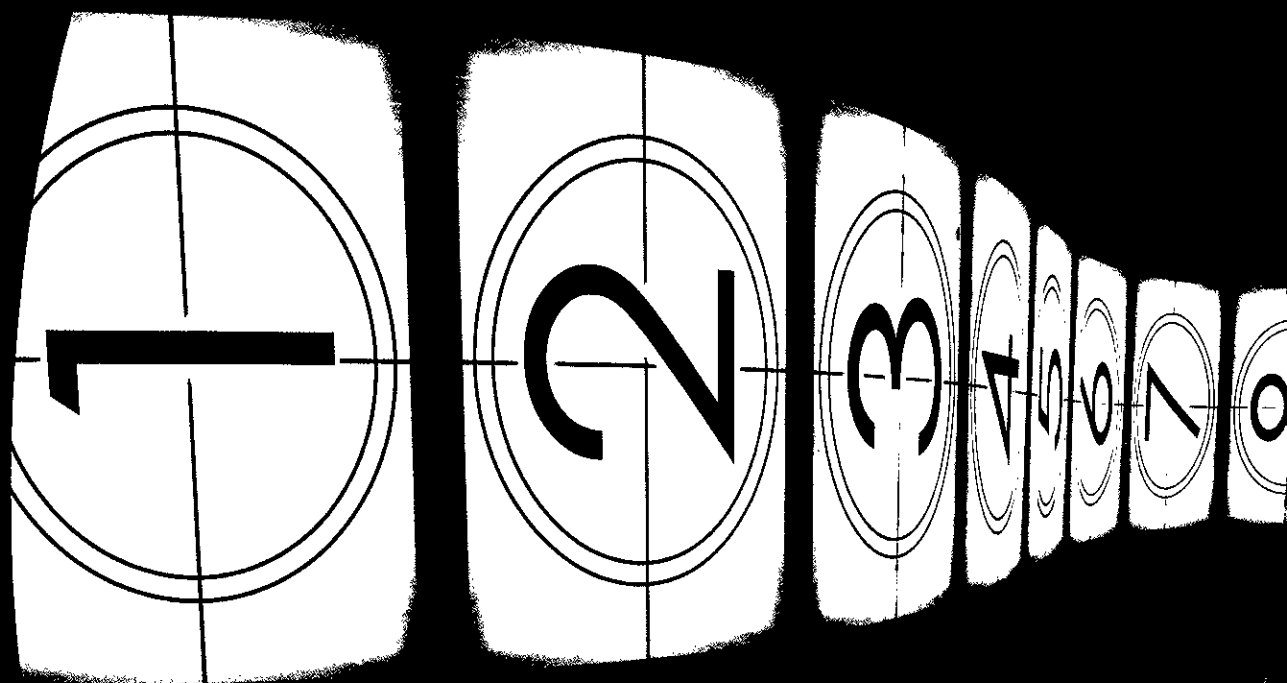


Vol 37 No 2 March/April 2012

ACOUSTICS

BULLETIN



in this issue... One-Third-Octave Equalisation
and its Use in Cinemas

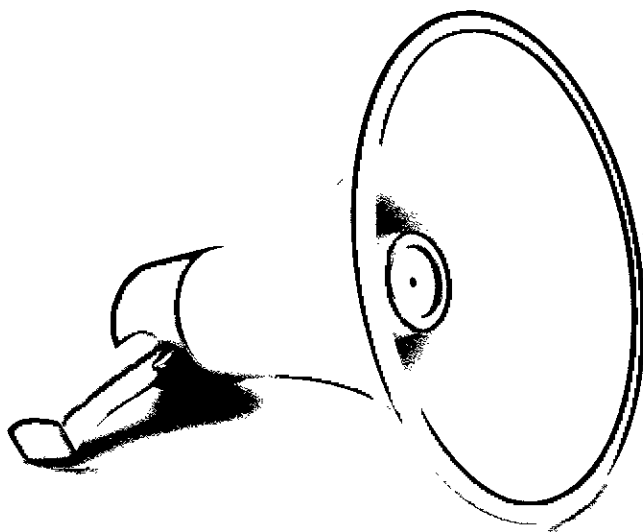
plus... Reproduced Sound 2011

IOA backs retention of schools acoustics regulation

Environmental noise a 'Government priority'

Sources of sound in air

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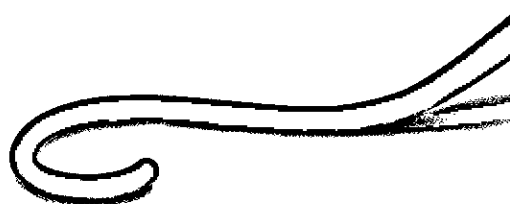


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ACOUSTICS

BULLETIN

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Front cover photograph: What should be the prescribed equalisation of cinema sound systems? See page 29 for more details.

The Institute of Acoustics is the UK's professional body for those working in acoustics, noise and vibration. It was formed in 1974 from the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society. The Institute of Acoustics is a nominated body of the Engineering Council, offering registration at Chartered and Incorporated Engineer levels.

The Institute has over 3000 members working in a diverse range of research, educational, governmental and industrial organisations. This multidisciplinary culture provides a productive environment for cross-fertilisation of ideas and initiatives. The range of interests of members within the world of acoustics is equally wide, embracing such aspects as aerodynamics, architectural acoustics, building acoustics, electroacoustics, engineering dynamics, noise and vibration, hearing, speech, physical acoustics, underwater acoustics, together with a variety of environmental aspects. The Institute is a Registered Charity no. 267026.



Institute of
Acoustics

Audio innovation greets delegates at Reproduced Sound 2011

Full conference round-up

Report by Bob Walker

The 2011 Reproduced Sound Conference was held on Thursday 17 and Friday 18 November. This year it returned to the Thistle Hotel, Brighton, back to the more usual type of integrated conference venue following the excursion to the Wales Millennium Centre in 2010.

The Institute's thanks and appreciation go to Paul Malpas for chairing the organising committee, to all the committee members for their contributions in organising the event and especially to Nick Screen for providing the technical cover. Thanks also go to the hotel staff, who were always helpful and co-operative, adding greatly to the smooth running of the conference.

The meeting room had also been equipped with a reinforcement system consisting of multiple small loudspeakers and an automated level/delay matrix to provide well-localised and unobtrusive sound reinforcement for the conference, tied to location tracking devices worn by the speakers. This had been installed by d&b audiotechnik and Timax jointly. The aim had been to demonstrate to the delegates how, as an industry, they might take the perceived quality of sound reinforcement to a new level. In the event, the system worked well and the organising committee gratefully acknowledges the effort put in by many people in setting it up.

The contributions of the exhibitors to the success of the conference are also gratefully acknowledged. Several also included sponsorship as part of their exhibition package. Those were valuable and much-appreciated contributions to the conference budget.

The technical presentations took place in the Renaissance Suite, with space in the lobby immediately adjacent to the meeting room for the exhibitors and for the refreshment breaks. The venue facilities fitted the conference requirements well. The hotel bar and lounge areas provided space for informal daytime and evening breaks, though there were some comments about the main lounge area being rather large and impersonal.

The conference theme continued from previous years, with its focus on developments in electroacoustics, room acoustics and intelligibility. In addition to one invited lecture and the Peter Barnett Memorial Award lecture, 21 technical papers were presented in seven sessions.

The conference was well attended, with 90 registered delegates, of whom eight were registered as students, plus seven exhibitors. The committee was again pleased to see a large number of new faces to RS, as well as the number of students.

A feature of the conference was an elaborate demonstration of the "Constellation" system by Meyer Sound. Special thanks go to John Pellowe and the crew of Meyer Sound for taking such considerable care and time to set up the facilities for the Thursday evening demonstration and audience participation session. This had involved a great deal of effort by many people over the whole of the Wednesday in first setting up acoustic treatment to "moderate" the room's natural acoustic and then a large number of loudspeakers, microphones and signal processing systems. The result was a simulated acoustic space in which performers and listeners could get impressions of a wide range of acoustic environments. The Institute expresses its thanks and appreciation to all those involved.

The delegates certainly appeared to have had an enjoyable and worthwhile conference, with many already looking forward to next year. Overall, the Electro-Acoustics Group committee was happy with the response to the programme and is now planning the 2012 event, to be held on 14-16 November, again at the Thistle Hotel.



The conference programme

Registration was open from 6:30pm on 16 November in the hotel reception area, with a glass of wine and the opportunity for delegates new to Reproduced Sound to make contact and to explore the venue and for old delegates meet old friends and colleagues.

An informal introductory session was held from 6:30 pm to 9 pm. Lara Harris (University of Southampton) started the session with *An introduction to statistics for audio engineers and acousticians*, a review of statistics for experiment design. Lara's tutorial was followed by a lively discussion. That was followed by Sam Wise (Arup Acoustics) and Larry Elliott (Marshall Day Acoustics) with *A retrospective on audio design*. In another lively discussion, an impromptu audience response was taken on "noteworthy steps" in the historical development of the modern audio chain. Perhaps predictably, there were many individual opinions and an enthusiastic 'exchange of views'.

The conference was formally opened the following day by the chairman, Paul Malpas, who welcomed the delegates. He said that the conference had been well supported, with many papers submitted and excellent attendance numbers. He thanked the committee, the delegates, the Institute, the students and all of the other people who had helped to make sure the conference happened.

The first day's sessions were followed by the presentation of the Peter Barnett Memorial Award. Afterwards, there was a break until a reception, which was followed by the conference dinner.

After dinner, John Pellowe (Meyer Sound) hosted a presentation of "Wonders of the Constellation". The delegates were divided into smaller groups because the controlled space was limited to about 20 seats. Live music was played in the space until about 1am, when those few remaining finally repaired to the bar.

The second day of the conference started with an invited lecture and further technical sessions. The Electro-Acoustics Group annual meeting was held immediately after the lunch break. An informal dinner in the hotel restaurant followed a reception.

Technical sessions, 17 November

Session 1, Room Acoustics 1, Chairman - Paul Malpas

The technical programme began with *The cone of an ancient New Zealand tree inspires the acoustic design for the New Zealand Supreme Court* by Glenn Leembruggen, Mark Hanson and David Gilfillan (ICE Design Australia). The paper was presented by Glenn. The presentation described the potential difficulties in a dome-shaped space and the use of light beams to identify

potential problem areas. Taking inspiration from the Kauri tree, the internal surface of the dome had been angled in segments to diffuse the potential discrete reflections. The design had resulted in a pleasant-sounding space, with good intelligibility that was also visually interesting and attractive.

The programme continued with *Alternative applications for the use of electro-acoustic technology* by John Pellowe (Meyer Sound). The paper described the use of electro-acoustic systems to change the acoustics of a building to suit differing applications. Two different examples of the use of the technology were described in detail. The first was the Miami Beach SoundScape, which allowed listeners in a large outdoor park to experience live relays of concerts in an open-air environment. The second part described Constellation systems installed in two major Californian sound recording facilities.

The final paper in the session was *Implementing wave field synthesis in an ITU spec listening room part 1: keeping it at ear level* by Robert Oldfield, J. A. Hargreaves, I. A. Drumm and A.T. Moorhouse (University of Salford). The paper was presented by Robert. It described the installation of a Wave Field Synthesis system in an ITU listening room at Salford, using 112 loudspeakers. The presentation described the testing and verification of the system. The completed installation was used for the evaluation of reflection effects and the auralisation of soundscapes. The presentation was followed by a lively and extended discussion.

The three papers were followed by a coffee break in the exhibition area. There, delegates could take a break, get some refreshment and discuss matters of interest, as well as speaking with the exhibitors.

Session 2, Room Acoustics 2, Chairman – Bob Walker

After the break *Implementing wave field synthesis in an ITU spec listening room part 2: bass without modes* by Jonathan Hargreaves and M. Wankling (University of Salford) was presented by Jonathan. It described the installation of a Controlled Acoustic Bass System (CABS) in the same ITU listening room using eight subwoofers. The rear delay and attenuation were adjusted to minimise deviation from a flat frequency response over the listening area. The result was a significantly more uniform frequency response and the elimination of the most prominent tonal artefacts. This allowed corrective equalisation to be applied giving the system a nominally flat response over its operating frequency range of 30Hz to 120Hz.

In the paper *An investigation into the effectiveness of active room correction* by Adam Craig and D Moore, (Glasgow Caledonian University), Adam described an investigation into the effectiveness of three different proprietary systems for room acoustic correction, using listening tests carried out in a controlled environment. Excerpts of 10 seconds for each of eight different genres of audio were used. They were normalised to

equal loudness. The best performing product was further analysed by making test recordings in four different professional studios. Two recordings were made in each studio, with and without the room correction system active and the pairs compared. The results showed that, generally, a good studio was not changed but that a bad studio was significantly improved. The presentation was followed by a lively and extended discussion.

In the final paper of the session *The Truly Green Recording Studios – a reality or still just a dream* Aurelien Folie (University of Edinburgh) presented options for a more ecological recording studio. He started from the assumption that neither the quality nor the cost of the studio should be compromised by any ecological considerations. The intention was to reduce the consumption of primary sources of materials and energy. He went on to discuss ecological aspects of the equipment, the building and the energy sources and usage. He concluded that recycled materials could reduce the environmental impact of the building and choice of equipment could reduce the energy consumption. He also compared the lifetime costs of different methods of providing the inevitable electrical energy requirements. The presentation was followed by quite a lively and questioning discussion.

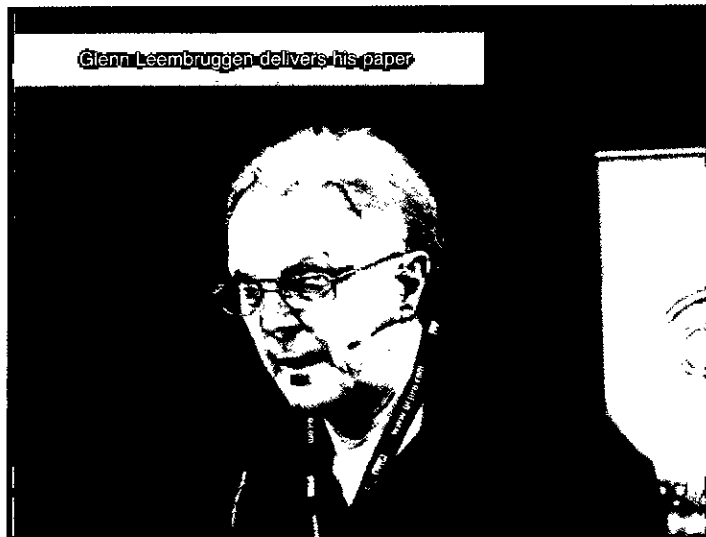
Session 3, Audio Quality, Chairman – Sam Wise

Philip Newell presented *Does 1/3rd octave X curve equalisation improve the sound in a typical cinema?* by Philip Newell, (Consultant), Glenn Leembruggen (Acoustic Directions), Soledad Torres-Guijarro, Fernando Mato, David Gilfillan (Gilfillan Soundworks), Keith Holland (University of Southampton) and Julius Newell (Newell Acoustics Engineering). This paper continued the investigation into the relevance of the prescribed equalisation of cinema sound systems. Acoustic measurements using different time-window lengths were used to assess the direct, early and late sound fields. The effects of smoothing in the frequency domain were explored. These were compared with measurements in an equalised room to assess the usefulness of the equalisation process and its impact on listener enjoyment and dialogue intelligibility.

In *Format agnostic audio recording and reproduction for football broadcasts on the television*, by Robert Oldfield, B Shipley (University of Salford), J Spille (Technicolor) Robert first described the conventional microphone arrangement for recording football sound. It relied on the sound engineer to control the balance of the mix and pick out the focus of the action. He then described an algorithm designed to perform that process automatically. It extracted the key on-pitch sounds and determined the source position on the pitch by time-domain correlation. The extracted "audio objects" could then be located for reproduction using any spatial audio system. He said this represented a paradigm shift for such broadcasts where all on-pitch sounds are currently panned to front centre. The work formed part of the EU-funded project, FascinatE, which aimed at more interactive and immersive broadcasting and which was format agnostic.

The final paper before the break was *The sound of sport: what is "real"?* by Peregrine Andrews (Moving Air). He first described the historical progress of programme sound over the years from actuality, in which the microphones essentially picked up the sound that a listener would hear at a distance, through the use of close microphones at the sound sources to the modern concept of adding artificial sounds that didn't exist at all at the venue. This was all intended to satisfy modern audience expectations, as influenced by modern cinema productions. He said that sport audio production was now becoming more like film production using a Foley suite.

After a tea break, Jamie Angus (University of Salford) presented the final paper in the session *Recorded music amplitude statistics revisited*. The paper described an extensive study of the amplitude distributions of a number of CD recordings. It developed an earlier study by Allen Mornington-West on signal amplitudes in recorded music. It extended that work and was able to present results to a much higher resolution than the earlier study had been able to. Results were presented for both filtered, as in active **▶ P8 ▶**



P77 crossover networks, and broadband music of diverse genres, from thrash metal through pop to classic. Simple analytic expressions were shown to be reasonable approximations to the measured probability density distributions. The implications for the design of efficient power amplifiers and audio coding systems were also discussed. A lively discussion followed the presentation.

The day's technical sessions were followed by the presentation of the Peter Barnett Memorial Award to Bob Walker by the Institute President, Trevor Cox. The citation was read by Glenn Leembruggen. That was followed by the award lecture *Early reflection control in stereophonic control rooms and listening rooms – a personal view*. In his talk, Bob reviewed his many years of work on early reflections, their effects on the localisation of stereophonic image sources and the design of rooms to overcome them. He emphasised that his work had always been directed towards the perception of virtual images and that the perception of real, physical sources was significantly different. He concluded with a design for a multi-channel listening room incorporating reflection control with minimal impact on the room décor and layout.

Afterwards, there was a break until a reception which was followed by the conference dinner. After dinner, the delegates were divided into groups to attend the Constellation demonstration, take time to socialise with other delegates, catch up on the day's events and relax.

Technical sessions, 18 November

Session 4, *Speech intelligibility*, Chairman – Paul Malpas

The day started with the keynote paper *The future is bright for the speech transmission index: dealing with new challenges after four decades of development* by Sander Van Wijngaarden, H J M Steeneken and J A Verhave (Embedded Acoustics). Herman Steeneken described the origins of the STI measurement methodology and its implementation in early measurement systems. Sander continued the presentation with an overview of the future for STI. He described the potential development of methodology, hardware platforms, including mobile applications, and possible developments in the standards. He also developed the concept of machine interpretation or assessment, perhaps based on binaural processing, and the prospects for measurements based on speech or speech-like signals.

The next presentation was *Characterising the source: an important aspect for more accurate and meaningful speech intelligibility and privacy assessments* by Francis Li (University of Salford). In his paper, Francis discussed the effects on the character of the voice of different levels of effort and presented some of the results from a large-scale study into statistical features of speech levels in anechoic conditions. He also presented some results from a pilot investigation into the relations between speech perception and the variations in vocal effort. The paper concluded by suggesting appropriate speech levels when setting up speech intelligibility and privacy tests.

Session 5, *Prediction and measurement*, Chairman – Keith Holland

In *New Tools in room acoustic simulation* by Wolfgang Ahnert, S Feistal, W Richert and H Schmalte (AFMG, Germany), Wolfgang discussed the requirement for a database of absorption and scattering behaviour of different constructions, geometrical structures and materials. In particular, scattering coefficients are less commonly available and some form of calculator is needed. He demonstrated tools presently being developed as part of his acoustic modelling system that permitted calculation of the frequency-dependent absorption and scattering coefficients for different geometrical arrangements and the calculation of complex reflection factors or wall impedances for wave acoustics. Tools had also been developed to predict complex sound insulation coefficients of different wall constructions. When asked, he replied that the absorption model didn't yet include allowance for the angles of incidence.

The second paper of the session was *Synthesised musical stimuli to enable occupied room impulse response measurement* by

Massimo Serafini and F F Li (University of Salford). The paper was presented by Massimo. It presented a method of generating and analysing test signals made to sound like musical notes. The individual test signals were intended to be played in sequence as notes in a musical composition. The objective was to obtain measurements of acoustic parameters of occupied rooms. The use of well-defined musical signals as stimuli enabled the measurement to be made without causing too much disturbance to the audience. Moreover, as the measurement could be completed in a relatively short period, problems induced by temporal variation would be reduced. The paper presented the algorithms, simulations and validation test results.

The next paper was *ExpoChirp toolbox: a pure data implementation of an exponential sweep sine (ESS) impulse response measurement* by Serafino Di Rosario (Buro Happold) and K Vetter (Independent PD Programmer, The Netherlands). The paper, presented by Serafino, described an implementation of the ESS method and proposed a dedicated Pure Data (PD) class featuring a modified mathematical formulation of the exponential chirp with control of both the frequency and the phase at any point. The resulting chirp exhibited minimum ripple in the high frequencies without compromising the frequency range. An optimised time domain window was used to control the low frequency ripple. In the discussion, Serafino said that the software had already been released and that the use of ESS overcame the problems with non-linearity inherent in the pseudo-random noise approach.

Patrick Macey (PACSYS Limited) then presented *Room acoustic analysis using a 2.5 dimensional approach*. In this, Patrick described a hybrid FE calculation method that assumed an acoustic enclosure had a constant cross-section and uniform height. A complete 2-D mesh was created for the cross-section to calculate the cross-sectional modes. The model could then be extended to the third dimension by simple modal expansion of the Green's function. Comparison was made between results computed using the full FE and BE approaches and the hybrid approach, for an irregular shaped room of constant height. Agreement was close, but the hybrid computation was orders of magnitude faster. The presentation was followed by a lively discussion.

Session 6, *Applications and engineered sound 1*, Chairman – Nick Screen

After lunch and the EAG AGM, Oliver Sahm (EV) presented *Sound reinforcement systems in stadiums, a comprehensive task for safety, operation and acoustics*. He described how contractually enforced parameters such as frequency response, sound level and intelligibility could be satisfied while, at the same time, less objective requirements like reliability and ease of operation could be included in a system design from the outset. The object was to end up with a system that was much more than just satisfying the acoustic parameters but also the operator, the facility management and the owner. This comprehensive approach was illustrated using recent designs from large stadium installations in South Africa and Germany for the last two soccer world championships.

In *When entertainment meets life safety* by Jim Gilroy and David Howe (Protec), Jim and David made a joint presentation of how Broadcast Sound and Voice Alarm can be integrated, particularly in stadia and indoor arenas. The presentation covered the design of systems that were robust, secure and delivered broadcast quality audio. It also described how multi-rack networks could be designed to be safe and efficient and included a discussion of the commercial advantages of using a digital system to combine what could be two fundamentally different sets of requirements. The presentation was followed by a very lively discussion.

In the final paper before the tea break, *The need for diplomacy in acoustical consulting* by Daryl Prasad, Larry Elliott and Miklin Halstead (Marshall Day Acoustics) Larry described the liaison issues between the various groups of specialists associated with important projects. He highlighted the need for diplomacy as much as acoustical expertise. The presentation was illustrated by reference to one particular project. In the brief, the client **P10**



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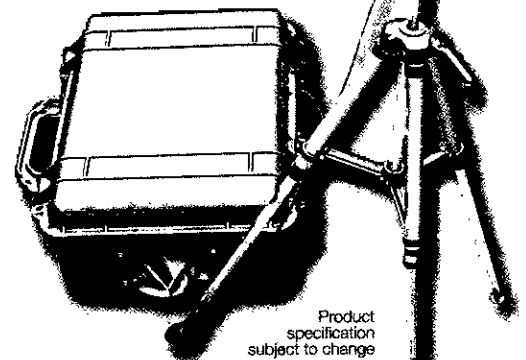
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IP8 had initially required an approach that was fundamentally wrong. Furthermore, the funding had been conditional on that outcome being achieved. In his presentation Larry gave an overview of how the project had used a simple model to steer the project to a satisfactory outcome. In the following discussion, Larry said that the final results had been very close to the model predictions. He also said that the project had not been able to support a full modelling study.

Session 7, *Applications and engineered sound 2*, Chairman – Mark Bailey

After the break, in *What's in your toolbox? An examination of the amplifications of the human voice and what tools are appropriate for the task* by John Taylor and Steve Jones (d&b audiotechnik), John and Steve looked at the fundamental objectives for sound reinforcement systems. It included how one went about the task and what tools were needed to achieve it. The paper first considered the properties of the source, in this instance the human voice, in terms of its directivity and level to see what it could be achieved before starting to consider any amplification. The presentation then went on to consider how amplification effected the audience and how the "The Suspension of Disbelief" applied to many areas of sound reinforcement. Using a combination level and delay matrix, the possibilities of an "invisible" system were demonstrated. The system had been in use throughout the conference and had been shown to be both effective and inconspicuous.

The next paper was *Raising the tone of the debate: audio systems for the Northern Territory and New Zealand Parliaments* by David Gilfillan (ICE Design Australia). David described how Parliamentary situations placed severe demands on their audio systems. They needed to provide high quality and good speech

intelligibility for sound reinforcement, transcription and broadcast. The demands also include a wide dynamic range, high gain before feedback, and high audio output quality for transcription and broadcast of both speeches and interjections. Sometimes those demands were contradictory. The presentation outlined how the demands were met in Darwin in the Northern Territory of Australia and in Wellington NZ using multi-channel, steered loudspeaker arrays for sound reinforcement, complex automatic mixing and other innovative design and commissioning techniques.

The final paper of the conference was *Performance audio + intelligibility + evac = ??: a loudspeaker manufacturer's take* by Andrew Nagal, C Montrezor, G. LeNost (L-Acoustics, France) and David Yates (Vanguardia Consulting). The paper was presented by Andrew. He described how venues today had to be multifunctional, attempting to satisfy a number of conflicting requirements for entertainment, worship, and sports. Using several case studies, Andrew described working solutions to balancing high performance audio, intelligibility requirements and evacuation system integration. This was achieved through the use of line source array technology, loudspeaker performance monitoring, smart amplifiers and network control and switching.

After the final paper, there was a break until a reception, which was followed by an informal dinner in the hotel restaurant. After dinner, delegates were free to take time to socialise, catch up on the day's events and relax. **IP**

IOA backs retention of schools acoustics regulation

Strong support from membership

The IOA is strongly supporting the retention of the regulation of acoustics in the School Premises Regulations. Following the publication of a consultation document by the Department for Education in November 2011 entitled *Standards for School Premises*, the Institute asked all members for their views, and the comments received form the basis of its official response which is listed in full below.

Bridget Shield, President-Elect, who compiled the response, said: "It represents the majority view of the individual responses received from members.

"The draft SPR refers to a document *Acoustic Design of Schools* to be published in 2012. This will in effect be a revision of BB93. Some of the responses received from members discussed details of BB93; these comments have not necessarily been included in the SPR consultation response as the revised 'BB93' will be available for consultation later this year, and there will then be an opportunity for IOA members to provide detailed comment on its contents.

"Thanks are due to those members who took the time to respond to the SPR consultation document."

Section 3.1 Question

Do you agree that this [the acoustic regulation] adequately covers the requirements for acoustics. If not, why not?

The Institute welcomes the retention of the regulation on acoustics in the School Premises Regulations. It is essential that acoustic conditions within schools are designed to the high standards required to provide optimum teaching and learning conditions.

The regulation as stated is appropriate as an overarching statement subject to the qualification set out in Annex C. The Institute also welcomes the retention of a framework for the acoustic design of school buildings in the form of the revised document 'Acoustic Design of Schools', to replace Section 1 of Building Bulletin 93 (BB93). The link between the SPR and Requirement E4 performance standards provided by Annex C is a particularly useful addition to the SPR.

According to Annex C the SPR must ensure that school premises comply with Requirement E4 of the Building Regulations so that every room in a school has acoustic conditions appropriate to its use, as specified in the new document 'Acoustic Design of School Buildings' to be published in 2012.

It is noted that, according to Annex C, Requirement E4 will in future be satisfied if the specified performance standards for sound insulation, reverberation time and indoor ambient noise levels are satisfied. The implication is that speech intelligibility in open plan areas will in future be governed by the SPR alone. This requirement should be highlighted in Annex C.

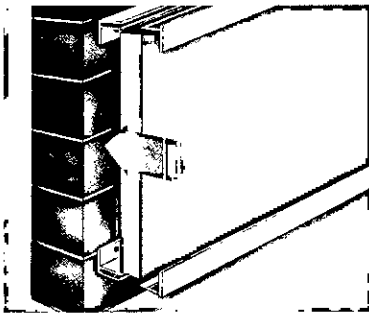
Section 3.3 Question

Do you agree that these regulations adequately cover the requirements for boarding schools? If not, why not?

It is not clear whether residential and sleeping accommodation in boarding schools qualifies as 'rooms for residential purposes' subject to Part E of the Building Regulations, in which case standards for sound insulation should apply. This needs clarification here and in Annex C. **IP12**

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EP10 Section 8.3 Question

Which of the current guidance documents do you particularly value and why?

Building Bulletin 93 is extensively used by members and its value as the only comprehensive source of technical and design guidance for acoustics in schools is widely recognised. Since 2003 it has helped to ensure that all new schools are designed to similar acoustic standards which provide appropriate acoustic conditions for teaching and learning.

It is recognised by members that BB93 requires revision and updating to reflect current aspects of school design and educational practice, in order to continue to maintain optimum acoustic standards in schools and other educational establishments. Guidance on the refurbishment of existing buildings or change of use will be particularly important in the current climate.

Additional comments

In addition to the responses to specific questions, the following areas of concern and query were raised by members.

Enforcement

It is generally felt that the current system of 'design checks by Building Control Bodies', referred to in Annex C, is a very unsatisfactory and inadequate means of enforcing the regulations. While

Annex C refers to 'recommended' acoustic testing of new school accommodation it is felt that mandatory pre-completion testing of at least a sample of rooms is required to ensure compliance with both the SPR and the Building Regulations.

Application of SPR

It is understood that the revised SPR will apply to all maintained and independent schools including academies and free schools. It is noted that nursery schools are also covered by the regulations but it is not clear whether they apply to all 'early years' provision or to sixth form colleges.

Concern was expressed about the difficulty of ensuring that all school estates including existing school premises comply with the performance standards of Requirement E4 of the Building Regulations, as now required by the revised SPR.

Management issues

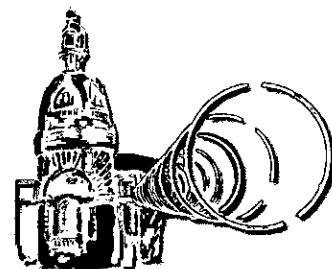
This section under 'Acoustics' in Annex C should be expanded to include particular advice on the importance of effective timetabling of adjacent and linked spaces (particularly open plan areas); using spaces for the purposes for which they were designed; and realistic expectations with regard to sound insulation. ■

Acoustics 2012: the countdown begins

Final preparations are under way for the Acoustics 2012 Congress in Nantes, France from 23 to 27 April 2012. Co-organised by the French Acoustical Society (SFA) and the Institute of Acoustics, it will represent the joining together the 11th Congrès Français d'Acoustique and the 2012 annual IOA meeting, and is also supported by the European Acoustics Association (EAA).

There will be more than 840 contributions, including two plenary lectures which will take place during the opening session, eight keynote lectures, 76 invited papers, 630 contributed papers and 138 posters and nine parallel sessions.

The plenary and keynote lectures have been the result of equal numbers of nominations from both SFA and IOA and are listed in the table below. Interestingly, one of the SFA ■



ACOUSTICS 2012

Lecturer	Topic
Kirill Horoshenkov	Acoustical monitoring of water infrastructure
Noureddine Attalla	Practical Modelling of the vibroacoustics response of structures with attached noise control materials
Daniel Juve	Aeroacoustics: Convergence between direct computations and experiments
Yiu Wai Lam	Time domain modelling of room acoustics
Carl Hopkins	Sound insulation in buildings: linking theory and practice
Daniel Pressnitzer	The adaptive auditory mind
Marc Deschamps	Multi-scale characterisations of materials and structures by ultrasonic methods
Stuart Bolton	The influence of boundary conditions and internal constraints on the performance of noise control materials
Robin Cleveland	Shock waves in medicine
Murray Campbell	An acoustical history of lip-excited musical wind instruments

nominees is Murray Campbell who is well known as a leading member of the UK musical acoustics community.

There will also be an invited lecture and concert, A Soundscape Composition Concert: Real and Imaginary Spaces, from Barry Truax, author of the Handbook for Acoustic Ecology and contributor to the World Soundscapes Project (see <http://www.sfu.ca/sonic-studio/handbook/index.html>).

The conference will cover all branches of acoustics. For example, there will be 12 structured sessions in physical acoustics and 11 in noise and vibration. Among the "hot topics" are sessions on wind turbine noise and acoustical metamaterials.

The conference will include a full social programme featuring a cruise and banquet, a social evening involving musical contributions from attendees, visits to local attractions and vineyards and welcome and closing cocktail parties.

The congress will mark the recent passing of Phil Doak through an "in memoriam" talk from Stuart Bolton, a Professor of Mechanical Engineering at Purdue University and a former PhD student of Phil Doak. Also Phil's name will be used for one of the conference meeting rooms.

So far the registrations so far are overwhelmingly (about 700) from French scientists. If there are IOA members who wish to join us and boost the proportion of representatives from the UK, the registration procedure is still open through the following web address:

<http://www.acoustics2012-nantes.org/index.php/en/congress/registration.html>

Note the following important deadlines:

- online registration closes on 2 April. After this date, the registration will be only possible on site from 1pm on 23 April
- the hotel booking service is available until April 6. ■



The Nantes congress centre

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We have Bi-monthly meetings that provide a forum for discussion and debate, both within the meetings and in a more informal social context.

Potential clients can search our website which lists all members, sorted by services offered and location.

Membership of the Association is open to all acoustics consultancy practices able to demonstrate the necessary professional and technical competence is available, that a satisfactory standard of continuity of service and staff is maintained and that there is no significant interest in acoustical products.

To find out more about becoming a member of the ANC please visit our website (www.theanc.co.uk) or call 020 8253 4518

IOA moves to new home as *Acoustics Bulletin* gets revamp

Where you can find us now

As many members will already be aware, the Institute of Acoustics has moved to a new home in St Albans. Following proposals by our previous landlords to redevelop the site as a hotel, it has taken advantage of a good opportunity to move before the end of its lease to new office a few hundred yards away.

The new address is St Peter's House (3rd floor), 45-49 Victoria Street, St Albans AL1 3WZ. Phone and fax number remain unchanged. For details of how to find it go to maps.google.co.uk/maps?q=AL1+3WZ.

Unlike the old office, there are no visitor parking spaces, although there is a large public car park in the Maltings shopping centre 75 yards away on the opposite side of Victoria Street. Visitors arriving via St Albans City rail station have a much shorter walk than before.

Kevin Macan-Lind, Chief Executive, said: "It was a bit of a wrench to leave our old home after 13 years as it had served us well, but we are very pleased with our new surroundings, which are slightly bigger, and we have settled in well."

After seven years in its previous format we have also decided to refresh the look of *Acoustics Bulletin*, with the emphasis being on a gentle but significant evolution rather than revolution.

We believe that adoption of Utopia as the body text will make it easier to read both on paper and on-screen. It is a design commissioned by Adobe for on-screen work, but which translates well to print. The slab-serif headline font (Geometric 703 XBD) is from a style of types designed to achieve impact and a good character count where space is restricted.

Together with the move away from boxed headlines and the introduction of a ragged right setting, we think these changes represent a marked step forward, which will considerably enhance the look of the magazine without making a complete break with the past.

In hoping that you approve of the changes, we looked forward to receiving your comments, not just on the question of the design but on other ways the magazine can be improved. For example, do you have any new content ideas? What would you like to see more, or less, of? Please contact the Editor, Charles Ellis, at charles.ellis@ioa.org.uk. ■

Food for thought

Campaign for 'sound dining'

When you leave a restaurant ears ringing and hoarse from shouting, restaurateurs need to urgently address their acoustics. Emma Greenland, consultant at the WSP Acoustics and chair of the Institute of Acoustics' Speech and Hearing Group, shares a checklist as food for thought



Picture the scene... long glistening tables, metal-frame chairs, tiled floors, mirrored walls, lofty chandeliers and sweeping stone staircase. The perfect environment to showcase minimalist, modern art, and possibly twenty years ago, that is exactly how leading restaurateurs wanted to frame their culinary masterpieces. Now, however, let us consider the prospect as a dining experience ...

Fire-up the open kitchen, shake-up the optics bar, power-up the espresso machine; cue the raucous office party, the clattering cutlery tray and the crashing bottle recycling; wash vigorously with throbbing music, and diners would be well advised to bring their ear-defenders.

It is against this cacophonous backdrop that the Noise Abatement Society has joined the Institute of Acoustics (IOA) to campaign for "sound dining". This movement exemplifies restaurants that achieve diner satisfaction through ambience and acoustic qualities and is also be an opportunity to call on persistent offenders of inhospitable acoustics to review their establishments.

For now, restaurant designers and managers, help is here in the form of a comprehensive checklist that will help reduce the decibel levels and protect staff and patrons from the ravages of these noise boxes we call modern dining rooms.

Restaurant acoustics checklist

Absorb the build-up of occupancy noise by providing moderate levels of sound absorption. Discrete areas such as acoustic baffles or wall panels, or moderate performance sound absorbing ceilings will reduce excessive noise without killing the atmosphere. A wide range of material types such as fabric, timber, metal, plastic, plaster-type are available

Diffuse where you cannot provide absorption, break up the sound reflections using scattering surfaces to walls and ceilings, or fixtures and fittings. These do not have to be expensive, ■



■ proprietary solutions they could just be shelves with objects on, and could be incorporated into a decorative feature

Dampen the clatter of crockery and cutlery by considering resilient, rubber-type surfaces or table linen for table top and counter surfaces.

Stop chairs scraping on hard floors by providing simple rubber stops to chair and table legs

Separate noisy bar/music areas and kitchens from dining areas using screens or partitioning wherever possible

Control noise from kitchen equipment and noisy appliances within the dining area by providing a sound absorbent hood or enclosure

Balance the background noise. Broadband noise from building services systems operating at 45-50 dB can be used to mask occupancy noise from other tables to maintain privacy, without

interfering with speech around the table

Keep background music where it belongs in the background so that it can still be enjoyed without causing a spiralling rise in noise levels as diners raise their voice to be heard over the music level

Furnishings can help to provide sound absorption – fabric or leather upholstered seating will help to achieve sound absorption whilst metal and timber benches will add to the problem

Size tables so that diners are able to communicate over less than 2 m distance, to avoid the need to shout over the occupancy noise level (and contribute further to the spiralling background noise)

Light dining areas well – don't forget that diners in noisy environments will also rely on visual cues to understand speech.

This article first appeared in the Noise Abatement Society's magazine, Soundscape. ■

Credit rating of the IOA Diploma

Although the IOA does not have credit awarding powers for its courses, both Derby University and NESCOT (Surrey University) allow a credit transfer of 90 credits to holders of the IOA Diploma wishing to enrol on their acoustically-related MSc courses. This represents 50% of the credits required to obtain the MSc.

At the Education Committee in January, the credit ratings of the five components of the Diploma were agreed as follows: general principles of acoustics module 30 credits; laboratory module 10; specialist module one 15; specialist module two 15; and project 20. It should be noted that those who choose to augment their Diploma studies by taking and passing the other two available specialist modules (which is now possible as students can register for individual Diploma modules) can amass a total credit equivalent of 120 credits.

Both Southampton Solent University and Trinity College Dublin are considering MSc courses in respect of which holders of the IOA Diploma might receive advanced standing of 90 credits. ■

Planning appeals – theory and practice

Young Members' Group

Report by Louise Beamish

The first meeting organised by the Young Members' Group was held on 2 February at WSP's office in London. There was a full house for the meeting on the theory and practice of planning appeals.

David Trew presented on the theory and procedures including giving expert evidence. A case study was introduced and a mock planning inquiry was held.

Expert evidence was provided by two young members – Valerie Collingwood (representing the appellant) and Mike Lotinga (representing the local authority). They were cross examined by Graham Parry and Rupert Thornely-Taylor.

Although the mood was relatively jovial at times, the mock inquiry followed the usual examination processes providing the delegates with an idea of what they might encounter at inquiry. The question and answer session that followed provided some useful hints and tips.

The same meeting will be held in Manchester in the near future.

For further information on the Young Members' Group please email youngmembers@ioa.org.uk ■

Discover new heights
in acoustics design



Room Acoustics Software



CP17 exposure in residential environments for the dataset generated by this project. The main considerations for these analyses were the type of averaging used and frequency weighting. Following this, the highlight of the evening for many, exposure-response relationships were presented for different vibration sources. The relationships take the form of curves indicating the percentage of people expressing annoyance above a given threshold for a given vibration exposure. Finally, and perhaps of greatest significance to the thinking acoustician, combined effects of vibration and noise exposure are also considered.

In summary, the work presented data from case studies comprised of face-to-face interviews and internal vibration and

noise exposures determined by measurement and calculation. In total, 1431 case studies were conducted encompassing railway, construction, and internal vibration sources. Exposure-response relationships were presented for different vibration sources. Combined effects of vibration and noise exposure were also considered. Comparisons with published guidance were presented, in particular BS 6472-1:2008, the ANC guidelines, and BS 5228-2:2009. It is expected that these findings will be of interest to policy makers and environmental health practitioners involved in the assessment of vibration complaints, as well as to planners and acoustic consultants involved in the design of buildings.

For further information: d.c.waddington@salford.ac.uk ■

The relative merits of different noise metrics in the assessment of transportation noise

Central Branch meeting

Report by Mike Lotinga

Central Branch's last meeting of 2011 was held on 6 December and preceded by the AGM at which branch management committee members were elected. The Central Branch is grateful to the outgoing committee members for their contributions to branch activities over the past years, including former-Chairman David Watts, Ralph Weston, William Egan and Richard George.

With the formalities out of the way, attention turned to the subject of the meeting, "A discussion on the relative merits of different noise metrics in the assessment of transportation noise," which was introduced by Professor Colin Waters.

Colin began by asking whether the metrics currently used to assess the noise impact of major transportation infrastructure projects are really much help in describing the situation to non-specialists. The controversial High Speed 2 (HS2) rail link was highlighted as an example and this project formed the general focus of the discussion.

He questioned the use (or over-use?) of the L_{Aeq} metric as a sole indicator of impact when assessing transportation noise (particularly rail traffic). He pointed out that the level of impact associated with L_{Aeq} analysis depends heavily on the assessment period considered. He then asked what it meant to the average person to be presented with a nominal change in L_{Aeq} noise level over a whole day or night-time period, when normally no person would actually be exposed to the noise change over such a period – a resident might have to wait in one place for 18 hours to experience the difference being described!

Colin suggested that the L_{Amax} metric provides a comparable correlation with human response to noise, which implies that the L_{Aeq} is insufficiently valid to be used as the sole metric for all (transportation) sources. Some examples were presented of situations based on high-speed train movements in which the L_{Aeq} might be considered to underestimate the actual level of population response.

Colin highlighted the WHO guidance that noise consisting of "distinct events...as with aircraft or railway noise" requires measurement (and consideration) of the L_{Amax}/SEL metrics. He also mentioned that the Environmental Noise Directive guidance uses metrics that impose penalties relative to the time of day.

It was said that public distrust was being fostered by the use of confusing metrics. Some residents' resulting perception that assessors 'have something to hide' was said to be potentially threatening to the development of new projects due to the level of public opposition galvanised by this approach.

Colin asked if other non-dwelling-related impacts should also be considered, e.g. countryside/protected areas etc., and finally

'should metrics be abandoned altogether?', as new approaches emerge such as graphical or auralisation techniques.

At this stage the session was opened to the floor, and an engaging, informed and, at points, emotive discussion ensued, not least due to the apt attendance at the meeting by some residents on the HS2-affected route, and members of an action group opposed to the project.

Dani Fiumicelli (Temple Group – the consultancy responsible for the HS2 Sustainability Appraisal) agreed that the profession had at times been guilty of using a 'catch-all' approach and pointed out that the results of cross-sectional studies on noise dose-response relationships could be highly dependent on factors not necessarily directly related to the noise itself.

Mike Breslin (ANV Measurement Systems) discussed his experience from working on the HS1 Channel Tunnel Rail Link, where extensive work had been done to identify the most appropriate criteria for assessing impact, and pointed out that there was no shortage of social survey data available to support the validity of the metrics used, which is why they had been selected.

The general attitude of the residents present at the meeting was that they had little confidence in the official interpretation of the HS2 technical information that had been presented to them. They had been shown what they had perceived as conflicting and confusing use of noise metrics and calculation methods, and they also felt the auralisation presentations they had received had been deliberately misleading.

This account caused concern amongst many of the acousticians present. It was generally agreed that the better and more openly-informed the public is, the more likely people are to trust the accuracy of the information and to accept some degree of adverse noise impact in their communities. However, it was also felt that there was sometimes a difficulty in convincing clients (developers) to present anything other than the best possible perspective on a situation (e.g. by failing to quantify factors such as uncertainty), despite the apparent evidence that such an approach could ultimately be counter-productive. These conclusions appeared to support Colin Waters' earlier suggestion that there was a serious 'communication problem' between specialists and non-specialists, and that acousticians need to take a lead in addressing this problem – if not through establishing new or different noise metrics, then through greater transparency and openness in explanation.

The Central Branch extends its thanks to Professor Colin Waters for chairing the discussion, and to Casella CEL for providing the venue. ■

Can I believe a peak reading from a dosimeter?

Report by Liz Brueck MIOA Health & Safety Laboratory

Dosimeters are often used to assess noise exposure. We also frequently see surprisingly high peak levels reported from dosimeters in risk assessments. In a recent series of measurements we observed inexplicable high peak readings in our own measurements. I tested the dosimeters used and found that one had an intermittent fault, which generated spurious peak readings. Having eliminated that one, I then extended the testing to see whether dosimeters, confirmed to be working within specification, had provided reliable peak indications.

I took three noise dosimeters (two of one model and one of another), each meeting the dosimeter standard (BS EN 61252) and compared their response with microphones and instrumentation meeting the sound level meter standard (Class 1 BS EN 61672-1). When the dosimeters and other instrumentation were tripod mounted they gave similar C-weighted maximum peak sound pressure level (Cpeak) readings for a range of impulsive noises. But when the dosimeters were mounted on the body, on the shoulder, the dosimeter peak readings were higher by 1 to 3dB. This increase is not a fault but due to the dosimeter being in the disturbed sound field around the subject's body. Mounting on the body increases the uncertainty associated with dosimeter measurements.

Physical activity and handling of the dosimeter are also often said to be causes of error or uncertainty. I tried a good five minutes energetic skipping while wearing dosimeters, pulling heavy outdoor clothing on

and off, and roughly removing and refitting the dosimeter. No dosimeter gave a peak reading above 106dBC, which is quite insignificant when you compare it to the 135dBC lower peak action value in the Control of Noise at Work Regulations.

However tampering with the dosimeters did cause significant peak readings. Singing directly into the microphone gave peak readings above 120dBC; a few heavy taps on the microphone (with the windshield still fitted) gave over 130dBC; and blowing over the microphone, without the windshield, gave up to 138dBC. Other people have recommended making dosimeter measurements over several days and only using the later results when the novelty factor and hopefully the incidence of tampering have reduced.

Perhaps the most critical factor affecting the uncertainty of dosimeter readings is that dosimeter measurements are unsupervised. A competent person with a sound level meter will avoid measuring near a compressed air jet, avoid physical contact with the noise source and is wary of measurements in the very near field of a source. However, dosimeter measurements are largely uncontrolled.

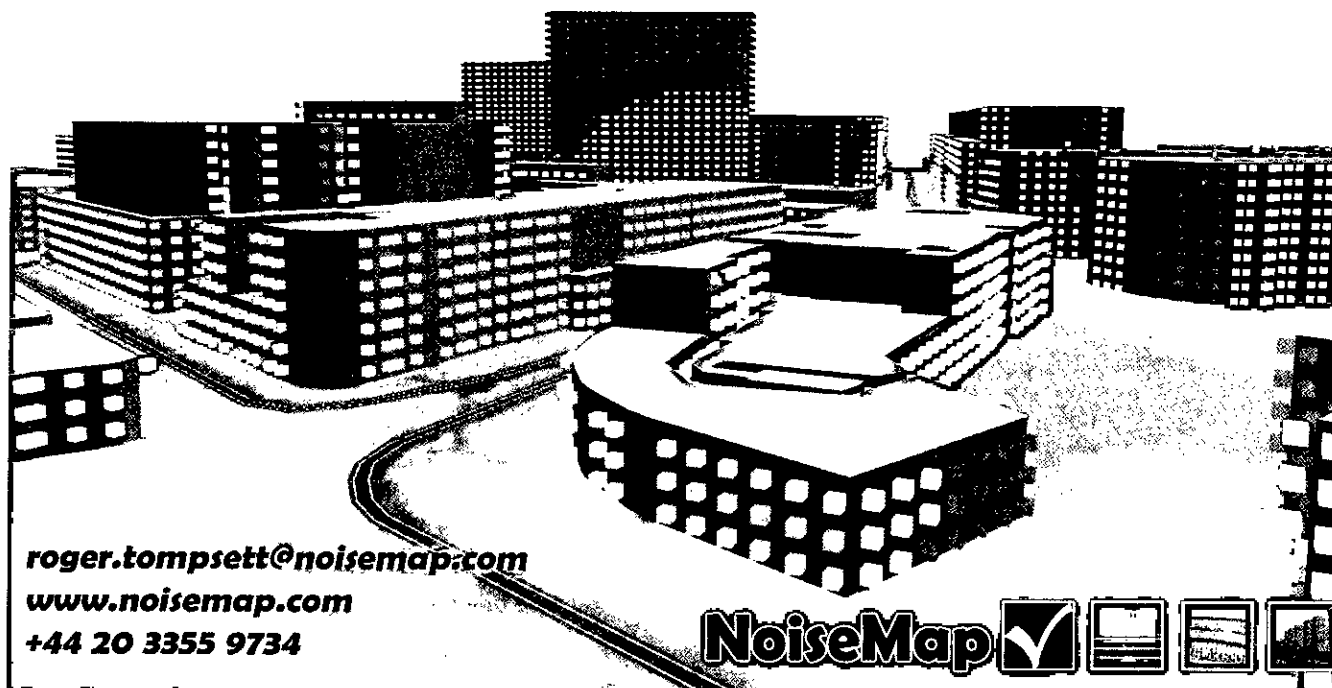
So how do dosimeter and sound level meter measurements in the real world compare? I analysed noise measurements made in seven printing works using a Type 1 sound level meter meeting the older standards of BS EN 60804 and BS EN 60651, and shoulder-mounted dosimeters meeting BS EN 61252. Figure 1 plots all 378 spot sound level meter readings (a mix of mostly 1 minute readings and some 30s readings), and 3398 one minute logged dosimeter readings as a cumulative distribution. In this Figure the percentage of readings (Y-axis) exceeding a sound level in dB (X-axis) is shown. Data plotted are the sound level meter and dosimeter Cpeak and LAeq readings. Under-range dosimeter results (below 70dB LAeq and 103dB Cpeak) have been included, but no sound level has been assigned to them.

In Figure 1 the LAeq distributions are shown in blue (dark blue for the dosimeter, light blue for the sound level meter); the Cpeak distributions are shown in pink and red (pink for the sound level meter, red for the dosimeter). **P20**

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New vehicle noise limits 'on the way'

Call for stricter controls

The European Commission is proposing stricter noise emission limits for cars, vans, lorries and buses. Vehicle noise standards, last revised in 1992, provide a critical tool to drive down transport noise emissions however current limits are widely accepted to be inadequate. The new regulations, which will replace the Vehicle Noise Directive (70/157/EEC), are expected to reduce the noise limits for cars by 4 decibels and lorries by 3 decibels within five years of entry into force.

The regulations propose a two-step approach: step 1 introduces a 2 decibel noise emission reduction for new types of cars and a 1 decibel reduction for lorries; step 2 requires a further 2-decibel cut for new types of cars, vans and lorries.

Reacting to the Commission's proposals, Nina Renshaw, deputy director at Transport and Environment, said: "While this proposal is a welcome move in the right direction, it should have gone farther and faster. The vast majority of cars for sale already meet step 1 of the Commission proposal, and almost a quarter even achieve step 2; so these steps are clearly not tough enough. 50,000 heart deaths in Europe are caused by transport noise every year, it is obvious that the problem merits bolder action."

Environmental and health groups are recommending a third cut in noise levels in 2020. The groups are also particularly concerned that the limits for heavy goods vehicles do not go far enough. Lorries represent only 3% of vehicles, but are responsible for half of vehicle noise emissions.

Ms Renshaw added: "It's far cheaper to add readily-available noise reducing technology to vehicles than for cash-strapped local authorities to spend millions on noise barriers along roads. The benefits outweigh the costs by 20 to 1, so there is no excuse for inaction."

More than 200 million EU citizens are exposed to long-term road traffic noise at levels that pose a risk to their health. Traffic noise is the most widespread environmental problem in the European Union and is second only to air pollution in terms of its public health impacts.

Despite these wide scale health impacts, intense lobbying from German vehicle manufacturers earlier this year looked likely to weaken the commission's proposals, causing consternation amongst environment and health campaigners. Further lobbying is expected as the proposals go to the European Parliament and member states for agreement.

Environmental Protection UK (EPUK) calls on member states and members of the European Parliament to put public health interests of millions of citizens above the interests of vehicle manufacturers by backing these new limits.

James Grugeon, EPUK Chief Executive, said: "Reducing transport noise at source is the most effective way of reducing this public health burden. Appropriate vehicle noise limits are critical to supporting a wide scale reduction in noise levels from cars, vans, lorries and buses by placing requirements on manufacturers and providing a level playing field."

"European Policy makers must not be swayed by self-interested lobby groups over and above the health needs of over 200 million citizens. The proposed limits are achievable and necessary. Should the Parliament or Council be inclined to amend the proposals they should speed up the timetable for introducing the revised standards and introduce a commitment to further noise reductions in the future to support continued innovation and improvements in vehicle manufacturing." ■



Slump in council out-of hours noise services

There has been a dramatic drop in the number of local authorities offering out-of-hours noise services, the Chartered Institute of Environmental Health Officers (CIEH) has found.

A survey has revealed that only 105 councils in England now provide such services – compared with 245 10 years ago. And of today's total, just 27 provide a 24/7 service – compared with 105 in 2002.

The CIEH also found that the situation is set to deteriorate again. Of the 150 councils still providing out-of-hours services, 49 said they expected to have to scale back those services in the foreseeable future.

CIEH Principal Policy Officer Howard Price said: "We are

acutely aware of the on-going squeeze on resources in local government and the very real consequences of that.

"Noise is perhaps the most significant cause of complaints to local authorities, and it is their statutory duty to take reasonable steps to investigate.

"Although councils do not necessarily need to provide permanent night patrol, to refuse to investigate as a matter of policy would leave them open to legal challenges."

Mr Price said CIEH had carried out the survey because of the Department of Culture Media and Sport's proposals to deregulate entertainment licensing relied heavily on environmental health officers dealing with excess complaints. "With the reduced number of out-of-hours services, this is not going to happen." ■

Environmental noise a 'Government priority'

The problem of environmental noise is "rising up" the Government agenda, says Junior Environment Minister Lord Taylor of Holbeach.

Addressing a reception of noise experts in Westminster entitled Why Noise Matters, Lord Taylor, whose responsibilities include noise, said it was seen as a "priority" within Defra, with work being undertaken across the Government to ensure its importance was recognised more widely.

He said 42 per cent of people questioned in a survey 10 years ago had complained their home life was affected by noise, and he expected that a new survey currently being undertaken would show that it was still an issue.

Among the actions the Government was taking in order to protect quality of life was working with local authorities to identify and protect quiet areas in cities, he said.

Describing the management and assessment of environmental noise issues as a "very technical matter", Lord Taylor said that it was important to work with experts to find solutions.

In answer to a question about the effects of proposed planning deregulation, he said it was not intended to result in a "free for all" and there was no suggestion that noise did not matter in the planning process. The aim of the changes was to remove high volumes of bureaucracy.

John Stewart, head of the UK Noise Association, the event organiser, said there were four key barriers as to why the message that noise really did matter was not getting across:



Lord Taylor addresses the meeting

- it was often seen as a local issue when it was in fact a national one
 - it was often dismissed as something suffered by specially or super sensitive people
 - despite incontrovertible evidence as to the adverse effects of noise on health, these were not fully appreciated
 - the issue was not seen as something that affected the Earth when in fact it was having a profound effect on eco systems.
- Other speakers were Stephen Turner, head of the technical noise team at Defra, who outlined his team's work, and Alan Laws, an environmental health consultant who works for Sanctum Consultants.

The event also highlighted the recent launch by the UK Noise Association of *Nelson's Story*, an account of an eight-year battle by Nelson Ayayi, a London housing association tenant, against noise he had to endure, which led to him winning a court injunction to stop the nuisance. For more details go to www.ukna.org.uk ■

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ACOUSTICS

Sources of sound in air

Three basic qualitative categories

Report by Frank Fahy HonFIOA

Sound sources are almost infinitely diverse in mechanism, temporal characteristics, frequency range, and directional radiation of energy. They all generate sound energy, but their efficiencies of conversion of mechanical, chemical or electrical energy into sound energy vary widely. In spite of this diversity, it is possible to place sources into three basic qualitative categories, as illustrated by Fig. 1. The following examples are chosen purely to illustrate this categorisation.

Category 1 sources

Category 1 includes those sources by which *air volume is displaced or fluid mass is injected in an unsteady fashion*. They constitute the most efficient forms of source. It is actually the rate of change of the rate of volume displacement (volume acceleration) that generates the sound. This is illustrated by the sound of a handclap. Place your hands together close to your nose with your fingers pointing upwards and with the fingers of one hand resting on the palm of the other. Now clap your hands rapidly together. Your face will feel the increasingly strong outflow of air, but no sound will be heard until the hands collide. At this point the outflow rapidly stops, and the sudden change in the rate of air volume displacement (volume acceleration) 'stretches' the local air and slightly reduces its density; this is what I think causes the sound. Alternative explanations are welcomed by the author. Strangely, very little if any research appears to have been published on this very common sound. Please let me know if you are aware of any (frank.fahy@gmail.com). The sound wave produced by the discharge of gas from an AK-47 rifle barrel is seen in Fig. 2, together with the shock wave generated by the supersonic bullet.

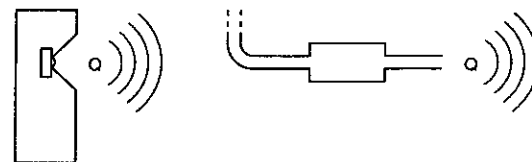
In direct radiator loudspeakers, a flexibly mounted diaphragm is vibrated by the force exerted on the voice coil that carries the signal current by the field of the surrounding magnet. Various sizes and configurations are employed to cover different, but overlapping, parts of the audio-frequency range. A commercial cabinet system typically contains a large diameter, low frequency unit (woofer), a smaller diameter mid-range unit and one or more smaller high frequency units (tweeters). The cabinet serves to support the units and also to prevent cancellation of displaced volume between the front and rear of the diaphragms. In some cases a 'sub-woofer' is also used to radiate very low frequency sound.

The various sizes of direct radiator loudspeaker that cover different parts of the audio-frequency range are necessary for various reasons. The efficiency of sound radiation by a Category 1 source is low at frequencies such that the acoustic wavelength substantially exceeds the spatial extent of the source. (The wavelength in metres is $343/(\text{frequency in Hz})$.) Hence, a large diaphragm is necessary to radiate low frequencies. But the mass of the diaphragm increases with size, and mass becomes increasingly 'difficult' to vibrate as frequency increases (Newton's Second Law of Motion). Large diaphragms 'break up' and do not vibrate uniformly at high frequencies. And the radiated field becomes increasingly concentrated in the forward arc as the acoustic wavelength decreases (frequency increases). If you mistune your radio to produce noise and move your head across the front of the mid-range unit you will experience this effect. Hence, smaller, lighter diaphragms are necessary for higher frequencies.

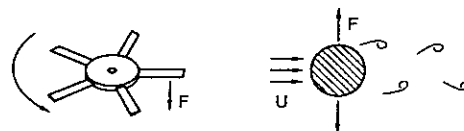
The typical efficiency of conversion of electrical energy to acoustic energy of such loudspeakers is between one and two percent. The *rated* power is the electrical power supplied: one watt of *acoustic* power would be deafening. The remaining 98 to 99%

Figure 1-Source categorisation

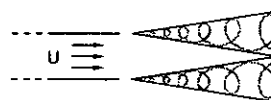
Fluctuating volume/mass displacement/injection



Accelerating/fluctuating force on fluid



Fluctuating fluid shear stress



goes into heat in the electromagnetic driving mechanism.

However, horn loudspeakers can reach an acoustic efficiency of up to 40%. An interesting characteristic of Category 1 sources is that if a pair of equal strength, operating in anti-phase (push-pull), are sufficiently close together, they largely cancel each other's radiation. Try switching the polarity of the connections to one of your stereo units and you will observe this effect, particularly on the bass frequencies.

The so-called 'voiced' sounds of speech are generated by vibration of the vocal cords which modulate (vary in time) the airflow produced by the lungs. The temporal variation of the airflow rate is not sinusoidal; but in a steady tone, such as a sung note, the sound contains many equally spaced frequencies (harmonics) which gives it its characteristic quality. This is the 'engine room' of the voice. The vowel sounds are voiced. Say 'aaah'. Now say 'cat' slowly: the 'c' and the 't' are not generated by vocal cord vibration; nor is a whisper. How do you think these are generated? Hint: look at Category 2 below. Now sing 'aaaaah'; you can vary the pitch by tightening or slackening your vocal cords, keeping an unchanging configuration of your mouth and tongue. The tonal sounds of the singing voice are generated by the filtering effect of the acoustic resonances of the oral and nasal cavities on the multi-frequency sound produced by modulated flow through the vocal cords, in much the same way as Helmholtz's glass spheres filtered the passage of external sound into his ear in his 1860 investigation of the frequency response of the auditory system. If you open your mouth wide and sing a note while maintaining a constant tension in your vocal cords, you can hear the effect of the shape of the oral cavity by pushing your lips forward to form an 'O'. Try whistling and slide the pitch up and down: feel what your tongue is doing to change the pitch. It's remarkable that such wet, softly lined, body cavities can resonate so sharply, as witnessed by the pure sound of a soprano singer.

Sirens are devices that periodically release compressed air or steam into the atmosphere. This is generally effected by means of opening and closing holes in a rotor that passes over a set of matching holes in a fixed plate. They are therefore similar in principle to the voice, but thousands of times more powerful. They were used in WW2 to give air raid warnings and to signal 'all clear'. They are mounted on pylons in many towns as danger warnings

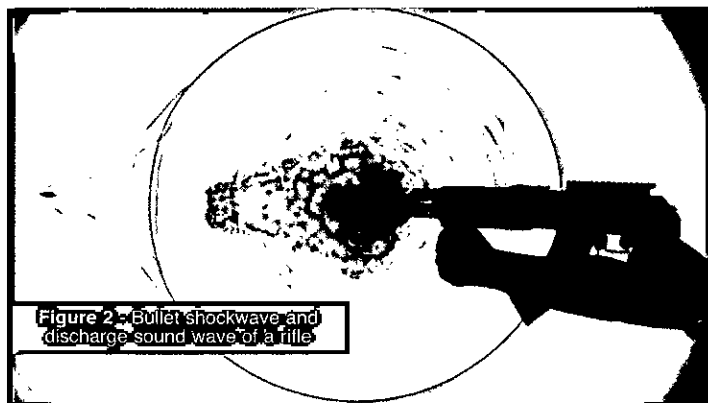


Figure 2 - Bullet shockwave and discharge sound wave of a rifle

and are test sounded at fixed times of the week. In the nineteenth century, the famous Irish physicist, John Tyndall, employed an enormous steam-driven siren and horn, shown in Fig. 3, to investigate the propagation of sound through fog at the bequest of the Trinity House, the then lighthouse authority for England, Wales, the Channel Islands and Gibraltar. He also sent up explosive rockets for the same purpose.

As the outlet valves of an internal combustion engines open and close, they produce a periodically varying flow through the exhaust pipe. This unsteady component of the flow out of the pipe radiates as a Category 1 source. When one opens a bottle of champagne the gas escapes suddenly to produce the 'pop'.

Vibrating surfaces constitute very common sources of sound. For example, the sound that is transmitted through a wall is radiated by the vibration of the wall in response to the pressure field of the sound falling on its other side. Much of the noise of machines, including internal combustion engines, is generated by vibration of their surfaces. Although such sources do radiate by displacing air volume at their surfaces, the vibration fields are not uniform. Different areas vibrate with different amplitudes and phases; at any one instant of time, some parts are moving in one direction and others are moving in the opposite direction. If neighbouring areas vibrate in anti-phase (opposite directions), the radiation cancellation effect described above in relation to an incorrectly wired stereo system operates, particularly in the low frequency range. This feature makes vibrating surfaces difficult to categorise in a generic manner. We will simply state that if two sheets of the same size and material (e.g. steel), but of different

thickness are *mechanically* vibrated at the *same frequency* with the *same amplitude*, the thicker one will radiate more strongly than the thinner one. But beware: this does not apply to sound transmission through walls! Heavier walls will almost always transmit less sound than lighter walls.

The noise of road vehicle tyres, which generally dominates traffic noise at speeds above about 50 to 60 kph is generated by a number of mechanisms. Vibration of the tyre wall due to the unevenness of the road surface is one of the principal noise sources, but also important is so-called 'gas pumping'. As the tyre rotates, air contained in the tread wells is squeezed out when they contact the road and re-enters when they leave the road, thereby producing volume acceleration. The presence of water on the road greatly increases this noise due to ejection acceleration of water particles. Gas-pumping noise is reduced by the use of porous road surfaces which ease the entrapment and compression the air. The curve of the tyre amplifies this noise by acting as a form of acoustic horn. Slicks produce little gas-pumping noise, but have low skid resistance and poor water ejection and are not suitable for general use.

Category 2 sources

This category includes sources that radiate by applying fluctuating forces to the ambient fluid but which involve *zero net volume acceleration of the fluid*. The general equation that governs sound generation in a fluid, such as air, includes a term that expresses the action of a force, in addition to one accounting for Category 1 volume acceleration. This category of source is much less efficient at radiating sound than Category 1 sources: examples follow.

At frequencies where a vibrating tube or cable or pipe, or other slender body, has a diameter very much less than an acoustic wavelength, it produces almost no net volume displacement because, in simplistic terms, when the body vibrates transversely, the fluid displaced by the advancing half of the body 'slips' around towards the retreating half and cancels any net volume displacement. However, in order to generate the oscillatory acceleration of the fluid in 'sloshing' it to and fro, the body must exert some oscillatory force on it; hence the radiation. A very thin linear structure such as a violin string exerts negligible force on the air and radiates negligible sound itself. It vibrates the violin body, which is the principal sound radiator.

Surprising though it may seem, the action of the unsteady action of turbulent flow in producing fluctuating pressures on a solid surface generates sound, even though the surface does **P28**

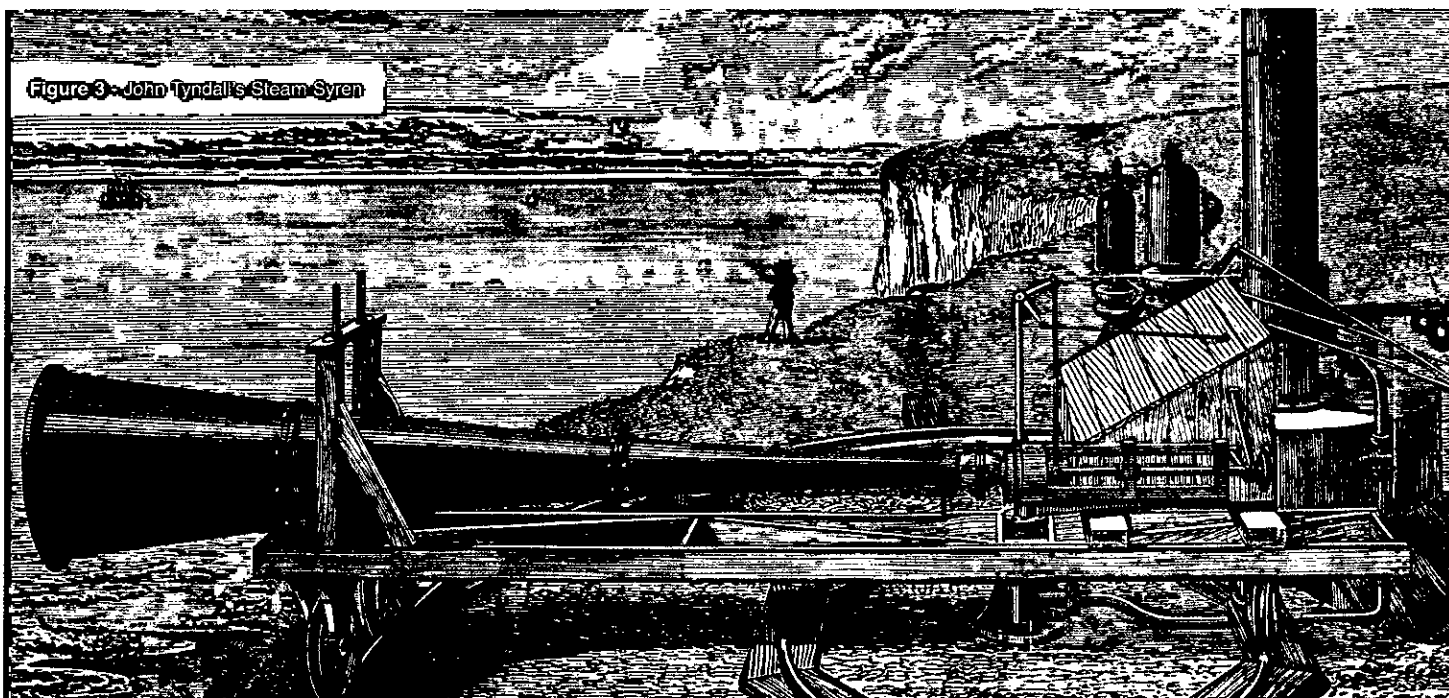


Figure 3 - John Tyndall's Steam Siren

◀P27▶ not vibrate. The presence of the surface constrains the unsteady fluid motion normal to the surface, producing density changes; thereby, a small proportion of the kinetic energy of the flow is converted into sound energy. You can demonstrate this for yourself by blowing closely on your finger tip and moving the finger to and fro across the airstream. Blowing in the absence of the object produces much less sound which comes largely from the action of turbulence on your lips. This form of source accounts for much of the noise of wind blowing through trees; the noise of clashing leaves is generally less important, especially in the winter. The noise produced by the flow of air through the grilles or louvres at the exit of ventilation ducts is similarly caused. The sound power of Category 2 sources increases with the sixth power of the air speed; for example, doubling the flow speed increases the sound power by a factor of sixty four, or an increase of sound pressure level of 18 decibels, which is nearly four times as loud. This is why the speed of flow through the terminal devices of ventilation and air conditioning systems must be minimised, especially in auditoria (spaces designed for listening).

This category of source mechanism has recently become of great concern to engineers seeking to minimise the noise of landing aircraft because the noise of turbulent flows generated by devices deployed on the wings to increase lift and drag, together with that generated by the landing gear, termed 'airframe noise', is now comparable with engine noise. Environmental noise so generated is also a limiting factor on the speed of electric trains that sport overhead pantographs.

When air flows transversely over a structure of circular cross-section, such as a rod, it generates a sequence of vortices that are shed periodically into the wake. This process generates an oscillatory force on the object, and associated sound, even if the structure does not vibrate. This can be demonstrated by swishing a rod rapidly through the air: the faster the motion, the higher the frequency. The 'singing' of wires and cables in the wind exemplifies this form of source. They do vibrate, but this movement generates little sound as explained above. Vortex shedding from cross-flow heat exchanger tubes of power stations has been known to 'cooperate' with acoustic resonances of the enclosed space to excite damaging vibration of the tubes. However, the flow turbulence does enhance the heat exchange.

Propeller, fan and turbine blades all act as aerofoils. They generate lift and drag like aircraft wings. In moving through the air, wings deflect it to produce a predominantly downward steady flow and an associated upward force is produced by the generation of downward fluid momentum. The aerodynamic force on a blade is more or less constant, unless the inlet flow is made non-uniform by the presence of upstream flow obstructions, such as radial support struts and poorly designed duct bends, which therefore cause sound generation. Sound is not generated by aerofoils travelling subsonically at constant speed. Rotor blades do radiate, even in the absence of inlet irregularity, because the aerodynamic force accelerates in rotation around the axis. The sound generated in this manner consists principally of a series of harmonics of the frequency with which the blades pass any point fixed in space (blade passage frequency) which increases with speed. You may hear the effect by running a desk cooling fan at top speed and placing an obstruction such as a ruler immediately upstream of the rotor. The tips of the propellers of some older forms of propeller driven aircraft, such as the Harvard, moved at supersonic speed. This caused extremely loud noise because of the generation of shock waves.

Category 3 sources

Category 3 sources produce neither *net volume acceleration* of a fluid nor *net force* on the fluid. They are extremely inefficient. A commonly experienced example is the 'clack' produced by the collision of snooker or pool balls and of children's marbles. The air remains in contact with them during impact and suffers acceleration and changes of density which radiate as sound. The sound is not made by vibration of the spheres because the lowest natural frequencies are above the limit of human hearing. Another such

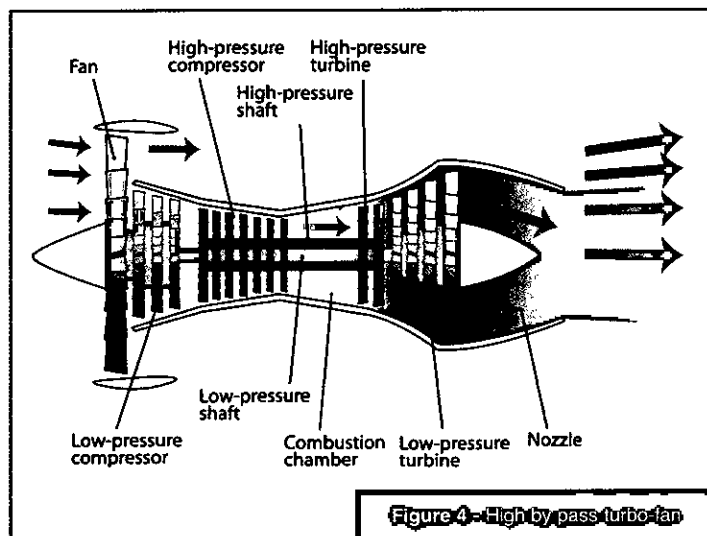


Figure 4 - High bypass turbo-fan

source is that of the struck tuning fork. The vibration of each tine constitutes a Category 2 source. But the tines vibrate in opposite directions and largely cancel the two individual sources. This is why the stalk is usually placed on a convenient flexible surface which it vibrates and enhances the sound. If the ear is placed close to the tines, and the fork is rotated about its axis, a figure-of-eight radiation pattern will be heard.

Another Category 3 source of far greater practical importance is that of jet flow. A jet of fluid issuing from a pipe mixes with the surrounding ambient fluid by means of viscous stresses. The shear layer at the interface between moving and ambient air is unstable and the resulting turbulence generates sound over a wide and continuous range of frequencies. The actual mechanism of sound generation is far too complex to be described in simple, qualitative terms. It was first explained just 60 years ago by James Lighthill. Fortunately for the aircraft business, the efficiency of conversion of jet flow kinetic energy into sound is extremely low; although people regularly exposed to aircraft noise would be reluctant to accept this fact. For example, at take off, the engines of a large modern jet airliner deliver over one million newtons of thrust. The associated mechanical power is over one hundred million watts. A typical ratio of radiated sound power to mechanical power of the engines of large airliners in the mid-1990s was about 0.02%; this was reduced to about 0.003% by the installation of sound absorbent treatment in the air intake duct. By 2005, improvements in engine acoustic design and sound absorbent treatments had reduced this ratio to about 0.0004%. The associated sound power is now of the order of 400 watts. The sound power generated by a subsonic jet varies as the jet speed to the power eight; halving the speed reduces the sound power by a factor of 256 which translates into -24 decibels (a reduction of perceived loudness by a factor of over four). This extreme sensitivity has been exploited by the introduction of large by-pass turbofan engines in which the hot jet core is surrounded by a cold flow produced by a very large diameter fan, as illustrated by Fig. 4. Earlier, pure jet engines, such as those of Concorde, produced very fast, supersonic jet flows that were extremely noisy.

Credits

This article is based upon a chapter in 'Air: the Excellent Canopy' by Frank Fahy published in 2010 by Woodhead Publishers of Cambridge, UK, whose permission to reproduce this material is gratefully acknowledged.

Figures

1. Photo courtesy of Gary S. Settles, Penn State University, USA
2. Out of copyright
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One-Third-Octave Equalisation and its Use in Cinemas

Report by Philip Newell FIOA

The cinema is one of the few places in which, despite sound is an important component part, nobody is locally in control of its reproduction. Even in a bar with music, somebody usually has access to 'volume' and 'tone' controls which can be adjusted to the prevailing conditions. In the cinema, however, the soundtrack is 'fixed' in terms of both sound pressure level and equalisation at the time of mixing.

Experience in the early days of 'talking pictures' indicated that the only means by which to adequately judge how a soundtrack would be perceived in large theatres was to *mix* in large theatres. It has been shown how, for various psychological reasons, larger screens call for more SPL and more low frequencies in a soundtrack as compared to watching the same picture on a smaller screen¹. The perceived 'natural' dynamic range also tends to be proportional to the picture size. People with large domestic televisions may inadvertently tend to disturb their neighbours more than they would do if they had a smaller screen, even though they feel sure that they are listening with the same volume level in both cases. What is more, they may even listen with proportionately more sub-woofer level with the larger screen. These characteristics are all totally natural when simply adjusting the levels to taste. To take an extreme case, to highlight the point, imagine watching a war film on a mobile telephone at 100 dB SPL. Patently, the sensations of sound and vision would not match. The *overall* perception would be ridiculous. Cinema soundtracks therefore simply cannot be mixed in small rooms with small screens because the appropriate sound levels and frequency balances would probably be wrongly judged.

Of course, public cinemas come in a wide variety of shapes and sizes, and with correspondingly different reverberation times. Loudspeakers

also come with a wide variety of directivity characteristics, which can be even further changed by the woven or perforated projection screens that are placed in front of them. Clearly, where such a range of reproduction environments exists, some form of standardisation would seem to be in order if the general perception of the soundtracks were to be reasonably uniform from one cinema to another.

In the 1930s, responding to all the rapidly developing technology, the Motion Picture Research Council, reporting to the Academy of Motion Picture Arts and Sciences (AMPAS – the people who give out the Oscars), introduced what became known as the 'Academy curve', which is shown in Figure 1. In those days, the emphasis was on getting a uniform response from the different loudspeakers, which were all in their infancy. This was not surprising because the first 'talkie', *The Jazz Singer*, was released only around three years after Rice and Kellogg had invented the first moving-coil loudspeaker. The progress had been so rapid that loudspeakers had gone from being something in a small box, to being able to fill a room with 1,000 people or more, in just three years. Not surprisingly, given the needs, research had concentrated on how to get them louder, rather than on controlling the niceties of the frequency responses, so the Academy curve set a standard to be matched as closely as possible by means of electrical equalisation. Different curves were applied for different diaphragm materials – metal or phenolic. The range of available loudspeakers was quite limited.

As can be seen from Figure 1, the available bandwidth was rather narrow. Also, the room acoustics were largely uncontrolled, as many cinemas were put into theatres designed for totally different purposes. These two things together did not bode well for either the quality **P30 ▶**



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Figure 1 • The Academy Curve

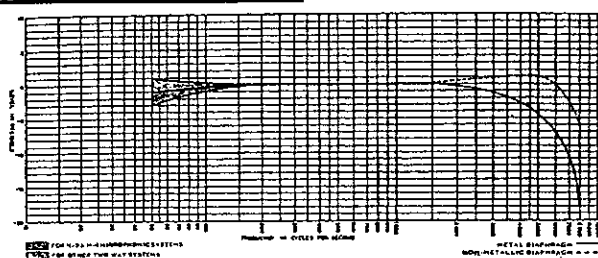


FIG. 1. Research Council standard electrical characteristic for two-way reproducing systems in theaters (June 8, 1937). Electrical run measured at the output of the power amplifier with a response equivalent to the speaker load, using BRPI test-film (*ED-20, corrected*), or RCA test-film (*cat. No. 27637*).

(Curve applying to non-metallic (bakelite) diaphragm supersedes curve in specifications of March 31, 1937. Curve applying to metal diaphragm remains unchanged.)

Figure 2 • The X-curve

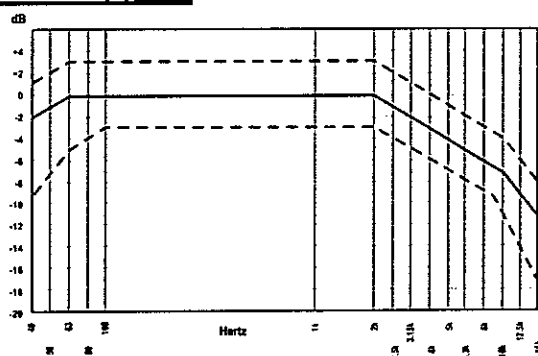
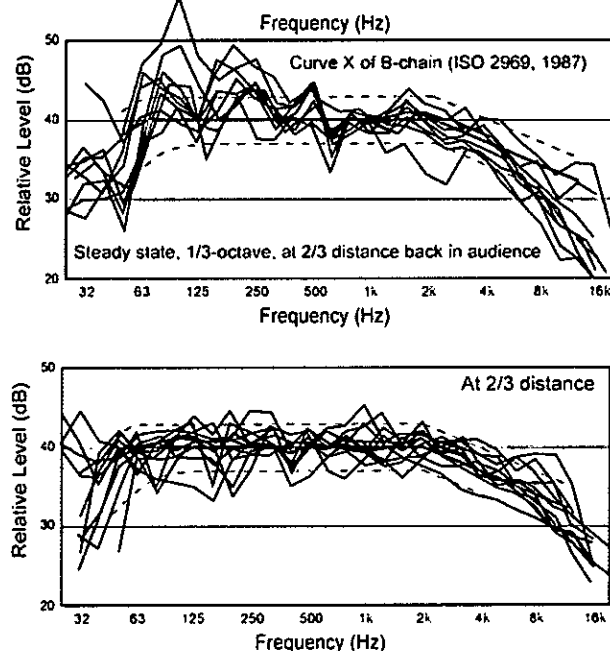


Figure 3 • Twenty responses, far into the room, all taken in rooms meeting X-curve specifications



sound timbrally natural if played back in a large room with the X-curve already applied to the loudspeaker systems. This would ostensibly reduce the need to apply the 'large room equalisation' to each track of the recording. However, the question still remains as to precisely why this should be so. Allen, himself, spoke of the reverberant build-up in the larger rooms being one possible reason, as the typical overall build-up could lead to a changed frequency balance, at least with more sustained signals. He also spoke of distortion in typical loudspeakers making the high frequencies objectionable; and even psychoacoustic phenomena involving far away sound and picture'. It has even been common practice in music studios, for over 40 years, to roll off some of the high frequencies on the larger, more distant monitor systems. Nevertheless, there is no simply applicable solution because the degree of roll off can depend on whether the sounds are more percussive or sustained, the degree of reverberation, and the size of the room. Moreover, perhaps we are more accustomed to hearing less top in larger spaces because of the air absorption, which can lose 1 dB every 5 metres at 10 kHz, but to be 10 dB down at 12 kHz, as is the case with the X-curve, is straining credibility. There is therefore probably a combination of factors at work. As yet there is no simple explanation for why the X-curve should be appropriate, except for that provided by its purely empirical origin.

Nonetheless, since the late 1970s, the X-curve (ISO 2969) has been applied to the loudspeaker systems of not only the cinemas but also the dubbing theatres in which the soundtracks are mixed. In principle, there is an adjustment to the slope of the curve to allow for different room sizes and decay times, but in practice it does not appear to be used much. There is also a range of calibration curves for the *surround* loudspeakers, but in this case it is dealt with not by a change in the slope, but by adjusting the turnover frequency, which lowers with increasing room size and decay time. Again, the adjustments rarely seem to be applied.

Implementation of the calibration; and its consequences

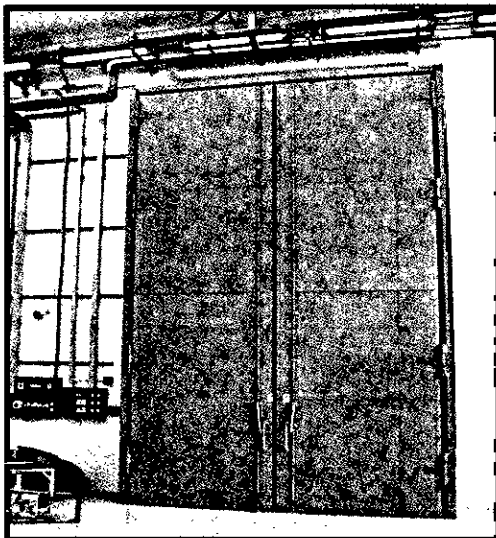
1. In practice, the means of applying the X-curve is as set out below.
2. Either a fixed microphone, a group of multiplexed microphones or a single microphone being waved about is/are used to capture the sound in the region of the supposedly prime listening position on the centre line of the room, about two-thirds of the distance from the screen to the rear wall. **P32**

P29 or the room-to-room compatibility of the soundtracks. Nevertheless, the discipline and skill of the professionals involved in their production ensured that they got the maximum from what was available, and they created some classic films in the most charismatic years of the industry.

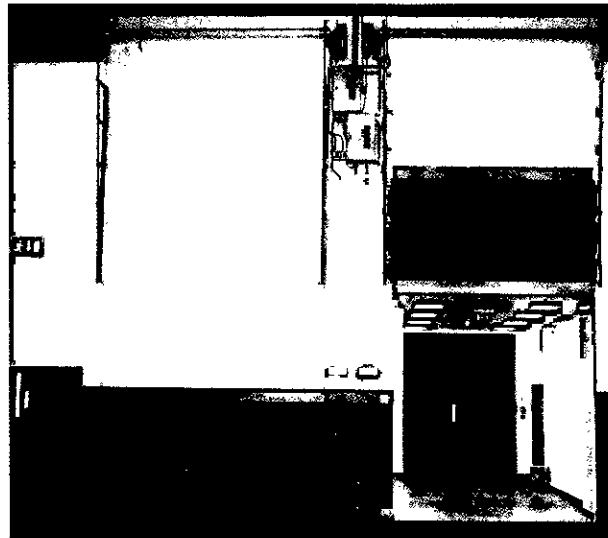
In those days, the dialogue was the most predominant sound to be heard, and the diction of the actors was usually exemplary. Music was largely something that was used incidentally. Dialogue rarely had to fight with it. The musical arrangers of the day also took great pains to ensure that the scores were written for instruments that would be clearly reproduced by the available loudspeaker systems. Listen to an old Errol Flynn film, for example, and on whatever system it is reproduced the dialogue will be easily understood.

However, by the early 1970s, loudspeaker and amplifier systems had developed a great deal from the state of the art in the 1930s. Magnetic soundtracks had also arrived, and Dolby noise-reduction had been invented. Together, these offered a much-improved level of performance over the still-applied standards of 40 years earlier, so Dolby engineers, amongst others, set about trying to define a new standard that would take advantage of the new capabilities arising from the technological developments. Much of the details of the work is described by Allen in his 2006 SMPTE paper², but, in brief, experiments were made at Elstree studios with two sets of loudspeakers. In the close field, a pair of large KEF loudspeakers was set up about three metres from the listening position, about 2/3 of the way back into the room, and a nominally flat recording was played back through them. The recording was then played back through the normal loudspeakers, behind the screen, at a distance of over 10 metres away. A graphic equaliser was employed to try to adjust the spectral balance of the sound from the distant loudspeakers to match that from the KEF loudspeakers in the close field. The frequency response of the large loudspeakers was then measured at the listening position, and an experimental response curve was formulated, based on these measurements. This experimental curve later became the X-curve, as shown in Figure 2.

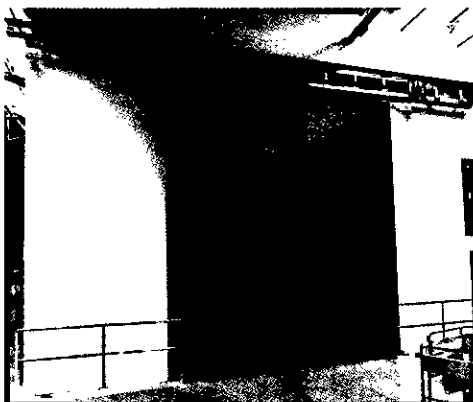
The reasoning behind this seems to be that if the component parts of a soundtrack are recorded conventionally, they could be expected to



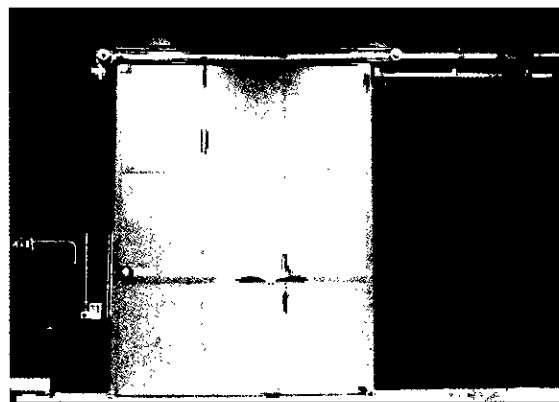
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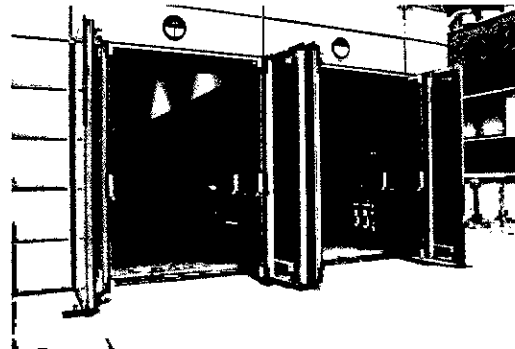
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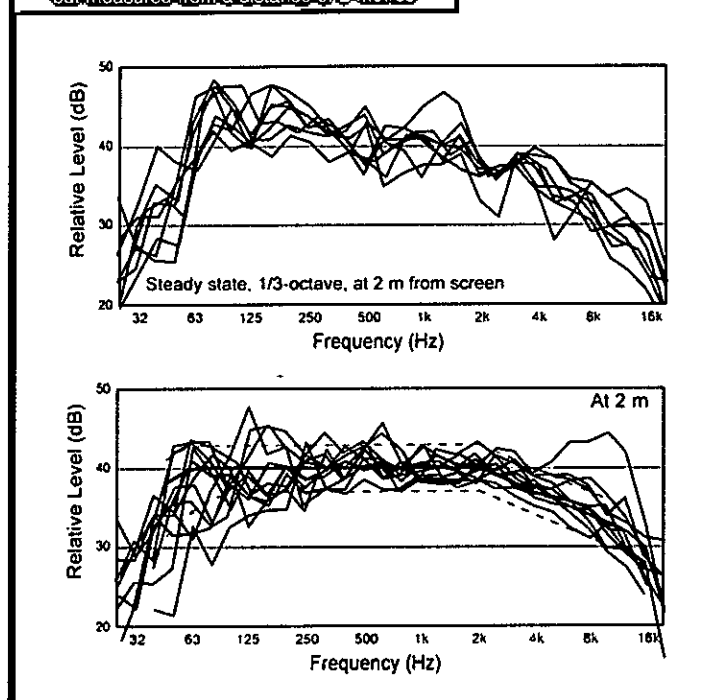


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Figure 4 The same responses as in Figure 3, but measured from a distance of 2 metres



3. **P30** Pink noise is passed through each loudspeaker in turn (or group of loudspeakers in the case of the surround channels).
4. The response is monitored with a one-third-octave, real-time analyser.

By means of equalisation (usually one-third-octave), the response is adjusted to be within the tolerance bands of the curve shown in Figure 2.

The continuation of this practice is now a very contentious issue. The concepts were developed in the 1970s, not long before the introduction of the X-curve precursors. They were founded on beliefs that the human hearing system functions in 'critical bands' of one-third-octaves, and that a uniform spectral balance was the key to the uniformity of the timbral balance. Forty years later, we now know that the ear is much more sensitive for narrow-band sounds (the third-octave critical bands apply to listening to broadband sounds). We also know that there are several other factors involved with achieving natural sounds. The spectrum is not everything: there are temporal aspects that are also very important. And, even within the frequency domain itself, the precise *nature* of how the spectrum varies can be as important as *how much* it varies. What is more, when one-third-octave analysis and measurement are applied, the centre frequencies of the filters rarely coincide with the centre frequencies of the problems to be rectified, and the slopes of the filters rarely coincide with those of the responses to be corrected. One-third-octave equalisation often seems to do little more than shift the problems around.

In a paper presented to the 2010 Reproduced Sound conference in Cardiff³, it was clearly shown how the responses of rooms, even after ostensible 'correction', were still very different from one to another. Figure 3 shows the responses of 20 cinema rooms which had been equalised in the standard manner, as described above. It can be seen when using more detailed analysis how they all remain very different, despite all meeting the Dolby criteria. However, the most worrying thing about these responses is that they have been achieved by the severe linear distortion of the direct sounds, as can be seen from Figure 4. These latter measurements were taken at a distance of around two metres, and so contain a significant proportion of the direct sound, along with a few early reflexions, and then the rest of the reflexions and reverberation at a significantly lower level. Had the output of the loudspeakers all been relatively the same, then the close-range curves could have been expected to be much more similar. In fact, what *can* be seen is just how *unsmooth* and how different they all are from one another.

There is a strong implication here that the application of the equalisation derived from the measurements in the far-reverberant-fields has

Figure 5 The 8 microphone positions in the auditorium, as used for the described tests. The loudspeaker was just off the side of the plane in front of microphone number 1

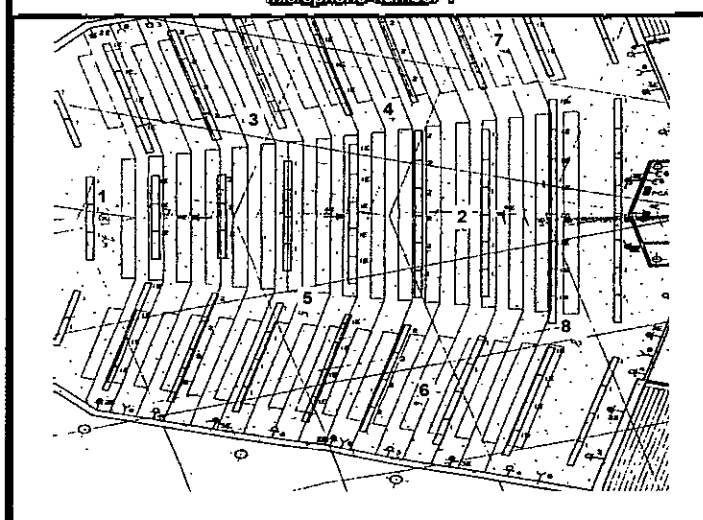


Figure 6 Comparison of results using pink noise and FFT analysis

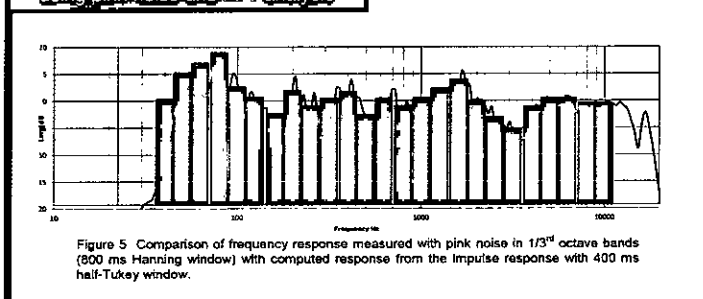


Figure 5 Comparison of frequency response measured with pink noise in 1/3rd octave bands (800 ms Hanning window) with computed response from the impulse response with 400 ms half-Tukey window.

given rise to totally unacceptable spectral imbalances in the direct sounds. After seeing the true level of variation in both the far and close field responses, it becomes apparent that the goal of room-to-room uniformity is not being achieved by these means, even though almost the entire cinema industry is still trying to do so.

In both the music recording and live-sound industries, the use of one-third-octave equalisation had been phased out since the late 1970s or early 1980s. It was apparent to so many people that loudspeaker systems so adjusted tended not to *sound* natural. Furthermore, what was measured in one part of an auditorium could not be taken to be representative of the sound over a wider area, and so 'walk-arounds' became part of the standard routine, in order to assess the more global situation and to find the best compromise. There was also a growing awareness in both the studios and the live venues that the integrity of the direct sound was of great importance.

In fairness, when the X-curve concept was first formulated, the industry was very limited in what it could measure, and many important psychoacoustic factors were also not well understood (which was partly due to the inability to measure many things). The 'one-third-octave mania' had gripped most of professional sound for quite a few years, but in all but the cinema industry its misconceptions and pit-falls had led to its abandonment after a decade, at the most. Nevertheless, we now have both a greater understanding of psychoacoustics and much more advanced measuring equipment, and so it does not seem reasonable to continue with outmoded 1970s concepts in the 2010s.

New tests

In 2011, a series of tests was carried out in the University of Vigo, Spain, and the results were presented to that year's Reproduced Sound conference, in Brighton⁴. A three-way loudspeaker was set up in an auditorium with generally good acoustics. It was positioned on the stage, towards the front of the room, and in a central position not far from the screen (the room was occasionally used for film projection). Measurements were taken at 8 positions, as shown in Figure 5. Pink noise was played

Figure 7 Responses at different positions with different time windows

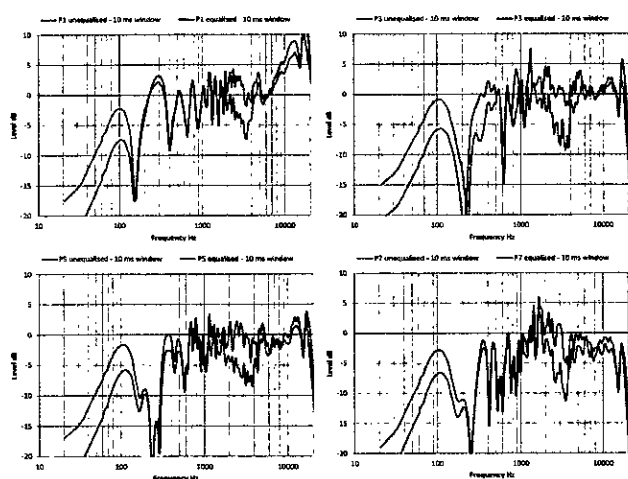


Figure 6a Frequency responses at Positions 1, 3, 5 and 7 with 10 ms window

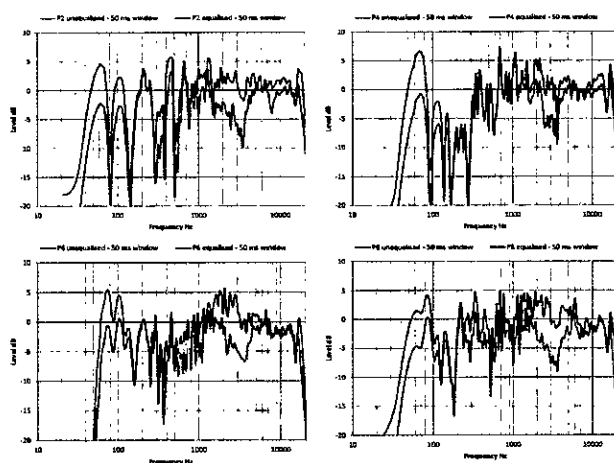


Figure 6b Frequency responses at Positions 2, 4, 6 and 8 with 50 ms window

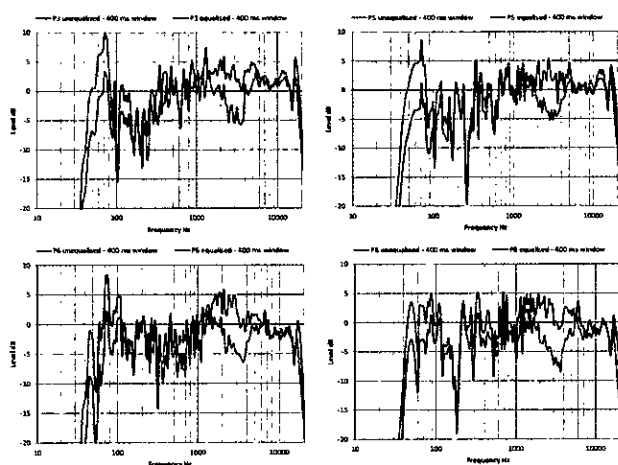


Figure 6c Frequency responses at Positions 3, 5, 6 and 8 with 400 ms window

through the loudspeaker, and two minutes of it was recorded at each position. From the recordings, the impulse responses were derived. A basic attempt was then made to 'improve the room response' with a one-third-octave graphic equaliser, referenced to a single microphone about 10 metres from the stage, about two metres off the centre line, and at the ear height of a seated person. Pink noise from the loudspeaker was again recorded, and further impulse responses were generated.

The frequency response of each measurement was computed from the impulse response via the Fast Fourier Transform, using Tukey windows of different lengths. The resulting responses were then energy averaged over a one-fifteenth-octave bandwidth and the values were assigned to the associated centre frequencies. A Tukey window shape is also known as a 'tapered cosine window', and the actual window used consisted of rectangular sections of 10, 50, 80 and 400 milliseconds, based on the rationale that different lengths would represent the different effects on the perception of sounds of different lengths, from percussive to sustained.

Figure 6 shows a comparison between a response measurement with pink noise in one-third-octave bands (using an 800 ms Hanning window) and another computed from the impulse response with a 400 ms half-Tukey window. The agreement between the two is generally quite good, and shows that no great differences are to be expected which could be due to the measurement techniques themselves. Both of the above representations, within the limits of their resolution, broadly represent the steady-state response of the system, but the impulse-response based measurements are clearly more revealing. Simple, one-third-octave, real-time measurements must now be considered to be obsolescent given the wide availability of the more advanced techniques, even on iPhones.

Positional variations

A sample of the frequency responses at different locations, with and without equalisation and computed with different window lengths, is shown in Figure 7. It can be seen that, in reality, despite the fact that the responses had been equalised with a one-third-octave graphic equaliser to try to achieve a smoother response, none of the frequency responses are particularly smooth. It can also be seen that the responses change over time as the response field builds up, with the reflexions and reverberation 'filling in' the gaps.

Figure 8 compares the smoothed differences at each of the 8 positions between the unequalised and equalised responses, with each the four window lengths. It can be seen that the adjustments made were too coarse or too far off the problem frequencies to yield any truly significant benefits. Only the 3 kHz dip from a loudspeaker anomaly has seen any general improvement, but this was not a room problem, it was a loudspeaker problem (shown in the paper on which this article was based) that should be fixed in other ways. [In fact, the electrical equalisation mentioned in the opening paragraphs, as applied from the 1930s, was only designed to fix loudspeaker problems - not rooms - so it looks like the old-timers already knew a thing or two!] Although the average trend of the equalisation is apparent, the narrow-band variations still exist. In fact, some of these may be due to an error resulting in the need to re-take one set of measurements, and despite the efforts to put the microphone back in the same position, perfect re-positioning was clearly not achieved.

The above-mentioned error serves well to highlight the fact that when in-room responses are measured by other people, at different times, the minor differences in microphone positions can give rise to significantly different readings. This point leads to two conclusions, i) that this type of measurement can be rather fragile in terms of

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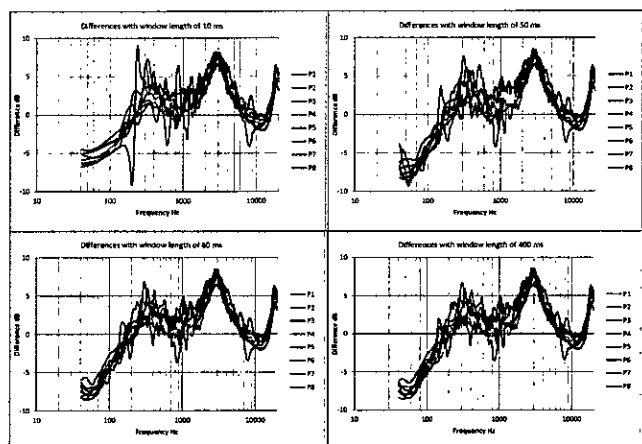
Figure 8 - Unequalised vs. equalised responses


Figure 7 Differences between unequalised and equalised responses at eight positions with the four window lengths.

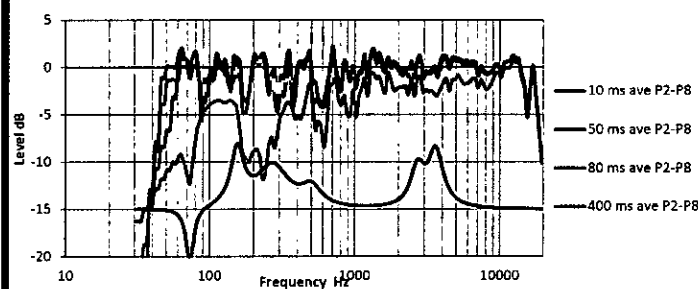
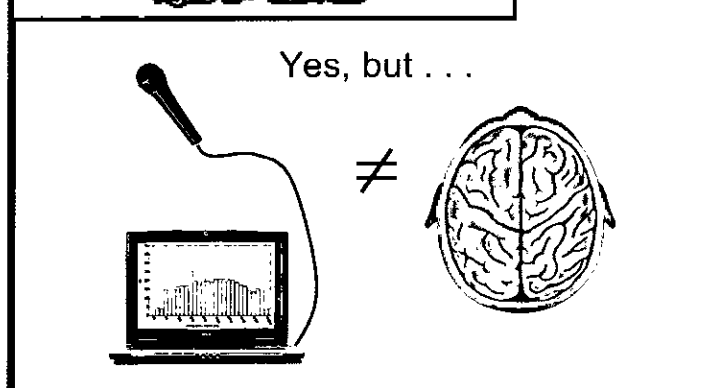
◀P33 repeatability, and ii) that skilled interpretation of any such measurements is a fundamental requirement. It was long ago recognised that different engineers, setting up one monitor system in one control room under stable conditions would rarely, if ever, end up with the same settings on a one-third-octave graphic equaliser⁵. So, if the *equaliser settings* were not the same, the *direct sound* would not be the same, and the *perception of timbre* would not be the same. This was the sort of uncertainty that led to the widespread abandonment of the use of one-third-octave equalisation in music recording studios by the early 1980s. In addition, percussive and sustained sounds may behave very differently in terms of the 'room' equalisation.

Average responses

In order to examine the overall effect of the one-third octave equalisation, the mathematical averages of the responses were found for the different positions. It is clear from the unequalised and equalised responses for the eight positions and four time windows, shown in Figure 7, (and referenced to the single measuring position which had been used for the reference calibration), that the applied equalisation has not produced any overall improvement in the room as a whole. What is more, the effect of the equalisation on the direct sound could also degrade the dialogue intelligibility.

It was referred to earlier how a typical Errol Flynn film of the 1930s could be clearly understood in almost any likely playback environment. It was also explained how the professionals of those days worked within the limits of the available technology. What is more, the diction of the actors in those days was also, generally, theatrical and precise. They were not often *see/heard* mumbling into their beers in a bar scene. The films were mixed with a desired, given response, *direct from the loudspeakers*. No attempts had been made to compensate for the rooms, so there was a certain integrity and uniformity to the direct sound that became obscured from the 1970s, onwards.

Somewhat unfortunately, as the loudspeaker system capability increased, film directors began to exploit it to the full; and then often some more! Soundtracks also became ever more complicated, and so the balances became ever more finely poised. Consider a tense situation in an action film, for example, with threats being made in low voices within a background of loud music and shouting. Yes; the tension *can* be increased by balancing the dialogue on a knife-edge, but whether it remains intelligible or not can be tipped either way by the different equalisations of the direct sound, as well as by its level relative to the other components of the soundtrack. The only way round this problem would either seem to be for directors to revert to less complicated soundtracks (of which there is little hope) or to review the means by which cinemas are currently calibrated and equalised.

Figure 9 - Attempted flattening using mathematically derived parametric equalisation

Figure 10 - 'Toole's Law'


Equalising the average responses

The unequalised responses at the eight positions were averaged with respect to their sound *pressures in decibels*, as opposed to their *powers*, as this tends to give a better correlation with subjective differences. The frequency response of a set of parametric filters was then computed and mathematically applied to the average response for each time window (although position 1 was excluded due to a very narrow, on-axis anomaly). Figure 9 shows the mathematically equalised averages, along with the response of the filter. It can be seen that the 10 ms windowed response droops significantly at low frequencies. This is not untypical for short-windowed measurements in large rooms as there has not been time for any low frequency reverberant build-up to take place. Furthermore, the overall group delay at low frequencies often means that the impulse response of the system is still decaying as the measurement truncation takes place. The LF droop could therefore be partly real, and partly a measurement artefact. Nevertheless, the 10 ms window does have some relation to subjective perception as it contains a large proportion of the direct sound. For this reason, the considerable boost seen in Figure 9, between 100 and 200 Hz, would need to be examined audibly for colouration. The responses as a whole have definitely been improved by the applied equalisation, but examination of the equalisation curve itself shows that some of the boosts are rather pronounced, and experience suggests that there can often be a risk of colouration when such equalisation is applied, even though the overall response appears to be flatter.

Figure 10 (kindly supplied by Floyd Toole), is from a presentation made to an AES workshop on this subject in 2010⁶. It shows a very important point, which should never be lost sight of with this type of work. When we measure different aspects of a system response, we look at individual characteristics, but we have no way of making any global measurements which can simultaneously integrate as many aspects of the sound as can the ear/brain combination. Systems, ultimately, must be judged to *sound* right in order to *be* right. In fact, as can be seen from Figure 11, the applied equalisation has clearly resulted in a general improvement in the response over a wide area, but the comment about the *sound* of such equalisation must still be borne in mind. Suggestions about the more widespread use of automated measurement and equalisation processes often fail to fully take this point into account. ▀

Figure 11 - Equalisation of the average responses

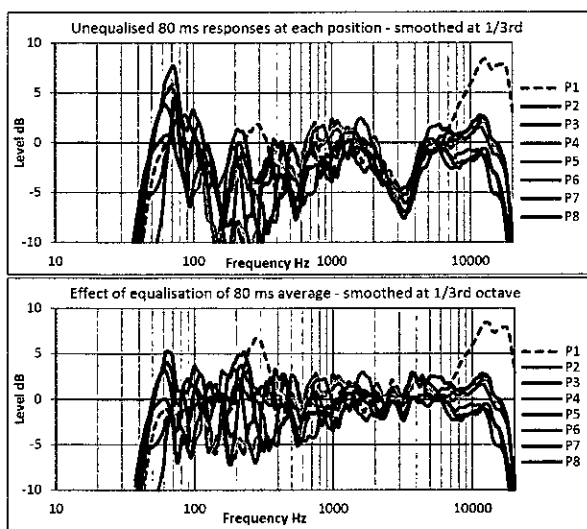


Figure 10 Effect of equalisation of the average response at each position (80 ms window, smoothed over 1/3rd octave)

As ever, these days, in an attempt to cut costs by dispensing with the use of skilled people, many companies and organisations are now leaning in the direction of automated measurement and equalisation. However, the question must be asked as to just how capable such systems are of making skilled judgements about what they are doing, and if the appropriate judgement skill can be written into a program. It is well-known that floor dips, for example, should not be equalised

because they are highly position dependent. It is also equally well-known that their perceived effect is largely innocuous. For these reasons, changing the very important *direct* sound in order to 'correct' an uncorrectable yet innocuous 'problem' would seem to be absurd. Floor-reflexion dips do not lend themselves to equalisation, but how can an automated system recognise the difference between a floor dip and any other response dip? What is more, any boosts applied around the typical frequencies of floor dips can risk the overload of the loudspeakers and amplifiers when any high-level programme coincides with them. Cinema owners, in general, are not renowned for spending 'unnecessary' money on systems with sufficient headroom for such eventualities. Typical, installed systems are often very marginal indeed; a fact verified by the unacceptable distortion level heard in many cinema on loud programme. In many of these cases, inappropriate equalisation is definitely a factor in exacerbating the overloads.

Ideally, the average response should be taken on the direct field, but it is not possible to clearly measure the direct arrival so deep into the room. The inevitable reflexions and reverberation would arrive within any time-window of sufficient length to accurately represent the low frequencies. On the other hand, equalisation based on one-third-octave measurements is usually derived from a 'steady state', pink noise signal, and therefore *clearly* cannot differentiate the direct sound from the reflexions and reverberation. From a practical perspective, it is recommended by many that a combination of measurement and critical listening is the best way to address the questions of intelligibility, listener comfort and music enjoyment. No automated measurement systems can do this. *Perceived loudness* is another aspect of calibration which has so far defied simple measurement.

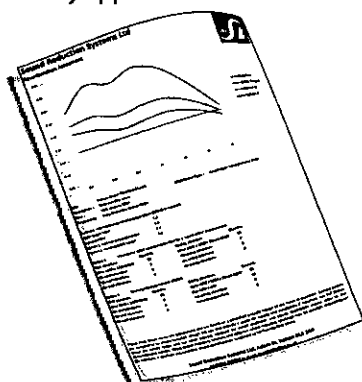
Loudspeaker directivity considerations

After carrying out the measurements described so far, another set of tests was made with a loudspeaker of different directivity characteristics to the first one. The differences between the loudspeakers were **P36**

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►P35 examined at each position by normalising the responses to that at position 2, which equates to the normal Dolby calibration position. The normalisation was carried out on the 80 ms responses (although it must be noted that the range of integration times that our ears use with speech and music may be better represented by other time windows). However, this highlights the problem of making general measurements which relate optimally to sounds as diverse and complex as cinema soundtracks. Figure 12 shows the difference between the 80 ms responses for the two loudspeakers, at each microphone position, after normalisation.

For clarity, the responses were first smoothed over each one-third-octave before the differences were computed. The significant differences that resulted can be attributed to the different loudspeakers driving the room in different ways. The differences in the frequency response between positions are considerable. They also further signify that different equalisation of the direct sound would be needed for each loudspeaker in order to achieve the best average response for each loudspeaker over a wide area of the room. This is clearly absurd. The direct sounds *must*, by definition, be substantially the same. If the sounds are not the same *at source*, then there is no hope for 'fidelity'. Faithful to what; where is the reference?

Discussion and conclusions

The results of these investigations illustrate various issues concerning equalisation, which many skilled audio professionals have been aware of for some time, yet which are not adequately accounted for in the calibration processes for the cinema industry. The measurement of the frequency response of a loudspeaker/room combination at a given 'calibration position' tells us very little about the general response over the whole of the room. These measurements lump the direct sound together with all the reflexions and resonances and reverberation. In every room, the steady state, far-reverberant-field responses will have their own, unique signatures, and so will call for their own, unique, 'corrections'. The implication here is that if we begin with flat loudspeakers in all the rooms, then in each case the direct sound would be 'unflattened' in its own, unique way as 'corrective' equalisation was applied. This begs the obvious question as to how we can expect the sound in the auditorium to be similar if, in every case, the direct sound is differently equalised. It is beyond reason to expect that sounds that originate with different spectra can somehow be transformed into uniformity by convolution with the time-response modifications incurred whilst passing across the different rooms. If one thinks of the loudspeaker as an acoustic instrument, then the situation becomes easier to understand. The instrument would, of necessity, have to be the same in all rooms in order to be *perceived* to be the same instrument.

As has been called for in numerous recent papers^{3,4,8,9}, it would seem to be a basic minimum that if sonic compatibility was the goal, then the sources should at least *start out* with the same characteristics. Equalisation can be used judiciously to calm any peaks, or fill any broad troughs, which may be present over a wide area of a room, but attention should always be paid to the possible audible repercussions.

The fact is that the ear and brain are well adapted to 'hear through' the rooms¹⁰. In this way, the direct sound from the source is perceived as the reference. The ear is sensitive to the direction and spectral content of any discrete reflexions, and detects reverberation for what it is. As quoted from Toole in reference 6, *'Unlike a human, the microphone does not take any note of the angle of incidence of the direct and reflected sounds, nor does it make any allowance for the time of arrival of the sounds, nor does it acknowledge spectral variations among any of the sounds. The microphone simply adds them together.....It is well known that two ears and a brain are vastly more analytical than a microphone and an analyser. Humans respond differently to sounds arriving from different directions at different times.'* [Hence Figure 10, once again.]

Back in the 1970s, one-third-octave graphic equalisers represented 'fine tuning', but subsequent advances have rendered them to be very coarse. As we now have much more precision measurement equipment easily available there seems to be little point in persisting with one-third-octave analysis, especially as the way that it is often currently used is so misleading. Measurements computed from the impulse responses, with different time windows, provide much greater insight into both the frequency *and* the time domain behaviours of the loudspeaker/room

Figure 12 - Comparison of responses using two different loudspeakers

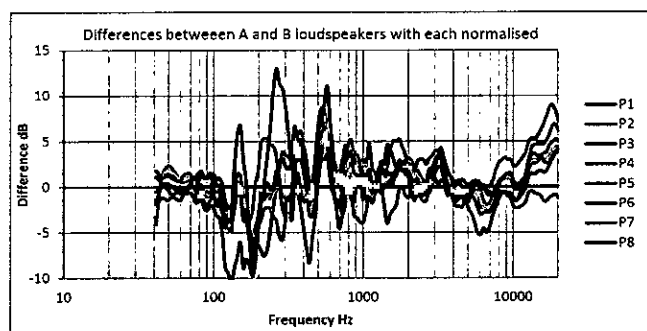


Figure 11 Differences between responses of Type A and B loudspeakers at the eight positions after normalisation to their respective responses at Position 2. (80 ms window)

systems. Whilst the current use of one-third-octave equalisation may be 'better than nothing' in some circumstances, the centre frequencies of the filters rarely coincide with the centre frequencies of the problems.

When viewed on a one-third-octave 'real time' analyser, the coarseness of the measurements will allow two rooms which measure the same to *sound* very different. This completely fails to achieve the goal of room-to-room standardisation as perceived by the ear. Another aspect of 'wrongly' equalised soundtracks is that there can be a tendency to produce a fatiguing sound character and a great variability in intelligibility. The latter problem is especially apparent if the main energy in an actor's voice coincides with a frequency that has been substantially cut in the direct sound.

What is more, if, as it seems, there is a difficulty in finding skilled and experienced people to align the cinema rooms around the world (and the tales of misalignments are abundant), it would appear that a more robust standard of alignment would be a useful goal to aim for in order to provide more accuracy and compatibility in the responses. Flattening the response in the close field could go some considerable way to solving this problem.

As loudspeaker technology is now well advanced, there is no excuse for using any system which cannot achieve a reasonably flat response in the close field with only minor tailoring by equalisation. At the same time, cinema theatres are tending towards being much acoustically drier. This has led to the direct sound becoming more audibly prominent, and hence its integrity needs to be maintained as far as possible if the same sound character is to be perceived from one room to another. The increasing proportion of smaller cinemas emphasises even more the perception of a drier sound. After all, if the ambience of the soundtrack's own surround channels is to be as flexible as possible, then the decay times of the cinemas theatres, themselves, should be minimised. A result of this is that there are fewer room 'problems' to 'correct', anyway.

As for the automation of the process, the question remains about just how to position the microphones around the current calibration positions. If FFTs were to be used as the basis for the analysis, the procedure of waving the microphone around could not be used because the response would no longer be time-invariant. A single microphone at one fixed position is not representative of how or what we hear. If multiple microphones are used at pre-specified positions, it has already been shown how difficult it can be, even in university conditions, to re-position them precisely from one measurement to another. The narrow-band differences so produced were shown in Figure 7, which demonstrates how positionally sensitive such measurements can be.

The only hope for the standardisation of automatic calibration would seem to be if it were to be carried out in the close-field, measuring substantially the direct sound, but, even then, pitfalls are waiting if there is no audible check of the results. The problem also remains that there is no truly 'accurate' point of reference from which to measure a loudspeaker system with drivers distributed over a large front-baffle area. Nevertheless, whether the calibration is to be carried out either by humans or machines, it would appear to be the case that

■ it must be carried out in the close field, and that one-third-octave equalisation is to be avoided.

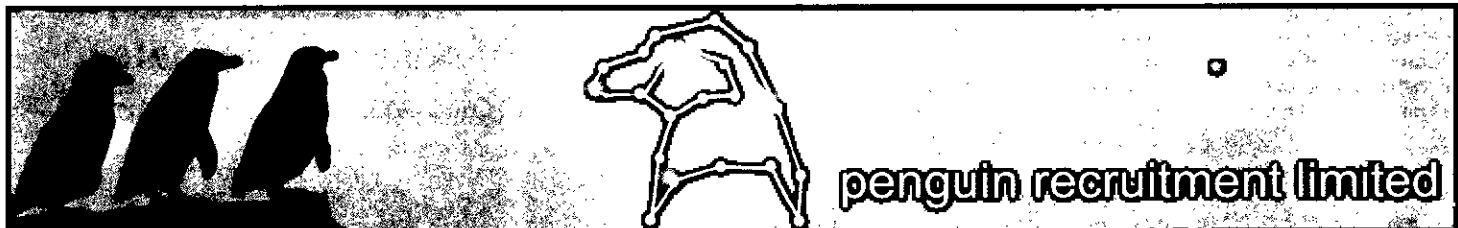
What is more, if in-room frequency responses are adjusted solely on the basis of the currently standard, far-reverberant-field measurement technique, the direct sound from the loudspeakers can be significantly degraded. A *fixed*, frequency-domain correction is being applied to a *moving*, time domain problem, and the different direct responses thus obtained do not bode well for room-to-room uniformity.

Acknowledgement

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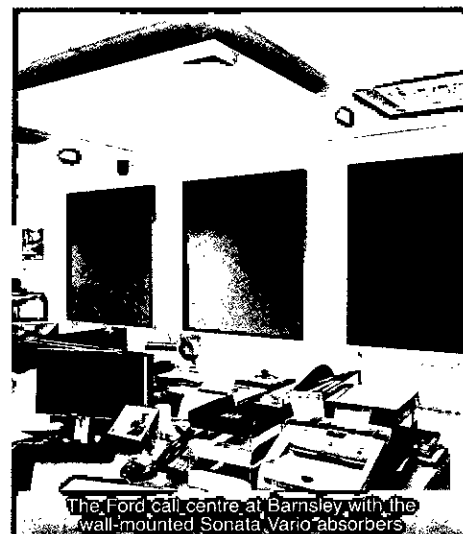
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bedrooms but this combination did not provide the required level of noise insulation.

To remedy this, Selectaglaze provided sliding secondary units fitted flush to the window openings, thus allowing easy access to the shutters and external windows. This has not only produced exceptionally quiet rooms but will help considerably in reducing energy consumption.

At Hotel Indigo it was decided to replace the windows with double glazed frames but

standard double glazing would not provide the levels of sound insulation needed by the guests. The solution from Selectaglaze was to install secondary glazing, thus creating triple-glazing which offered noise insulation in excess of 45dB and further improved the energy performance of the window, reducing heating costs and improving sustainability.

For further details ring 01727 837271 or go to www.selectaglaze.co.uk



Panels cut lunch time din for nursery youngsters

Mealtimes at a North East nursery school are now far more enjoyable – thanks to measures to cut excessive levels of reverberation and echo.

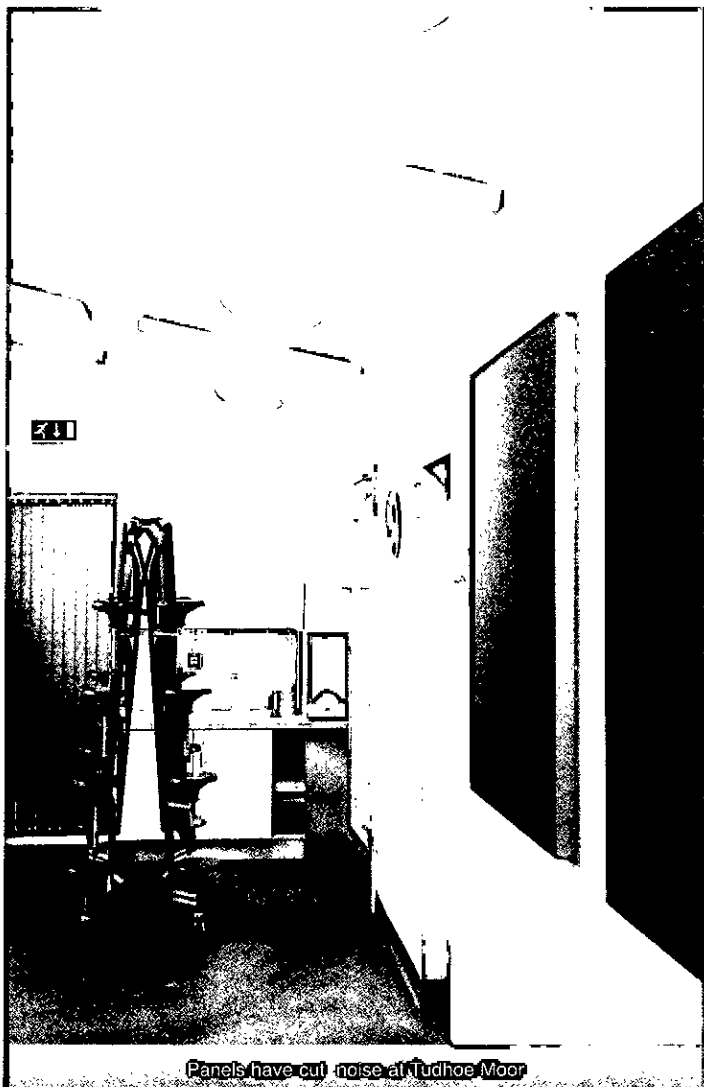
Using acoustic modelling software, Sound Reduction Systems (SRS) were able to predict the current reverberation time of the dining area at Tudhoe Moor Nursery School, Spennymoor, and to work out how much absorption would be needed to solve the problem.

SRS Director Richard Sherwood said: "A combination of acoustically reflective surfaces on the walls, floor and ceiling, along with the high frequency noise generated by the children, was resulting in excessive levels of reverberation and echo within the room."

SRS recommended the installation of their Sonata Vario panels on the ceiling to reduce the reverberation time. The panels are mounted on fixing brackets to stand proud of the ceiling, giving the effect of a floating absorber.

Unlike the traditional, directly bonded absorbers, this allows the back of the panel to absorb sound as well and greatly improves the acoustic performance of the product, which means fewer panels are needed.

Head teacher Stephanie Colling said: "We were all so impressed with the service and the product in the first room that we have re-ordered for another very similar room that needs the 'wonder' treatment." ■



Panels have cut noise at Tudhoe Moor

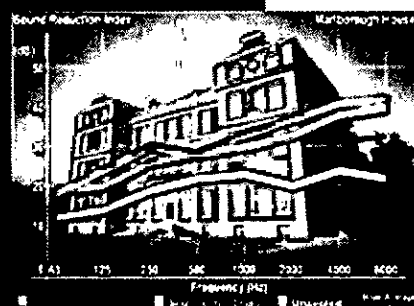
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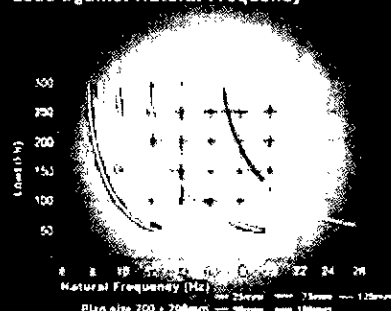
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Concern over noise measurement numbers

I have read the correction in the January/February 2102 edition of *Acoustics Bulletin* regarding the Den Brook AM condition. Is it really the case that RES took noise measurements at only two sites?

I am not an acoustic consultant but I have been in acoustics long enough to know that considering such a small sample and to make conclusions which do not reflect actual background noise levels is probably not scientific.

Reference is also made to the Salford report which is six years old and did not actually take any measurements.

It is disappointing that in the rush for wind health concerns with regards to noise are not being considered properly.

Chas Edgington BSc. MIOA
Sales Manager – Acoustic Products, Retical Corby

The author of the article in question in question has responded to Chas Edgington as follows:

RES would like to clarify that the erratum published in the Jan/Feb 2012 edition, and the original article published in the Nov/Dec 2011 issue, referred to an assessment of the AM planning condition (Condition 20) imposed on Den Brook wind farm. This study analysed background noise data recorded on two different sites – Turncole in Essex and Rotsea in Yorkshire. This assessment did not examine background noise recordings at Den Brook – it only applied the planning condition that was given to Den Brook on the two different background noise recordings.

Daniel Leahy, RES ■

Fond memories of Pete Watkinson

I was greatly distressed to read of the early death of Pete (as we in the musical acoustics group of the University of Surrey called him) Watkinson. I had the privilege of supervising his PhD work and have just “speed read” his thesis again. It brought back many memories of how well the members of the group worked together and what obstacles we had to overcome in those days.

I feel I might mention one obstacle which may amaze modern day workers: part of Pete's work involved performing a finite element analysis of the vibrations of trombone bells. In those days the finite element program resided in the IBM 360/195 computer at the Rutherford Laboratory which could be connected to the University's Prime computers; I was able to obtain a special grant giving us a few (I think four) night-time hours on this machine. Pete had therefore to establish communications between three computers with three different operating systems and, moreover, having the mantissa and exponent of the words reversed in one of them. He overcame all these little difficulties

and found a reliable way of coping with the output of the IBM machine – nearly 14,000 lines of text for each run – by writing programs to run on the University's Prime computer before he transferred those results to our Nova 2 computer where he could analyse the data. Happy days!

The work he did was significant and I am still sad that I wasn't able to obtain a grant to continue it and thence produce something which would undoubtedly have been of great value to the musical instrument industry.

On a musical note (pun intended), Pete didn't only play in local brass bands, he also joined me in local orchestral work and I have strong memories of his language when he struggled with a particularly evil 2nd trumpet part in a work by Stravinsky – what made it worse for him was that the first trumpet part was much easier and he had volunteered to play second to give another player the chance to play the first.

I hope my little remarks will give readers a picture of Pete's early days in acoustics.

John Bowsher HonFIOA ■

Why is electric vehicle tyre/road noise lower?

In the article entitled *The sound of silence* in the November/December 2011 issue, the authors state that “Recent research suggests that the A-weighted noise levels from electric vehicles may be 20dB lower than those of standard vehicles at rest, but the differences may be only 5dB at speeds of about 50km/h because tyre/road noise then predominates”. Perhaps the authors could explain the physical reasons why tyre/road

noise can be so much lower than that of conventional vehicles at speeds above 30 mph if it is predominant for both forms of vehicle. It might be apposite to report that, as a school boy, I witnessed the occurrence of two fatalities caused by trolley buses which appeared to be caused by unawareness on the part of the victims of the almost silent approach of the buses.

Frank Fahy HonFIOA ■

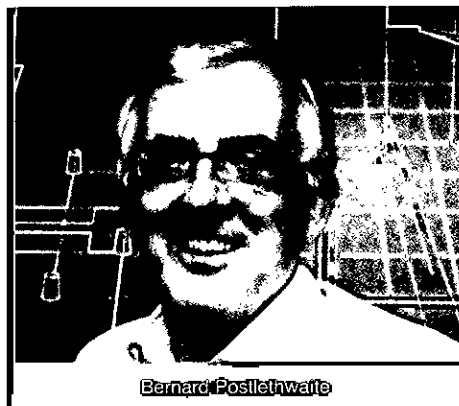
People News

New recruits to Xodus Group

The acoustics team of Xodus Group has appointed Bernard Postlethwaite as an Acoustics Specialist and Lisa Payne as an Environmental Consultant. They are based at the company's Southampton office in the University Science Park.

Bernard and Lisa, both previously with Bureau Veritas, say that they are delighted to have joined the engineering consultancy company, which was only formed in 2005, but now boasts some 400 employees and is rapidly expanding into overseas markets.

Bernard brings some 40 years' noise consultancy experience to Xodus, of which the last 10 have focussed on the port industry, while Lisa brings extensive noise modelling skills. ■



Bernard Postlethwaite



Lisa Payne

PCB Piezotronics' new microphone pre-amplifier is 'hot stuff'

PCB Piezotronics has launched a microphone pre-amplifier which can withstand the same temperature as the microphone capsule and operate at 1200C.

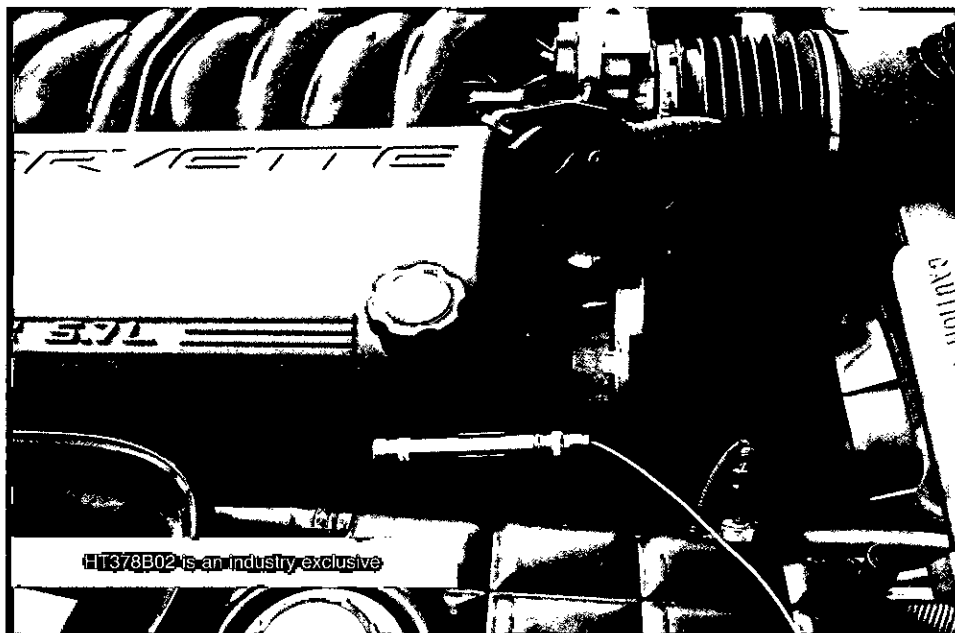
Housed in a package with a BNC connector, the new model HT378B02 is an industry exclusive microphone and preamplifier that operates from ICP sensor power over

a wide frequency range – 5Hz to 10kHz (± 1 dB), 3.15Hz to 20kHz (± 2 dB). The preamplifier was designed with the microphone in mind and works seamlessly to ensure optimum performance. The wide temperature range from -40 to +1200C eliminates the need for probe microphones.

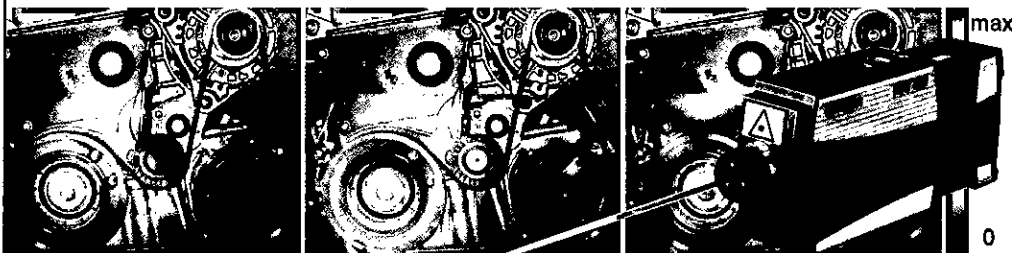
PCB Piezotronics says the integral ICP pre-polarised microphone is more cost-effective than using older style externally polarised products and enables customers using existing ICP input analysers and DAGs (data acquisition systems).

With low noise floor (cartridge thermal noise) of 17dBA and dynamic range at nominal sensitivity of 135dBA (146dBA at 3% distortion), it delivers high accuracy in a broad range of high temperature applications. These include engine analysis, manifold testing, transfer path analysis, exhaust pipes, heating/ventilating and air conditioning (HVAC) and general acoustic testing in high temperature environments.

For further details ring 01462 429710, email ukinfo@pcb.com or visit www.pcbensors.co.uk



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New updates for the Optimus Green range of sound level meters

Many improved features

Cirrus Research has introduced new updates for the Optimus Green range of sound level meters. Existing customers can update their instruments through the NoiseTools software.

Designed to be simple to use with a high resolution OLED display, 120dB dynamic range in a single span and high resolution audio recording, Optimus Green aims to be "ideal for both environmental and occupational noise measurements".

The updates include:

- AuditStore data verification
- advanced acoustic fingerprint audio recording
- tonal noise detection using ISO 1996-2:2007 and an improved method created by Cirrus Research
- up to 32GB of memory for long term noise measurement applications
- new outdoor measurements kit with 3G/GPRS communications & GPS positioning

AuditStore allows the user to verify measurements that have been downloaded to the NoiseTools software against a secure data store within the instrument. This allows the user to present data with confidence and to have the facility to verify that the measurement data has not been modified or adjusted.

When a measurement is made, the instrument stores a set of data into secure memory. A function within the NoiseTools software allows the user to check the measurement being displayed against the AuditStore. The software then checks that the data displayed matches the values within the secure memory and displays a verification symbol if

the information matches, a unique feature which will be useful in any legal proceedings.

The C version instruments include tonal noise detection. The detection can use either the ISO 1996-2:2007 simplified method or an improved method that expands on this to detect tones in outer bands as well as tones between bands.

The threshold levels for the improved method can also be adjusted within the NoiseTools software and when a tone is detected, the appropriate 1:3 octave band is highlighted in blue, contrasting the green colour used for the other bands.

Acoustic Fingerprint is the new name for the advanced audio triggering technology standard across the Optimus Green range. This advanced system allows users to define up to five different templates, with up to 20 rules available across the templates.

These rules can be simple or complex, depending upon the nature of the noise to be recorded, and can be constructed from three types.

The first rule type is the Level rule. This allows recordings to be started and stopped whenever the noise level exceeds a preset threshold, with the trigger parameters chosen from any available in the instrument.

The second rule type is Rate of Change. This allows the instrument to trigger when the noise level changes at a certain speed. For example, a trigger can be created that activates when the LAeq has increased by more than 10dB in 5 seconds (2dB/sec). As with the simple level rule, any parameter within the instrument can be used to set the trigger conditions.

The third rule type is the Tone Rule. This uses the tonal detection in the C version instruments and uses 1:3 octave band values and the currently selected tonal detection method.

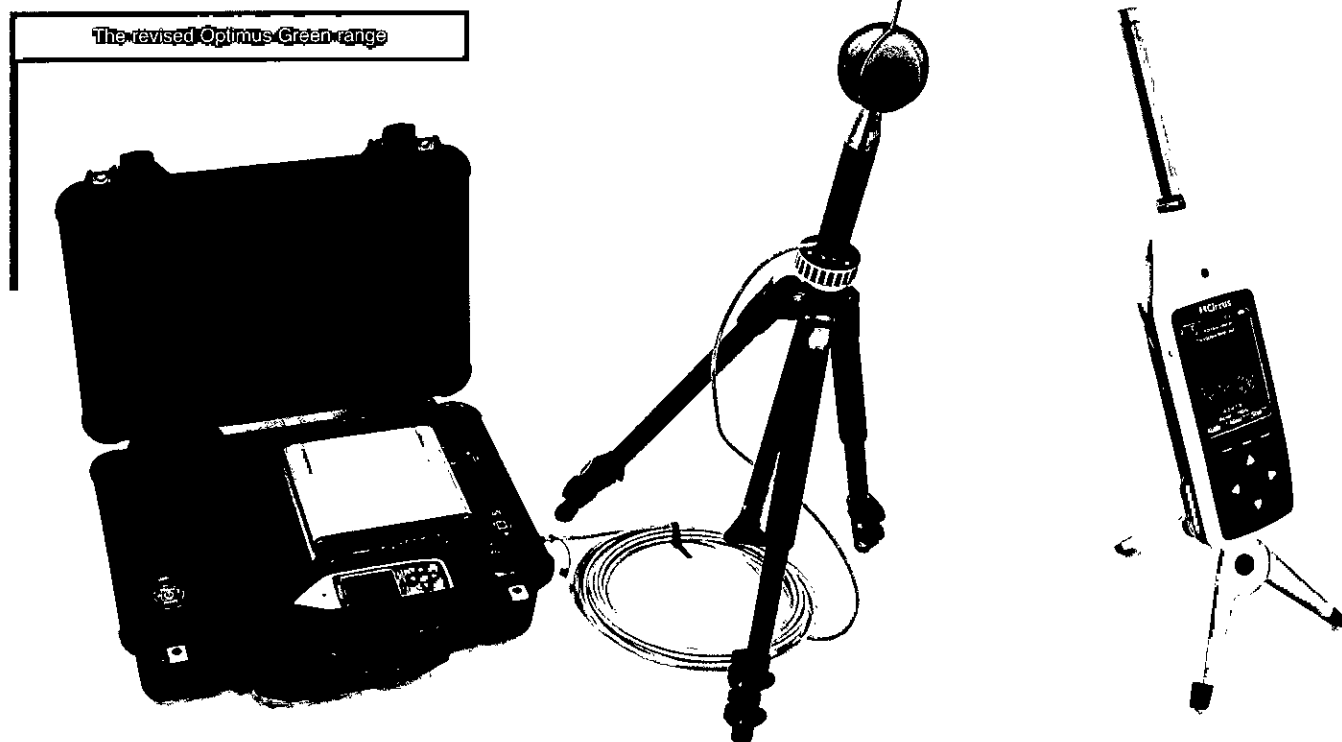
A template can contain any combination of these rules and also includes AND/OR functions to increase the capability, with a pre and post trigger to ensure that any impulsive noises are recorded.

Audio recording in the Optimus Green instruments is available in either standard quality (16 bit, 16kHz) or studio quality (32bit, 96kHz) with the data stored as uncompressed WAV files.

The new CK:680 outdoor measurement kit adds remote data connectivity over 3G/GPRS along with GPS positioning information. The GPS data is stored with each measurement allowing the data to be displayed on a map within the NoiseTools software. The clock in the instrument is synchronised automatically with the GPS time ensuring accuracy over long periods.

Measurements can be downloaded over a 3G/GPRS connection and stored within the NoiseTools software. By using a cloud based system, Cirrus Research has removed the need for users to setup complex communications systems. Once an Optimus has been connected to NoiseTools via a USB connection, that instrument will appear within the software whenever the modem in the outdoor kit is enabled.

For more information, contact Cirrus Research on 01723 891653, email sales@cirrusresearch.co.uk or visit www.cirrusresearch.co.uk 



Ship sensors will improve sea-state forecasting

Channel ferry will provide key data

Novel sensors, provided by the Chelsea Technologies Group, are to be fitted to a cross-channel ferry to collect vessel motion data as part of the WaveSentry project which is being managed by Marine South East.

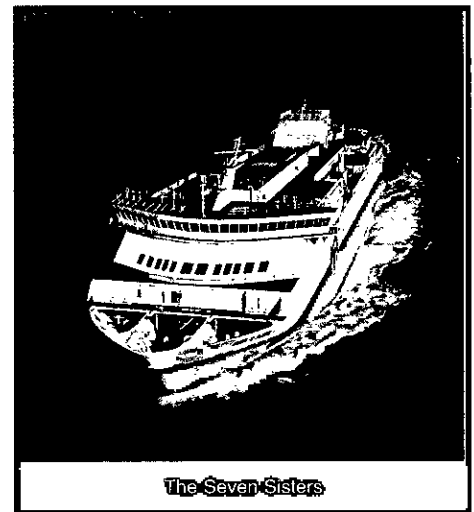
This motion data will be processed to derive certain indirect sea-state measurements which will be merged with a range of other data feeds within the WaveSentry sea-state measurement and forecasting system.

The sensor box will be fitted to a Transmanche ferry, the Seven Sisters, which crosses the channel daily. The data collected from the ship will be relayed to the shore and analysed using software from WaveSentry collaborators, QinetiQ, to infer the sea state from the ships motion throughout the crossing.

The data collected will be logged against the GPS position of the ship and will be merged with additional data streams by HR Wallingford, to enable much more accurate "nowcasting" and forecasting of sea state including wave height, period, direction and steepness.

This information should greatly assist many marine operations, such as shipping, offshore oil platforms, maintenance boats and renewable energy projects, which depend on high quality information on sea-state for economic and safety decision making.

Sea-state information is currently based only on atmospheric/ocean models and lacks sufficient temporal and spatial resolution. Wave conditions are always changing and can vary tremendously over just 100km, or over a period of a few hours. Operators need to



The Seven Sisters

know what current conditions are before commencing an operation.

For more information contact Ellen Keegan at ekeegan@chelsea.co.uk, or 0208 481 9019 or visit www.chelsea.co.uk/marineapps/sea-state-forecasting ■

Castle launches new sound meter

Aim is to simplify measurement process

Castle Group of Scarborough has launched a new sound meter, the SONUS E, dedicated to environmental noise measurements.

It says the meter is quite straightforward, the result of a recent study showing that the majority of environmental noise tasks only ever need three things

According to the study, compiled by Chris Gilbert (MIOA) and Simon Bull (MIOA), 90% of all environmental noise measurement tasks can be completed using only three measurement parameters: L_{Aeq} (Equivalent Sound Level), L_{90} (Sound level exceeded for 90% of the time) and L_{Amax} (Maximum Sound Pressure Level).

"This makes the whole process of environmental measurements a lot more accessible and more straightforward," said Simon.

He added: "It appears that most people are using equipment that is expensive, over-complicated, power-hungry and data-intensive, when it is absolutely not needed."

He continued, "The traditional approach has always been to take a powerful sound meter and put it in a weatherproof box. This leads to increased battery requirements which often mean a very heavy box that pulls your arms out of their sockets just getting it onto site!"

Castle Group has released the new SONUS E to make the most of this new research, with a single lead-acid battery lasting over a week and a total system weight of less than 5.5kg.

Robert Hawksworth, head of the Castle development team, said, "There is a clear need for something a little simple in the field of environmental noise measurements, so we have designed the SONUS E and its weather-proof housing to suit. Most existing kits weigh in at between 15kg and 20kg, so this is a definite improvement here"

The SONUS E will measure down to 22dB and will give 2 parallel measurements, which is required in some environmental standards. The parameters measured include L_{eq} , L_E , L_{max} , L_{10} , L_{90} and one user defined L_n value and the



The SONUS E

data-logging is capable of taking a measurement every one second as well as overall levels.

For more information contact: Dianne Hamblin on 01723 584250 or dianne@castlegroup.co.uk ■

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Lift off for new aviation impact measurement tool

Phased roll-out in United States of flight modelling system

The United States Federal Aviation Administration (FAA) and Volpe are poised to launch a new environmental analysis tool that will offer a robust, integrated way to quantify the environmental impact of aviation—from a single flight up to full-scale global impacts.

The FAA's Office of Environment and Energy is to begin a phased public rollout of the Aviation Environmental Design Tool (AEDT), a software system that dynamically models flight, taking into account the aircraft weight, performance characteristics, and weather conditions, and calculates the resulting noise, air quality, greenhouse gas emissions, and fuel burn. This capability will allow users to analyze the trade-offs between

noise, fuel burn, and emissions, and quantify the environmental impact of changes in a flight's trajectory or an engine's design.

Gregg Fleming, director of Volpe's Center for Environmental and Energy Systems, said: "The reality is, there are environmental trade-offs in aviation, and AEDT will, for the first time, provide the analyst with a means of understanding these trade-offs in a robust, meaningful way."

Volpe is the lead AEDT developer, functioning as the system architect and integrator of all modules and related databases. "As the FAA moves towards NextGen, it is critical to be able to accurately quantify fuel burn changes associated with various NextGen

initiatives, and AEDT provides that capability," Fleming said.

He added that AEDT's ability to capture the gate-to-gate, integrated environmental impacts of flight offered substantial enhancements over existing air quality and noise analysis tools, which model only individual environmental consequences (like noise or emissions) for a single airport or region.

As another major advancement over legacy systems, AEDT incorporates geographic information systems, which provide the environmental analysis with a data-driven visual representation of aviation operations in concert with noise, air quality, greenhouse gas emissions, and fuel burn. ■

Internet age dawns on neighbour noise investigations

Environmental health officers can now use live Internet connectivity to remotely monitor investigation progress with Brüel & Kjær's 'MATRON Live' Neighbour Noise Monitoring system.

Using unattended noise monitoring equipment for investigating persistent noise complaints has been standard practice for many years with local government noise control officers. The results, however, may sometimes be invalid due to operator error, complainant tampering, incorrect setup or equipment damage – all of which can go undetected until the equipment's recovered seven days later and it is too late to correct. Arranging a repeat investigation is time consuming, costly and frustrating for both the officer and the complainant.

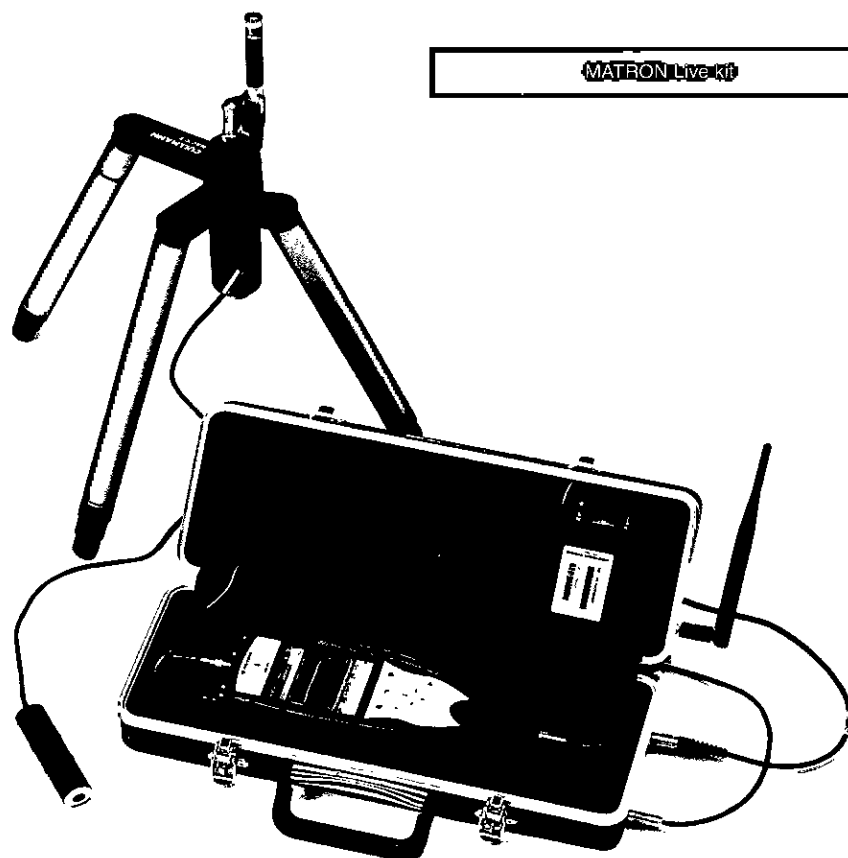
Live Internet connectivity, with the installed equipment to monitor progress of the investigation, is an entirely new practice which keeps the noise officer in touch with their equipment 24/7, by sending them regular e-mail updates of measurement status, instant e-mail alerts when tampering or damage occur and real-time display via the internet of noise level trends from the installed equipment.

The low cost and wide availability of wireless Internet coverage throughout the UK presents local authorities with an opportunity to reduce the cost of noise nuisance investigations by facilitating a 'Get it right first time' approach when using web-based noise nuisance monitoring equipment.

Existing users of the Brüel & Kjær MATRON systems can upgrade their equipment to MATRON Live with a minor hardware upgrade. This allows all MATRON users to benefit from the new, smarter tech-

nology, helping to minimise their noise nuisance workload.

For more information about MATRON Live from Brüel & Kjær, please visit: www.bksv.com/matron ■



Car noise sound simulator aids safety

Device saves time

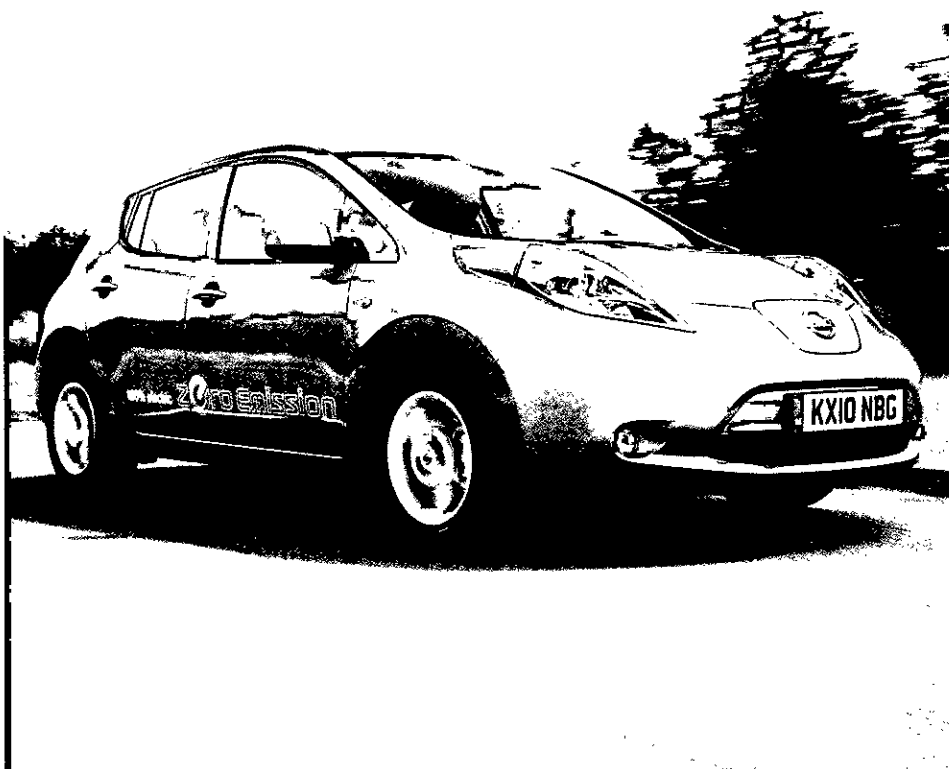
How quiet should the new generation of "quiet" vehicles sound? As almost-silent hybrid and "quiet" vehicles gain in numbers alongside their internal combustion engine counterparts, pedestrians no longer hear the usual motorcar noise cues they are used to, which may put them in danger.

Finding the right compromise that satisfies environmentalists, pedestrians and motor manufacturers is not a simple task. To address this issue, Brüel & Kjær's Exterior Sound Simulator (ESS) software is designed to accurately simulate the exterior sounds of any vehicle moving through a virtual environment.

In the design phase of a project, these sounds can be modified in real-time by the user, and the sounds of specific vehicles swiftly assessed for a variety of scenarios and background noise conditions.

Using the same simulation in the evaluation phase, selected sounds can quickly be tested and experienced by many people in the lab, removing the need to stand on a variety of street corners as test vehicles are driven by at different times of day.

Further information go to http://www.bksv.com/Products/PULSE_AnalyzerPlatform/PULSESolutionsOverview/AcousticApplications/NVHVehicleSimulator.aspx □



New version of Olive Tree Lab-Terrain

Advanced outdoor sound propagation software application

A new version of Olive Tree Lab—Terrain, an advanced outdoor sound propagation software application, is being launched shortly by Mediterranean Acoustics of Cyprus. The 1.4 version will include ISO 9613-2 calculations to help engineers who need to comply with this methodology.

Attendees at the IOA's conference in London on 21 March entitled Environmental Noise Propagation—Definitions, measuring and control aspects will be able to learn more about the application when Mediterranean Acoustics presents a paper on a comparison of ISO 9613 and advanced calculation methods using Olive Tree Lab-Terrain: predictions versus experimental results.

For more information visit www.otlterrain.com or www.mediterraneanacoustics.com □



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Committee meetings 2012

DAY	DATE	TIME	MEETING
Thursday	1 March	10.30	Engineering Division
Tuesday	6 March	10.30	Diploma Examiners
Thursday	8 March	11.00	Council
Monday	2 April	11.00	Research Co-ordination
Tuesday	3 April	10.30	CCWPNA Examiners
Tuesday	3 April	1.30	CCWPNA Committee
Thursday	19 April	11.30	Meetings
Thursday	3 May	10.30	Membership
Thursday	17 May	11.00	Publications
Tuesday	22 May	10.30	CMOHAV Examiners
Tuesday	22 May	1.30	CMOHAV Committee
Thursday	29 May	10.30	Engineering Division
Tuesday	29 May	10.30	ASBA Examiners
Tuesday	29 May	1.30	ASBA Committee
Wednesday	20 June	10.30	CCENM Examiners
Wednesday	20 June	1.30	CCENM Committee
Thursday	21 June	10.30	Distance Learning Tutors WG
Thursday	21 June	1.30	Education
Thursday	28 June	11.00	Executive
Thursday	12 July	11.00	Council
Thursday	26 July	11.30	Meetings
Tuesday	7 August	10.30	Diploma Moderators Meeting
Wednesday	12 September	10.30	Membership
Thursday	13 September	11.00	Executive
Thursday	27 September	11.00	Council
Monday	1 October	11.00	Research Co-ordination
Thursday	4 October	10.30	Diploma Tutors and Examiners
Thursday	4 October	1.30	Education
Thursday	11 October	10.30	Engineering Division
Thursday	18 October	11.00	Publications
Thursday	1 November	10.30	Membership
Tuesday	6 November	10.30	ASBA Examiners
Tuesday	6 November	1.30	ASBA Committee
Thursday	8 November	11.30	Meetings
Thursday	15 November	11.00	Executive
Wednesday	21 November	10.30	CCENM Examiners
Wednesday	21 November	1.30	CCENM Committee
Tuesday	4 December	10.30	CCWPNA Examiners
Tuesday	4 December	1.30	CCWPNA Committee
Thursday	6 December	11.00	Council

Refreshments will be served after or before all meetings. In order to facilitate the catering arrangements it would be appreciated if those members unable to attend meetings would send apologies at least 24 hours before the meeting.

Conference programme 2012

21 March 2012
Organised by Measurement & Instrumentation Group
Environmental Noise
Propagation-definitions, measuring and control aspects
The Royal Society, London

23-27 April 2012
ACOUSTICS 2012
Nantes, France

21 May 2012
Organised by the Musical Acoustics Group
The King of Musical Instruments-Acoustic Challenges
National Museum, Cardiff

12 June 2012
Organised by London Branch
Music to your Ears – Outdoor Entertainment and Environmental Noise
London

2-6 July 2012
Organised by the Underwater Acoustics Group & ECUA Committee
ECUA 2012
Heriot Watt University, Edinburgh

Early November 2012 (date TBC)
Organised by the Measurement and Instrumentation and Young Members' Groups
Basic Measurement Techniques
London (TBC)

14-16 November 2012
Organised by the Electroacoustics Group
Reproduced Sound 2012
Brighton

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Campbell Associates	9 & IBC	Polytec Ltd	43
Cirrus Research	39	SAFE-door International Ltd.	31
CMS Danskin Acoustics	23	Sound Reduction Systems	35
Custom Audio Designs	33	SoundPLAN UK&I	21
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Gracey & Associates

Sound and Vibration Instrument Hire



We are an independent company specialising in the hire of sound and vibration meters since 1972, with over 100 instruments and an extensive range of accessories available for hire now.

We have the most comprehensive range of equipment in the UK, covering all applications.

Being independent we are able to supply the best equipment from leading manufacturers.

Our ISO 9001 compliant laboratory is audited by BSI so our meters, microphones, accelerometers, etc., are delivered with current calibration certificates, traceable to UKAS.

We offer an accredited Calibration Service traceable to UKAS reference sources.

For more details and 500+ pages of information visit our web site,

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Nor 848 Acoustic Camera

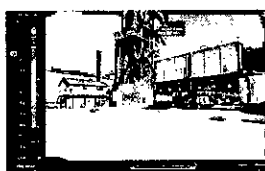


SEEING SOUND

We are pleased to announce the new Norsonic 848 Acoustic Camera with outstanding performance.

- 225 microphones provide incredible resolution of the noise climate you are analysing.
- Battery operated with no signal analysis interface box between the camera and supplied MacBook Pro.
- Quick and easy to set up requiring no expert training or experience.

- Both live intensity plots as well as post processed analysis with the user-friendly software package.
- Includes a Virtual Microphone to enable you to listen to any part of the image in isolation in one click.
- Octave, Third Octave and FFT analysis modes.
- Applications include internal leak detection, environmental source identification and noise reduction in product development.



AVAILABLE FOR HIRE £385 per day

See more details and demo videos at www.campbell-associates.co.uk and follow the links to Acoustic Camera.

Long-Term Monitors

Reliable - Site Proven - Quick & Easy To Use - Realistically Priced

RION Outdoor Protection with Two Layer Outdoor Windshields

- Site proven – years of continuous use at some sites
- Practical simple and effective
- No complicated additional calibration procedures
- Widely deployed on windfarm and construction projects
- Class 1 (WS-15) / Type 1 (WS-03) frequency response with appropriate Rion meters



Remote Control and Download Software (RCDS)

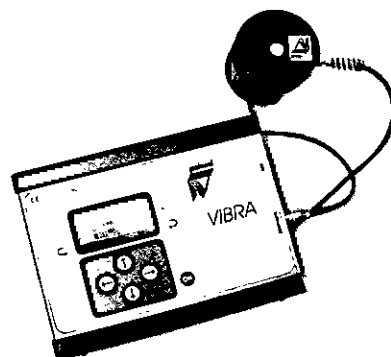


- Downloads & controls noise monitors using the GSM network
- Cost effective and reliable
- User configurable alarm levels
- SMS text alarms to multiple numbers
- Downloaded data in csv format easily imports into online systems
- Software displays live data remotely
- Hundreds of systems already supplied & principally deployed on construction sites
- Automatically downloads up to 30 monitors with auto scheduler (ARDS)



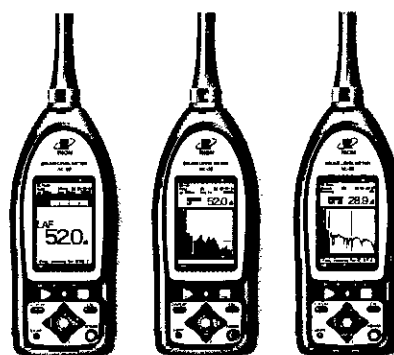
Vibra + Designed for Demolition and Construction Monitoring

- Logs PPV and dominant frequency (essential for BS 7385: 2 evaluation)
- Extended frequency range down to 1 Hz
- Measures peak displacement (essential for evaluation of low frequency vibration)
- Accuracy complies with DIN 45669 Class 1
- Integral GPRS modem sends out daily data & alarm e-mails
- User friendly software displays data and exports to csv file
- Real time clock and dominant frequency given for each measurement
- Very easy and intuitive to use



RION NL-52 A Complete Solution for Environmental Noise Measurement

- L_{Aeq} , L_{Amax} , L_{Amin} , SEL & 5 Statistical Indices
- 100 msec data logged simultaneously with processed values
- Uncompressed audio recording NX-42WR (option)
 - Continuous
 - Manual start /stop
 - Triggered by up to 4 user selected levels (different triggers for different times)
 - Periodic samples (including 2 minutes – perfect for windfarm compliance)
- Real time octaves/third octaves NX-42RT (option)
 - Full logging functionality maintained but in octaves or third octaves
- Narrow band FFT analysis NX-42FT (option)
 - 8000 line FFT up to 20 kHz (2.5 Hz resolution)



NNR-03 Noise Nuisance Recorder Quicker, Better and Easier – A More Professional Solution

- Uncompressed WAV files - superb audio quality
- Up to 1 minute pre-trigger
- Simply drag and drop data into the new and intuitive Rion AS-60 software
- Extremely easy to use
- Outer pilot case for discrete deployment
- Handset with illuminated buttons clearly shows when audio is recording
- Wireless remote (up to 50 metres) included as standard

