

In his medal lecture, Professor Lam presented an overview of various aspects of his research. He described his work related to the prediction of noise in factories and highlighted the different approaches required for diffuse and non-diffuse sound fields. He presented the results of work done to validate ray-tracing and empirical methods and concluded that an accuracy of <3 dB could be achieved depending upon the approach adopted. The main effort now required in this area, is the acquisition of more accurate input data.

Professor Lam went on to describe how prediction models could be used to determine the energy incident on room surfaces and how this data could be used as input data for transmission calculations. The problems with predicting the transmission of sound through single and multi-layer panels were also described. He indicated that empirical models for sound transmission through single and double skin panels have now been developed and validated with the co-operation of industry.

In the final part of his lecture Professor Lam described the environmental factors which affect sound propagation outdoors, in particular those which it is difficult to control. He described the conclusions from both measurement and prediction of noise propagation in the presence of wind gradients and indicated that more work was required in this area.

R W B Stephens Medal

Design criteria for efficient noise barriers (Professor David Hothersall, University of Bradford)

In his medal lecture, David reviewed the several standard methods of predicting the effects of noise barriers and provided an interesting and comprehensive review of the factors affecting the design and efficiency of barriers including the effects of incorporating sound absorbent surfaces on barriers. The effect of the atmosphere on barrier performance was also discussed. David explained that prediction methods have, in the past, generally been dedicated to specific noise sources such as traffic, aircraft and industrial. More recently the trend has been to aim for some rationalisation of approach, particularly in EU countries. L_{Aeq} is now very widely accepted as a suitable index for describing noise from a range of noise sources. He then described the use of several computer-based prediction methods including the US Federal Highways TNM model introduced in 1999, the Nordic2000 model which will be introduced in Nordic countries in 2001 and of course the well known UK CRTN model for use with traffic noise barriers. The numerous questions that followed David's paper included several on the environmental effects of barrier performance and the effect of large stretches of grassland in the vicinity of the barrier.

Technical Sessions

Friday 10 November

Session: Standards and Measurement
Chair: Andy Raymond (Philip Dunbavin Acoustics)

The noise emission in the environment by equipment for use outdoors – Directive 2000/14/EC (Fran Buckle, Department of Trade and Industry)

Fran is a Directive Negotiator for the Standards and Technical Regulations Directorate of the Department of Trade and Industry and her paper described the new Directive relating to the noise emission in the environment by equipment for use outdoors. This directive will replace the current noise emission legislation and covers 57 types of outdoor equipment first placed on the market or put into service within the Community; as she put it 'the testing of outdoor equipment from concrete breakers to wheely bins'! The new Directive becomes mandatory on 3 January 2002. Fran, who negotiated the directive on behalf of the UK and is now involved in its implementation, described the process and building blocks of the directive and went on to describe the awareness campaign and consultative process, finishing by discussing the difficulties of enforcement. The discussion was postponed until the end of the next, related, presentation.

The new EU outdoor machinery directive – what must I do to comply? (Rukhsana Adam, SRL and Mike Hewett, AVT)

Rukhsana developed the previous speaker's presentation by describing testing procedures and the requirements of the test houses. She brought out the conflict between the equipment manufacturers and the environmentalists who claim the manufacturers are not doing enough. Rukhsana peppered her presentation with interesting and amusing anecdotes and examples.

The joint discussion included technical questions covering the use of sound intensity and the role of 'notified bodies', the organisations chosen to carry out the EC type examinations as the means to conformity assessment.

Many of the questions were concerned with the durability of the test outcome – what happens after the equipment is sold. The answer was that the directive does not concern itself with in-use noise levels; this is up to the local authority, which would have to police any problems.

A new method of measuring noise from pipes (Jon Richards, M W Kellogg Ltd & J Neil Pinder, ISVR)

Noise from piping can be the dominant contribution to the noise in the surrounding community from a modern petrochemical plant. The aim of this paper was to discuss a user-friendly transducer to estimate pipe radiated noise, particularly in high background noise situations. The volume velocity transducer (VVT) was described and exhibited and its pros and cons versus a conventional sound level meter, intensity meter or accelerometer were discussed. It is based on an existing ISVR-designed instrument developed by Professor Frank Fahy.

Discussion centred on the problem of ensuring good performance of the VVT especially with regard to low frequencies.

Measuring and assessing the sound you intend and not everything else instead (Richard A Collman, Acoustical Control Engineers and Belair Research Ltd)

Richard defended the conventional approach to noise measurements that has served him, and others, well over the years. He stressed the extra information available by combining experience of the noise being measured and the results the instrument is producing. By implication this can mean that your instrument may not tell the full story. He emphasised the importance of adjusting your method to make sure you capture what you want, taking careful notes throughout being the key.

Industrial Noise Group AGM

With lunchtime imminent the Annual General Meeting was conducted in an efficient and rapid manner.

Session: Noise Control
Chair: David Lewis (Unilever Research)

Keynote paper: *Plant noise control engineering* (Eric B Tromp, Shell Global Solutions International bv)

The theme of the keynote paper was the standard ISO 15664 being developed by the ISO Working Group 48, of which Mr Tromp is the Convenor. The background and scope to this standard were described, in particular

Ms Fran Buckle, DTI

its relationship with the established Shell Design and Engineering Practices. Mr Tromp went on to review the elements of the schematic flow chart, included in the standard, which outlines the elements of recommended noise control process. The importance of defining both a workplace sound pressure limit and an overall sound power limit for the plant, with appropriate allowance for pipe work were emphasised. The priority that should be given to noise control at source was highlighted.

A key question related to whether the issue of uncertainty was considered in the standard with reference to defining targets. It was indicated that it was not. The issue of availability of data from suppliers was also questioned.

Meaningful specification of plant tonal noise emissions (Mike Hewett, AVT)
Mr Hewett started his paper by indicating that he hoped to stimulate debate regarding the subject of his paper rather than provide a solution. He described the problems that can arise in proving tests where a development complies with overall noise limits but the character of the noise presents a problem. He went on to give an example of a consent clause having a specific qualitative requirement for tonal noise with no quantitative reference. The problems with BS 4142 referring to 'distinguishable tones' was also highlighted. Mr Hewett presented some in-house data on tonal audibility for persons of different ages and then discussed the variability in perception. He went on to discuss BS 7445 and other systems for defining tonality. The lack of knowledge and availability of data from suppliers regarding tonal noise was also highlighted.

Several questions/comments related to the issue of planning. The planning authorities do not necessarily have noise experts and often do not consult Environmental Health Officers when drafting consent clauses. This can lead to inappropriate qualitative references to 'distinguishable tones'. There was also some discussion regarding the implications of IPPC in that once an operating license has been issued the operating site is exempt from prosecution for nuisance.

The 75 dBA threshold level of the physical agents directive: a flawed evolution (Ben Lawton, ISVR, University of Southampton)
Mr Lawton introduced his presentation by describing the Physical Agents Directive and indicated that, although the current emphasis was on vibration, noise was still 'bubbling away' in the background. The emphasis of his paper was the origins of the 75 dBA threshold level in the Directive which he indicated originated from ISO 1999, the WHO and a paper from the US EPA. Mr Lawton's key contention was that the input data to ISO 1999 comprised two data sets, one of which was seriously flawed. In addition he discussed the conclusions of more recent work which indicated that, below an $L_{ex,8hr}$ of 80 dBA, there is no risk of hearing loss apart from that related to age. Based on this he asserted that the 75 dBA Threshold level in the Physical Agents Directive is unnecessarily restrictive and could be higher.

Saturday 11 November

Session: Noise Control
Chair: Jon Richards (M W Kellogg Ltd)
Control of tonal noise – a structured approach. A case study at an aluminium recovery plant (Peter Simpson & R Woolley, Sound Research Laboratories Ltd)
Peter described an investigation by SRL into the cause of tonal noise alleged to be emanating from an aluminium conversion plant in Wales. The factory, which had been the subject of a Noise Abatement Notice, is one that recycles scrap aluminium and recasts it into billets. Residents of a local housing estate had complained about low frequency noise appearing to come from the factory. The notice served by the local authority, as a result of an investigation by an acoustic consultant retained by the authority, demanded a reduction in the 40 Hz one third octave band and specified a considerable amount of remedial work. SRL was not convinced about the need to do all the work and adopted a structured approach in analysing the noise source.

The point was made that a result was achieved at a much reduced cost compared to the treatment demanded by the environment directorate and demonstrated the value of careful investigation compared with a broad brush approach. The paper generated a lively discussion with EHOs, who have to assess the noise complaints, defending their position.

Design of a skid-mounted gas turbine enclosure (Eric Fung and T Struthers, GE Energy Services (UK) Ltd)
Eric described the design challenges that were faced when designing a high performance skid-mounted acoustic enclosure for a high power gas turbine (42.1 MW). Factors that had to be taken into account included noise targets, accessibility, fire rating, ventilation flow, structural support loading, lighting and others. One of the main objectives of the design exercise was to design for minimum total cost and for this purpose a cost model was developed and used throughout the project to monitor actual costs against estimated costs. He concluded by stat-


Keynote speaker, Eric B Tromp

ing that acoustic enclosures can be designed that are operator friendly, allow easy access to the interior and are cost effective, by careful attention to details and having a good understanding of the noise source and its transmission characteristics. A useful discussion followed.

Acoustics in large industrial halls (Soren Damgaard Kristensen, Acoustics-Carl Bro-Denmark in association with Rockfon Ltd-UK)
Soren described a case study concerning the acoustic design of two large industrial halls using the ray-tracing program ODEON. He worked to the requirements of a Danish code of practice whose recommendations resembled those of the ISO 11690, Acoustics – Recommended Practice for the Design of Low-Noise Workplaces Containing Machinery. Soren explained that although the halls were large they had a high degree of symmetry and repetition that meant that the description of the various absorbing and diffusing surfaces for the surface files was quite easy and was completed in a few hours. The intermediate reverberation times were longer than predicted and there was a flutter echo. The use of Rockfon Cosmos on the gables improved matters. There followed a discussion on costs involved in treating this type of building.

Noise reduction in a cyclone separation system – a case study (D N Lewis, SEAC Manufacturing, Unilever Research & M G Smith, ISVR, University of Southampton)
Dave described the case study that involved the reduction of noise from the cyclone plant that had increased over the years due to plant modifications until it had caused complaints from residents. The sources included the fans, where the noise was transmitted through various elements of the cyclone and exhaust stack system, and noise due to the turbulent mixing in the exhaust stack. Redesign of the cyclone to act as a silencer, based on modelling work at ISVR and careful selection of the fans to minimise the sound power entering the system resulted in both the solution to the problem and cost savings. Dave said that since this study was completed such situations have been avoided by the implementation of company standards on the management of environmental noise.

Real fingers in real ears (Geoff Kerry & Danny J McCaul)
Although an amusing title, Geoff managed to convince the audience that the formal study of the protective effects of peoples' response to a loud noise by placing their hands over their ears, putting fingers in the ear canal or using their fingertips to depress the tragi, showed that these strategies have a real protective effect. Geoff described the experiments on these 'self help' methods using procedures laid down in European standard BSEN 24869-1 for the measurement of the performance of ear protectors. The tests showed that all three methods performed as well as commercially available devices. The use of a finger in the outer ear canal provided a mean protection value in excess of 20 dB.


David Bull demonstrating

Session: The Wider Implications of Industrial Noise
Chair: Mike Hewett

Noise generation by demonstration (David Bull, Colchester Institute & dB Acoustics)
The last session of the conference began with a collection of practical demonstrations by David Bull. The demonstrations proved hugely entertaining with David managing to compress a session that usually takes a full day into one hour. He worked through the various principles of noise generation, vibration, impact and fluid disturbance and gave demonstrations of how each process works and can be reduced.

Those lucky (or foolish) enough to be sitting at the front got to make lots of noise with a variety of hammers, nozzles and balls monitored all the time by a, slightly hypnotic, FFT display. It was clear from the faces in the audience that many people were reminded of fundamental principles they had learned, and possibly forgotten about, many years before and everyone seemed a little disappointed when the session had to come to an end for afternoon tea.

Environmental noise measurement – documenting measurement positions with GPS (Doug Manvell & J Simpson, Bruel & Kjær, Denmark)
After the break Doug Manvell presented a paper on the use of GPS in documenting environmental noise measurement positions. Doug introduced us to the B&K 2260 GPS interface and described the effects of various measurement environments on the accuracy which can be expected from the system. Questioners asked for more information on the accuracy of the system and the effects of large metal surfaces and electrical machines. Doug was able to flesh out some of the earlier points and explained the ways in which different co-ordinate systems can be used with the equipment.

Industrial noise planning and monitoring (Jon Richards, M W Kellogg Ltd & Mike Newman, Odegaard & Danneskiold-Samsoe)
Jon Richards of M W Kellogg presented a paper he had co-written with Mike Newman of ODS on industrial noise planning and monitoring. The paper described the environmental noise issues surrounding a very large gas plant extension in Norway and how Jon had ensured that the plant design produced noise levels which complied with stringent limits. Part of this process had involved issuing questionnaires to equipment suppliers to determine whether they fully understood acoustics and the noise information that they were being asked to provide. He also described tests undertaken by M W Kellogg of the noise control features that were necessary to meet the plant limits and the monitoring set-up established at the site after completion.

Several of the questions focused on the issue of in-duct noise measurement, which stimulated a discussion about possible errors and the best procedure. The question was also raised about whether the possibility of reducing noise from existing plant on the site was considered before the decision was made to design the new plant to be non-contributory. Jon explained that the existing and new plants on the site were operated by different organisations. In response to a question about the noise control add-on costs, he indicated that noise control accounted for approximately 4% of the total project spend.

Acoustics pipe insulation: a new ISO standard (Martin J Hassett, M W Kellogg Ltd)
Martin Hassett presented the final paper of the session on the new ISO standard for acoustic pipe insulation. ISO 15665, which will hopefully be published some time next year, gives performance data for various classes of acoustic pipe insulation and suggested construction methods which can be assumed to produce those performance figures.

Once the need for a particular acoustic performance has been identified, an engineer will have an easy reference for a construction that will achieve that performance. The standard also includes methods by which other constructions can be assessed and compared with the performance levels of the various classes. Many of the questions asked for more detail about the physical characteristics of the materials used in the standard constructions. In particular, details of the flow resistivity and stiffness of the porous in-fill layer were requested. This stimulated a discussion amongst the audience about the various test methods and sources of data for these two quantities.

Thus ended an Autumn Conference that has set a high standard, both in the papers presented and in the extent and quality of the discussions, and should provide a challenge for organisers of future autumn conferences.
Report and photographs by John W Tyler FIOA ❖

Acoustics Bulletin

Restructuring for 2001

As members will have seen from recent mailings, this is the last Bulletin to be produced by Cathy Mackenzie and Roy Lawrence. Their task has been to acquire and edit all material and create the Bulletin to the point of handing the printing company the entire issue in electronic form.

Their's will be a hard act to follow, as they provided a unique mix of acoustical expertise and publication skills. The Publications Committee has come to the view that, to take the Bulletin forward to new heights, we need to split up these tasks. The Institute has, therefore, appointed a new publications contractor and, by the time you read this, we plan to have appointed a new Editor.

Our New Publications Contractor

Following extensive research, we have appointed St Albans-based company International Labmate to provide design, layout and reprographic services. They will also sub-contract the printing services and instruct the printers. (Unwin Brothers were given notice of termination of the printing contract, effective with the September/ October and November/December issues). The new company already publishes an impressive range of scientific and environmental journals.

Key players for International Labmate are Director Russell Purvis, who is in overall control of the Institute contract, and Ann Satchell and Norman Simpson, who will do the day-to-day work on the design and layout of each Bulletin. We welcome them and look forward to a long and happy association.

Ann and Norman will work closely with our Editor, who will supply them with news and features and will be responsible for maintaining our high editorial standards. They will also liaise with our Advertising Manager, Keith Rose, to ensure that our advertisers are provided with a high quality service.

Their work will be produced using state-of-the-art hardware and software and their output will be in digital form, suitable for immediate printing and publication on the Institute website.

Our New Editor

We are grateful to John Tyler, who has assumed the role of Acting Editor for the January/February issue which is now well into production. John is a former Editor of the Bulletin and has been active for many years as an Associate Editor. He has also contributed greatly to our work in appointing a new publications contractor and editor.

We have received a good response from within the membership to our advertisement for the post of Editor. Interviews are scheduled for mid November and we plan to have made an appointment by the time you read this.

To assist the future Editor, we have set up a new Editorial Board. This is made up of members representing the many strands of Institute activity. They will provide regular news and views from their selected area and will work with the Editor, as required, to gather material for main feature articles.

We are looking for more volunteers to join the Editorial Board, so, if you think you can make a contribution, please contact the Institute Office. We would also be pleased to receive material on a one-off basis, so if you have something you think might be suitable for publication, please send it in. Photographs, particularly if they are of good quality, would be welcomed.

Our New Look

At the time of writing, final touches are being made to the new Bulletin design. Familiar features will be enhanced by more pictures and a more liberal use of colour. A three-column layout will be introduced for our news pages and a new cover design will provide a higher profile for our sponsor members. As in the past, 'blue pages', giving late information on forthcoming events, will appear in the centrefold. We plan to maintain our current editorial/ advertising ratio of 2:1.

We hope you will enjoy reading the new-look Bulletin. If you have any views on forthcoming editions, for publication or otherwise, please write to the Editor at the Institute Office.

John Miller MIOA
Publications Committee Chairman

Group and Branch News

Eastern Branch

Technical Visit

Twenty-four members of the Eastern Branch visited Group Lotus Plc, Hethel, Norfolk on 28th September and enjoyed an evening lecture covering Automotive Noise Vibration and Harshness (NVH) and a tour around their anecohic chamber noise test facilities, both delivered by Tim Saunders of Group Lotus Plc. The NVH analysis incorporated initial Body in White Structure and Finite Element analysis assessing Body Normal Modes and Body Acoustic Cavity Modes, Modal Alignment and Misalignment and Triaxial Accelerometer Dynamic Testing; all of these combined many types of complex software to give correlation between design and practice.

Evening Meeting

An enjoyable evening lecture, delivered by James E Duke (LLB ACIS ACIArb FRSA Barrister) entitled *Noise and the Law*, was received by an enthusiastic audience of twenty-two Eastern Branch members at Colchester Institute on 26th October. Within this lecture framework many areas of Noise and the Law were covered addressing a consideration of the Protection from Harassment Act 1997, Crime and Disorder Act 1998, Anti-Social Behavior Orders, Human Rights Act 1998 and Statutory Nuisance. These areas were expanded to look at Second Offences causing Fear of Violence, developments in Law for Controlling Nuisance Persons, alternatives to Civil Injunctions under the Protection from Harassment Act 1997 and Local Authority involvement by way of civil procedure.

Michael Alston MIOA

Scottish Branch

The Scottish Branch has been fairly active this year. The last report published in the Bulletin was a late report on the inaudibility debate and, as I am sure many of you are aware, the debate continues.

In May of this year we hosted a half day workshop on PAN 56 at which Bernadete Mckell and Nigel Cogger gave presentations on different aspects of the guidance. The workshop was very well attended with some good feedback on problems encountered with PAN 56.

In July there was the joint meeting with the Govan Law Centre on *The Legal and Technical Remedies for Sound Insulation.* The latter meeting was in response to the uncertainty of the ramifications of the Baxter and Mills case in Scotland. Mike Dailly of the Govan Law Centre gave his legal interpretation on what Baxter and Mills meant in Scotland and basically Mike's summary was as follows • *Mills & Baxter effectively eliminates the 'nuisance' limb from EPA noise nuisance cases in England & Wales, where noise is attributable to a lack of sound insulation – although the 'prejudice to health' limb remains intact, in terms of section 79(1)(a), (g) and (ga).* • *The common law definition of nuisance in Scotland is not the same as that in England. In Scotland there is no distinction between 'public and private' nuisance.* • *The concept of 'reasonable use' has no relevance to the common law of nuisance in Scotland. The key test in Scots law is simply whether what was exposed to was 'plus quam tolerabile' (more than tolerable).* • *Mills and Baxter is not binding in Scotland as its ratio turns upon aspects of English law which are not known to Scots law.* • *Given the Scots common law definition of 'nuisance', the decision of Mills & Baxter does not prevent local authorities and/or aggrieved persons from raising EPA noise nuisance actions (where there is a lack of sound insulation) upon the 'nuisance' limb of section 79(1)(a), (g) or (ga).* • *Notwithstanding Mills & Baxter, tenants in Scotland may have a contractual right of action against landlords where subjects had inadequate sound insulation, and were rendered reasonably unfit for human habitation or not tenantable and habitable.*

The Scottish Branch is also indebted to Danny Fumicelli from the London Borough of Islington who presented his thoughts on the case from an enforcement officer's perspective and as always Danni's presentation was very informative and entertaining at the same time.

Our 2000 AGM will now need to be held in early 2001, so a late AGM early in the year and a programme of events for 2001 will be discussed at our first committee meeting. All suggestions from Scottish Branch members gratefully received.

Bernadette Mckell MIOA

Building Acoustics Group

One-Day Meeting

On 12 October, a successful one day meeting and workshop was held at the Commonwealth Conference Centre, London. Entitled *Nursing Acoustics – Acoustics in Hospital Design,* the meeting included presentations ranging from discussions on the effects of noise and vibration on patients, staff and sensitive medical equipment, to a comparison of various design criteria. David Howe, of ZBP, also presented a building services consultant's view of the NHS Estates design guidance, Health Technical Memorandum 2045 *Acoustics: Design Considerations.* The meeting ended with an open discussion on hospital design criteria.

As many readers will be aware the Building Regulations 1991 Approved Document E: *Resistance to passage of sound* is being revised. A draft document is currently in circulation within the Department of the Environment, Transport and the Regions (DETR) and should be issued for public comment by the end of the year.

A consultation period of three months will follow, during which time members will be given opportunity to air their views and comments. It is intended to hold an open discussion meeting towards the end of January 2001 for members to explore the proposed document and feed back comments and suggestions to the DETR. Details of this meeting will be circulated in due course.

Adrian Popplewell AMIOA

Professional Development Committee

Professional Development is something everyone in the IOA should undertake. As individual members it is the best way to maximise your talents and to tailor your skills and competencies to your present and future career. As employers, agreeing a programme of professional development is a good way to get the best out of your staff. For large and small businesses staff training and professional development, when it is correctly targeted, is an important investment.

Members of the IOA by definition have attained a level of technical knowledge and skills, and continually update that knowledge with a variety of information which is provided by the Institute in different ways – in meetings, conferences, seminars and courses. Other skills may be required, and the Institute could provide information on these if the call is there. Issues such as health and safety, time and people management, effective writing, giving presentations, negotiation skills and many others are extremely important. Large organisations will often do this type of training in-house, but many of our members work in smaller organisations without access to such facilities. The PD Committee would be interested to know whether members have had any difficulty in finding providers of high-quality non-technical development courses or material, and whether there are any particular subjects which are important to them for which they have not found any provision.

The new scheme for PD is progressing, and a short brochure will be available soon. There will also be information available at conferences and seminars. Please send any comments to Sue Bird at the IOA office, or on sue@birdacoustics.co.uk.

Citations

Professor Y W Lam
Tyndall Medal – 2000

Yiu Lam graduated with a first class honours degree in Mechanical Engineering from the University of Hong Kong in 1982. He then moved to the University of Birmingham to undertake research into the noise radiation mechanisms of drop forging machines. This led to the development of a boundary element modelling program to predict noise radiation from an arbitrary vibrating body in an enclosure for which he was awarded his PhD in 1986.

From 1986 to 1988, Dr Lam was engaged in consultancy and testing work at the Motor Industry Research Association, where his duties involved the analysis and design of control measures for vehicle noise and vibration. Among his achievements were the formulation of a computer prediction model of noise from heavy goods vehicles and software for automated engine noise data acquisition.

He joined the University of Salford in 1988 as a Lecturer, having since progressed through appointments as Senior Lecturer in 1995, Reader in 1998 and Professor in 2000. His initial research interest was to develop mathematical and computer models for underwater transducers, but since 1990 Professor Lam has been responsible for the building acoustics and environmental noise research in the Department of Applied Acoustics (now the School of Acoustics and Electronic Engineering), and holds the post of Director of the Acoustics Research Centre.

His research activities have been concentrated in three areas; the computer modelling of the acoustics of enclosed spaces, the noise transmission through metal cladding systems, and the modelling of environmental noise propagation from industrial premises. The emphasis of the research in the first area is on the assessment and improvement of the accuracy of modelling methods. Adaptive beam tracing, surface diffusion modelling, and auralisation are among the main subjects of this research. In the second area the research is to characterise the noise transmission performance of commonly used metal cladding systems by means of extensive measurements and finite/boundary element modelling. A significant achievement is in the advance of the prediction methodology. This led to the Metal Cladding and Roofing Manufacturers Association commissioning the development of a practical computer prediction program, which has helped the industry to produce cost effective designs. In the third area the aim of the research is to improve the accuracy and applicability of the prediction of environmental noise propagation. Particular areas of interest are meteorological and ground terrain effects, and a user-friendly ray tracing computer model has been developed in collaboration with Powergen Plc. Other research interests include a long-running series of European projects for the reduction of noise from aero-engines, and collaboration with the University's Centre for Virtual Entertainment to integrate audio auralisation into virtual reality systems. Professor Lam has led the Acoustics Research Centre into a thriving internationally recognised research unit, and in so doing has attracted considerable funding from Research Council, government and industrial sources. As a result of his extensive research programme, Professor Lam has been the author or co-author of over 60 publications in refereed journals or international conference proceedings and some 25 other publications.

In addition to his research interests Professor Lam has been actively involved in the teaching duties in the School of Acoustics and Electronic Engineering. He has developed and delivered a range of BSc and BEng course modules in acoustics, is the course tutor of the BEng Electroacoustics course, has supervised several PhD and MSc students and is an external examiner for higher degree students at other universities. Professor Lam is a Chartered Engineer, a Member of the Institute of Mechanical Engineers, a Member of the Institute of Acoustics and of the Acoustical Society of America. He is an Associate Editor of Applied Acoustics and was the guest editor of a special issue on surface diffusion in room acoustics. He is also a member of two ISO Working Groups and a BSI Technical Committee, is actively involved in other academic and industrial research forums, and provides consultancy services to industry in the fields of building acoustics and environmental noise.

The Institute of Acoustics is pleased to award the Tyndall Medal for 2000 to Professor Yiu Lam for his distinguished achievement and services in the field of acoustics.

Professor David C Hothersall
R W B Stephens Medal – 1999

David Hothersall graduated in 1965 with an honours degree in Physics from the University of Sheffield, and was awarded his PhD in 1968 at Salford University for research into Domains and their Boundaries in Thin Sections of Iron. David then took up a research fellowship at the Department of Metallurgy at Oxford University until 1970 when he returned to Salford University as a Research Fellow in the Physics Department. Following this, in 1973, he was appointed Lecturer in Civil Engineering at the University of Bradford, being promoted to Senior Lecturer in 1983, Reader in Acoustics in 1991 and Professor of Environmental Acoustics in 1999.

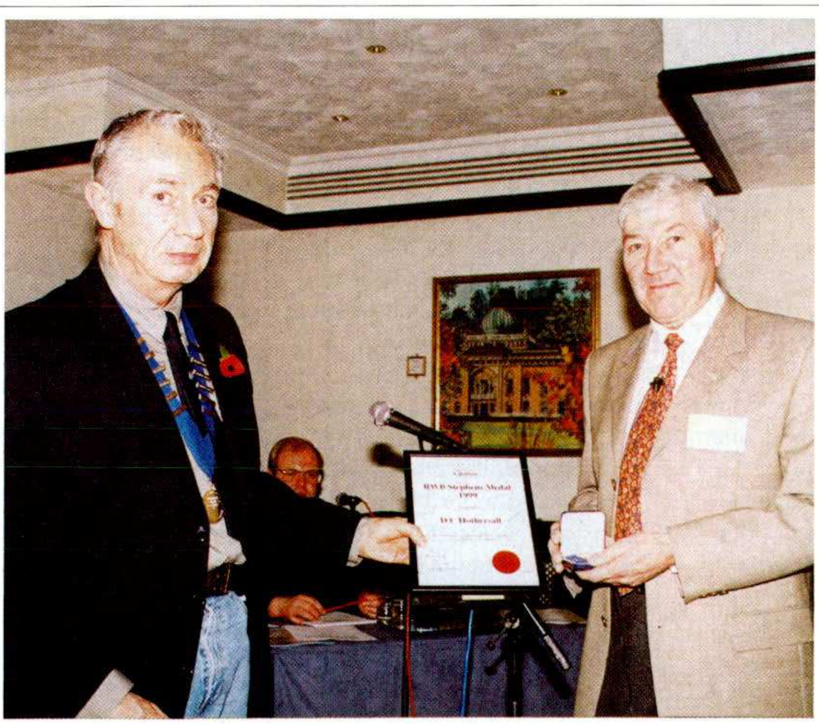
Professor Hothersall has taught at various undergraduate and postgraduate levels in a range of subjects including applied mathematics, physics, civil engineering, transport and the environment, computing, building acoustics, environmental noise control, environmental acoustics and occupational noise. He has undertaken final year project supervision on topics such as transport noise, industrial noise, building vibration, traffic engineering and acoustic transmission in buildings. Numerous PhD, MPhil and MSc students have been supervised by Professor Hothersall; he is an external examiner for several degree courses and PhDs at other universities as well as being an internal PhD examiner at Bradford University. As a proponent of continuing professional education, Professor Hothersall has coorganised several courses notably relating to the in-service training requirements for membership of the Institution of Civil Engineers.

Professor Hothersall is leader of Bradford University's Environmental Acoustic Research Group, which was recognised as holding an international reputation for research in the 1996 Research Assessment Exercise. His acoustical research interests are in the prediction of outdoor noise using numerical, mathematical and experimental models and the development of techniques and materials for the abatement of outdoor noise. This has notably included the prediction of traffic noise at road junctions, the development of boundary element methods to predict outdoor noise propagation over multi-impedance surfaces and barriers, and the performance of noise barriers with complex upper edges and in various configurations.

Professor Hothersall developed an experimental modelling facility to study sound propagation effects in complex environments, and has proposed the Fresnel Zone concept to describe the area of a surface which is primarily active in determining the form of a reflected or diffracted wave – an approach which is becoming widely accepted in engineering noise propagation models. His current research interests lie in developing the design criteria for efficient noise barriers, techniques for improving the accuracy of noise mapping and the development of new practical sound absorbing systems including the use of recycled materials.

As a result of his research work, Professor Hothersall has been the author or co-author of more than 40 papers published in refereed journals and in excess of 50 other papers presented at conferences and published in journals, books or proceedings, including several invited papers. He has been a member of the Editorial Board of Applied Acoustics since 1985 and was the editor of a special issue on the subject of road traffic noise. His work on new barrier designs has resulted in his being a co-inventor of a patented noise barrier. He was awarded the degree of Doctor of Science from the University of Salford in 1994.

In addition to his teaching and research work, Professor Hothersall's expertise has attracted consultancy engagements from a variety of organisations, he has participated in numerous committees for Bradford University, the Institution of Civil Engineers, and in connection with various national and international meetings and conferences, standards organisations and journals.



Professor Hothersall has given much of his time to the Institute of Acoustics. In addition to several roles connected with Institute meetings and Branch activities, he was a Member of Council from 1986 to 1995, for the last six years of which he was the Honorary Secretary and a member of the Executive Committee. Professor Hothersall is a Fellow of the Institute of Acoustics, a Fellow of the Institute of Physics, a Chartered Physicist and a Chartered Engineer.

The Institute of Acoustics is pleased to award the 1999 R W B Stephens Medal to Professor David Hothersall for his outstanding contribution to research and education in the field of acoustics. ❖

Hansard

30 October 2000
Traffic Noise

Mr Drew: To ask the Secretary of State for the Environment, Transport and the Regions (1) what measures his Department has taken to assist the introduction of barriers to reduce traffic noise; (2) what actions his Department has taken to introduce noise attenuation methods where traffic is concerned.

Mr Hill: One of the main methods of mitigating and attenuating traffic noise is to reduce the noise emitted by new vehicles. The Department has a continuing involvement in negotiating EU directives in this area. These measures have already delivered a substantial reduction in noise levels from new vehicles. A large lorry today makes no more noise than a car of the early 1970s and three modern cars now make less noise than one 1970s model. These measures will bring improvements as the vehicle fleet is renewed. Negotiations on further noise reduction are likely to focus on heavy vehicles such as trucks and buses. In addition the Department has recently been involved in negotiating an EU directive to limit tyre noise, the dominant source of noise from traffic at speeds above 40 miles per hour. This directive is expected to be adopted shortly.

£5 million a year ring-fenced budget is being spent to mitigate and attenuate noise, primarily using barriers, at locations on the national network where detailed studies have confirmed the severity of the problem and shown that barriers are the most effective solution in the short term. As indicated in my reply to my hon Friend on 6 December 1999, Official Report, column 427W, studies have been commissioned at a large number of locations. The Highways Agency will be dealing with nearly all of these locations over the next few years. In a number of cases where the road has been reassessed for resurfacing, the use of quieter materials has affected the priority for other measures.

Mr Drew: To ask the Secretary of State for the Environment, Transport and the Regions if he will list by area those schemes assisted by his Department to introduce noise barriers for traffic, stating his Department's financial contribution in each case.

Mr Hill: I refer my hon Friend to my answer of 11 November 1999, Official Report, column 681W, which included a letter from the then Chief Executive, Mr Lawrie Haynes, to my hon Friend the Member for Chatham and Aylesford (Mr Shaw). The Department will bear the whole cost of the works that it considers necessary.

Mr Drew: To ask the Secretary of State for the Environment, Transport and the Regions if he will make a statement on his Department's policy towards traffic noise.

Mr Hill: An Integrated Transport White Paper explained that we need to gain a better understanding of the effects of transport noise and expect advances in technology to provide some reductions in the impact of noise from road traffic. It is for local authorities to decide what further measures would be appropriate on their roads. My policies as highway authority for the strategic national road network were set out in *A New Deal for Trunk Roads* which was published along with the White Paper in July 1998. This states that quieter surfaces are to be used for all new trunk road schemes and resurfacing existing roads in an area where noise was a matter of concern. The *Ten Year Plan for Transport* published in July, should enable the Highways Agency to install by 2011 quieter surfaces on over 60 per cent of the national road network including all concrete stretches. In addition, funds are to be ring-fenced to permit the Highways Agency to provide over the next ten years other measures such as noise barriers in some of the worst and most pressing cases where there is no immediate need for the road to be resurfaced.

7 November 2000
Road Noise

Mr Robathan: To ask the Secretary of State for the Environment, Transport and the Regions what sift criteria will be used to determine which trunk roads are priorities for resurfacing to reduce noise levels.

Mr Hill: The criteria for prioritising the trunk roads for resurfacing with quieter materials are being developed by the Highways Agency. The Agency will be seeking the views of local authorities on these criteria early in the new year with a view to finalising them in the spring.

16 November 2000
Noise Act 1996

Mr Green: To ask the Secretary of State for the Environment, Transport and the Regions if he will list the local authorities which have implemented in full the provisions of the Noise Act 1996.

Mr Hill: There is no requirement for local authorities to inform the Department once they have decided to adopt the Act. The local authorities in England which have, so far as we are aware, adopted the Act, are: London Borough of Barnet, London Borough of Bromley, London Borough of Havering, London Borough of Waltham Forest, Westminster City Council, East Devon District Council, Guildford Borough Council, Hertsmere Borough Council, Newark and Sherwood District Council, Rushcliffe Borough Council, Shepway District Council, Surrey Heath Borough Council.

Mr Green: To ask the Secretary of State for the Environment, Transport and the Regions what actions he has taken to encourage local authorities to implement the provisions of the Noise Act 1996.

Mr Hill: The Noise Act was introduced following consideration of the effectiveness of neighbour noise controls by the Neighbour Noise Working Party and consultations with local authorities. When the Act was introduced the Government at the time left open the option of adopting it to local authorities in the light of their local requirements and available resources.

Following a commitment made to Parliament, we commissioned a review of the Act last year and expect to announce the outcome of this to the House shortly.

Noise Strategy

Mr Green: To ask the Secretary of State for the Environment, Transport and the Regions what plans he has to introduce a noise strategy; and if he will make a statement.

Mr Meacher: The Government have given a commitment to consider the case for a national ambient noise strategy. A first step will be to issue a consultation paper on the options.

Extracts provided by Rupert Taylor FIOA

BSI News

BS EN Publications

BS EN ISO 3747:2000 Acoustics – Determination of sound power levels of noise sources using sound pressure – Comparison method in situ. Supersedes BS 4196-7:1988.

British Standards Withdrawn

BS 4196: Sound power levels of noise sources.

BS 4196-7:1988 Survey method for determination of sound power levels of noise sources using a reference sound source.

Drafts for Public Comment

00/203403 DC IEC 61672-2 Electroacoustics – Sound level meters – Part 2: Pattern evaluation tests (IEC Document 29/464/CD) (Possible new British standard).

00/203572 DC IEC 60749-12 Vibration, variable frequency (IEC Document 47/1536/CDV) (Possible new British standard).

00/203794 DC IEC 60268-2 Edition 3 – Sound system equipment – Part 5: Loudspeakers (IEC Document 100/164/CDV).

00/564239 DC Draft BS EN ISO 354 Acoustics – Measurement of sound absorption in a reverberation room (Revision of ISO 354:1985 and ISO 354/Amd 1:1997.

CENELEC Publications

EN 60068: Environmental Testing

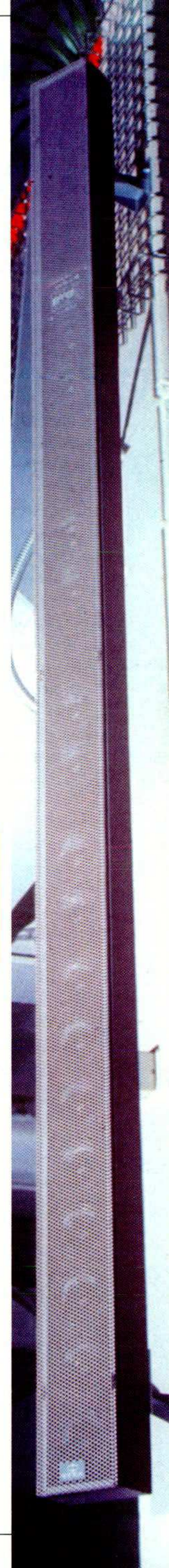
EN 60068-2-47: Test methods – Mounting of components, equipment and other articles for vibration, impact and similar dynamic tests (IEC 60068-2-47:1999) Corrigendum: June 1999 to EN 60068-2-47:1999.

ISO Publications

ISO 3747:2000 (Edition 2) Acoustics – Determination of sound power levels of noise sources using sound pressure – Comparison method in situ. To be implemented as BS EN ISO 3747.

ISO 14964:2000 Mechanical vibration and shock – Vibration of stationary structures – Specific requirements for quality management in measurement and evaluation of vibration.

This information was announced in the September and October 2000 issues of BSI Update, copies of which are kept in the Institute library. ❖



PETER BARNETT MIOA 1944 – 2000

Peter Barnett MIOA died suddenly on 29 November.

Peter Mapp MIOA writes:

Peter was principal of AMS Acoustics and one of the industry's characters. His contribution to the field of electroacoustics and in particular to the prediction of speech intelligibility brought him international recognition. His deep understanding of acoustic concepts and dexterity of thought and reasoning, made him a formidable consultant, as anyone foolish enough to publicly challenge him soon found to their cost. Presenters at conferences knew that with PB in the audience they had to be absolutely sure of their case and could not make an ill thought out comment, claim or explanation if they were to survive intact!

Peter began his professional career through the formidable Graduateship examination of the Institute of Physics and commenced working in thermodynamics. In typical PB fashion he went against conventional thought and by mathematical analysis alone, improved the thermal radiation efficiency of an entire class of space heating radiators. From problems of thermal radiation he gravitated to those more associated with acoustic radiation and noise control, so beginning his career in acoustics.

Peter always claimed to know nothing about electronics but he certainly knew one end of a transistor from the other, a knowledge he found useful when he joined the Acoustical Investigation and Research Organisation (AIRO) in 1969. Here, working with Peter Parkin of BRE, he helped develop *Assisted Resonance* technology as a viable commercial system for enhancing and increasing the reverberation time of auditoria. This work took him around the world, where he was responsible for the design and installation of systems in the USA as well as Europe and the UK. It was whilst working on such systems in the USA that his long and fruitful association with Chris Jaffe began. It was also around this time in 1977 that I first met Peter.

In 1983 he left AIRO and set up AMS (Acoustic Management Systems) in 1984. It was during this period that Peter conceived of the idea for a new reverberation enhancement technology called the *Reverberation on Demand System (*RODS). This he commercially developed in conjunction with Spectrum Audio. In conceiving RODS, Peter tackled one of reverberation enhancement's greatest problems, that of achieving sufficient acoustic gain and perceived effect before the onset of feedback. To this end he was highly successful.

I shall never forget setting up a trial system with Peter in a theatre/concert hall that I was working on and switching on the system just as the piano tuner walked across the stage. The look on the man's face, as his previously muffled footsteps echoed around the previously

'dead' auditorium which had suddenly become more akin to St Paul's Cathedral – system gain was from then on no longer a problem. The RODS system was successfully installed in a number of venues, primarily in the USA, where it integrated perfectly with Jaffe's *Early Reflected Energy System* (ERES).

In 1986 Peter and I joined forces to undertake the design of the PA system for the Royal Hong Kong Jockey Club's Happy Valley racecourse stadium. This turned out not only to be a mammoth and technically demanding project but also at times a highly entertaining one. Peter's trademark of fountain pen and indecipherable scribbles were much in evidence, either deriving equations on serviettes or beer mats or in writing withering letters to tardy contractors and suppliers.

Not only was it here that he began his attempts to 'bring some science' to the problem of predicting speech intelligibility but also where for once in his life he and his fountain pen met their match in the form of a Chinese typist who regularly misunderstood his writing – often with surprising effect. One classic example occurred with what was designed to be the final damning remark in a letter Peter had written to express his displeasure at the slow progress of a particular aspect. The final line should have read '... and were it not the case of your inability to deliver, we would not be in this sorry state'. The memo that actually went out however read '... and were it not the case for your inability to deliver we would not be in this sexy state.' Not quite what he meant !

Peter was a stalwart supporter of the IOA and in particular of the 'Reproduced Sound' series of conferences – attending every one and either presenting or coauthoring a paper at each one throughout their current 16 years of existence. In fact during his career, Peter authored over 100 papers and articles and was just setting out to write a book on his work. A quick count of his published papers shows that some 19 related to reverberation enhancement and 25 to speech and sound system intelligibility.

Peter served for many years as the Examiner for the Sound Reproduction module of the Institute's Diploma in Acoustics and Noise Control

Although Peter did not suffer fools gladly, he was keen to bring an understanding of acoustics to the sound and communications industry. He was a prime mover in setting up the training courses that accompanied several of the Reproduced Sound conferences in Windermere.

He also became actively involved in the development of the Institute of Sound and Communications Engineers of which he was a Vice President, giving strong support to that Institute's new quarterly Journal, the first issue of which has recently been published. Through that organisation he was very much engaged in giving lectures and seminars on the acoustic aspects of sound system design and this is another area in which he will be particularly missed.

Unusually, perhaps, for someone outside the academic sector, he undertook extensive and significant research into the prediction, measurement and enhancement of the intelligibility of sound systems. Through this, AMS was awarded a Smart Award by the Department of Trade and Industry in 1998 for innovative work in speech intelligibility.

His investigative work had a marked impact on the development of a number of National and International standards including IEC/EN/BS EN60849 (*Sound systems for emergency purposes*) and IEC/EN/BS EN60268 – pt 16 (*The objective rating of speech intelligibility*). Developments on the Jubilee Line extension in London became the stimulus and focus for much of this work, with AMS becoming the approved sound system prediction and verification consultants.

Peter was also heavily involved with the Inter Institutional Working Group that produced the Code of Practice for sound systems at sports grounds and stadia – which later became BS 7827. His work in this area led him on to becoming the Football Trust's expert on sound systems, with each new grant application requiring his approval before being awarded.

Peter never allowed his prior treatment for a longstanding heart condition to diminish his enthusiasm for everything he undertook. His energetic support for Saracens Rugby Football Club put him in the non-availability category most winter Saturday afternoons.

Those that knew him will never forget Peter's incisive mind and ready wit and for those that did not know him personally, the legacy of his papers will ensure that he will be remembered for a very long time to come. I count myself lucky to be able to remember him as my friend, arch rival, antagonist and mentor and hope that in some way the work on intelligibility by this mercurial character can be continued. ❖

Non-Institute Meetings

2001

14–17 January, Patras, Greece. 4th European Conference on Noise Control (euro-noise 2001). (LFME, University of Patras, P.O. Box 1400, Patras 26500, Greece; Fax: +30 61 996 344; Web: euro-noise2001.upatras.gr)

26–29 March, Hamburg-Harburg, Germany. German Acoustical Society Meeting (DAGA 2001). (e-mail: dega@aku.physik.uni-oldenburg.de)

21–25 May, Beijing, China. 5th International Conference on Theoretical and Computational Acoustics. (E. C. Shang, CIRES, University of Colorado, NOAA/ETL, Boulder, Colorado, USA. Web: www.etl.noaa.gov/ictca01)

28–31 May, Jurata, Poland. 3rd EAA International Symposium on Hydroacoustics. (G. Grelowska, Polish Naval Academy, Smidwicza 69, 81-103 Gdynia, Poland; Fax: +48 58 625 4846; Web: www.amw.gdynia.pl/pta/sha2001.html)

04–08 June, Chicago, Ill, USA. 141st Meeting of the Acoustical Society of America. (Fax: +1 516 576 2377; Web: asa.aip.org)

02–05 July, Delft, The Netherlands. Ultrasonics International Conference (UI'01). (W. Sachse, T&AM/212 Kimball Hall, Cornell University, Ithaca, NY 14853-1503 USA; Fax: +1 607 255 9179

02–06 July, Kowloon, Hong Kong. 8th International Congress on Sound and Vibration. (Fax: +852 2365 4703; Web: www.iiav.org)

28–30 August, The Hague, The Netherlands. INTER-NOISE 2001. (e-mail: secretary@internoise2001.tudelft.nl; Web: www.internoise2001.tudelft.nl)

02–07 September, Rome, Italy. 17th International Congress on Acoustics. (Fax: +39 6 4976 6932; Web: www.ica2001.it)

10–13 September, Perugia, Italy. International Symposium on Musical Acoustics (ISMA 2001). (Fax: +39 75 577 2255; e-mail: perusia@classico.it)

07–10 October, Atlanta, GA , USA. 2001 IEEE International Ultrasonics Symposium joint with World Congress on Ultrasonics. (Fax: +1 217 244 0105; Web: www.ieee-uffc.org/2001)

17–19 October, La Rioja, Spain. 32nd Meeting of the Spanish Acoustical Society. (Fax: +34 91 411 76 51; Web: www.ia.csic.es/sea/index.html)

03–07 December, Ft. Lauderdale, FL, USA. 142nd Meeting of the Acoustical Society of America. (Fax: +1 516 576 2377; Web: asa.aip.org)

Listed at http://gold.sao.nrc.ca/ims/ica/calendar.html. Send meeting announcements to: Walter G. Mayer Physics Department Georgetown University Washington, DC 20057–USA mayerw@gusun.georgetown.edu Fax: +1 202 687 2087

New Products

BRÜEL & KJÆR

PULSE Order Analysis

Brüel & Kjær has produced a multimedia presentation on CD-ROM that describes the company's PULSE™ Order Analysis solution.

The CD-ROM provides a comprehensive description of order analysis and its uses. This is followed by a simplified explanation of the various order analysis techniques covering the merits of machines, sources of machine vibration, principles of order analysis and four methods of order analysis (FFT-based, order tracking, time signal recording and short-time Fourier transform) and to which applications they are best suited.

A further section looks at the features and benefits of PULSE Order Analysis with live video clips demonstrating order analysis with PULSE. This section includes an introductory tour of PULSE software with comprehensive audio-visual descriptions of PULSE screen recordings that help to explain some of the essential PULSE concepts and provide background knowledge that enables users to better understand many other PULSE features.

Also included on the CD-ROM is a Brüel & Kjær company presentation covering sound and vibration in general and its effects on everyday life.

Brüel & Kjær multimedia presentation of PULSE Order Analysis is available free-of-charge from the company on 01438 739000.

WorkFlow Manager Launched

Brüel & Kjær announce the introduction of WorkFlow Manager Type 7756 a tool intended to streamline and organise repetitive sound and vibration test performed with the company's PULSE multi-analyser system. Output is available in annotated PULSE formatted data files with extended file headers containing user-selected information.

Additional features include structured archiving of test data and predefined test set-ups, creation and display of reference curves for pass-fail criteria, streamlined testing with fast switching in a single, open format data file and high visibility overload status monitoring.

WorkFlow Manager also links PULSE with other Microsoft Windows™-based applications.

More information from: Lene Gerstrom, Brüel & Kjær, Bedford House, Rutherford Close, Stevenage, Hertfordshire SG1 2ND Tel: 01438 739000 Fax: 01438 739099 e-mail: info@bkgb.co.uk Web site: http://www.bk.dk

Brüel & Kjær is a Key Sponsor of the Institute.

LMS INTERNATIONAL

Test.Lab

LMS International has launched LMS Test.Lab™, a new family of testing and analysis systems designed from the outset for ease-of-use and laboratory automation. Based on the LMS SCADAS III multichannel front-end and running in native Windows NT, Test.Lab is capable of handling the most sophisticated of testing situations.

However, the design emphasis was not to produce a 'next generation' product-line to replace LMS CADA-X, but one that complements it by providing a process-centric tool that focuses on helping a technician perform a specific application – such as engine run-up testing, closed-loop vibration screening or modal testing – quickly, accurately and with the minimum of fuss.

LMS Test.Lab is based on 20 years testing experience and over 100 man-years investment in a new and very sophisticated software architecture that is fully Windows NT/2000 compliant. The design was focussed on one goal: within a day of starting, a technician, an untrained engineer, or even a complete novice will be able to be able to run the most advanced of tests and publish their report onto the web.

Clearly the traditional open-ended menu-driven testing and analysis system, even those based in Windows operating environment, is far too complicated to learn – and use effectively – in such a time.

The way of interacting with LMS Test.Lab is very different. In effect each system is not a general purpose tool, but is set up by the test-lab manager to become a precision process-centric solution that captures user workflow and is tailored to a given task or application.

Now, instead of having a document that tells what the software is capable of doing and training the operators in executing the procedures correctly, it will be the software itself that guides the operator. The procedure to follow is embedded in the software, but more than that, the workflow is managed by the system itself. Procedures (engine testing etc) are defined in 'templates' by the lab manager which clearly describe what to do next.

These can be more than a list of tasks to do, they can use embedded graphics, pictures, video, and sounds that really help anyone understand and accomplish their tasks.

Users are guided through an enforced procedure, each step in the task process described in their own language and using familiar terminology. As such, an operator could perform a sophisticated test sequence after a minimum of training.

Although intended for ease-of-use, the LMS Test.Lab is said to still pack an awesome measurement performance – at least equal to that of LMS CADA-X. It runs on the LMS SCADAS III multichannel measurement front-end and is scalable all the way from a few channels to hundreds of static and dynamic measurement channels working over the full vibro-acoustic frequency range. It runs on a standard PC workstation – and can even take advantage of the latest multi-processor PC systems and distributed DSP power within the front-end itself for maximum performance.

Naturally all data can be transferred to Windows Office for a complete report at the local testing station. Test.Lab data are seamlessly compatible with other LMS products, so, for example, run-up data collected by a technician could be analysed over the network minutes later by an engineer performing a transfer path analysis of the full vehicle in LMS CADA-X.

The first Test.Lab modules – Signature Testing and Signature Processing – are already available and have been installed at some major user sites.

Sine and Random Vibration Control will be released by the end of this year which is the beginning of a product roadmap release that foresees a major product release every six months. The next release is scheduled to include Structural Testing (Impact & Broadband) workbooks, and completely new workbooks for Signature Engine Testing and Environmental Test.

For further information contact Buno Massa, Marketing Communication Manager, LMS International, Leuven, Belgium Tel: +32 16 384 200, Fax: +32 16 384 350
e-mail: buno.massa@lms.be
Website: http://www.lmsintl.com.

BIODATA LTD

Microlink 751

The new, compact, Microlink 751 unit from Biodata plugs into the computer's USB (universal serial bus) port and includes the Windmill 5 data acquisition software for Windows. No programming or opening the computer is required. With the Microlink 751 scientists can measure temperature, strain, pressure, voltage and current; monitor and control 32 digital inputs and outputs; and count events. Eight Microlinks can be connected to one PC and Biodata offer free technical support for life.

Microlink is powered from the USB port: very useful for portable data acquisition in the field.

It can automatically recalibrate itself. How often recalibration occurs is chosen using Windmill software.

The resolution of the measurements can be selected from 12- to 18-bits: letting users choose high throughput or high resolution. There are 4 input ranges available, and the software can automatically select the ranges most closely encompassing the signals.

With linearisation for B, E, J, K, N, R, S and T type thermocouples, a wide span of temperature measurements are supported.

All readings are presented in engineering units (°C, % strain etc), rather than raw voltages. Strain gauge bridges can be individually configured in software for full, half or quarter bridge wiring, and normal, tensile, compressive and transverse strain can be measured.

USB ports are found on most new computers and are gradually replacing RS232 and parallel interfaces. Designed for ease-of-use, USB devices like the Microlink 751 can be unplugged and plugged back in as required, with no need switch off the computer or even restart Windows in between. Using USB hubs, the Microlink 751 can be up to 30 m from the PC.

As well as the Microlink 751, the software handles most laboratory instruments with a RS232 (serial or COM) port. So users could log data collected by the Microlink 751 alongside data obtained from, say, a balance, a GPS or a calorimeter.

All data can also be automatically sent to a spreadsheet or other Windows program for analysis.

For more information contact: Dr Graham Collins, Biodata Ltd, 10 Stocks Street, Manchester M8 8QG Tel: 0161 834 6688 Fax: 0161 833 2190 e-mail: USB@microlink. co.uk

WILLAN BUILDING SERVICES LTD

Passivent Acoustic Wall Ventilator

Designed as a large air inlet/extract, the Passivent Acoustic ventilator's high sound reduction and large free open area are said to make it ideal for any application requiring ventilation.

The weighted normalised sound level difference is 30 dB across the ventilator in the open position, and 36 dB in the closed position based on independent Salford University testing to BS EN 20140-10 1992.

The ventilator will provide 100,000 mm^2 free area in the open position. It has a low airflow resistance with a cd of 0.36. At 10 Pa wind pressure it provides 154 l/s.

It is suitable for wall widths from 265 mm. Internal louvres use a 24 V or 240 V actuator controlled by direct linked wall mounted switch, or wall mounted/hand held infra red remote control, which are supplied separately if required. The actuators can be either two position or modulating.

External and internal acoustic cowl are manufactured from ABS. The ABS hood will resist a large soft body impact of 50 kg dropped from a height of 2.4 m onto the face of the product with a material temperature of 0°C. The internal louvres are insulated PVCu. There is acoustic lining to the hoods and internal acoustic baffles.

Appraised under BS EN ISO 9001 and 9002 which cover design, development, manufacture and installation (if by approved installers) giving an independently audited and maintained assurance that the products will meet their intended purpose.

For more information on this and other Passivent Natural Ventilation Products contact John Wright, Passivent Technical Manager, Willan Building Services Ltd, Unit 6, Tonbridge Chambers, Pembury Road, Tonbridge TN9 2HZ Tel: 01732 355519 Fax: 01732 355536 e-mail Johnw@willantn.demon.co.uk.

NEWS ITEMS

BRUEL & KJÆR

New Handbook

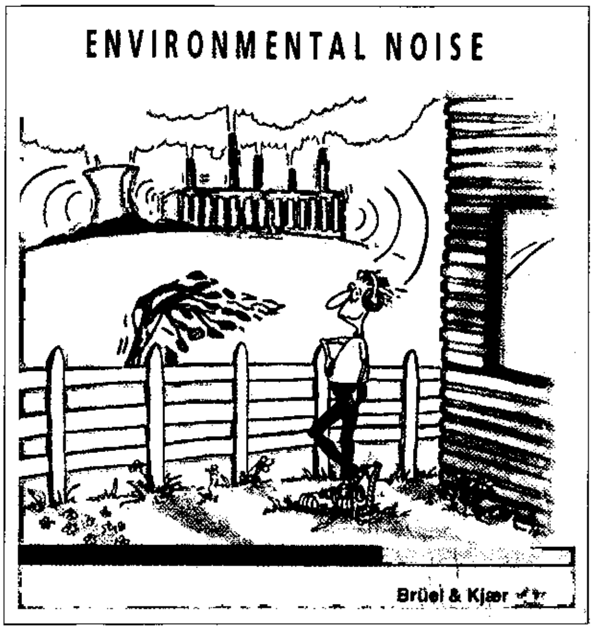
Brüel & Kjær announce a new 65-page educational handbook dealing with environmental noise.

The list price is £5 per copy but for a limited period the company is giving away free copies.

Contact should be made on email info@bkgb.co.uk or by fax on 01438 739099.

New Website

Brüel & Kjær has launched a website on the Internet, opening up a world of sound and vibration for visitors. The new site offers a wealth of resources for engineers involved in the sound and vibration field. It features sections covering company information and news, job information, products and applications



ranging from general sound and vibration, noise source identification through to sound power and building acoustics.

The service section includes information on calibration and repair plus a complete list of B&K service offices. The site also includes Brüel & Kjær global course calendar with up-to-date news on the courses and training that the company offers worldwide, together with information on exhibitions and conferences.

Also included is a list of worldwide contacts plus links to a wide range of sound and vibration websites. There is also a comprehensive search facility and a frequently asked questions (FAQ) forum.

A huge library of Brüel & Kjær literature is available for download from the site including application notes, brochures, bulletins, product data sheets and system data. Brüel & Kjær's magazine can also be downloaded.

Engineers interested in B&K's world of sound and vibration should point their browsers at http://www .bksv.com

Further information may be obtained from Lene Gerstrøm, Brüel & Kjær, Bedford House, Rutherford Close, Stevenage, Hertfordshire SG1 2ND Tel: 01483 739000 Fax: 01483 739099 email: info@bkgb. co.uk Web site: http://www.bk.dk.

Brüel & Kjær is a Key Sponsor of the Institute.

AVI LTD

New UKAS Accredited Laboratory

AV Calibration is the new UKAS accredited calibration laboratory (no. 0653) from AVI Ltd. Calibration available under this accreditation covers sound level meters to BS 7580:Part 1:1997, acoustic calibrators and pistonphones. The typical turnround time is said to be just seven working days.

AV Calibration is independent of all the major manufacturers, and has developed its accredited calibration procedures from the standard calibration service already offered. Most makes of equipment can be calibrated in the one laboratory. Whatever manufacturer is involved, the equipment must meet certain standards.

Sound level meters should claim compliance with IEC 60651 Type 1 and integrating meters with IEC 60804 Type 1 or their equivalents; Type 2 instruments are not included for UKAS accredited calibration. Calibrators and pistonphones should claim compliance with IEC 942 or IEC 60942 (or equivalents) if used with a sound level meter in a BS 7580 verification.

Few instruments manufactured in the last 20 years do not claim conformance to these requirements.

For more information, pricing and any questions answered, please contact Richard Tyler at AV Calibration, AVI Ltd,13C Old Bridge Way, Shefford, Beds SG17 5HQ Tel: 01462 638600 Fax: 01462 638601 e-mail: sales@avi.f2s.com website: www.avcalibration.co.uk.

ARUP ACOUSTICS

Address change

The postcode for 13 Fitzroy Street, London changes to W1T 4BQ and telephone/fax direct dial prefixes change from 020 7465 xxxx to 020 7755 xxxx. The two telephone systems will run in parallel until 1 April 2001.

IAC LTD

New web site

A complete library of technical documents has been created in downloadable .pdf file format for the company's new web site at www.iacl.co.uk.

Further information from Dave Greggor on Tel: 01962 873000 Fax: 01962 873132 email: daveg@iacl.co.uk.

IAC Ltd is a Sponsoring Organisation of the Institute.

ROYAL FESTIVAL HALL PROJECT

Documents Sought

Professor Bridget Shield is currently carrying out research into the history of the acoustics of the Royal Festival Hall. If anyone has any documents or information relating to the RFH acoustics, or any other items of interest, she would be delighted to hear from them.

She would also like to hear from people who attended the opening concert, or early concerts there. Please contact her at School of Engineering Systems and Design, South Bank University, London SE1 0AA Tel: 020 7815 7658, or email: shieldbm@sbu.ac.uk

DTI

News of Directive Adopted

The adoption of *Noise Emission in the Environment By Equipment For Use Outdoors Directive* is announced.

Noise emissions from various outdoor equipment have been harmonised in a new Council Directive adopted by the Council of Ministers and the European Parliament in Brussels.

The EC Noise emission in the environment by equipment for the use outdoors Directive, (2000/14/ EC), came into force on 3 July 2000. The purpose of the Directive is to remove technical barriers to trade by harmonising national laws of member states regarding noise emission limits and labelling requirements at the manufacturing stage, whilst producing environmental benefits.

The new Directive applies to 57 categories of outdoor equipment ranging from construction and waste management equipment to lawnmowers being placed on the market or put into service for the first time. Second-hand equipment and equipment already in use within the EC is not covered by the Directive. However, the Directive does apply to second-hand equipment in any country or territory outside the EC when it is imported into the EC for the first time.

Lord Sainsbury, Minister for Science and Innovation welcomed the Directive and stated that although the Directive's mandatory application will not be until 3 January 2002, manufacturers should now be considering what they have to do to comply with this legislation. He also noted that the labelling requirements of the Directive permit buyers to make an informed choice when seeking to purchase quieter equipment.

For further information, a free guidance booklet – *Product Standards: The Noise emission in the environment by equipment for use outdoors Directive 2000/14/EC – Guidance notes on the Directive* is available from the DTI's publications orderline Tel: 0870 1502 500 Fax: 0870 1502 333 or email: dtipubs@echristian.co.uk. It can also be downloaded from the STRD website: www.dti.gov.uk/strd/strdpubs. htm.

HEALTH & SAFETY EXECUTIVE

Guilty Firms Listed

The Health & Safety Executive has published its first ever enforcement report which names hundreds of companies, organisations and individuals convicted of health and safety crimes in 1999/2000. This action implements the commitment in the Revitalising Health and Safety strategy statement.

In 1999/2000 the HSE prosecuted 1,133 cases, involving 2,253 charges – an increase of 9% and 28% respectively on the previous year. In total, the HSE served a total of 11,304 improvement and prohibition notices. Of the 2,253 informations laid before the courts, only 72 led to a 'not guilty' or 'not proven' verdict. All of these figures are provisional.

The report is in two parts. The first contains a commentary on trends in the level of penalties, enforcement issues in specific industrial sectors, how those sectors need to improve and what the HSE is doing to help achieve this. The second gives details of all 1,600 convictions, with additional detail of these provided on the database.

The Revitalising Health and Safety initiative was launched by the Deputy Prime Minister and HSC Chair Bill Callaghan on 7 June 2000. This includes a 44-point action plan which aims to achieve, by the year 2010, the following targets: reduce the incidence of working days lost from work-related injury and ill-health by 30 per cent; reduce the incidence of people suffering from work-related ill-health by 20 per cent; and reduce the rate of fatal and major injuries by 10 per cent. There is an additional target of achieving half of each improvement by the year 2004.

Health and Safety offences and penalties can be downloaded from the HSE's website at http://www.hse.gov.uk/policy/enforce.pdf

ACOUSTICAL SOCIETY OF AMERICA

New Journal On-line

On 28 August 2000 the Acoustical Society of America (ASA) launched its second archival journal, Acoustics Research Letters Online (ARLO). ARLO is an international electronic letters journal. The submission and review process are handled with ASA's new online Manuscript Management System, which is stated to enable publication in as little time as one month. The abstracts of all articles will also appear in print in the Journal of the Acoustical Society of America (JASA), and full articles will appear on the JASA CD-ROM.

ARLO accepts colour and multimedia content (for example, audio, video, and computer animations). These are part of the reviewed manuscript.

ARLO is published and archived by the American Institute of Physics (AIP) on behalf of ASA. AIP also provides searching and linking functions to titles, authors, abstracts, key words, and references through its Online Journal Publishing Service.

ARLO is free to all individual readers with an internet browser (Netscape or Internet Explorer). There is no subscription fee. ARLO is financed by authors who pay a $350 publication fee for accepted manuscripts, and by libraries and institutions that are charged a modest annual fee ($150) to support the archiving and the migrating of multimedia material to new formats. Information can be found online at http://ojps.aip.org/ARLO.

Items for the New Products section should be sent to John Sargent MIOA, Oak Tree House, 26 Stratford Way, Watford WD1 3DJ e-mail j_w_sargent@hotmail.com.❖