Vol 38 No 6 November/December 2013

# ACOUSTICS BULLETIN

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**Recreational noise – the ticking time-bomb?**

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Problems in residential design for ventilation and noise
Floating room systems for noise reduction in mechanical spaces

Institute of Acoustics

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Vol 38 No 6 November/December 2013




**Front cover photograph:**
Audio entertainment devices risk damaging users' hearing.

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Institute of Acoustics

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.

## Conference and branch programme 2013

**12-14 November 2013**
Organised by the
Electro-acoustics Group
**Reproduced Sound 2013**
*Manchester*

**19 November**
Irish branch:
**Acoustics design of schools – 100 years of guidance**

**19 November**
South West branch:
**Sounds familiar? English accents and dialects at the British Library**

**20 November**
London branch:
**Annual dinner**

**28 November**
Eastern branch:
**A good practice guide to the application of ETSU-R-97**

Please refer to
**www.ioa.org.uk**
for up-to-date information.

## Dear Members

I want to tell you about two changes that have been agreed by Council – one concerns the distribution of the Bulletin, the other the membership renewal forms. Next year we are going to look at different ways of distributing the Bulletin. From January you will receive a paper copy as usual, but it will also be available in a pdf, page turning format, which you will be able to read on, or download from, the members' section of the website. After a few issues all members will be surveyed to see whether they would be happy to accept the Bulletin in just electronic form from 2015 onwards. This would reduce costs to both the IOA and the environment, so it is hoped that most members will choose to access it electronically in future. It will still be possible for members who prefer to receive a paper copy to do so, but there will be a small discount in the membership fees for those who accept it only electronically, to represent the reduction in printing costs, postage etc.

You will also notice changes to the membership renewal form, which you will receive in December. From this year you will be asked to provide some personal data on the form. Obviously you do not have to give this information if you would rather not do so. However, it will be very useful in tracking changes to the demographic makeup of the Institute over the years, which in turn will help in formulating future strategic plans. For example, the Women and Families working group has been trying to find out how the number of women members has changed during the Institute's 40 years, and we do not have the data to provide that information.

Monitoring our membership statistics is also an important part of our commitment to the Engineering Diversity Concordat, which I recently signed on behalf of the Institute. The Concordat was developed by the Royal Academy of Engineering and has so far been signed by 26 of the professional engineering institutions. Our signed certificate can be seen in the IOA office in St Albans. The objectives of the Concordat are to demonstrate commitment to equal opportunities and diversity, to take action to increase diversity in the engineering professions; and to monitor and measure progress. An article describing the Concordat in more detail will appear in a future Bulletin.

A further change is the appointment of a new Honorary Secretary for the Institute. As many of you will know, Nigel Cogger, our Honorary Secretary since 2010, recently retired from the English Cogger Partnership. As he now lives in France he decided that he should resign as Honorary Secretary, and Council reluctantly accepted his resignation. I would like to thank Nigel for his valuable hard work and advice over the past three years, which we will miss, along with his humour (not to mention his keen interest in grammar and punctuation...!). However, I am delighted to tell you that Russell Richardson has agreed to take on the role of Honorary Secretary, so we look forward to welcoming him to his first Executive and Council meetings.

By the time you receive this Bulletin 2013 will be almost at an end and we will be approaching our 40th year. The plans are progressing well for our 40th birthday celebrations, the main event of which will be a conference on 15-16 October 2014 at the NEC, Birmingham. Council would also like to encourage the regional branches to plan their own local celebrations, and will provide some funding for good ideas. So if you can think of an appropriate way for your local branch to mark the occasion, let the branch committee know and encourage them to apply to Council for funds to make it happen.

In the meantime I wish you all a very happy Christmas and good wishes for the New Year.

Bridget

Bridget Shield, President

# Are you sure? Uncertainty in the measurement, prediction and assessment of noise

*Report by Tony Garton and Bob Peters*

After a London Branch evening meeting on the subject of uncertainty there was a feeling that we had hardly scratched the surface of the subject; and so the idea of a one-day meeting was born and eventually 55 delegates gathered at London South Bank University on 25 September 2013.

After a brief introduction by Bob Peters, the conference began with a paper from John Hurll of UKAS. John gave us an overview of the basic mathematics of uncertainty including its likely causes, how it should be expressed in quoting measurements according to the various standards and experimental and mathematical methods by which it can be minimised. He concluded his talk by telling us that we can never be completely certain, but we can be reasonably certain about how uncertain we are.

The next paper was presented by David Waddington of the University of Salford on behalf of himself and Sonia Alves. The paper moved more specifically to uncertainty in environmental noise measurements and in particular at the estimation of uncertainty using the revised draft of ISO 1996-2. They considered uncertainties that can arise in the reproducibility and repeatability of environmental noise measurements and looked at practical methods by which these uncertainties can be reduced. This was illustrated by two case studies: one involving measurement of noise from a road and one from a railway. The studies showed that even with very well conducted measurements there was a large uncertainty in the measurements of road traffic noise an even greater one in the measurement of railway noise.

David Trevor-Jones of Vanguardia followed with a case study which illustrated the dangers of not considering the uncertainty of measurements. A developer had relied on a single survey of background noise and assumed it to be absolutely accurate with no consideration of the uncertainty involved. As a result of this survey, the developer had committed to expensive noise protection works that, in the light of a fuller survey carried out later, could probably have been avoided. Initially this looks like an example of cost cutting not paying off, but one wonders whether the local authority in question would want to use a worst case rather than a more accurate average with well defined confidence limits.

Colin Cobbing of ARM Environmental presented a paper on behalf of himself and Andrew Bird that looked at another specific requirement for the consideration of uncertainty in measurements viz: the draft version of BS4142. He told us that earlier studies had shown that there was substantial uncertainty in the measurement of both ambient levels and background levels. He examined possible sources of these uncertainties and considered the various means by which the problem was being addressed in the draft standard. The standard attempts to keep uncertainty measurements simple where the measurement itself is simple. In many cases, the uncertainty may simply be changes in weather conditions and is likely to be small. In other cases, the uncertainty will require a fuller statistical treatment. However, in all cases a statement of uncertainty must be given in order to allow the decision-makers to take a proper view of the likely problems.

Bill Whitfield of the University of Liverpool brought the morning session to an end with a presentation by himself and Barry Gibbs (also of the University of Liverpool). The paper considered the many sources of uncertainty in sound insulation measurements. The examination of the sources of possible uncertainty was illustrated by a study where the variability of measurement of a number of timber and concrete floors was compared. The variations in the measurements in each case were considered and it emerged that the variability of the timber floors was considerably less than the variability of the concrete floors. The paper showed the information that is needed in order to make informed decisions about reducing uncertainty in the measurements.

The afternoon session began with a paper from Ian Campbell of Campbell Associates in which he considered the changing standards for accuracy of sound level meters and calibrators and how the basic uncertainty that must occur in any measurement can be minimised. He considered the various types of calibration, the traceability to primary standards and how the sound level meter and microphone must be calibrated and used in order to minimise the uncertainty of measurements due to the instrumentation. It has to be said that the scope of errors in properly calibrated instrumentation is lower than the errors likely in the noise being measured by at least an order of magnitude.

Roger Tompsett of Noisemap presented a paper which examined how uncertainty in noise from a major construction project can be handled. The site in question was in central London and had a number of constraints imposed by the local authority.The developers needed to be certain that they did not go above the legal limits, but were anxious not to find themselves responding to short term noises that, although in the instant loud, were not going to have a significant effect on the long term $L_{Aeq}$ which is actually what was being controlled; nor did they wish to respond to ambient noise such as passing emergency vehicles as if it had occurred on the construction site. A monitoring regime was introduced that reported 15 minute $L_{Aeq}$ measurements which were monitored to ensure that an amber alert was produced if the running average reached the trigger level (when remedial action can still be taken) and a red alert only when the period $L_{Aeq}$ has reached the trigger level. Construction noise is inherently variable and the paper considered what assumptions it was reasonable to make about it when considering what noise is likely to occur on the site.

Emma Eldret of noise.co.uk and John Fenlon of the University of Warwick presented a paper which examined preparing uncertainty budgets for environmental noise measurements. The paper examined variability in measurements taken over several days and presented the results of two experiments set up to examine the effects of measurements at different distances of noise from a road and also from a major railway line. The results showed that there were very clear day-to-day differences found in the measurements. The results also showed that there were unforeseen variations with distance. At present the results of this experiment have not been completely analysed and more statistical analysis is to be undertaken.

John Tofts of the Environment Agency presented the final paper on behalf of himself, Tony Clayton (also of the Environment Agency) and David Waddington of the University of Salford. The paper examined monitoring environmental noise using BS4142 for a number of industrial processes controlled by the Environment Agency. A series of 15 minute LAE Q measurements was made and the time taken for the measurement to be within ±1 dB and the time taken to achieve a stable LA Q was measured. It was shown that there was roughly a 50% chance of a one hour measurement being within 1 dB of the true value and that the time taken to achieve a stable measurement is closely correlated with the SPL.

The final half-hour of the meeting was taken up with discussion among the delegates about the papers that had been presented. It is intended that some of the papers will be reproduced in *Acoustics Bulletin* in the near future.

Ian Campbell (centre) prepares for his presentation

# Russell Richardson elected as new Honorary Council Secretary

Russell Richardson

Russell Richardson is the new Honorary Council Secretary. He succeeds Nigel Cogger who has stood down as a result of moving to France and retiring from the English Cogger Partnership.

Russell studied electro-acoustics at the University of Salford, graduating in 1995. After a few years of working in acoustics consultancy he returned to the academic world to undertake research into the subjective response of audiences in concert halls at London South Bank University.

In 2002 he founded the consultancy practice RBA Acoustics with Charles Bladon and Torben Andersen. From its humble beginnings the practice, an Institute sponsor member, is now one of the largest in the UK and continues to grow both in size and in its UK and international workload.

Russell sat on the board of the Association of Noise Consultants from 2006-2012, firstly as Secretary and thenTreasurer, during which time he collaborated with the IOA on the organisation of joint events. He has also sat on ANC committees covering school design and residential sound insulation, consultation panels for the BCSE and staffing committees for the IOA. Having spent many years contributing to various other professional bodies he says he is looking forward to having the time to take a more active role for the IOA.

He continues to contribute to life at London South Bank University, lecturing on the environmental and architectural acoustics MSc course on both acoustics and business-related topics. RBA Acoustics has also sponsored a prize for the best project dissertation for several years.

# Lifetime achievement award for Andy Munro

Andy Munro receives his award

IOA member Andy Munro has become the first person to receive a Pro Sounds Lifetime Achievement Award. The unanimous choice was made by the awards team – the editors of Intent Media titles *Audio Pro International, MI Pro, Audio Media, Installation, TVBEurope, Music Week* and *PSNEurope.*

"I am extremely flattered to be given this accolade," he said after receiving the award at the Ministry of Sound, London. "The world of acoustics has often been regarded with a mixture of suspicion and reverence, a status quo I have always tried to debunk so I accept gratefully this award as recognition of a job well done by everyone at my company, Munro Acoustics."

Andy Munro studied mechanical engineering before joining the Shure Corporation of America in 1972 as a technical writer. His interest in microphone and loudspeaker design led to involvement with the design of speaker systems for large auditoria for sound reinforcement purposes. He worked with many of Shure's clients and sponsored artists, including the Rolling Stones and rental giant Showco during their Led Zeppelin tours in 1975.

In 1980, he started his own design practice, specialising in studio design and acoustic analysis, using techniques such as time-delay spectrometry that, at the time, were not generally known in the UK. In 1990 he co-founded Dynaudio Acoustics with the eponymous Danish manufacturer to design professional monitor systems for recording and film mixing facilities.

Munro Acoustics has become one of the most respected design companies in the audio business and that is the result of a "complete commitment to high-fidelity sound", he said. A small team of acoustic and architectural experts has expanded the range of projects to every corner of the professional sound business. Studios such as British Grove and Sphere have set very high standards for mixing, while the custom-built monitor systems at AIR Lyndhurst have been in continuous use since 1992.

In the last 10 years, Andy has established a thriving consultancy in India and a studio construction business with Architect Clive Glover. Chris Walls has assumed overall responsibility for acoustic design so that Munro can work on new products and software.

Andy was elected as a corporate member of the Institute of Acoustics in 1985 and has been a member of the Institute of Sound and Communications Engineers since 1975. He is an active member of the Audio Engineering Society in both the USA and Europe where he has delivered many papers on studio design techniques. Munro Acoustics has recently worked closely with Dolby, Disney and the Pinewood-Shepperton Group to develop the new ATMOS standard for film mixing theatres. He is currently designing studios for the new BBC headquarters in central London including a new TV studio along the public glass façade of the Peel Wing of New Broadcasting House.

"I consider any recognition by one's peers to be encouraging and meaningful and, as our very existence depends on a combination of reputation and value engineering, this award is especially welcome."

# Council approves extension of webinar trial for a further year

*By David Trew*

As some of you will be aware, the IOA has recently carried out a trial of online webinars to broadcast its presentations over the Internet. This has included the live broadcasting of various one day/regional and specialist meetings along with a trial of an online only lunchtime CPD presentation.

I would like to thank all those who registered, participated and provided valuable feedback. I would especially like to thank the presenters (Angela Lamacraft, Mike Wright, Brian Hemsworth and John Miller). Despite some teething problems, the feedback has been positive with more than 90% of feedback respondents supporting further development of the webinar format from the IOA.

Council has now approved costs for a licence to extend this trial for one year. Following this period we will review the success of the system with a view to further development. The IOA can now offer this service to provide more accessible CPD opportunities for IOA members whatever their location. The system can allow presentations to be broadcast live over the Internet and a facility to record presentations for an "on demand" service. The IT requirements for the host are basic. As a minimum, a single computer with sound card, microphone and hard wired internet connection are required (Wi-Fi connections can work but are not recommended). The software uses most internet browsers (Safari/Explorer/Chrome etc.) with a small Javascript download.

As noted above, the system has been used to broadcast IOA regional and specialist meetings. It can also be used as an additional form of meeting to discuss and promote the art, science and technology of acoustics. Examples could include notable regional meetings which deserve a wider audience, remote access for those who cannot attend regional meetings, taster sessions to promote forthcoming conferences, joint presentations with other professional institutions, briefing presentations to promote forthcoming consultations or IOA good practice guides etc.

All presentations will need to be approved by the IOA. To further assist, we will be developing an IOA protocol/guidance document setting out further information on hosting these events, technical requirements, feedback procedures, required consents, archiving etc. For this year's trial I would welcome all who are interested to start using the system to contact me. I am more than happy to help new hosts with dry runs so that people are more familiar and comfortable with the software prior to their first event. Additionally, any ideas/suggestions for future webinars will be gratefully received. I look forward to hearing from you. (**dtrew@bickerdikeallen.com**)

# Highly rewarding visit to the Health and Safety Laboratory Buxton

*By Ralph Weston*

The Health and Safety Laboratory (HSL) has a number of roles that include health improvement, occupational health, human factors and hazard reduction among others. It carries out research, maintains standards and assists the Health & Safety Executive (HSE) in promoting health and safety in the workplace. It has a large semi anechoic chamber (which can be made fully anechoic) and a thermal test chamber.

This visit, organised by the Senior and Young Members' Groups, concentrated on the noise and vibration work at the laboratory. Liz Brueck, in introducing us to the work of the laboratory, explained that, by having groups like ours visit, gave it the opportunity to spread the message of health and safety in the workplace.

The group was split into two to visit the three areas, namely noise and hearing, hand-arm vibration and whole body vibration. During the visit Sue Hewitt demonstrated the hand-arm vibration issues with Paul Pitts. Alison Codling (senior occupational health nurse) demonstrated the tests for the diagnosis of hand-arm vibration syndrome and talked about the use of otoacoustic emission testing as a possible additional tool in the diagnosis of NIHL. Liz Brueck explained the noise and whole body vibration element.

We were shown the anechoic chamber which is used for testing equipment to noise emission standards. We discussed some of the difficulties, mainly due to the way that equipment standards relating to noise emissions have been drafted. We went on to talk about hearing loss and how it affects people. We were shown a demonstration of what someone is hearing who has suffered a hearing loss. It was similar to demonstrations I have used in the past but brought up to date in this digital world and as such is

A vibration sensitivity test

available on the HSE website.

The other area new to me was the development of an otoacoustic emissions hearing test. This is based on sounds made by the inner ear as it responds to external sounds and is related to how the hair cells are extracting the sound information and passing it to the brain. When a person has a hearing loss the outer hair cells are damaged and this changes the nature of the otoacoustic emissions and can be measured by a probe inserted into the ear. The advantage of a test of this sort is that it is objective and not controlled by the subject as in current standard Bekesy tests. This test is in routine use on babies just after birth to detect hearing defects. The HSL is still developing a set of standards for this test in conjunction with other researchers around the world, particularly in South Africa. Another advantage is that lack of OAE shows up before hearing loss becomes evident, i.e. the person does not necessarily have a hearing loss (yet), and could perhaps be a predictor of susceptibility to NIHL.

In the hand-arm vibration laboratory we were shown and experienced various hammer drill tests. To obtain a repeatable response the hammer drill under test is drilled into a container of ball bearings and illustrates the difficulty of producing standard tests to compare different tools. We were shown where measurement instruments were placed on the handles. We tried on various vibration absorbing gloves that demonstrated that they are not very effective. Trying to add absorbency to tool handles also P10

◄P8 creates handling problems. The lab explained the importance of maintaining the tools in good condition. There was a demonstration of out of balance grinders. We also learnt about a hand sensitivity test and a grip test.

The whole body vibration is centred on vehicle seats and we sat in an example of a lorry cab seat which was then vibrated. We were shown that so called anti-vibration seats were limited in what they can achieve as they depend on a resonance in the system. Consequently anti-vibration seats are not as important as the maintenance of the vehicles, their tyres etc. There is also a big role in training and ergonomic issues to take account of the human factors to gain a health improvement in this area.

Taken as a whole, this visit was very useful to all the delegates. As one said, it was worth double CPD points! It is recommended that other groups and branches from the IOA visit this laboratory. I am also pleased to report that combining the Young with the Senior Members seemed to work well.

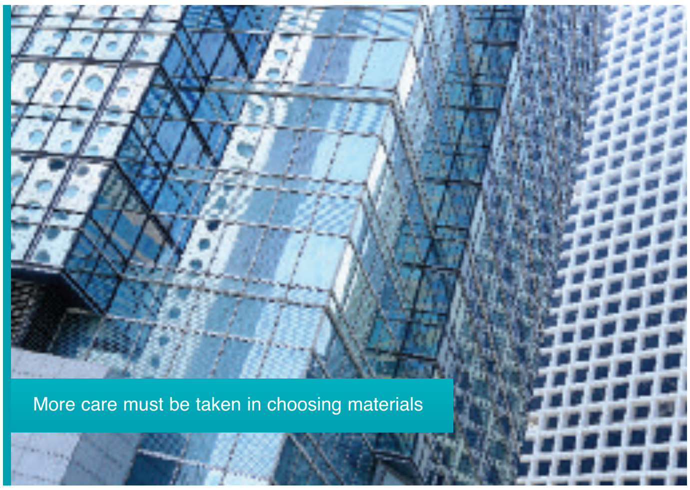
A demonstration of vibration absorbing gloves

# Sustaining – a wider acoustic agenda?

*By Richard Cowell*

We are delighted that the IOA has given backing to an initiative to explore more support for sustainable design. Peter Rogers and I are leading an inquiry into how this can be best achieved, and offer this short article as a piece to communicate our direction of travel, following our first meeting.

The word "sustainability" is the ability to continue, which seems a simple idea, but the word has gained the reputation of being a clumsy noun, which is widely misunderstood and misused; for example as a catch phrase by politicians. However, the concept has become embedded in so many of our design objectives on projects and actually carries a simple and important objective for humanity in our time. Combined with the zeal of the pioneers in adjusting our priorities, the word has been off-putting to the engagement of many within acoustics. Getting past this malaise and focussing on what we need to do, to look after current and future generations, has taken time and now can be considered to be becoming a more mainstream idea. The interest in what it means to acousticians is also gaining some momentum. There have been several IOA meetings over the years focussing on sustainability, which have identified that there are many facets to the subject. Some are obvious and some subtle, but it is clear that further work is needed to provide clear guidance for acousticians



More care must be taken in choosing materials

to identify the principles and how they might be tangibly delivered. Some of the most significant issues for practitioners and researchers in the many fields of acoustics to consider are:

- Focussing on ways to enhance human well-being e.g. music, health, inclusion, society
- Collaborating with other disciplines in the restraint on energy use
- More care in choosing, reducing and re-using materials
- Carrying on the efforts to reduce noise and vibration pollution
- Attention to survival, health and wellbeing of ecology (underwater and on land)
- Using positive sound for improving health and social cohesion.
- Expanding the idea of "soundscaping" to include sound fields across the different environments (including inside buildings and connecting people with their environments)
- Using sound and vibration energy to communicate more effectively
- Measuring the subjective impacts and positive effects on people and other species, as much as the objective physical parameters
- Striving to find ways to communicate how good acoustic design can benefit the delivery of sustainability in terms of environment, economy and social benefit, without compromising the next generation
- Providing guidance on how acousticians should implement evidence-based advice in relation to this area, and exhibiting good governance through their actions.

In view of the importance of the subject, and because there is so much to learn, (which will take some time), as noted in the March/April 2013 Bulletin, the Institute is supporting the formation of our small task force devoted to exploring this area, with a view to making proposals to Council later in the year.

There is already plenty of activity in the IOA's specialist groups and branches, which relates well to a commitment to sustaining our society, our fellow creatures and our environment. At the same time, there remains enormous potential to provide (a) better support for this and (b) better collaboration with non-acousticians to widen our approach, for example with joint meetings on an holistic approach to the many issues we touch.

We are therefore contacting each group in turn to better understand the specific ways in which we can support their work, on the front line, and pass on the emerging thinking to IOA members and beyond. We aim also to encourage collaboration with other disciplines inside and outside the Institute to build up holistic approaches to the various issues. It is our intention to enhance the groups' and branches' contributions to the IOA's leadership in exploring and enhancing sustainable design.

Those who have expressed their interest in supporting our efforts will be contacted in time, as and when specific chances arise that suit their talents. However, please let either myself (**richard.cowell@arup.com**) or Peter (**progers@tecp.co.uk**) know if you have thoughts, large or small, to help find the best ways to provide you, the members, with the support that you need in this area. We will continue to capture developments in dispatches as progress is made.

# STEM ambassadors continue to spread the acoustics message

IOA STEM ambassadors Richard Collman and Alex Krasnic were in action again at this year's STEM Engineering Festival at the Imperial War Museum, Duxford.

As at previous events, they were invited to showcase the Institute's much-vaunted You're Banned demonstration to groups of eager pupils representing a number of local schools from the surrounding catchment area.

"STEM's Engineering Festival continues to attract a greater number of schools each year and this year saw an unprecedented turnout of pupils with an interest in all things science, engineering, technology and mathematics related," said Alex.

"Everything from Lego Robotics to K'Nex to water-propelled vehicles were on show from many big name industry representatives, so the onus was very much on us as the IOA ambassadors to step it up with our acoustics activity."

This year the pair were joined by Dr Alexander Quayle of British Petroleum whose specialism lies in deepwater facilities technology and who has considerable industrial noise and engineering applications expertise within the process industry.

"With around one whole school group in the morning session followed by a further two in the afternoon, Richard, Alexander and I managed to run the You're Banned activity to well over 50 pupils in total, a resounding success for acoustics on the day!" said Alex.

Alexander Quayle provides advice to You're Banned participants

The aim of the acoustics ambassadors scheme is to encourage aspiring engineers of the future by awakening an interest in the subject early on.

"This type of event is a great way to encourage pupils to consider acoustics as a worthwhile academic subject. Hopefully with more of these events becoming commonplace in the future, we can also encourage more IOA members to become STEM ambassadors, thereby swelling our ranks to meet future demand."

If you already are a STEM acoustics ambassador or interested in becoming one, please contact either Richard (**RichardAC@acoustical.co.uk**) or Alex (**krasnica@hotmail.com**) for more information on registration, training and upcoming events.

# Future challenges in acoustics

*By Kirill V Horoshenkov, Chairman of the IOA Research Coordination Committee*

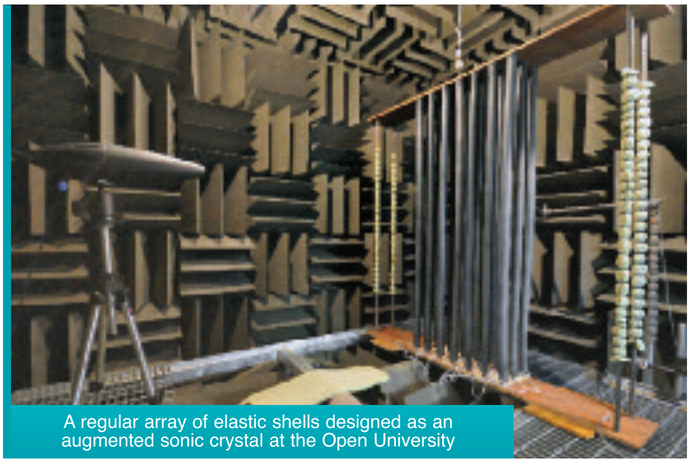
This report is a compilation of the responses from IOA members to the call issued by the Institute's Research Coordination Committee (RCC) in September 2012.

Members are now welcome to comment on it and express their views on any other challenges which they feel are missing from it or have emerged since its publication.

It is the RCC's intention to continue to collect this information from members and convey it to the Research Councils as well as to the EU Commission to ensure that acoustics-related research in the UK, particularly those in the challenging areas of acoustics, are properly supported.

Please send your comments to Professor Kirill V Horoshenkov at **k.horoshenkov@sheffield.ac.uk** by 10 January 2014.

The challenges listed here reflect the areas of acoustics in which members of the Institute see themselves working in the foreseeable future. These challenges can be split into the following eight groups:



A regular array of elastic shells designed as an augmented sonic crystal at the Open University

**1. Sensors and actuators**
- acousto-optic sensors
- advanced sensors and actuators for active noise control
- multi-purpose 2D acoustic arrays including high-power ultrasound transducers for medical and industrial applications, associated manufacturing and characterisation methods.

**2. Sonic cleaning and treatment**
- sonic and ultrasonic cleaning
- sonic filtration
- high-value materials processing including sonic decontamination.

**3. Imaging and diagnostics**
- medical ultrasonic imaging: registration, segmentation, 3D ultrasound including tomographic reconstruction, quantitative ultrasound, ultrasonic therapy monitoring and opto-acoustic hybrid techniques, ultrasonic elastography
- passive acoustic methods in medical imaging and photo-acoustics
- structural health monitoring and diagnostics, including complex media
- acoustic characterisation of meta-materials and media with complex surface morphology and micro-structure.

**4. Materials with novel acoustic properties**
- lightweight and multi-functional acoustic materials
- acoustic meta-materials and smart materials
- acoustic materials for extreme environments.

**5. Psycho-acoustics, noise effects on humans and noise control**
- psychological aspects of sound perception with and without integration with other senses
- hearing loss in an ageing population and other health impacts

- role of hearing in situation awareness and machine auditory scene analysis
- noise effects on the restorative value and perception of spaces
- advanced noise prediction models
- transportation noise.

**6. Environmental and infrastructure applications**
- acoustic methods for hydraulic process monitoring, water purification and conservation
- development autonomous low-cost systems for monitoring urban noise in real-time using MEMS sensors
- acoustic monitoring in agriculture.

**7. Biological applications**
- prediction, measurement and control of anthopogenic noise (underwater and airborne) and its effect on animals, marine mammals and insects
- acoustic means of communication between biological species
- the role of environmental acoustics in evolution
- use of sound to affect and control the behaviour of marine species.

**8. Ultrasonic therapies**
- ultrasonic drug delivery
- ultrasonic ablation
- ultrasonic histotripsy
- ultrasonic lithotripsy.

## Additional comments

Some of the members who responded to this call also made the following additional comments which are correlated with the one of the eight groups of challenges.

**1. Sensors and actuators**
No additional comments.

**2. Sonic cleaning and treatment**
**C2.1** Cleaning is certainly one of the most important areas of application of acoustics. There are massive losses in the UK economy from poor cleaning. However, funding the wrong teams is catastrophic, because in this and other 'sonochemical' technologies, the problem is that it is led by chemists or sonochemists who do not seem to have the necessary skills in acoustics to get reproducible results. Hence, sonochemistry for industry should strongly be linked to rigorous acoustics and teams that just have only chemists or sonochemnists on board are a waste of money. Even worse, they give industry the impression that sonochemistry (including cleaning) cannot be scaled up because it is irreproducible.

**C2.2** It is of interest to understand better the way in which ultrasound and related cavitation effects deal with bacteria and other organic material, i.e. if it can kill bacteria and oxidise organic material at a reasonably low energy cost. In this case, efficient technologies for water treatment in the home or in remote locations may be developed.

**C2.3** Recent industrial developments are for higher frequency (>500 kHz) systems employed for fine-cleaning applications required for optical component and microelectronics manufacture, where understanding cavitation severity and type are crucial to minimising surface damage. This will lead to a better understanding of factors affecting the application of cavitation, optimising its use and enabling high power ultrasound to be further applied in an economically viable way, over a wide range of technical fields such as food (crystallisation control, pasteurisation), pharmaceuticals (particle size control) and biofuel production industries.

Novel therapeutic applications of ultrasound will continue to emerge, supporting drug delivery concepts based on high-power ultrasound or cavitation and more extensive use of High Intensity Focused Ultrasound (HIFU) or High Intensity Therapeutic Ultrasound (HITU). For manufacturers, micro-bubbles P14

◂P13 coupled with therapeutics will drive developments of the next wave of ultrasound technology into clinical practice over the next 5 to 10 years. Microbubble-based drug/gene delivery vehicles for cancer and Alzheimer therapies promise significant advances in treatment. Applications involving the spatially and temporally-controlled application of ultrasound-induced heating or acoustic cavitation, high-frequency imaging or micro-machined transducers will come into use demanding underpinning metrology at various stages of instrumentation development and application.

**3. Imaging and diagnostics**
**C3.1** Ultrasound has become one of the most frequently used diagnostic tools in medicine with, world-wide, and estimated 250 million examinations. Development in new imaging techniques will continue, with an emphasis on quantitative tissue characterisation. Developments in elastrographic imaging techniques will continue and there will be a significant growth in the application of photo-acoustic methods to clinical medicine, offering optical tissue property contrast, with acoustic penetration and beam-forming capabilities. Acoustic methods for characterising the properties of biological and non-biological tissue will continue to be developed. Validated methods of determining the acoustic properties of materials over a wide frequency range, 20 kHz – 50 MHz, are required in order to enable reliable estimates to be made. These properties include absorption, attenuation, scattering, speed of sound and nonlinearity parameter. The ability to make such measurements over a wide-bandwidth, and use this to characterise liquid composition, is likely to find increasing application, for example in the evaluation of protein solutions, or assessment of nano-particles, where the requirement may be for acoustic frequencies in excess of 100 MHz.

**4. Materials with novel acoustic properties**
**C4.1** Acoustic modelling coupled with measurement methods will mostly be an issue in the "Design Engineering" sector which is emphasized by the Department for Business Innovation and Skills as a UK strength, so particularly important for the EPSRC to support. There will be significant challenges in these areas particularly with regard to reducing weight which will require significant improvements in design methods. Modelling will be key to getting round the fact that light, stiff materials are generally bad for acoustics. For the foreseeable future, complementary measurements will also be very important for generating the right input data for models and for checking the results. For reasons mentioned above there will be significant challenges in materials, especially lightweight materials in transportation. Meta-materials can potentially play a big role in this agenda and can potentially find many other applications. Research in this area has strong novelty which should appeal to the EPSRC.

**C4.2** I think that there might also be an additional challenge for acoustics in providing relatively simple and experimentally-accessible analogies that can be used to inform modern material physics research.

**5. Psycho-acoustics, noise effects on humans and noise control**
**C5.1** One of the grand challenges is a much better understanding of how humans respond to all sounds. Current engineering models deal with physiology well, but are limited then by dealing only with relatively simple attributes (localisation) and the early parts of the neurological processing of sound. We need to develop engineering models of our emotional response to sound. With the recent development of experimental tools in neuroscience (e.g. fMRI), there is an opportunity to tackle this. Impacts could be huge, an analogy would be how a proper model of masking led to mp3 and changed the music industry.

**C5.2** Another important challenge is understanding and managing the subjective human response to combined vibration and noise. With the large infrastructure projects in planning and under construction in England, consultants need better tools to determine and manage the acceptability of proposed noise and vibration criteria. This is a question that we are constantly asked by consultants at every relevant event.

**C5.3** Following on the subjective/cognitive/emotional theme, one critical area that will be a challenge is the role of hearing in situational awareness, which basically is looking at attention and safety and the aspects of being deprived from the sense of hearing when wearing "ear occluders". This mainly refers to people wearing headphones in urban environments but can extend to operators (drivers) inside a vehicle, workman wearing ear defenders, motorcyclists wearing helmets, use of earphone for mobile phones, etc.

**C5.4** Hearing loss in an ageing population will undoubtedly become a big issue in the future. To what extent EPSRC would see research in this area as within their remit I'm not sure but I think it is worth mentioning so that it doesn't get forgotten.

**C5.5** With every project, I became increasingly aware that, for acoustics at any rate, the window was not anything like as narrow as it could be. In my view, the normal tools in the consultant's armoury, particularly those for prediction, are simply not up to the task. Considering the social, cultural and economic importance ▸


A free field test of a parametric loudspeaker as part of research into the sound transmission loss of hedges

of building infrastructure, this has been a very uncomfortable realisation. Research development shows a lot of promise but these advances often fail to achieve their potential in building engineering. The challenge, I believe, is for consulting engineers and researchers to collaborate more and more productively. It is with this in mind that I am suggesting the following three research challenges in building acoustics prediction:

**C5.6** Extensive and coupled models. There are now many intensive models for specific fluid and solid problems. Examples include a variety of discretised schemes and implementations to numerically solve the wave definitions. There are, however, few if any wave models that are sufficiently extensive or integrated to address real engineering challenges such as the prediction of airborne sound insulation. In the first instance, it is likely to be a matter of coupling existing isolated intensive models to address extensive problems. Where coupled models prove to be computationally intractable, guide models could be developed.

**C5.7** Scope and precision of input data. All acoustic models, including any newly developed coupled models, rely on good input data. The use of otherwise viable models in engineering is often limited by a lack of relevant information. A case in point is air flow resistivity data for the prediction of the acoustic impedance of porous materials. "Research" could rise to the occasion, carry out comprehensive testing and inspire manufacturers to follow suit.

**C5.8** Quantifying uncertainty. Building design engineers need to know the available precision of models if they are to meaningfully reduce the "window". As long as it is unspecified, the precision of a sophisticated model is no greater than that of a primitive one. Validation and sensitivity analysis therefore need to be undertaken to quantify uncertainty. Again, this emphasises the need to develop existing schemes rather than attempt to break new ground.

**C5.9** It is certainly my impression that, in acoustic consultancy, a failure to understand the science is preventing problems from being identified and articulated. Without this information from the "front line", the potential to focus research work on these immediate challenges is reduced.

**C5.10** New ambitious environmental goals for the aviation industry have been set by the Advisory Council for Aeronautics Research in Europe, including a 15dB reduction in civil aircraft by 2050. The advent of the high-bypass-ratio turbofan engine around 40 years ago led to a step-change reduction in noise from jet engines, principally by reducing jet noise by having lower exhaust velocities. In order to make further step-change reductions in noise, it is likely that radical changes to aircraft engines and/or aircraft design will be necessary over the next 30 years. A key challenge in acoustics is to be able to accurately predict aircraft noise in order to assess new low-noise designs of airframes and aero-engines.

**6. Environmental and infrastructure applications**

**C6.1** Water conservation and acoustics has to date focussed on methods of detecting and reducing water leaks from pipes. I think the EPSRC should broaden its thinking here – a litre of water saved anywhere in the water cycle is a litre saved. A priority should be the use of acoustics to reduce water use in the home and industry, use of acoustics to assist in purifying and processing water and waste etc.

**7. Biological applications**

**C7.1** Some of this work is covered by funding by the NERC. There needs to be a clear dividing line between underwater research funded by the NERC and research funded by the EPSRC. A general perception is that the NERC fund saltwater acoustics work whereas the EPSRC fund freshwater research. Both councils seem to fund research in estuaries.

**C7.2** "The role of acoustics in evolution" is the "new" line of study in animal acoustics that looks at, for example, the influence of propagation and background conditions on communication.

# Why not become an IOA sponsor member?

*By Paul Freeborn, Chairman of the Membership Committee*

Have you considered becoming a sponsor member of the Institute? By doing so your organisation gains a package of benefits including discounted fees for advertising and exhibiting at conferences, a 20% discount on conference fees for up to five members, a free place for a delegate at the spring conference and the right to use a specially designed logo both on paper and on your website. This is the only logo that can be used and its use is restricted to sponsor members.

All members can help to raise the profile of the Institute and the use of web links to the Institute website is encouraged. However, use of copies of the IOA logo is not permitted. To clarify the situation Council recently approved the following policy:

- Sponsoring organisations may use the specific IOA sponsor logo on their literature and on their website or the words "A Sponsoring Organisation of the Institute of Acoustics".
- Other organisations may have a link to the IOA website but must not use the IOA logo or any text that implies the organisation is a member of the IOA. A "click here" link for the IOA website is welcomed but should be in plain text.

The Institute is extremely grateful to its sponsor members for their sponsorship, support and promotion of the Institute, and we are very keen to encourage other organisations to come aboard, so if you are interested please contact the Membership Officer, Chantel Sankey, at **membership@ioa.org.uk**

# More than 50 applications for Institute membership given green light by Council

Fifty-two applications for Institute membership were approved by Council in September following the recommendations of the Membership Committee.

Of the total, 36 applications were for new or reinstated membership and the remainder were for upgrades.

**Fellow**
Liu Y
Smith M G

**Member**
Brewer P A
Britton T A
Doken D
Garnett M P
Goodwin K D
Habeshaw R J
Harrison M
Heyes M
Higham C J
Hopkinson M A
Kandaswamy S
Leslie S C
Logie S
Long N C
Mohamed Ishak S
Pickford A R
Pires G
Rasheed A T
Smyrnowa J
Szczepanczyk N M
Thompson M

**Associate Member**
Auckland N C
Baldwin J
Banks C J
Bentley P E
Boote D T
Cahill-Smith O G
Delaney D J
Evason J D
Golacki P
Grace A
Gregory N D
Hunt C D
Martin A T
McIlroy M
Potaz T E
Woodhams S
Wright J D
Ridgard S K
Speed M A
Taylor P J

**Affiliate**
Fenton M
Robinson J
Sills A

**Technician**
Pigrem J M

**Student**
Chaffer T
Hudson J
Smith R
Tickner C

**Sponsor**
Raisborough, M J – WSP Acoustics

# Environmental noise and effects on health: recent developments

## London Branch meeting

*By Roslyn Andrews*

September's meeting saw Bernard Berry, a Past President of the Institute and Director of BEL, take to the stage, in front of an extremely well attended and mostly standing audience, to discuss the recent developments in environmental noise and the effects on health, which is a complex issue both scientifically and politically.

Bernard's presentation began by considering the journey from antiquity to the modern day.

Apps are now available which enable both noise measurements and rated perceptions of noise to be undertaken. An increasing amount of evidence, which has been accumulated over the last five to10 years, suggests possible associations with more severe health effects such as cardiovascular disease, hypertension and strokes. The recent advances in technology have the potential to further increase the pool of evidence and refine assessment methodologies.

Bernard introduced some of the basic concepts and theoretical models which are currently used to try and understand the links between various non-auditory effects of noise. These included models used in the Airports Commission Discussion Paper 05: Jul 2013 which deal with the effects on people's health, amenities, productivity and learning. Bernard noted that the Commission considers that a fair balance must be struck between these negative effects and the positive economic benefits. “Causal connections” models which show the interactions between noise, community reaction modifiers and health effects were also reviewed. These models have a bearing on planning priorities and what may be done to compensate and improve the local environment. This also includes the monetisation of health effects, which has become increasingly common.

Bernard went on to look at the status of the evidence. This is thought to be generally sufficient in many areas, such as annoyance and sleep disturbance. The European Environmental Agency Good Practice Guide on noise exposure and potential health effects: 2010 details acoustic indicators and associated numerical thresholds. However, it was recognised that some areas, such as the long term effects on sleep and effects on mental health, are still lacking conclusive evidence. Bernard also expressed the view that whilst evidence is generally sufficient, there is still a need for further research to improve our understanding of the effects of noise exposure and of the response relationships for various noise sources. He also mentioned difficulties in quantifying “annoyance” and other subjective effects.

Cardiovascular effects were also discussed in a paper which was presented at last year’s Internoise 2012 conference. The main findings of that paper were that “there are limitations to the most widely used exposure response relationship between transportation noise and myocardial infarction risk established in 2006 by Babisch” and cited in a number of other publications. In particular, the 2012 paper suggested that the reference curve cannot be used to establish a “no observed adverse effect level” or a “lowest observed adverse effect level” (NOAEL/LOAEL). Bernard’s opinion is that, although a number of new studies have been published since then, more studies are needed to examine the range of exposures, and to define more clearly the exposure-response relationship and investigate the possibility of threshold levels.

Hypertension effects were also reviewed. Studies by Babisch, soon to be published in *The Lancet*, provide an overview of the risk ratio associated with noise levels over certain thresholds. These exposure-response curves “show a higher risk of approximately 20-40% for subjects where the weighted average outdoor noise levels at the façade of their dwellings (approximately LDN) exceed 65 dB(A)”. Increases in risk, of approximately 7-17% per 10 dB(A) noise level increment are associated with these curves. However, Bernard cautioned that, as the number of studies continues to rise, the evidence is constantly evolving. More recent studies and meta-analyses, soon to be published in *Noise Health* have suggested that the risk increase starts at a lower noise level, although a smaller effect estimate trend is expected.

The need for further development in the area and more accurate assessment of the risks is becoming more and more crucial; with the continued development of airports and other transport links such as high speed rail. Bernard’s perspective is that new technological developments including the use of wearable body sensors to monitor stress along with the continued mining of data via social media might be an interesting approach to the future assessment of the risk. New apps that allow people to upload and record noises and their responses to them could be used. This information can be stored and shared online, which gives the potential for much more immediate and objective data to be gathered relating to various noise sources within specific GPS locations. Bernard was careful to note that, as with everything, there are accuracy and uptake limitations with this type of data gathering and important things to consider relating to how this data is used. Nonetheless he was optimistic about its potential.

If you are interested in finding out more on the topic, look out for information on SOAEL, LOAEL etc, expected from Defra in support of the Noise Policy Statement for England, along with a new WHO report on Aviation Noise and Health currently being edited, and the revised WHO Community Noise Guidelines which are expected to be updated by the end of 2014. The EEA Good Practice Guide can be found at **http://www.eea.europa.eu/publications/good-practice-guide-on-noise**

A big thanks to Bernard for his excellent presentation and thanks to WSP for once again providing the venue. We look forward to seeing another packed crowd at our next evening meeting.

# Excellent presentations by IOA Diploma students

## Midlands Branch meeting

*By Kevin Howell*

September saw our annual visit to Derby University to hear project presentations from students who were just completing the IOA Diploma course. As well as the general branch membership, the meeting was attended by the new intake of Diploma students who were on the first day of their course, resulting in an audience of 50 people to hear three student presentations.

First was Chris Parkin who presented *An assessment of the sound exposure levels within Cineworld theatres.* Chris cited press coverage where concerns had been raised about the high noise levels during performances. He reviewed briefly the requirements of the Noise at Work Act and also described the damage that is caused in the ear by excessive noise exposure. With the permission of Cineworld, he conducted a noise survey using a dosimeter located on his shoulder and sat as close to the centre of the theatre as he could. He attended six different films: horror, thriller, adventure, action and two films for children. The measured $L_{Aeq}$ ranged from 72.3 dB for the thriller to 80.5 dB and 82.2 dB for the two films for children. When normalised to a daily dose $L_{ep,d}$ the range was 67.3 dB to 75.5 dB. Chris concluded that no film he attended exceeded the NAW regulation lower action level of 80 dB $L_{ep,d}$. In response to questions, Chris said he did not consider that the “screams” of children were significant enough to contribute to the high noise levels for the children films and employee exposure was not an issue since they were in the theatres for only a very short time.

The second presentation was by Christina Girvan whose project was *Evaluation of smartphone apps for use in common noise measurement scenarios.* Christina investigated the performance of SLM applications for iPhone and iPad, using both internal and headset microphones, and compared them with a Class 1 SLM. She found there were 67 such apps available. When she applied her minimum requirements of A-weighting, Leq or some sort of average function and a calibration function the list was reduced to five. Two of these were very expensive so she chose the other three: RTA (real time analyser), Sound Meter Pro and NoiSee. She first evaluated the frequency response and measurement accuracy of these systems and then carried out measurements in four real-life scenarios: neighbour noise (through a party wall), workplace noise, environmental industrial noise and road traffic noise. She presented the results of these studies and found that for the road traffic noise the results appeared reasonably reliable but for others were variable, and concluded that these apps would not be compliant with Class1 or 2 SLM. In response to questions, she suggested that the more expensive apps available were unlikely to provide better results since they still used the same microphones but if companies P18

P17 invested in improved microphones and software then it would be interesting to see what could be achieved.

The third presentation was by Nicholas Bush and entitled *A comparison of the acoustical properties of the existing and future teaching areas in a secondary school.* Nick was, until recently, a physics teacher at a secondary school in Derbyshire. He carried out his study during the summer holidays at this school, where a new school (designed to meet BB93) is due to open in November. The aim of the study was to "assess whether the new school will improve the environment for teachers and pupils". Nick assessed the acoustic characteristics (RT and ambient noise levels) of various areas in the old school, many of which he and his colleagues considered to be poor spaces for teaching. He found that some of the teaching spaces considered poor did, in fact, comply with the recommendations of BB93. He further noted that in term time ambient noise levels would be higher. He concluded that the teaching environment in the new school would therefore not necessarily be an improvement. It would be interesting to see what the teachers thought of the new building. Nick observed that with the increasing inclusion of students with special needs (hearing problems or attention deficit) the need for good acoustics would become more important.

The branch committee had decided that to fill the time while the judging panel retired to consider their decision it would be useful to have a brief presentation from a previous Diploma student to talk about their career in acoustics. The first presentation, from Branch Chairman Paul Shields, took us through a whistle stop tour of his career, and throwing in a few words of wisdom for those looking to develop a career in acoustics.

When the three judges returned they congratulated all three presenters on their excellent presentations, and the prizes (sponsored by ANV Measurement Systems) were awarded to Christina, Nick and Chris in that order. Mike Breslin of ANV presented the prizes. Christina's name will also be the first to go on a new trophy for this annual event, the Andy Nash Award, which has been presented by URS in memory of Andy Nash, a member of the URS Acoustics Team, who sadly passed away last year at the age of 33.

Christina Girvan receives her prize and the Andy Nash Award from Mike Breslin of ANV Measurement Systems

Thank you to all the presenters, to ANV and URS for the prizes and to John Pritchard and Derby University for once again providing an excellent venue.

The August meeting of the Midlands Branch had been held at Arup Campus in Solihull where Andrew Parkin of Cundall Acoustics presented a talk on *The Review of BB93* Many thanks to Andrew and to Arup. Andrew had earlier given a similar presentation to Eastern Branch, a report on which appeared in the last issue *Acoustics Bulletin.*

# Wind turbine noise – the debate continues

*The article by Dick Bowdler in the last issue of the Bulletin on the Institute's wind turbine noise good practice guide has generated a lively response, as we might have expected. Below we print a letter from Mike Stigwood and an article by Gwyn Mapp on the subject. The Institute recognises that there is still a long debate to be had about various issues concerning the assessment and acceptability of wind farm noise, and we will be continuing to discuss those issues through a series of technical meetings starting with a meeting in Edinburgh on 7 November, and further articles in the near future.*

## The IOA good practice guide, excess amplitude modulation and the failure of wind farm noise controls

In August 2013 at the 5th International Conference on Wind Turbine Noise in Denver, we presented extensive research which amongst other things identified that excess amplitude modulation is common and the main noise problem and source of annoyance caused by wind farms. Unbeknown to me prior to the conference, a major Japanese study looking at 34 wind farms had also concluded AM was common and warranted controls similar to those I have previously promoted with small peak to trough values[1]. The good practice guide (GPG) focuses on ETSU-R-97 (ETSU) as do councils investigating complaints about wind farm noise. This obfuscates the real problem and leaves communities unprotected. Focus on ETSU procedures rather than the main problem, EAM, provides a powerful distraction. Unfortunately, it remains necessary to continue debating the issues surrounding this distraction.

In 2009 a group of acousticians devised a new way of interpreting ETSU to address wind shear. They had not based this on any empirical data or published research and assumed that of the two options available to address wind shear both gave similar results. This was the thrust of a talk by one of the authors of the article which appeared in *Acoustics Bulletin* in March-April 2009. They were wrong. Our research comparing actual data from sites and then separate subsequent research by the Renewable Energy Foundation found repeatedly the method adopted allowed more noise, levels up to 5dB(A) higher.[2,3] This equates to significant reductions in separation distance. Our research remains unchallenged and every wind farm site we have evaluated since that study provides the same results.

At best the article authors try to argue our research is flawed but do not contradict our findings with any meaningful research or data. Dick Bowdler has reiterated erroneous arguments in an article in the Bulletin (September-October 2013) to which I need and intend to respond. In short, predicted turbine noise referencing 10m standardised wind speeds can be directly compared to 10m measured wind speeds ("apples with apples"); it roughly approximates the situation where the wind shear between 10m height and turbine hub height (approx 80m) is equal to 0.16.

It is of interest that the same group of acousticians effectively concluded, in the same article, that low frequency noise was not an element of concern in wind farm noise impact despite emerging research demonstrating this was wrong. I had personally presented some evidence of low frequency impact at an IOA meeting two months earlier. The evidence of low frequency impact is now abundantly clear including an extensive Japanese study which has recently confirmed that these claims were wrong. Researchers have identified significant LFN issues in various papers since 2009. None of the authors has retracted their claims in the three and a half years since.

In 2012 the Institute of Acoustics selected a noise working group which was dominated by individuals who were party to the 2009 article, either originally or shortly after the article was released and before it was tested. They had effectively agreed to a method that allowed an increase in wind farm noise and from whatever position they approached the change, they had arguably compromised their future impartiality in that process. They had certainly argued the article was correct creating difficulty in any retraction. It is also of note that the majority of the working group are primarily employed by the wind industry, are promoting its aims or prosper from wind farm development. That is not necessarily unusual or disadvantageous, but it is not surprising that in these circumstances the new IOA working group endorsed their original idea, the article method shown to allow more turbine noise, in May 2013 in the GPG. Despite the lack of any contrary evidence to our research highlighting the issues with their method, the noise working group members defended their position.

The fact that the method does allow more turbine noise, including in their recommended prediction methodology, is also manifesting itself in reduced separation distances between turbines and housing. This is further testament that the method is allowing more noise. Simple comparison of sound power level versus separation distance demonstrates this in a simplistic way. A major problem with the change is that it has sidestepped the procedure in ETSU, and which is generally adopted for noise impact assessment, that would normally expose excess noise. The new method cannot enable investigation of noise levels under the conditions leading to complaint. Adopting the change recommended in the article gives the illusion that this is still achieved, but in reality it is now prevented as conditions are assessed at hub height and standardised to 10m height. They cannot determine the conditions or crucially the wind shear leading to complaints experienced at 10 m height, the conditions people experience around their homes. We now see industry acousticians re-interpreting existing planning conditions that used 10m measured wind speeds as if standardised wind speeds were originally intended. This thereby allows a greater margin and minimises the likelihood that a breach will be shown.

Dick Bowdler is one of the original authors and he defends their position in his article in the Bulletin, arguing standardised wind speeds are better. The science is so complex on this issue that few understand it and many readily confirm they do not understand it. Phrases are then banded such as “like with like” and “apples and pears” attempting to imply one method is correct and the other incorrect as a way of deflecting from the significant noise increases standardised wind speeds now allow. Further deflection arises through implying the whole ETSU methodology is wrong. The latter may well be the case but it is arguably misguided when it allows more noise.

Dick suggests the Renewable Energy Foundation (REF) criticisms of the standardised method come from the MAS Environmental research. That assumption is wrong. REF undertook its own research without reference to MAS using different data and applied different methods. It led to similar conclusions; the standardised method allowed more noise.

Dick suggests either 10m measured or 10m standardised could have been adapted for wind shear, but this is a misconceived assumption as they both give very different results. In the standardised procedure wind shear effects are aggregated with a large number of other variables influencing background noise levels and so are effectively subsumed and diluted in the process. Using 10m measured controls wind shear effects are considered independently and influence wind turbine noise as a separate variable. This is why our research shows case by case that the article and GPG method allows more noise.

Dick asks if the GPG method gives less protection but this is already answered in both the MAS and REF research with a resounding yes. Every case compared has allowed more noise, a finding demonstrated in both the REF and MAS research using actual data from a number of sites. Every site we have considered since has produced the same results. It is a complex interaction of meteorology, acoustics, statistics and physics, and has taken us countless hours of analysis. In part this is why we conducted the research, to better understand the interactions.

Dick accuses me of perpetuating a scientific inaccuracy, which professionally I cannot allow to go unanswered. It is misconceived and incorrect, arising from a misunderstanding of the relevant principles. Our research was scrutinised by many including independent non UK-based acousticians who peer reviewed the work. We had to go overseas as most we approached in the UK did not have sufficient understanding of meteorology to comment. Incorrect assumption from a failure to fully read and understand the research is part of a wider problem, a common trap most of us have fallen into from time to time. It could be argued, from a cynical perspective, that wind industry acousticians have capitalised on those misunderstandings.

In as simple terms as I can express it:

- The generation of power and hence turbine noise is related to the wind speed at the turbine hub height, whereas the background noise masking the turbine noise is related to the actual (not standardised) wind speed at or near ground level. The object of the ETSU methodology is to derive limits to protect residents in dwellings at ground level. Those limits should only rise in decibel level as the near ground masking noise rises. ETSU was not designed to derive limits that increase as the turbine noise rises whilst the background noise does not. This allows uncontrolled operation. The ETSU principle intends setting limits to control the level of turbine noise so that it does not emerge excessively above the background/masking noise. That is how context based limits and BS4142, on which ETSU was framed, work. In other words, we do not say “let us set noise limits to match the noise of the turbines” but “let us set noise limits which match the levels of masking noise present”. The standardised wind speed approach adopts the former and departs from the latter. Adopting this approach abandons the basic mechanisms commonly applied to control any site noise.
- High wind shear results in greater turbine noise and lower background masking noise than assumed in ETSU. The ETSU document discusses why it considered turbine noise would rarely exceed the background noise except by levels of up to 5dB and then only for a limited range of wind speeds. The standardised wind speed method abandons this concept by ignoring those circumstances when turbines emit maximum noise but background levels are low.

As a consequence of adopting standardised wind speeds, the GPG now mandates a sophisticated and deceptive averaging process for wind shear that fails to consider the periods when wind shear is higher than average. Unfortunately, this occurs at key times of the evening and night and as such is when complaints most commonly arise. The use of hub height wind speeds, recommended in the standardised method, does not differentiate high wind shear conditions. I am content that time will demonstrate those supporting the standardised method will be shown to have allowed significant noise increases and promoted a method that prevents assessment of actual conditions causing complaints. We are documenting this and will continue to publish the consequences of adopting this procedure. Residents who suffer the increased noise are not content and regrettably we are seeing a large increase in complaints. Ultimately it is our profession which is likely to be seriously tarnished.

The problem arises from a loss of sight of the purpose of assessment and controls. The assessment is not an exercise in determining the maximum energy that can be extracted from wind farms for a given decibel level, or through changing how that is defined to further allow more energy extraction, but what controls actually protect residents. To understand this latter point, we need to look again at decibel level objectives and also reflect on how these have become muddled to benefit developers.

In essence, there are two separate decibel control regimes with different aims and objectives.

**Threshold levels.** Protecting human health from excessive general environmental noise where that noise does not convey a message. We would normally consider this benign anonymous noise. I call this “general noise”. General noise is normally considered to cause harm when it exceeds certain thresholds.

**Context levels.** These are used to protect amenity, welfare and sometimes health from noise which intrudes because of its character rather than its level. It is the message it imparts to the inadvertent listener. In other words, context levels are used for irritating noise that triggers adverse response because the noise conveys a message. P20

◀P19 I call this "site noise" as it normally arises from a particular site or source. Site noise is generally considered unacceptable when it reaches a certain level of audibility or dominance.

The latter can equally impact upon health but not so much in terms of active damage, because of its energy levels, but in terms of a psychological stressor because of the psycho-acoustical responses of listeners. Naturally there is noise which falls within both categories and we may need to look differently at how we control this, especially if we seek to combine both objectives.

We can readily see examples of both. An example of the first is road traffic noise which we tend to filter out of our thought processes and so ignore any message it may impart. It is just there and many do not notice it. It may cause difficulty getting to sleep or lead to lower quality sleep but we are not consciously listening to it. An example of the second is noise from a party at a neighbour's which continues, albeit at low levels, into the core sleep hours. Commonly we cannot avoid listening to it and interpret messages such as the lack of care for neighbours' sleep by revellers, the irritating nature of an individual's laugh and so on. It can be quieter than the road traffic noise but impacts significantly more.

ETSU assessed wind turbine noise as primarily falling in the general noise category. An element of context is recognised in the application of a penalty for tonality and relationship to background noise. The first and most serious error was to assume wind farm noise did not or still does not contain substantial psycho-acoustic messages other than tonality. Unfortunately, even the tonal element of wind farm noise considered in ETSU and its adjustment assumes that impact can be applied to general noise thresholds, rather than relate it to its dominance or audibility. That is a fundamental error of analysis and is one reason why wind farms that are considered compliant cause so many complaints.

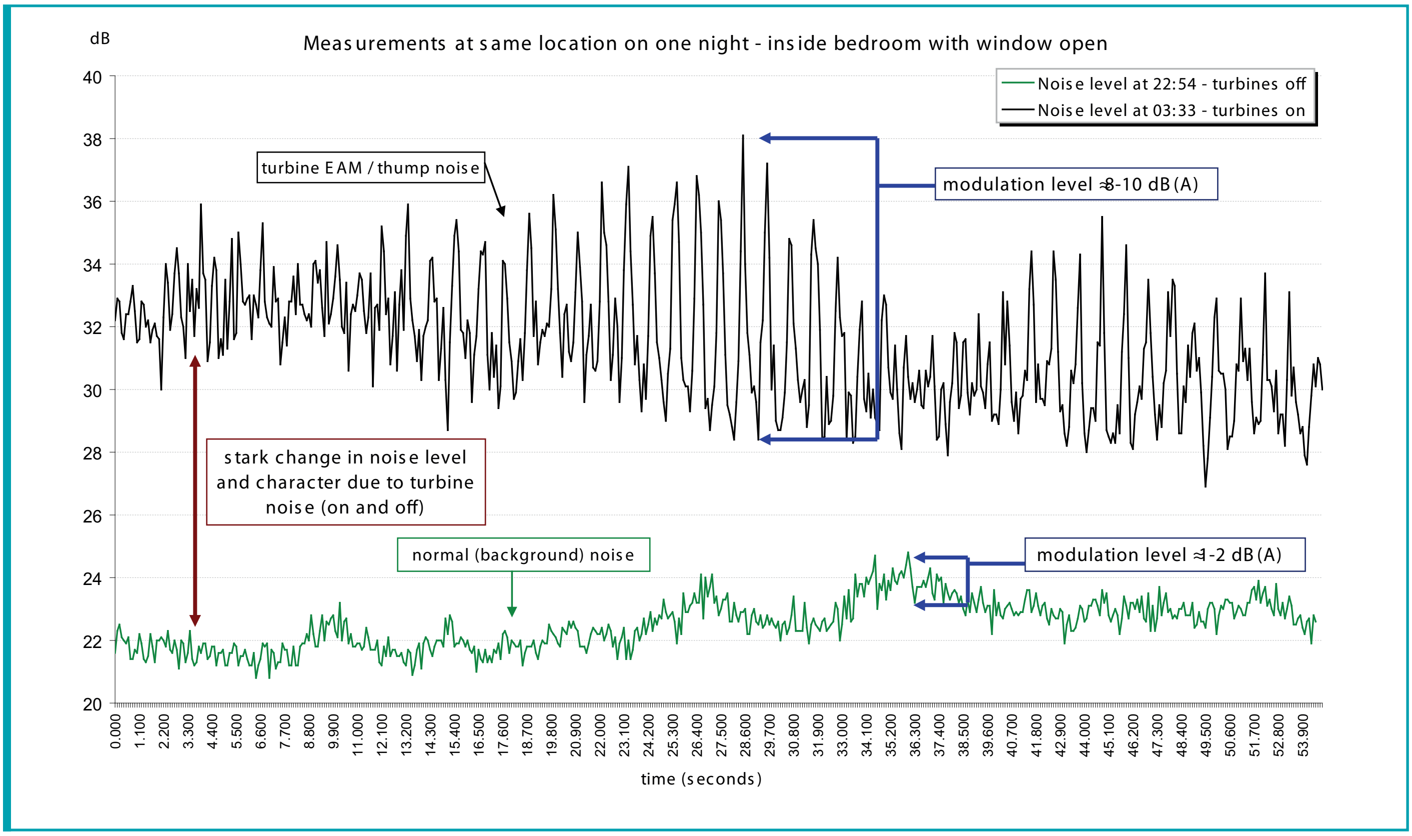
In summary, it all promotes bad science allowing more noise by varying the procedure increasing the margin of error. The graph below shows a comparison of context; the background noise level in a bedroom without turbine noise and the turbine noise inside the bedroom post development but which complies with ETSU.

An example confirming the bad science of ETSU is the Bilberry Farm planning inquiry in 2012. A small turbine had been built in the wrong place without a noise control. It caused a tonal nuisance and statutory nuisance action was taken. Planning enforcement action was also taken and appealed. All experts for all parties at the appeal agreed it caused nuisance. Works were being implemented to reduce the tonal noise content and decibel levels but were not completed by the time of the appeal hearing. Nuisance was not continuing as the turbine had been parked for some considerable time. Tests during the inquiry showed nuisance level noise continued. The appellants proposed a condition based on the lowest levels in ETSU, including its tonal penalty, to control the noise in the event that the inspector approved the new turbine position. It was promoted on the basis it would render the turbine compliant with ETSU. Cross-examination of the evidence confirmed the ETSU-based condition did not prevent the noise that had already been judged a nuisance. In other words, the ETSU controls permitted undisputed statutory nuisance. The failure of the condition was acknowledged by the inspector but it is instructive it was not specifically identified as an ETSU condition in the decision letter. That would amount to an open criticism of ETSU by a government inspector.

Returning to the issue of the noise working group and interpretation of ETSU, no published research supports the standardised procedure. It cannot as the change introduces an averaging process, not originally envisaged by the authors, which effectively subsumes the effect of wind shear averaging it with other influences and thereby losing its effect. The outcome of the IOA GPG working group is very helpful for the wind industry and the acousticians who work for it. Arguably it is also procedurally convenient; it avoids an argument about how it gives a false illusion of protection.

The harm of all of this process is ultimately to the profession. We see politicians vilified and a number of other professions also. Acousticians who promote procedures that give a false illusion of protection must expect the same attacks on professionalism but from which we will all suffer.

The simple fact is that proportionately a huge number of wind farms cause noise complaints but almost every wind farm causing complaints has been deemed to comply with ETSU-R-97. Only in one case has a wind farm been confirmed to marginally exceed limits that I am aware of. There is an obvious anomaly in that. Either we have a very high percentage of unreasonable/abnormal people in society living near wind farms, the controls and those who devised them are wrong, the method of applying those controls and those who apply those methods are wrong or it is a combination of all of these P22▶



◀ P20 factors. It is of note that many complainants were in support of the wind farm development before it became operational.

We need to learn from this problem and so it is now a matter of documenting the harm caused, who said what, who endorsed those processes and procedures causing that harm and who allowed those promoting an erroneous approach to wind farm noise to do so. Currently we see environmental statements confidently claim that excess amplitude modulation is only a rare problem. In reality it is the main problem with almost all the wind farms that cause complaints. We are in the process of documenting these cases. Some difficulty has arisen as wind farms are not built for several years allowing a time lapse before the evidence emerges that decision makers have been misled. Many of the sites approved in 2009-2011 are now being completed and are leading to widespread complaints.

We need to return to environmental noise assessment basics and look at the principles we have abandoned in wind farm noise assessment without any research to support that abandonment. We need to look at why bad science prevails and before it is too late. In the words of the World Health Organisation, only one third of noise nuisance is due to the decibel level. We need to properly evaluate the other two thirds. We need to stop averaging the quietest 10% of the source of noise for comparison with the average of the background noise. We need to stop assuming noise with substantial psycho-acoustic character can be assessed as if it is benign and anonymous noise.

In the acoustics profession we assess noise generally by:

- Looking at short term noise impact and not long term averages
- We are interested in the impact at a moment in time and the disruption that it causes, such as sleep disturbance on a particular night, and not what the average noise is.

If we looked at average speed on a journey it would not tell us if inappropriate speed was applied in relevant circumstances, whether the driver was too close to the car in front or drove erratically and dangerously. In the same way the average of the noise during periods when it was not excessive does not inform us of adverse impact. The averaging now applied by those using the standardised method was not the original intent of ETSU or, if its authors now claim it was so, meant to be worded that way and it does not mean what it literally says (as they have claimed in relation to wind shear) then the intent was clearly wrong.

We assume too much in acoustics. It was assumed thalidomide would not be passed genetically but this was a serious error. It was assumed the people of Liverpool would ultimately accept repeated inquiries using individuals with known persuasions with a view that they were responsible for the Hillsborough disaster but this was wrong. It is wrong to assume people will accept the noise they suffer from wind farms, accept disturbed sleep and associated heath effects and move out of their homes just because it meets an illusionary standard. The growing evidence is they will not. The sooner we recognise the failings and get back to basics the better.

**Mike Stigwood**, MAS Environmental Ltd (MAS)

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## Wind farm noise – all blown over?

*By Gwyn Mapp*

### Introduction

On 20 May 2013 the IOA published a good practice guide to the application of ETSU–R–97 for the assessment and rating of wind turbine noise.

The guide was commissioned by the Department of Energy and Climate Change (DECC) who also endorsed the guide along with the Welsh and Scottish Governments. The Department of the Environment of Northern Ireland issued a holding response. It is agreed by the endorsements that the good practice guide would improve the consistency of application of ETSU–R–97.

So, everything is going to be fine then, right? Well, not quite. Criticism of the good practice guide has been vociferous in some quarters[1].

In order to understand why the issue of wind farm noise is still proving to be controversial it is necessary to understand how the planning system method of dealing with wind farms fits in with the law of the land.

### What are the legal rules for noise in the UK?

There are two elements to the law that applies to noise in the UK. These elements are civil law and criminal law.

Under the civil system noise can be considered to be a tort, i.e. a civil wrong, if it is considered to be a private nuisance. A private nuisance is the unreasonable interference with the use and enjoyment of land or some right in connection with it. Case law provides a range of issues that should be considered when judging whether a noise is unreasonable. These issues include give and take between parties, particular sensitivity of the complainant, motive of the defendant, time of day of the disturbance, duration, frequency and intensity of the disturbance, nature of the area and the importance and value of the activity to the community[2]. In order to claim under private nuisance, the complainant needs to have some property rights in the land that is being affected[3].

Under the criminal system noise can be considered to be a crime by two main routes. The first is for the noise to be considered a public nuisance. A public nuisance is defined as a nuisance which materially affects the reasonable comfort and convenience of life of a class of the public who come within the sphere or neighbourhood or its operation[4].

The second way noise can be considered to be a crime would be for the noise to be considered a statutory nuisance as described by Part III of the Environmental Protection Act 1990 (as amended). Noise is considered a statutory nuisance if it is either prejudicial to health or a nuisance. Nuisance in this context is not defined but is taken to mean either private nuisance or public nuisance[5]. It should be noted that there are some technical differences between private nuisance in tort and private nuisance in statutory nuisance, the most important of which is that there is no need for a complainant to have a proprietorial interest in the land if statutory nuisance is being used to deal with the noise[6]. There is also no such need to have proprietorial interest in order to take action under public nuisance[7].

The planning system as provided by the Town and Country Planning Act 1990 (as amended) is frequently used proactively to manage noise and could be considered to be all conquering due to its sheer ubiquity. However, the planning system is fundamentally a political system that operates under the law. As such, the planning system is required to avoid permitting potentially illegal activities in both civil and criminal law.[8] In fact, it has been established that public officials who permit a criminal offence to occur or recur are acting *ultra vires*.[9] This means that, in effect, the planning system needs to avoid permitting criminal or civil offences that affect all neighbours at all times. This requirement cannot be over-ridden by the social or economic benefits of the development.

### Non-nationally significant wind farms

The usual way that the planning system manages to avoid permitting criminal or civil offences for noise from all noise sources is to assume a restrictive approach that protects the rights of individual neighbours unless there is a nationally significant reason for the development.

In practical terms, a standard methodology is adopted that can be used to design out the potential for nuisance claims. This has typically meant the application of BS4142 to determine, on a case by case ▶

basis, as to whether a proposed noisy activity is likely to provide an indication as to whether complaints are likely. The indication of the likelihood of complaint is used as a proxy to estimate the presence of nuisance, whether in the civil or criminal legal systems.

Legally, non-nationally significant infrastructure project (non-NSIP) wind farms should be considered in the same way as other non-NSIP noise sources, such as factories or air conditioning units. Wind farm developments, however, are required to apply the methodology of ETSU–R–97[10]. This document describes how to assess and rate noise from wind turbines for the purposes of planning applications. Justification for this departure from the status quo for wind farms is found in ETSU-R-97 itself which states that:

"*A literal interpretation of how BS4142 should be applied to wind turbine noise assessment is difficult and its use may be inappropriate and problematical.*"[11]

The ETSU–R–97 document sets out a framework that creates a variable noise limit based upon background noise, in a similar fashion to BS4142, albeit at the permissive end of what BS4142 might be considered appropriate. However, for low background noise levels, and more controversially, at night, ETSU-R-97 creates an absolute noise level that is applicable regardless of local conditions. The noise limit applied at night of 43dB $L_{A90,\ 10\ min}$ is frequently described as being unique in the world as it is higher than the daytime noise limit.

There are a couple of problems with the noise limits contained within ETSU-R-97. The first is that the concept of an absolute noise level, i.e. a noise level where the non-acoustic factors have been harmonised to a national level, is incongruous with the principles of nuisance. Absolute noise limits, applied nationally, penalise the wrong people at the wrong times. They penalise neighbours of new developments in quieter areas by imposing less noise controls than appropriate while at the same time they penalise developers introducing new noise sources in noisier areas by insisting on a level of noise control that may not be necessary, or at least it should be the case, but ETSU-R-97 changes from an absolute noise level to a variable noise level once the background noise level gets within 5dB of the absolute noise level.

Secondly, the noise level chosen for the night noise limit is too permissive. According to the National Noise Incident Study of 2000 (NIS)[i], the ETSU-R-97 night limit provides a positive indication that complaints are likely, using the methodology of BS4142, at approximately 50% of properties in England and Wales[ii]. This percentage includes all properties in England and Wales, urban and rural. It is likely that this figure would be significantly higher if only rural properties were considered. Incidentally, by using the same methodology it was estimated the percentage of properties where the ETSU-R-97 night limit would provide a positive indication that complaints were unlikely was less than 5%.

As a result, it can be argued that the ETSU-R-97 night noise limit might be appropriate for the noisiest 50% of the dwellings in England and Wales under certain circumstances, but probably would not be appropriate for the quietest 50% of the dwellings in England and Wales. Either way, it could easily be said that the ETSU-R-97 night noise limit is too permissive as it does not protect all of the neighbours, all of the time, thereby leading to the argument that Government officials, planning officers and by extension environmental health officials are acting *ultra vires* in applying this document to the assessment and rating of noise from non-NSIP wind farms.

**Nationally significant wind farms**

Up until 2008 there were no circumstances where wind turbine developments could be considered to be nationally significant. This changed when the Planning Act 2008 was given Royal Assent. Section158 of the Planning Act 2008 extended the defence of statutory authority in "*civil or criminal proceedings for nuisance*" to developments that received development consent using the streamlined system introduced by the act. Onshore wind farms in England and Wales with a capacity of greater than 50 megawatts and offshore wind farms adjacent to England and Wales with a capacity of greater P24

P23 than 100 megawatts are considered to be Nationally Significant Infrastructure Projects (NSIPs), therefore qualifying them for the use of the defence, in line with other NSIPs such as railways, roads and airports.

In applying the defence of statutory authority to large wind farms the Government is effectively saying that these developments are so important that individual rights in relation to noise and other nuisances are suspended and they are allowed to generate noise levels that would otherwise be unacceptable as the development is in the national interest. However, Government cannot simply remove the rights of an individual without offering compensation, to do so would invite challenge via judicial review and/or the human rights provisions. To resolve this, neighbouring land owners of NSIPs are entitled to compensation under the "*injurious affection*" route provided by section10 of the Compulsory Purchase Act 1965.

In developing the procedures for the streamlined planning system in the Planning Act 2008, the Government produced a suite of National Policy Statements (NPSs) that set out how key issues are highlighted, how these issues were to be evaluated and what mitigation (if any) might be expected to be applied if the issues were not adequately dealt with. It should be noted that the NPSs underwent public consultation and parliamentary scrutiny prior to publication[12] and the process of review lies with the Secretary of State, who may revoke part or all of the documents if they are no longer appropriate for decision making[13].

When discussing onshore wind farms NPS EN-3, the policy statement for Renewable Energy Infrastructure, states that when considering noise developers "…should use ETSU–R–97, *taking into account of the latest industry good practice. This should include any guidance on best practice that the Government may from time to time publish*"[14]. It is this paragraph that allows the Good Practice Guide to be adopted as current operational practice.

Paragraph 2.7.58 continues by stating that: "*Where the correct methodology has been followed and a wind farm is shown to comply with ETSU–R–97 recommended noise limits, the IPC may conclude that it will give little or no weight to adverse noise impacts from the operation of the wind turbines.*"[15]

The reliance of the NPS EN-3 upon ETSU-R-97 might initially seem sensible, but the whole point of providing the defence of statutory authority to NSIPs is to allow these developments to make more of an environmental impact than would otherwise be considered reasonable as they are nationally significant. Imposing the same noise limits upon NSIP wind farms as non-NSIP wind farms significantly restricts the generating capacity of wind farms that Parliament has considered to be vital to the wellbeing of the country and denies neighbours of proposed wind farm developments the opportunity to apply for compensation so that they may move from the area without incurring financial penalty, should they wish to do so.

### Health impacts from wind turbine noise

If it is accepted that NSIP wind farm developments should be allowed to generate more noise than currently allowed, what would be an appropriate methodology?

In the absence of the threat of civil or criminal action in nuisance, NSIP wind farms could be controlled by an absolute noise level, which could be considered alongside the social and economic benefits of the development.

Discussions between stakeholders on how noisy the absolute noise level could be could be framed in terms of seeking to "*avoid significant adverse impacts on health and quality of life*" as described by the Noise Policy Statement for England[16]. This discussion would undoubtedly involve the development of a Significant Observed Adverse Effect Level (SOAEL) for NSIP wind farms.

By introducing a health and quality of life element to the discussions of acceptable noise limits from NSIP wind farms, the debate could build upon the research by Eja Pedersen and others[17] and address directly the concerns of some about a possible "wind turbine syndrome".

### Conclusion

While it is too early to say whether the good practice guide has made significant improvements to the application of ETSU-R-97, it is endorsed by Government departments and is here to stay. However, the controversy surrounding wind farm noise assessments appears to be on-going.

Legally, wind farms can be split into two distinct groups, those that are not considered to be nationally significant, which are bound by nuisance law, and those that are considered to be nationally significant, which have a defence of statutory authority against civil and criminal action in nuisance.

ETSU-R-97 is the Government-approved method of assessing and rating noise from wind turbines. Despite the IOA good practice guide intending to improve the methodology of ETSU-R-97, the noise limits are unchanged.

The ETSU-R-97 noise limits are applicable to both groups of wind farms, and can easily be argued to be too permissive for non-NSIP wind farms and too restrictive for NSIP wind farms. Therefore, if ETSU-R-97 does not properly benefit either side of the debate, what is the purpose of persisting with it?

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i http://www.bre.co.uk/pdf/NIS.pdf

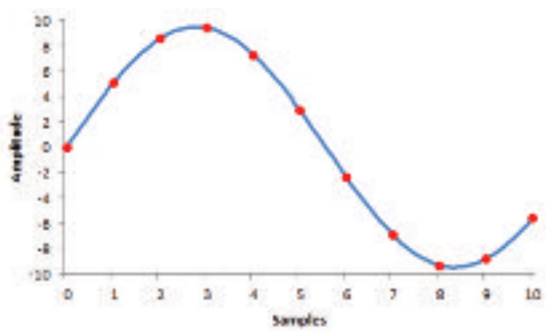
ii positive indication of complaints being likely requires the source noise to be at least 10dB(A) higher than the background noise. If the source noise is 45dB(A) LAEQ (43dB(A) LA90) then the background noise levels at the dwellings would need to be 35dB(A) LAEQ or lower, which according to the NIS was present at approximately 50% of dwellings in England and Wales in 2000.

# The basics of digital audio

*By Steve Cawser*

Many modern sound level meters have the ability to record digital audio as part of a measurement. This gives the ability to either carry out detailed post-processing on sections of recorded audio data, or enables users to carry out noise source identification for long-term unattended surveys. Both of these options have a multitude of benefits for acoustics consultants. However, even though advances in instrumentation have significantly simplified the operation of modern sound level meters, the audio recording options can introduce new settings with which some may be unfamiliar.

To explain the correct use of these settings, it is necessary to understand the basics of digital audio. Digital audio is essentially a method of representing an analogue signal using a series of numbers that can be understood by a computer. This requires converting the analogue signal into discrete steps in both time and level. The figure below gives a diagrammatic representation of this process, with the red dots representing the digital representation of the blue analogue signal.




Analogue to digital conversion process

The process of capturing the signal at a discrete time interval is called sampling. This is the rate at which the amplitude of the analogue signal is acquired. The rate at which a signal is sampled is measured in terms of the number of samples per second, or frequency. The sample frequency is usually set to be high enough to ensure the samples accurately represent the signal to be acquired. This is traditionally a frequency at least twice the bandwidth of the signal being digitised. As an example, an audio compact disc has a sample frequency of 44,100 Hz.

The process of capturing the signal at discrete amplitude intervals is called quantisation. This process involves taking the analogue signal and assigning a number to represent the amplitude at the time the sample is taken. As an example, an audio compact disc uses 16-bit numbers for amplitude quantisation, which allows the signal to be represented by an integer number in the range -32768 to +32767, a total of 65536 (216) possible discrete amplitude levels.

So what does all this mean when setting up your sound level meter? The first thing to decide is for what purpose the audio will be used. If you are capturing short samples of audio for noise source identification in environmental monitoring, a sample rate of 8 kHz is often sufficient to decide whether you can hear distant road traffic noise or overflying aircraft.

If you are capturing audio for post-processing purposes, it is good practice to capture at a higher sample rate of either 24 kHz or even 48 kHz. If you are not sure, go for the highest sample rate to ensure you have the widest bandwidth in the recorded audio. However, it is worth noting that higher sample rates generate larger files, so if you double to the sample rate, you will also double the size of your files.

The other consideration is what quantisation level to use. Many sound level meters will give you the option to select either 16-bit or 24-bit audio. This is possible because many sound level meters use 24-bit processing to produce the parameters we ask it to measure, so can often natively handle 24-bit audio. However, there are two major considerations in the choice of bit depth.

The first relates to hardware that will be used to play back the audio. The sound level meter will store the recorded audio as a .wav file, which can be played back on your office computer. However, the audio hardware included in many office PCs may not be capable of playing back 24-bit audio. 24-bit audio is still considered to be a "professional" standard by many PC makers and on-board sound cards may not be able to play them natively. Therefore, if you want to play them back on a standard office PC, or are not sure if your sound card can handle 24-bit audio, it is safest to record your audio at 16-bit to ensure maximum compatibility.

However, this does have another consideration. The bit depth used to record the audio sets the dynamic range of the signal. For 16-bit audio, this dynamic range is approximately 90 dB ($20x\log_{10}(2^{16-1})$). For a 24-bit signal, this will increase to approximately 138 dB ($20x\log_{10}(2^{24-1})$). A 24-bit audio processor will have a dynamic range that far exceeds the analogue hardware which is placed in front of the digital hardware, which is likely to be less than 120 dB dynamic range. There are, of course, other considerations in the sound level meter specification that limit this potential dynamic range being fully realised.

It should also be considered that any .wav files recorded in 24-bit resolution will store the numbers as a 32-bit number in the .wav file, which means that a 24-bit audio file will be twice the size of a 16-bit file. Another confusing parameter is the type of WAV file. PCM format is "standardise"' by Microsoft for 16-bit files for maximum compatibility with playback hardware. However, in 32-bit format, there is no similar standardisation. "IEEE extensible" is often used, but this is also not always supported by post-processing software, so it's useful to have access to a WAV editor such as Goldwave or Audacity to enable transcoding to different WAV formats.

The other aspect of recording in 16-bit is that because the audio file will be stored using a lower dynamic range than the internal processing of the sound level meter, there will need to be some adjustment for the gain of the signal being recorded. This will need setting carefully because, as with all audio systems, if you set the gain too high, you will cause an overload and the signal will distort; set this too low and most of your signal will be lost inside the noise floor.

So in summary, if you are looking to simply identify noise with little or no post measurement analysis, then you may only need 16-bit data with a sample rate sufficient for identification purposes. However, if you need to record data with a view to carrying out detailed analysis, then higher sample rates and possibly 24-bit measurement may be required to give the recorded sound the appropriate level of accuracy.

Finally, it is worth noting that while your recordings may be good, the quality is likely to be significantly influenced by your playback system; don't forget that the reproduction of data from a sound level meter costing thousands of pounds may be better than the £20 loudspeakers on your computer allow for.

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# 'Impressive innovation' in evidence at inaugural ANC Acoustics Awards

The first Association of Noise Consultants (ANC) awards to promote and recognise excellence among UK acoustic consultants were presented on 8 October in Birmingham.

The awards looked for examples of work displaying innovation, and originality in acoustic design or approach to a particular project. The judging panels were made up of representatives from other professions, academics, and consultants and chaired by Bridget Shield, IOA President. The judges did not visit any of the projects or hear the results and their decisions were based solely on the information provided by entrants.

The categories were:

- Environmental acoustics – best application of environmental noise measurement data (sponsored by Brüel & Kjær)
- Architectural acoustics – most innovative integration of an architectural acoustics solution (sponsored by Ecophon)
- Sound insulation design – most innovative sound insulation improvement solution (sponsored by Robust Details).

Sixteen entries were reduced to a shortlist of nine across the three categories and all those entrants were requested to make a brief presentation on their project to the ANC conference held immediately before the awards ceremony. An award (sponsored by IAC) was made for the best presentation by one of the shortlisted projects and Clarke Saunders Associates were the winners of this based on votes by conference delegates.

ANC Chairman Phil Dunbavin said: "These awards demonstrate the range and quality of the work undertaken by acoustic consultancies. I am particularly impressed by the innovation shown and care given to ensuring the client and all those affected by the projects were involved in the process."

## Environmental acoustics

**Winner:**
*BFK JV Tunnelling (Royal Oak – Farringdon) – Crossrail Contract C300*
**ACCON UK**

The project requirements from Crossrail include exceptionally stringent acoustic criteria related to re-radiated noise from the construction of the tunnel. The challenge was to implement robust vibration modelling for the movement of construction trains within the tunnel in order to derive noise levels within sensitive properties above the tunnel. The noise and vibration model has been refined empirically by the measurement of exceptionally low levels of vibration emanating from the temporary underground construction railway track, which has two main track variants one of which has a level of vibration isolation introduced between the sleepers and the tunnel walls (segments). The project represents the first rigorous method of determining noise and vibration at properties above the tunnel emanating from construction trains within a tunnel for the Crossrail project, with an associated detailed validation exercise in line with ISO 14837-1 'Mechanical vibration — Ground-borne noise and vibration arising from rail systems'.

This project utilised innovative methods and instrumentation in order to measure extremely low levels of vibration. As well as identifying instrumentation capable of accurately measuring such low levels, the consultant was required to measure in the centre of London, so an area as free as possible from extraneous sources of vibration needed to be found along the path of the Crossrail tunnels. The measured data was used to validate a computer model that could predict the level of reradiated noise induced from the movement of a construction train on a temporary rail track.

The aim of the project was to ensure that groundborne noise generated due to the movement of an underground construction train on a temporary railway did not exceed agreed limits. A combination of modelling and measurements were used to inform the predictions of groundborne noise levels. The measured data was used to validate the noise and vibration model, and to assist in determining the level of noise and vibration that would be experienced at recording studios and other sensitive properties above the tunnel. Utilising transfer functions obtained from measurement by consultancy partners on this project, ACCON were able to satisfy the client and the operators of the studios that there was virtually no risk of exceeding the noise criteria.

The judges noted that infrastructure projects can have a major impact on those affected by their construction and there is a huge risk factor if everything is not right. The judges felt that the care taken to ensure that residents and businesses were not affected was significant. This was a difficult project because of the need to isolate the construction train noise from the normal underground trains running on nearby tracks. The consultant successfully measured and modelled the effect of the construction trains on the sensitive sites.

**Highly commended:**
*European Noise Directive Action Plan*
**RMP Acoustics**

This project demonstrates the ability of a British acoustics consultancy to successfully compete internationally to win, design and project manage a large scale environment noise control project. It exhibits the technical ability, practical and often political skills


Graham Parry (centre) of ACCON UK receives the environmental acoustics award with guest speaker Johnny Ball (left) and Christophe Sinsou of sponsor Brüel & Kjær

Ian MacArthur of Clarke Saunders Associates receives the best presentation award with guest speaker Johnny Ball (left) and David Ballan of sponsor IAC

◂ needed of a modern consultancy, and how acoustics can be dovetailed with ventilation and thermal disciplines to achieve combined acoustic and energy improvements.

It has the widest application and greatest potential impact, being Europe's first large scale practical implementation of an END action plan. This provides real improvement in acoustic comfort to approximately 2,400 people, along with measurable improvements in energy efficiency.

The judges were impressed by the levels of engagement and methodology used involving more than 990 building assessments. The consultant took a holistic approach and the concept could readily be applied elsewhere. It was a great project with impressive project management and a multidiscipline solution.

**Commended:**
*Corrib Gas Project, County Mayo*
**Clarke Saunders Associates**
The consultant took a sensitive, detailed approach recognising that these types of projects can cause public concern and can have significant adverse effects if not properly implemented.

To assist the client in delivering their complex project, they developed a sophisticated noise management and monitoring regime to demonstrate to regulators and the local community full compliance with extremely onerous regulatory conditions. They worked hard to minimise the impact undertaking considerable ground work to bench mark the noise sources to the background in various weather conditions to produce the alert and exclude conditions.

## Architectural acoustics

**Winner:**
*University of East London Library*
**Adrian James Acoustics**
Acoustic problems with the UEL's existing library in Docklands led the client to seek the acoustics consultants' early involvement and to develop the acoustic and architectural briefs in parallel. This project is a rare combination of acoustic research and development leading to a very simple and efficient acoustic design in a type of building which has not previously been well understood. The seamless incorporation of the acoustic treatment into a very elegant architectural design by Hopkins Architects is also a consideration, as must be the cost-effectiveness of the acoustic solutions. This project is an excellent example of how architect and acoustician can work together to bring innovative design to a practical building.

There is no established acoustic criterion for open-plan libraries and so the design process involved complex 3-D computer modelling of the entire building as a single open plan space. The library is a three-storey building with the stories being linked by a central atrium and light well which effectively makes the building open-plan. An essential aspect of the design is the identification of "silent", "quiet" and "social" areas and a strategy for providing both acoustic separation and a management system to enforce these. As a result of this, several different acoustic criteria had to be considered. Unusually, therefore, the number of people present in each area became a significant consideration in the acoustic design. Having used this to develop an acoustic design for the social areas where most noise is generated, the remaining criterion simply became a measure of noise transmission from these areas to the quiet study areas elsewhere in the library.

The computer model showed that noise transmission between floors was very strongly affected by the location of acoustic absorption around staircases and openings between floors. This was hardly surprising, although the extent of the effect was. Bespoke acoustically absorbent timber finishes were developed for the stair and light wells, and with these in place it was possible to adopt a largely modular solution for acoustics in the P28 ▸

◀P27 open plan areas on upper floors. These use suspended "rafts" and baffles, so as to leave much of the concrete soffit exposed for thermal efficiency. The consultants were able to use the acoustic absorption of books and furnishings, which significantly reduced the amount of acoustic absorption required elsewhere. The transmission of noise along and across book stacks was particularly interesting, and led to a design for bespoke bookshelves with built-in acoustic absorption on top and at the ends.

The judges were agreed that for technical innovation this entry clearly deserved the award. The treatment of the stairs and the bookcases was inspired. Integration at all stages was very good.

**Highly commended:**
*Jesmond Gardens Primary School, Hartlepool*
**Apex Acoustics**
This entry demonstrated a bespoke approach which integrated acoustics and open learning areas. It was both practical and innovative with flexible use of drapes and stretching the open plan environment. The entry was supported by strong testimonials and the judges noted that the acoustics had helped the building win an architectural award.

**Commended:**
*Manchester Town Hall*
**BDP**
In a series of entries dominated by education buildings, the judges were pleased to find this project which involved restoration of a unique, listed building which is the UK's third busiest library. It was well planned and displayed good integration. They particularly liked the use of loudspeakers activated by visitors in the music library.

**Commended:**
*City Academy, Norwich*
**WSP**
The acoustics in the multipurpose atrium at the heart of this P30▶


The University of East London Library


Part of the Crossrail project

The Reed Mews Wellbeing Centre

◀P28 school provide a highly successful learning social and performance space. Innovative cross laminate timber set an acoustic challenge but very good levels of sound insulation and low frequency reverberation control were still achieved for the exposed structure using software prediction tools. The project showed the benefits to clients of appointing an acoustic technical advisor.

## Sound insulation design

**Winner:**
*Reed Mews at the Streatham Campus, University of Exeter*
**Hoare Lea Acoustics**
High levels of acoustic privacy were required in an existing old timber frame construction with many limitations and restrictions on the works. The refurbishment of the Reed Mews building encompassed the application of "outside the box" concepts to deliver an onerous client brief with short timescales and tight budgets. The client brief was purely subjective, "raised voices to be unintelligible in adjacent spaces". Reed Mews was an existing building not designed to provide high levels of sound insulation. The concepts implemented included sound insulation upgrades and bespoke background noise masking system design. The whole project had to be designed in three months and constructed over the university summer holidays.

The first challenge was to fully understand the acoustic implications of the intended use as a "Wellbeing Centre". Meetings were held with the end user representatives to establish this and appreciate the needs of the different stakeholders. The next challenge was to establish an objective acoustics design specification. A questionnaire was used to determine the end user perceived quality of their existing premises, followed by in situ sound insulation, reverberation time and ambient noise level measurements of the facility. These results were analysed and a bespoke acoustic privacy chart was developed. This was discussed with the end user group to confirm the level of privacy based on spaces they were familiar using and the proposed design goals.

Karl Simpson (centre) of Hoare Lea Acoustics receives the sound insulation design award with guest speaker Johnny Ball and David Baker of sponsor Robust Details

The prevailing performance of the existing Reed Mews building was determined and the feasibility of achieving the client's design objectives established. In situ measurements were undertaken to quantify the sound insulation between all the existing adjacent spaces and gather reverberation time and indoor ambient noise data to assist with the analysis. The measurements confirmed the prevailing acoustic privacy to be at lowest a privacy factor of 64. Predictions of enhancements likely to be achievable considering flanking paths concluded the existing construction would ▶

require extensive treatment and the integration of an artificial background noise masking system.

The suggestion of introducing noise into the spaces was a significant concern to the stakeholders. The end users were receptive to the concept, but opposed to generating noise in the counselling rooms. Their belief was that the quietest environment possible would put students at ease. The university had severe concerns regarding spending their limited budget on a bespoke system that might end up unused, and the other design team members were concerned over integrating the system within the timeframe available. After much persuasion that the acoustic privacy concept (sound insulation and artificial background noise) would be of benefit to the end users, the expenditure was authorised.

A bespoke design for the background noise masking system was developed with a specialist supplier. Due to lack of ceiling void, the standard installation approach could not be used at first floor level. Therefore, a rarely used concept of installing the loudspeaker driver unit in the partition void but fixed to one of the linings to act as a resonance board to provide an even sound field coverage (to reduce subjective location of the source) was designed in.

The judges were impressed by the attention given to the client's needs, and checking that they were fulfilled. The consultant made sure they understood and delivered what was required and came up with a solution that combined a standard approach with noise generation. This was innovative in an unusual way but made it all the more interesting for that.

**Commended:**
*Park House, London*
**Hann Tucker**
This is one of the most complicated vibration isolation buildings ever constructed and the acoustic performance of the fully glazed curtain wall system is exceptional providing suitable internal conditions even though the north façade of the building overlooks Oxford Street.

The judges felt this was innovative due to the nature of the buildings and a clever approach had been adopted. The entry was a fascinating piece of work that demonstrated that the required sound insulation standards can be achieved despite having continuous curtain walling.

# Pioneers of Quiet

*By Mike Goldsmith*

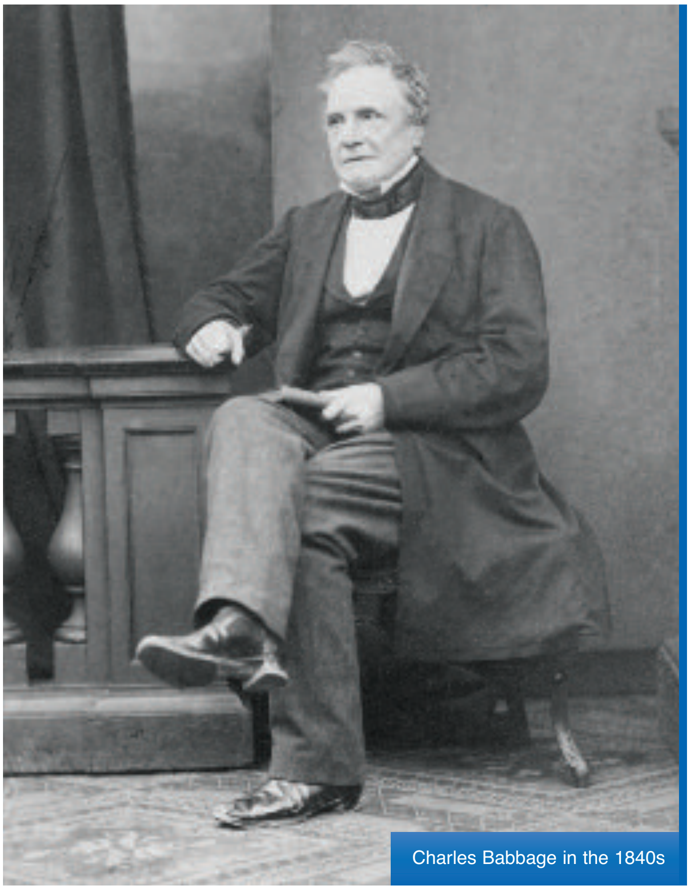
Many of us live in a world of noise, and many aspects of that world are being challenged, from airport expansion in the UK to boom cars in the USA and wind farms in Australia. Anecdotally at least, concerns about noise pollution have steadily gained ground in the last few years, and it might sometimes seem that the past was a quieter place than now, with noise a smaller problem.

In fact, however, there have been several times in the past when noise has caused such concern that individuals have stood up to pit themselves against the din, uniting the like-minded, directing their energies towards specific goals, and winning battles for quiet. It is not only unjust that the pioneers of quiet are largely forgotten today, it is also counter-productive: the types of noise they fought may have long fallen silent, but the methods and lessons of the past are often still relevant today. There is much to learn from the successes of the pioneers, and from their failures too.

In this article, the first of two on the subject, I am focussing on two individuals, born in the 18th and 19th centuries, who stand out as the great noise campaigners of their times.

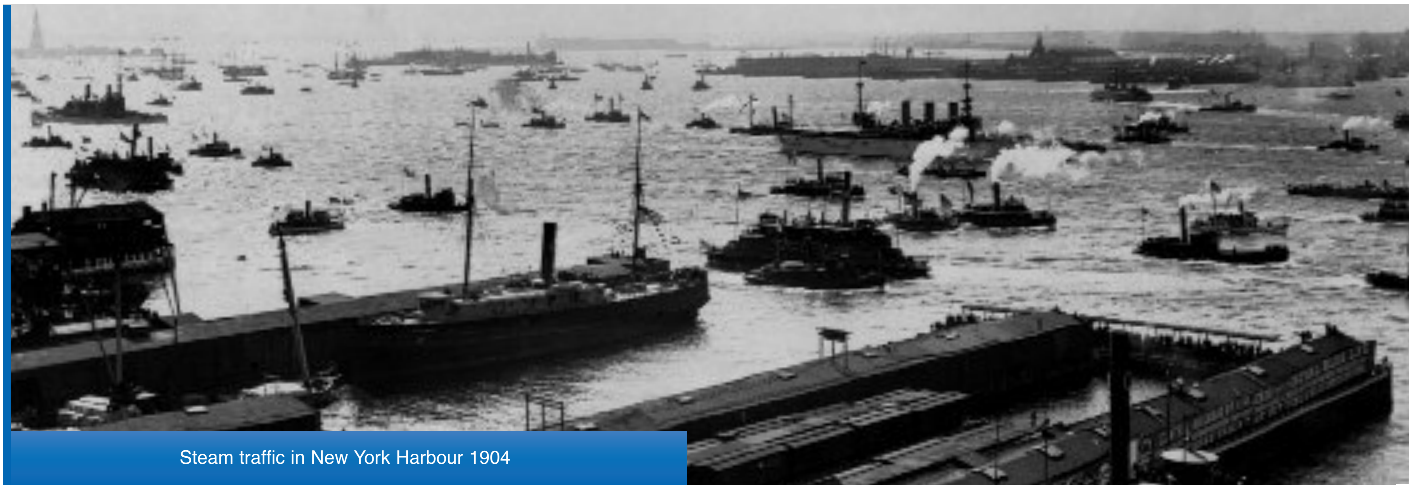
The first is by far the most famous, though not in the context of noise. Charles Babbage (1791 - 1871), the inventor of the mechanical computer, was a tireless collector of facts, a mathematician, an engineer and, by many accounts, a stubborn and abrasive man. For many years it was believed that his wonderful steam-driven computers were impossible dreams for his era – that the required tolerances to which the clockwork conglomerations would have had to be built to avoid jams and jumps were beyond what was then achievable. But 120 years after Babbage's death the London Science Museum, working to the standards of his time, built a functioning version. It seems that what stymied the device was Babbage's bad temper and in particular his conflicts with Joseph Clement, the engineer in charge of the project.

An achievement less well known than his visionary computers is Babbage's successful support of MP Michael Bass's efforts to get his Bill for the Better Regulation of Street Music in the Metropolis enacted in 1863[1]. The Act greatly increased the power of householders in dealing with street music, as it removed the requirement to show just cause in order for the police to respond to complaints. It also introduced fines for musicians who did not move on when so ordered.



Charles Babbage in the 1840s

For Babbage, this was the culmination of a long battle against noise: a very personal one. He was not a restful soul, constantly working on new projects from cryptography to optics and from economics to geology. The scene of his labours was his house in Marylebone. It was not known as a particularly noisy district, but by his own estimate, Babbage's prodigious output would have been one-third greater if not for the cacophony from his surroundings: a tireless collector of facts (including tracking down the separate causes of 164 broken windows in a factory), Babbage carefully categorised the types of noise to which he was exposed (at a rate of 165 per 80 days), including "Organs; Brass-bands; Fiddlers; Harps; Punch; Pantomime; Monkeys; Military; Dancing and P32



Steam traffic in New York Harbour 1904

◂P31 Musical; Athletes; Ladies and Gentlemen walking on stilts and looking inquiringly in at the Drawing Room windows; Hindu or Mohammedan imposters beating monotonous drums, or showing insanity; troupes of Scotch imposters dancing with bagpipes, ..."

Babbage was a very direct man and took on his neighbours in person – with predictable results. Retaliations ranged from blowing a tin whistle from a window facing Babbage's house for half an hour daily for several months to throwing a dead cat at his house. However, the primary target for Babbage's ire was street music. Itinerant musicians were active in many of London's streets in the 1860s, just as they had been for centuries. At the time, the only effective legal remedy against street noise-makers was an appeal to a local magistrate, who had the power to fine the perpetrators. Babbage made many such appeals, but he was rarely successful – and on at least one occasion when he was, the musician's fine was paid by a well-heeled sympathiser. At the time, street music was a hot topic; at the distance of years it is hard to establish how far Babbage himself made it so. That it was a genuine problem is very clear – there are many accounts of street musicians refusing to leave until they had been bribed.

Babbage's confrontational approach had its effect. The satirical journal *Punch* picked up his campaign, and cartoons caricaturing the personalities and issues involved appeared in it quite frequently. The publicity raised was very much to the advantage of Michael Bass, whose pamphlet *Street Music in the Metropolis* (written to support his Bill) cites hundreds of supporters. It also includes, among many letters of encouragement, a note written by Charles Dickens on behalf of a group of 28 household names, from a wide range of professions. So strongly was Babbage identified with Bass's Act that, in writing to the astronomer John Herschel about its passing, the mathematician De Morgan referred to it as "Babbage's Act."

Street music, however, seems to be the only kind of noise problem that Babbage was concerned about. This is really quite surprising given that his was the age of industry, when steam-driven machinery, railways and surging populations were filling London with more noise than ever. But about all these issues, Babbage was silent.

Disappointingly, Babbage identities the enemy in the noise war, or, as he puts it, the "Encouragers of Street Music" as members of "the lower classes of society", and, among the victims, his over-riding concern is for "brain-workers"; though he is clear that invalids need protection from noise too.

Babbage's victory was limited in terms of urban noise and not even very effective on a personal basis; as his obituary states, "He died at his residence in Dorset-street, Marylebone, ... at an age, in spite of organ-grinding persecutors, little short of 80 years".

In retrospect it is easy to see why Babbage's campaign met with limited success. It was narrow in scope and elitist in identification of the victims of noise. On the other hand, it was effective in defining a clear and achievable objective – the passing of the Act – in generating publicity and in bringing together influential supporters. It is easy to mock Babbage today, and he is a hard man to like. But it is questionable whether any other approach could have succeeded at the time when the idea of noise as a health issue, and the concept of a right to peace, were quite alien.

To see the limitations of Babbage's approach, we can look 5,000 km west and 40 years later where a medical doctor and society hostess called Julia Rice was in residence in a very special house on Riverside Drive, New York City, on the banks of the Hudson. In a highly unusual move for the time, it had been constructed (on the plans of her husband Isaac, a lawyer, musician and noted chess-player) with noise in mind: not only were the walls "sound-proofed", there was also an underground chamber constructed specifically for the sake of its quietness[2]. But air-conditioning was not among the modern conveniences of the Villa Julia, so its windows were routinely kept open on the warm summer nights of 1903. And through those windows came a near-constant cacophony of whistling from the many steamers that plied their trade along the Hudson. On some nights, the inhabitants got just a few hours' sleep.

Nothing if not scientific, and with ample funds, Rice started as Babbage had – with a survey. She deployed four students from the Columbia Law School along the river one night with instructions to note the numbers of hoots. The results were as startling as they were: the mean interval was around 10 seconds, and the rate sometimes so rapid that an accurate count was then impossible.

The only good reason for a steamboat to whistle was to warn, so one would expect the sounds to be much more frequent on foggy nights, but repeats of the survey showed that hoot-rate was independent of weather conditions. So it was quite clear that the whistling was largely unnecessary – and Rice saw no reason to put up with it. To head off any protests that "no-one else has complained", she deputed more students to take statements from other riverside dwellers who attested that they were irritated too. Rice then personally bearded some of the captains in their dens, some of whom revealed that they whistled simply to greet their friends. Others explained that they used their whistles to remind drunken crew members where they should be – and even to help arrange their romantic liaisons for them.

Armed with the results of her surveys, Rice took the offending companies to court and was successful in having all such "social" whistling banned – eventually. The New York City Health Department refused to act since it claimed that the Hudson was a national waterway. Consequently, Rice had no choice but to take her case to Washington. Before doing so she gathered all the expert testimony she could, including from the police and from members of the medical profession, that noise really was a problem. Finally she was granted a hearing by the Department of Commerce and Labor. Ten months later, it filed in her favour.

The recalcitrance of the New York City Health Department had the effect of raising the issue from a local to a national one, with the great advantage that "social" whistling was now banned not only in New York City but in Philadelphia and Boston too. Like Babbage, Rice was the target of reprisals – some steamers would ▸

drive up quietly to her house, let loose a volley of toots and sail quickly away. In response, she simply identified the captains and took legal action against them.

What made Rice very different to Babbage was that she was not concerned solely with noise that bothered *her*. With one major success under her belt, her next act was to form an anti-noise society: The New York City Society for the Suppression of Unnecessary Noise held its first meeting in 1906 and within a year it had 200 members. Not large by any standards, but it made up for in influence what it lacked in numbers, including many local businessmen and members of the clergy in its ranks.

The society successfully pressed for controls on the use of fireworks on 4 July, and it also targeted two groups of noise sufferers still regarded today as particularly important: the ill and the young. Since Hippocrates urged in the 5th century BC that ill people should be accommodated in quiet areas, it has been understood that noise is particularly troubling for those in poor health (Babbage had specifically mentioned this group too). Its focus on this issue led to the society's success in creating quiet zones near hospitals.

In its emphasis on the young, the society was a pioneer. Now, thanks to the work of Arline Bronzaft and many others, it is quite clear that children's learning is severely impacted by noise, but Rice's society seems to have been the first in the world to recognise this challenge, and was successful in establishing quiet zones near schools as well. (Rice also dealt with children as noise-makers in an innovative way, by appealing to them directly to keep the peace and rewarding them with badges too. By all accounts, this policy was a success).

This "outside the box" thinking was typical of Rice. While Babbage and Bass had relied on the tried and trusted methods of publicity and politics, Rice's attack was more nuanced: she marshalled the support of people with power, and concentrated on issues that affected large groups of people. She even deployed what might now be stunt-casting by inviting the famous and popular writer Mark Twain – an ex-river boat captain who had no doubt annoyed many with steam whistles in years gone by – to act as an honorary head of the children's branch of the society. Twain was happy to accept.

The success of Rice and the society she founded led to the formation of numerous anti-noise groups across the world and significant progress against noise pollution was made as a result. But most such activity came to an abrupt halt in 1939. In the face of international conflict, it was felt that to take such a relatively minor issue as noise seriously was, somehow, wrong. For example, a *Wembley Observer and Gazette* editorial claimed in 1941 that the concerns of the Anti-Noise League were "... incredibly puerile, if not comic, in comparison with our anti-aircraft barrage."[3] In quick succession, noise societies closed down in several countries, and the world turned its attention to war.

***Dr Mike Goldsmith** is a science writer and freelance acoustician; his history of noise, Discord, is published by Oxford University Press. In his next article, which will appear in the January-February issue, he will look at the work of John Connell, the driving force behind the Noise Abatement Act.*

## References


1. More information on the campaigns of Babbage and Bass may be found in John M. Picker's *Victorian Soundscapes* (Oxford University Press, 2003), from which some of the details in this article derive.
2. George Prochnik's book "*In Pursuit of Silence*" (Doubleday, 2010) was the main source for the material on Julia Rice in this article.
3. Quoted in John Agar, "Bodies, Machines & Noise", in *Bodies/Machines*, Iwan Rhys Morus (ed.) (Berg, 2002), page 212.

# High levels of aircraft noise 'increases heart disease and stroke risk'

Risks of hospital admissions and deaths from stroke and heart disease are higher in areas with high levels of aircraft noise, a study has found.

Researchers at Imperial College London and King's College London compared data on day- and night-time aircraft noise with hospital admissions and mortality rates among a population of 3.6 million people living near Heathrow airport.

The risks were around 10 to 20 per cent higher in areas with highest levels of aircraft noise compared with the areas with least noise.

The findings are published in the *British Medical Journal*.

Previous research has found links between living in a noisy environment and risk of high blood pressure, but few studies have looked at stroke, heart disease and circulatory disease.

The new findings raise the possibility that aircraft noise may be a contributing factor to these conditions, but the researchers say more work is needed to establish the exact relationship between noise and ill health.

Dr Anna Hansell, from Imperial College, London, the lead author of the study, said: "These findings suggest a possible link between high levels of aircraft noise and risk of heart disease and stroke. The exact role that noise exposure may play in ill health is not well established. However, it is plausible that it might be contributing, for example by raising blood pressure or by disturbing people's sleep. The relative importance of daytime and night-time noise also needs to be investigated further."

In another development relating to aircraft noise, councils have warned that the commission investigating London's airport capacity could underestimate the impact of noise on people under the flight path because it is working from outdated maps.

The 2M group, an all-party alliance of 24 local authorities, has voiced fears the inquiry could fail to take into account the increase in flights and shift in population over the last 30 years.

According to the group, which opposes the expansion of Heathrow, the Airports Commission is set to rely on noise surveys which were compiled in the early 1980s.

It said that relying on this data could leave several hundred thousand people being subjected to even greater levels of noise nuisance.

According to the group, not only has the number of flights risen dramatically since the study was compiled in 1982, but new communities have found themselves under the flight path, notably in London's Docklands.

In addition noise levels deemed acceptable in the 1980s – 57 decibels – have been deemed excessive by the EU and a study commissioned by the previous Government.

Aircraft noise may increase stroke risk


Markus Mainka / Shutterstock.com

# Innovative project aims to cut noise inside aircraft

Researchers from the University of Twente's CTIT research institute in the Netherlands have developed a prototype lightweight panel that uses anti-noise to reduce noise levels inside aircraft.

The panels can be used as a replacement for the heavy insulation materials in aircraft fuselages, leading to a significant reduction in fuel consumption. This will make flying not only cheaper, but also more environmentally friendly.

The research is being conducted in collaboration with Airbus, TNO, NXP and Merford. The researchers expect that the panels can be installed in aircraft in five years' time.

Aircraft fuselages are fitted with heavy insulation to keep interior noise within acceptable limits. Planes need to carry extra fuel for every kilogram of additional weight. Finding ways to save weight is therefore a key concern in the aviation industry.

The researchers are working on lightweight panels that can be used for active noise reduction. The panels measure the sound approaching them and then produce anti-noise that cancels the incoming sound. The result: complete silence in theory, and an enormous reduction of the noise level in practice.

The panels are equipped with plates (actuators) made of a piezoelectric material, which can convert changes in pressure into electricity and vice versa. This material can thus be used as a microphone and speaker in one: the actuators can measure sound (because they convert sound vibrations into an electrical signal) and produce sound (because the computer can induce vibrations in the actuators).

The project's biggest challenge lies in the adjustment of the various actuators. A central computer system that controls all actuators in the entire aircraft will not work, because of the tremendously complicated calculations and electronics involved. Moreover, a single malfunction could potentially affect all actuators throughout the fuselage. The UT researchers have therefore designed a panel in which the actuators are controlled individually. This prototype panel is now ready for thorough testing.

The underlying technology is not only suitable for aviation. It can also be deployed in many other applications, for example in home sound systems as extremely thin subwoofers that can be integrated into walls.


Quieter cabins may be on the way

# Charity publishes HS2 noise intrusion maps

The Campaign to Protect Rural England (CPRE) has published visualisations of High Speed 2's (HS2) noise impacts.

The charity is using them to highlight the need to work harder to minimise damage to the most unspoilt parts of the countryside.

Ralph Smyth, Senior Transport Campaigner for CPRE, said: "Current noise and compensation laws focus just on the impact to people's homes. While this is very important it means less attention is given to reducing the impact of new infrastructure on more sparsely populated areas of our countryside. Tranquil areas are important to people and nature; we need to defend them.

"CPRE's new HS2 maps show how HS2 could intrude on peaceful parts of countryside. Protecting these special areas may simply mean filling a gap in noise barriers between two villages, so that footpaths benefit as well as back gardens. But it may mean thinking again about the height and alignment of the route."

CPRE is highlighting three sections of the route as examples:

- Waterton Park, West Yorkshire: the eastern arm of phase 2 would pass on a viaduct and embankments, near the site of what is believed to be the world's first nature reserve, as well as popular reservoirs
- Trent Valley, Staffordshire: the western arm of phase 2 would pass on long viaducts within earshot of the Cannock Chase Area of Outstanding Natural Beauty (AONB)
- Danes Moor, Northamptonshire: the section of phase 1 with the heaviest noise footprint would pass near the site of the Battle of Edgecote Moor, a turning point in the War of the Roses.

The maps are available at http://hs2maps.com/

# Impact on vulnerable sub-groups from ultra-rapid hand dryers

*By Dr John Levack Drever, Goldsmiths, University of London*

I have been carrying out a preliminary study on the noise effects from ultra-rapid energy-efficient hand dryers on sensitive sub-groups in publicly accessible toilets. The project has studied hand dryer noise in BRE's Acoustics Laboratory, in situ sound pressure levels in a wide range of toilets and garnered data on the perceived loudness of these devices.

On considering the in situ measurements it would be anticipated that someone with normal hearing would experience some discomfort. Operating levels of the most popular dryers are often in the high 90s, the loudest of which in this study generated a sudden $L_{Aeq}$ of 106dB from a background of 55dB $L_{Aeq}$. Spurred on from my own son's terror of hand dryer noise, beyond the sensitivities of infant hearing, I found a wide range of vulnerable sub-groups that were experiencing problems with this style of hand dryer. Taking the lead from the WHO's Community Noise (1999) reference to vulnerable sub-groups, I found particular complaints among the following groups: visual impairment, hearing aid users, Alzheimer's disease, Ménière's disease and, most significantly, hyperacusis sufferers, and hyperacute hearing in autism and Asperger syndrome. Here is a typical comment from someone with hyperacute hearing:

"I can't stand those hand dryers and it amazes me whenever I see people nonchalantly using them like the sound is nothing. It's very painful for me. I won't go in restrooms that have them unless it's absolutely necessary and if someone uses the dryer while I'm in there, I plug my ears. I don't care if I look like an idiot." (From an ASD chat room)

Ultra-rapid hand dryers have been an engineering success story, chiming with the prevailing agenda of austerity and sustainability, but what is the trade off? The rule of thumb is, the faster the hand drying cycle the louder the noise. There are encouraging technological developments with a new range of dryers consciously designed for quieter operating levels, such as Jet Towel Dryer JT-SB216JSH and Airdri Classic+ MkII. However, the challenge of reducing noise is not solely for the product maker, but for the planner, the architect and, most importantly, building acoustics. WCs can be very small (e.g. 20m$^3$) and are often rectangular, surrounded by surfaces with very low absorption coefficients across the spectrum, resulting in an ultra-reflective space with high frequency room modes. They are the most problematic space, acoustically speaking, in which to install a high-speed hand dryer.

From a review of marketing material and communications, it is apparent that the information from product makers on noise levels is in general unclear. It is seldom explicit if they are referring to sound power or sound pressure, and there is a common misunderstanding that the operating noise level in dB or dB(A) that is stated on the product spec is the level that one would actually experience in situ.

It is evident, even from this initial study, that there is a major issue when considering the impact on vulnerable sub-groups, which in the most extreme case could result in people being excluded from public space, the workplace and education. This is not a call for silent loos as shared toilet provision requires a certain level of background noise for acoustic privacy, without which can impact on other common health issues such as paruresis, and parcopresis.

In conclusion, from a review of this study I propose the following recommendations:

- Urgent need for a large-scale interdisciplinary project including input from the FULL range of users.
- Prioritisation of the needs of vulnerable sub-groups vis-à-vis hand drying provision, in particular in disabled toilets and school toilets.
- In situ product testing in a range of toilet dimensions, not only free-field sound power tests.
- Sound power test should include 1/3 octave bands up to 20kHz.
- A review of the adequacy of A-weighting due to the high frequency content of hand dryers.
- Testing could include psychoacoustic metrics to predict a more subjective impression (i.e. roughness, sharpness, fluctuation strength).
- Installation guidance derived from acoustic know-how, which includes a limit on the number of dryers in relation to the combined predicted in situ levels.
- Clearly worded and standardised information given on the loudness of hand dryer models.
- The above points need to be dealt with holistically including other accessibility and epidemiological issues related to WCs and in accordance with sustainability and accessibility.


Hand dryer noise can be painful

# History of the Institute of Sound and Vibration Research

Apologies to those readers who were expecting to see a report on the history of the Institute of Sound and Vibration Research. This has had to be held over for unavoidable reasons until the January-February 2014 issue.

# Problems in residential design for ventilation and noise

## Part 1: natural ventilation

*By Jack Harvie-Clark of Apex Acoustics and Mark Siddall of Low Energy Architectural Practice (LEAP) Northumbria University*

### Introduction

The adverse effects of noise on residents are well known; the general limits for internal ambient noise levels are described in the World Health Organisations Guidelines for Community Noise (GCN)[1], Night Noise Guidelines (NNG)[3] and BS 8233[2]. The adverse impact of inadequate ventilation upon health and well-being is extensively documented[5-12]. Insufficient ventilation can also lead to adverse effects on the building fabric, and there are instances of mould growth in modern dwellings which once again can impact upon health and well-being.

Part F of the Building Regulations requires that there shall be adequate means of ventilation provided for people in the building; Approved Document F (AD-F) describes the meaning of "adequate". As new buildings have become more airtight[13] over recent years, the importance of, and requirement for, adequate provision of controlled ventilation has changed significantly. Although the 2010 edition of AD-F makes 30 references to noise, with recommendations to specific noise standards, noise levels are not generally regulated with ventilation provision.

These articles address three broad problems in residential design for achieving ventilation provision with reasonable internal ambient noise levels. The problems are for the residents who will occupy these buildings, rather than for any particular group of designers. Requirements to limit noise levels in new dwellings are described in planning conditions.

The first problem identified is due to insufficient or inappropriate qualification of the ventilation conditions that should be achieved while meeting the internal ambient noise level limits.

The second problem is with the practical provision of natural ventilation in new dwellings. While noise limits may be required by planning conditions, ventilation provision is regulated by the Building Control Body (BCB). The BCB may permit opening windows for ventilation, while the response to the planning condition assesses noise levels with windows closed, or a lesser provision of ventilation than required under Part F of the Building Regulations. This problem has become more widespread as the required provision of trickle vents has increased between subsequent editions of Approved Document F between 2000, 2006 and 2010 to the point where it is practically unfeasible in many dwellings.

The third problem is noise from mechanical ventilation provision. Mechanical ventilation is increasingly adopted to meet more onerous energy performance requirements, or to limit the potential for external noise ingress.

The problems identified in this article result in new dwellings currently being built that do not enable residents to enjoy reasonable internal air quality and noise levels simultaneously. The ventilation requirements and conditions under Part F are described first. Analysis and discussion of natural ventilation P38

◂P37 provision is then discussed in this article, with consideration of noise from mechanical systems in Part 2 to be published subsequently. These articles are based on the paper presented at the 2013 IOA Spring conference[4].

## Ventilation requirements

Ventilation is the supply and removal of air from a building. AD-F notes that ventilation is to be provided for the following purposes:

- To provide outside air for breathing
- To dilute and remove pollutants in the air, including odours
- To control excess humidity, particularly in rooms such as bathrooms and kitchens.

AD-F identifies three distinct ventilation conditions:

- Whole building / dwelling ventilation – provided continuously when occupied
- Extract ventilation from wet rooms – provided intermittently when required
- Purge ventilation – provided throughout the dwelling, intermittently

The provision of "adequate ventilation" includes meeting all these requirements at different times. Ventilation air may also be used as a means to cool buildings – i.e. to assist in the provision of thermal comfort, but this is not controlled under AD-F. In this respect AD-F may be understood to relate to the ventilation requirements during the heating season.

Overheating is also an increasing problem in new buildings, and becomes highlighted during heat waves such as experienced this summer. For buildings in use, using natural ventilation is typically the default – and may be the only practical – strategy to control overheating. The acoustic conditions while attempting to control overheating with natural ventilation is beyond the scope of this article; this subject is starting to be addressed in more detail elsewhere.

AD-F gives three methods of compliance for new dwellings:

- Providing the ventilation rates shown in Tables 5.1a and 5.1b of AD-F which are required for any ventilation system.
- Following the guidance provided for the four types of systems outlined in section 5 of AD-F. Where background ventilators (also referred to as "trickle vents" within AD-F) are employed, sizing charts are provided to determine the minimum provision. These systems are discussed in more detail below, as they are the most common means of compliance.
- Meeting the performance criteria set out in Appendix A of AD-F. These criteria are exposure levels of various indoor air pollutants; this method is provided for reference, and forms the reasoning behind the minimum ventilation rate based on floor area, which is frequently overlooked by designers and commissioning engineers.

AD-F describes four types of ventilation systems for dwellings, summarised below; there is more detailed guidance in the Domestic Ventilation Compliance Guide[14].

### System 1 – Background vents with intermittent extract

Background ventilators are considered to provide whole dwelling ventilation; this is then supplemented by intermittent mechanical extract from wet rooms (such as kitchens, bathrooms and utility rooms). Purge ventilation is generally provided by opening windows. System 1 is often the default ventilation strategy, bearing most resemblance to traditionally established systems and expectations. The effective area described in AD-F for trickle vents is based upon a defined set of meteorological conditions, Where the conditions vary, the suitability of the ventilation provision may be questioned; this is not a matter that is addressed further in this article.

### System 2 - Passive Stack Ventilation (PSV)

This system comprises vertical ducts to roof terminals from wet rooms. Polluted air is drawn up the ducts by wind or stack effects. The replacement air is considered to be provided by means of background ventilators. This system is rarely used (see below), hence is not discussed further in this article.

### System 3 –MEV and System 4 - MVHR

System 3, Mechanical extract ventilation (MEV), and System 4, Mechanical ventilation with heat recovery (MVHR) are discussed in Part 2 of this article.

### Popular ventilation systems currently used

According to BSRIA, a survey[16] of dwellings constructed in 2011 to the 2010 Part F requirements found the breakdown between ventilation System types to be as shown in Table 1. Given that more than 135,000 new dwellings were completed in 2011, this illustrates that large numbers of dwellings are being constructed with Systems 1, 3 and 4.

### Purge ventilation

| AD-F System | Percentage of new dwellings adopting System type |
|---|---|
| 1 | 30 % |
| 2 | 0.5 % |
| 3 | 40 % |
| 4 | 29.5 % |

Table 1: Percentage mix of new build ventilation System types from a 2011 survey sample

The requirement for purge ventilation is in AD-F is described as:

"*..to aid the removal of high concentrations of pollutants and water vapour released from occasional activities such as painting and decorating or accidental releases such as smoke from burnt food or spillage of water. Purge ventilation is intermittent, i.e. required only when such occasional activities occur.*"

There is guidance in AD-F for the provision of opening windows so as to allow for purge ventilation at a rate of 4 air changes / hour (4 ach). This guidance is again based on presumed temperature and meterological conditions; lower levels of ventilation may result if the conditions are different. If not provided with opening windows, mechanical systems are presumed.

AD-F provides guidance for a number of ventilation conditions. These are explored in more detail during the following section, as are further ventilation conditions that relate to acoustic design.

## Noise aspects of natural ventilation conditions

### Whole dwelling ventilation

It would seem entirely appropriate to achieve indoor ambient noise level limits while providing whole dwelling ventilation, as this is required continuously while the dwelling is occupied. This should be the minimum requirement associated with limits for external noise ingress.

### Control of humidity in wet rooms

For the control of humidity from bathrooms and kitchens, System 1 relies on fans providing intermittent extract ventilation. The intermittent extract rates required are similar to purge ventilation rates for those rooms. While high noise levels under intermittent extract conditions may be annoying and are reported anecdotally[17], no systematic research of acceptable levels has been identified. Although one fan manufacturer currently claims on their website that "*a recent survey showed that over 40% of people said that they or their children have been woken in the night by a noisy bathroom fan*", the manufacturer has been unwilling to elaborate on the survey to which they refer. Systematic research is needed to inform acceptable noise limits for this ventilation condition.

### Purge ventilation and over heating

As for intermittent extract, tolerance of noise levels under purge ventilation conditions has not been widely researched and is not widely reported, although interactions have been noted between noise, air quality, thermal comfort and lighting[18].

Although thermal comfort is not addressed by AD-F, purge ▸

ventilation may be used to control overheating. Whilst the relationship between noise, temperature and comfort in a residential environment is not well explored some studies have been undertaken. Research by Santos and Gunnarsen revealed that a decrease in noise level of 7dB gave the same decrease in annoyance as a 1°C reduction in operative temperature[19]. Separately, Clausen et al. found that, within a temperature range of 23-29°C, a 3.9dB change in noise level had the same effect on comfort as a 1°C change in operative temperature[20].

It is reasonable to suggest that purge ventilation and sleep may not be compatible as purge ventilation is intended to be intermittent and sleep is preferably taken continuously. Therefore if purge ventilation is necessary to control overheating, occupants may choose to sleep with the windows open overnight if the noise levels are tolerable.

The provision of purge ventilation (4 ach) may be considered by mechanical means using the same system components as for whole building ventilation. The purge ventilation rate is likely to be at least 8 times the whole dwelling ventilation rate which would result in fan noise increasing by many tens of decibels for this increase in flow, consequently the fan would need to be significantly oversized as compared to the whole building ventilation rate. Ducts also need to be sized sufficiently to prevent regenerated noise becoming excessive. For example, in a 40 m$^2$ flat, the primary duct may need to be 300 mm diameter to limit regenerated noise. The requirements for a mechanical system to provide the required purge flow while meeting the preferred noise level limits is not therefore considered to be particularly practical, sustainable or affordable, despite sometimes being required by planning conditions.

Larger mechanical ventilation systems that are not intended by the manufacturers for domestic installation are not generally tested for thermal performance in accordance with Part L requirements; the effect of this omission is that the mechanical efficiency is penalised in thermal performance assessment, with the consequent effect that the designers must make up for this shortfall in assessment of thermal performance elsewhere; this may mean more thermal insulation in walls, higher rated windows etc – all with design and cost implications. To overcome this problem, when forced down the route of providing purge ventilation mechanically, designers have recently proposed entirely separate systems for the whole dwelling ventilation and purge ventilation.

More research is required to identify acceptable noise levels under purge ventilation conditions. These limits may be different for external noise ingress, if purge ventilation is provided with opening windows, or for noise from mechanical services. The role of purge ventilation in controlling overheating needs to be both qualified and quantified to determine the actual ventilation rates required to control overheating to identified extents and to enable reasonable internal environmental quality. A means of mechanical cooling provision may be a necessary consequence of providing suitable standards of indoor environmental quality with ventilation and control of external noise ingress. Acoustic issues associated with mechanical cooling should therefore also be a consideration in the building services design.

## Requirement to limit noise levels in dwellings

Requirements to control external noise ingress into new dwellings are described in planning conditions, generally where environmental health officers identify external noise as being a concern. Some local authorities describe levels of external noise sufficient to warrant a planning condition in their local plans, others determine the requirement on a case by case basis.

In our experience local planning authorities (LPAs) lack a singular coordinated method for stipulating how noise related concerns may be addressed. For instance, planning conditions may require a scheme of sound insulation against external noise with windows shut and another means of ventilation provided, or refer to a scheme of “acoustic glazing” or “acoustic vents”. Planning conditions most commonly make no reference to, or requirement for, associating ventilation provision and noise levels, or they may call for internal ambient noise levels to be achieved when windows are open for amenity, irrespective of ventilation provision. Some LPAs require that the internal ambient noise levels are achieved during purge ventilation provision.

Without a coordinated methodology and standard it is not possible to ensure consistent and appropriate environmental noise standards at a national level; suitable technical guidance on this matter would be beneficial. Technical guidance to accompany the National Planning Policy Framework[15] would benefit many local authorities, who do not necessarily have the resources to develop this themselves. It is suggested that internal ambient noise level limits should be achieved whilst ventilation is provided at the whole dwelling ventilation rate.

## Details of natural ventilation provision

This section explores the constraints and limitations of providing trickle ventilators within dwellings. The general calculation method for the sound insulation provided by façade elements is described in BS EN 12354-3[21]. The application of this Standard and manufacturers’ literature for the sound insulation of their products is used in the assessment below. Six varieties of through-frame trickle vents of nominal 4000mm$^2$ free area were tested[22] and shown to have a typical $D_{n,e,w}$ ($C_{tr}$) of 34 (-1) dB. The equivalent area of such vents is typically a little over 2,500 mm$^2$, for a unit length of between 400 and 500 mm. The sound insulation provided by various elements and partially open windows has been extensively researched and documented[22,23]. The EU SCATS project[24] for example accepted that, at an open window, the noise attenuation is 10–15 dB. The example dwellings examined below have been taken from Appendix C of AD-F.

### Ground floor flat example

The example in Appendix C of AD-F shows that in a single bedroom, ground floor flat of 36 m$^2$ floor area, the total equivalent area of background ventilators should be at least 35,000 mm$^2$. Such a dwelling may only have windows in the bedroom and living room. The total length of typical trickle vents required for the flat would be in the region of six or seven linear metres. This extent of window frame is unlikely to be available in a dwelling of this size. Disregarding these practicalities for the time being, based on typical through-frame slot vents, seven units may be required to provide the required equivalent area, and the sound level difference into the small bedroom in example C1 of AD-F is some 19 dB with standard trickle vents. If the night time internal level limit is 30 dB(A), this would limit external noise impact to no more than 49 dB(A) if this ventilation strategy is to be feasible. Such an external noise level would not traditionally be considered to be incompatible with a natural ventilation strategy.

In this same example dwelling, if the design air permeability is less than 5.0 m$^3$/m$^2$.hr, an additional 10,000 mm$^2$ of background ventilator effective area is required. This would increase provision to 45,000 mm$^2$, with consequential implications for sound insulation. Even more significantly, however, if the flat has a single exposed façade, the area of background vents determined from Table 5.2a is required at both low and high level within the façade - the area requirement is doubled. This would appear to offer increasingly few possibilities for natural ventilation without a bespoke ventilator design, as well as being practically unfeasible with background ventilators.

### Semi-detached house example

Example C5 of AD-F shows that for a semi-detached house of 84 m$^2$ floor area, the total equivalent area of background ventilators should be at least 40,000 mm$^2$. With five habitable rooms and two wet rooms, let us assume 2,500 mm$^2$ equivalent area in the kitchen and bathroom, leaving 35,000 mm$^2$ required between the dining room, living room, and three bedrooms. Noting as above this would typically require three through frame trickle vents each around 450 mm long, in each habitable room.

Again disregarding practicalities, with three typical through-frame slot vents, the sound level difference into the small P40

P39 bedroom in the example of AD-F is some 21 dB. This may be compared with a typical sound level difference through 4-16-4 mm double glazing, assuming a window area that is 10 % of the floor area, of 31 dB for road traffic noise. Hence the limiting factor for the façade sound insulation is likely to be the ventilation detail and room volume, rather than the glazing.

**Challenges in natural ventilation provision**

The examples above illustrate how sensitive the façade sound insulation design is to the ventilation strategy, and how the background ventilator requirement is a function of not only the internal floor area and number of bedrooms, but also the design air permeability, the height of the dwelling above ground level and the number of exposed façades. The practicality of incorporating the number of background ventilators calculated is often unfeasible.

Evidence demonstrates that Building Control frequently accept that partially open windows may be relied upon for compliance with Part F, whether or not appropriate provision of background ventilators is made[17]; however, despite the merits of disregarding the guidance of AD-F, the ability of such a strategy to provide adequate ventilation is highly questionable, and clearly this undermines any façade sound insulation performance when ventilation is provided.

Building Control and Planning are separate functions; there is generally no coordination between them - so that the means of compliance with Building Regulations is of no concern to the LPA. The LPA may be satisfied that façade sound insulation is achieved with suitable glazing and perhaps one or two trickle vents (depending on their views), while Building Control may simultaneously consider that opening windows may be required to provide the ventilation. The occupants may therefore choose suitable internal noise levels or adequate ventilation, but not both.

When considering noise ingress through glazing, the glazed area is typically proportional to the floor area and hence room volume, so that the sound level difference is roughly independent of room size. When considering ventilation openings, the sound level difference is a function of room volume only. Hence meeting the requirement for background ventilators is typically the most significant constraint in controlling external noise ingress into small rooms, thereby limiting the potential for using System 1. The significantly increased requirement for background ventilators with System 1 in the current version of AD-F over previous versions can mean that this strategy is now acoustically unfeasible on sites where previously it would have been possible.

Although there has been some work to develop methods to assess openings for natural ventilation that control noise without unduly restricting air flow[25], there are no general solutions widely available for residential design. "Acoustic" trickle vents are widely available, and can provide higher levels of attenuation, however the acoustic attenuation also often typically reduces the airflow performance, and lower effective areas are achieved with larger units. Effective acoustic designs tend to be so much larger than "standard" type vents that it is entirely impractical to incorporate the effective areas calculated into the façade. Bespoke natural ventilation design solutions are available from a few manufacturers[26], but the impact on the façade is generally significant; this requires a commitment from the developer and architect early in the design process to adopt these solutions.

### Commissioning

The experience of the acoustic consulting industry clearly demonstrates that if a particular level of acoustic performance is sought, there needs to be a robust commissioning regime to ensure its implementation. Similarly as for insufficient sound insulation between dwellings, excessive ambient noise levels can be harmful to health, and ensuring compliance with the performance requirements that have been established for more than a decade would seem appropriate.

No doubt acousticians would agree that commissioning checks on performance are only effective if there is also a requirement for the person carrying out the measurements to be independently accredited by a third party, to ensure consistency and to mitigate potential pressure brought to bear on the tester by the contractor. Testing on completion is risky for contractors; they need to be able to effectively manage the risk, which would mean that buildings would need to be appropriately designed and constructed; perhaps a Robust Details type scheme may also be appropriate. In our experience commissioning measurements are very seldom conditioned by LPAs; without this requirement there is no effective enforcement of the conditions.

## Conclusion

Problems with achieving suitable natural ventilation and reasonable internal noise levels have been identified and discussed. The first problem is insufficient qualification of the ventilation condition that should be achieved while meeting the internal ambient noise level limits. It is suggested that as a minimum, the provision of whole dwelling ventilation in accordance with AD-F should be assessed and controlled to meet suitable noise limits, with a requirement for commissioning checks on completion.

The second problem concerns the practical provision of sufficient trickle vents if a natural ventilation strategy is sought; the sensitivity of the façade sound insulation design to the details of the ventilation requirements must be considered early in the design. It is noted that the trickle vent provision may also rely on the design air permeability. The example calculations demonstrate that natural ventilation using System 1 may require so many trickle vents that the achievable performance may be only marginally better than opening windows. Evidence demonstrates that there is often significant under-provision of the necessary quantity of vents in practice; this means that the Building Control body may consider that opening windows provide the required ventilation, while the sound insulation strategy offered to the LPA relies on windows being closed. This problem could be overcome if the combination of ventilation and noise levels – i.e. internal environmental quality – were addressed wholly within either Building Regulations or Planning requirements. A requirement for commissioning measurements is considered appropriate in all cases.

Further UK specific research is required into acceptable noise levels for the provision of intermittent extract and purge ventilation, from both external sources and mechanical services; owing to the complete lack of data currently, they may be temporarily excluded from consideration within design.

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# Floating room systems for noise reduction in mechanical spaces

*By Martin M. Deveci of Acrefine Engineering*


## Abstract
One of the main sources of noise and vibration in buildings is mechanical and electrical equipment. This includes, but is not limited to, pumps, fans, chillers, cooling towers, generators and compressors. These machines, whether rotating or reciprocating, generate vibration and noise which is emitted to the surrounding area as structure and airborne noise. These problems are naturally more apparent when mechanical rooms are close to occupied spaces, especially in high-rise buildings, where these rooms are often located in mid levels or in buildings with space limitations. A very effective way to overcome this problem is to use floating systems that create air gaps between the main structure and the mechanical room. Resilient mounts are used to create air gaps between the floor, ceiling and walls. The main purpose of these systems is to minimise noise transmission to the surrounding area. Floating floors are also used to limit vibration isolation for some types of equipment. These systems should not be used to carry large loads. Heavy equipment should be mounted directly to the main structure. Primarily these systems are used for noise and vibration control, thus allowing architects and designers flexibility in locating mechanical rooms in spaces that would otherwise not be possible.


## Introduction
HVAC systems are major sources of unwanted noise and vibration in buildings. The main reason for this is mechanical equipment running with disturbing frequencies, thus transmitting vibration to the structures. Advanced systems can be used to minimise these effects and make buildings more comfortable. Designers can locate HVAC equipment in common rooms, allowing them to control noise and vibration with floating room systems. This effective method can be very beneficial where space is minimal and mechanical rooms are built next to noise sensitive areas.

## Methods and materials
Floating rooms are resiliently mounted systems that create air gaps between the walls, ceiling and floor of mechanical rooms. They are used to isolate sound when transmission loss through the standard structure is not adequate. A floating room performs acoustically on the principle of creating air space that provides a much greater noise transmission loss than if the wall or floor were continuous.

A typical floating room system is shown in Figure 1.

## Floating floor
This is the most common part of the floating rooms system. It can also be used on its own when the main concern is minimising sound transmission to rooms below. Floating floors are constructed directly on the main supporting floor slab. P42

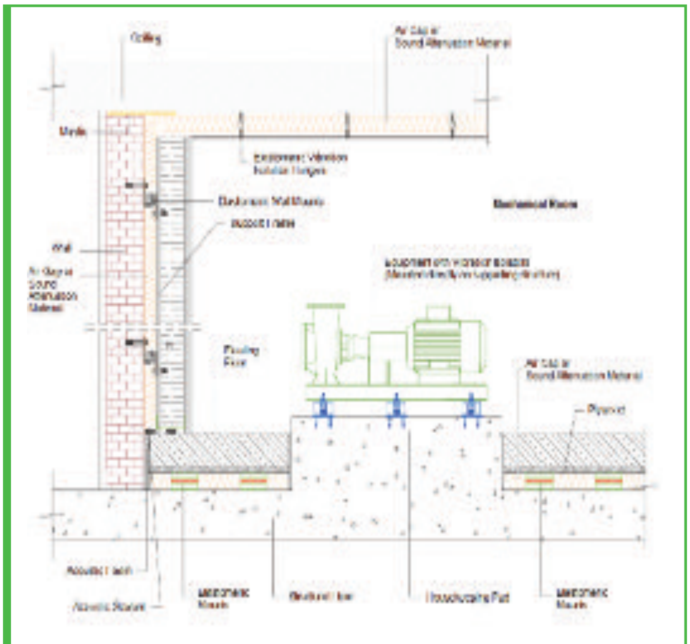


Figure 1. Floating room consisting of resiliently mounted floor, walls and ceiling in mechanical space

◀P41 Typically they are 100mm thick reinforced concrete on plywood and supported by resilient mounts. These mounts are points of short circuit which are not desirable for the acoustic performance. Selection of correct mounts and designing the layout become important factors that influence the sound isolation properties of the system. Hence the natural frequency of the mounts determines to a great extent the overall performance level. In practice, floating floors of natural frequency of 15 Hz can be achieved. This is low enough to have significant impact on audible frequencies. On the other hand, this frequency is not low enough to isolate vibration generated by common equipment types.

Two methods are used to eliminate vibration isolation. One is to install equipment on a floating floor and the other is to mount it onto a supporting slab. In both methods vibration isolators are used. Mounting equipment directly onto a floating floor reduces flanking paths and results in some acoustical benefit. However, it is important to note that this creates a system with two different stiffnesses. Attention should be paid to ensure there are no common natural frequencies present between the floating floor isolation system and any equipment isolation mounted on it. This requires adequate damping to be provided by the floating floor. If the selection of resilient mounts for both systems is not correct, vibration transmission can increase rather than decrease. Mounting all equipment, especially heavy items, directly on the floating floor increases the number of resilient supports. This results in more short circuiting points, hence compromise in the acoustical performance. This effect is more predominant on elastomeric-type resilient mounts. To decrease the loading on the floating floor heavy equipment is installed directly to the supporting structure. This also eliminates the problem of common natural frequencies between the floating floor and vibration-isolated equipment.

The most common resilient mounts used to support floating floors are elastomers and compression springs. Elastomers provide a cost-effective solution. They are easy to manufacture and come in different shapes and sizes as shown in Figure 2, Type A. The performance of the floating floor is directly correlated to the properties of elastomeric material, especially the dynamic stiffness. Elastomers with low dynamic stiffness should be selected as resilient mounts for floating floor systems. If elastomeric materials do not provide required performance levels, spring mounts shown on Figure 2 Type B, can be used. Helical compression springs can provide very low natural frequencies. A spring with 25mm (1") deflection will have a natural frequency of 3.13 Hz. When one considers the lowest audible frequency of 25 Hz, it is clear that the ratio of frequencies is about 8/1 providing great sound transmission loss even at the lower end of the spectrum. Since springs have very good dynamic stiffness, acoustical performance will not be affected under operational conditions or during the life time of the system.

Beside the natural frequency of the resilient mounts, trapped air between the floating floor and supporting slab is also an important factor in determining the acoustical performance of the system. The natural frequency of resiliently mounted floors with air gaps is given by:

$$f_n = \frac{1}{2\pi}\sqrt{\frac{k_a + k_{rm}}{M}} = \sqrt{f_a^2 + f_{rm}^2} \qquad (1)$$

where: $f_n$ = combined natural frequency (Hz)
$k_a$ = air stiffness (N/m)
$k_{rm}$ = resilient mount stiffness (N/m)
$M$ = total mass supported (kg)
$f_a$ = natural frequency of air gap (Hz)
$f_{rm}$ = natural frequency of resilient mount (Hz)

Air stiffness (ka) can be calculated from the equation given below:

$$k_a = \frac{\rho . c^2}{t} \qquad (2)$$

where: $\rho$ = density of air (kg/m³)
$c$ = speed of sound through air (m/s)
$t$ = thickness of the air gap (m) ▶

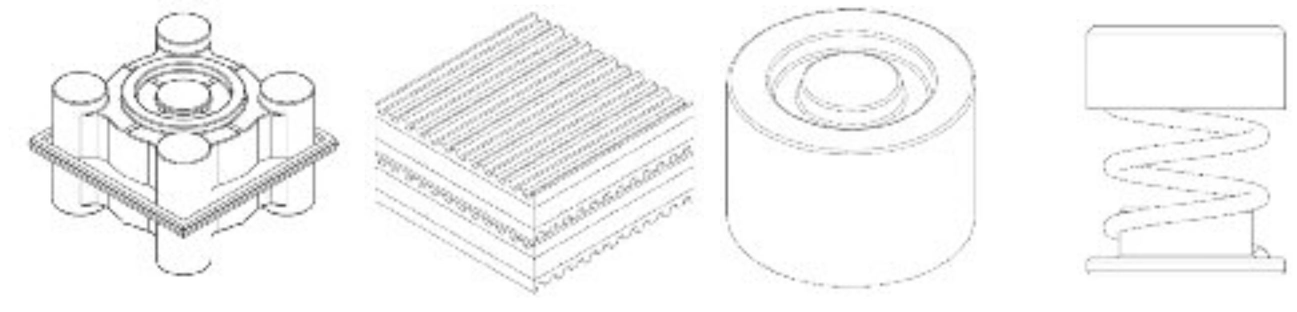


Figure 2. Floating floor resilient mounts: Elastomeric mounts Type A, Compression springs Type B

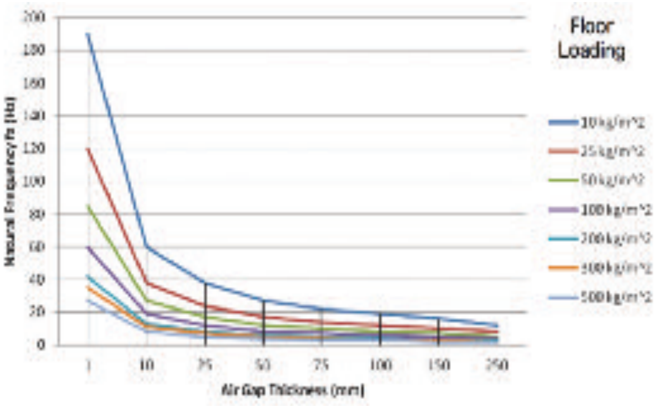

Figure 3. Effect of air gap thickness for various floor loadings

Natural frequency due to the air gap is:

$$f_a = \frac{1}{2\pi}\sqrt{\frac{k_a}{M}} \qquad (3)$$

substituting $k_a$ in equation (3) with air density r= 1.2 kg/m³ and speed of sound c= 340 m/s results in

$$f_a = \frac{19}{\sqrt{M.t}} \qquad (4)$$

Natural frequency of the resilient mount is given by equation:

$$f_{rm} = \frac{1}{2\pi}\sqrt{\frac{k_{rm}}{M}} \qquad (5)$$

which can also be expressed only as a function of the deflection:

$$f_{rm} = \frac{1}{2\pi}\sqrt{\frac{g}{d}} = \frac{0.5}{\sqrt{d}} \qquad (6)$$

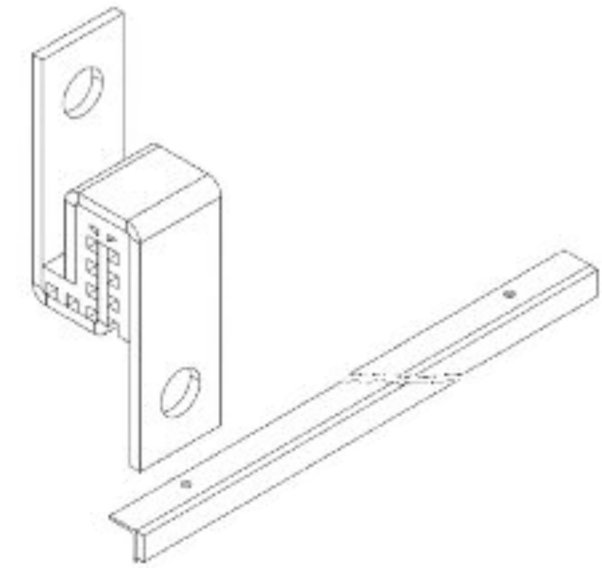
Figure 5. Floating wall mounting bracket and wall brace

where: $g$ = acceleration due to gravity (m/s²)
$d$ = static deflection of resilient mount due to weight (m)

Using the above equations, the effect of air gap thickness can be examined for various floor loadings. Results are plotted in Figure 3.

It is clear that increasing the air gap thickness reduces the natural frequency and results in better acoustical performance. Especially for lightweight systems larger air gaps are preferable. In many cases air gaps of 25 to 50 mm are sufficient to obtain low natural frequencies as the resilient mounts further reduce the natural frequency of the system. For example, a floating floor with 100 kg/m² loading that is supported by elastomeric mounts with static deflection of 10 mm and an air gap of 50 mm will result in a system with natural frequency of 9.9 Hz. Acoustical performance of the floating floor can be improved further by installing sound attenuation materials in the air gap. P44

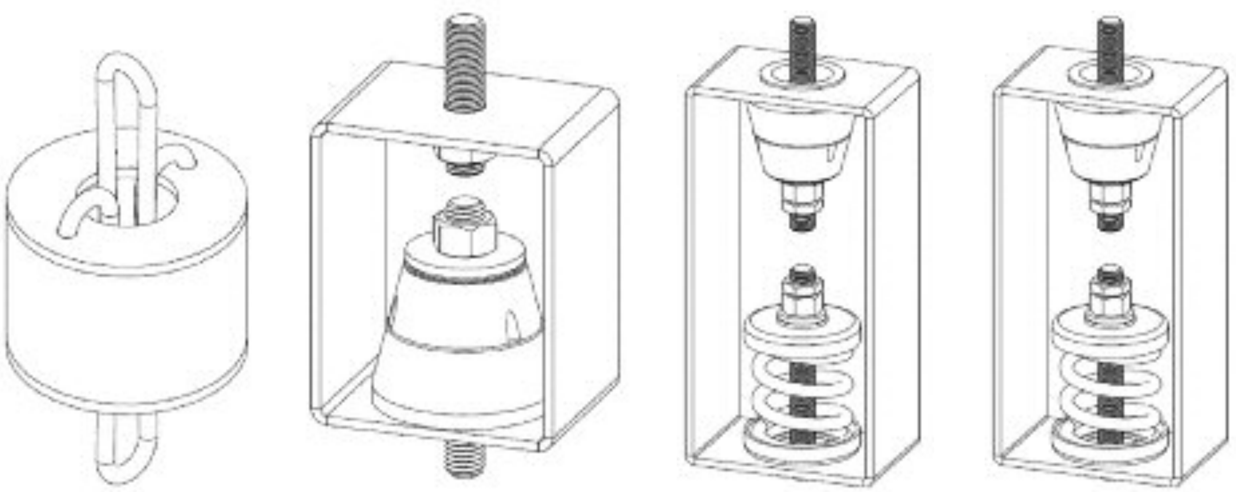
Figure 4. Typical isolation hangers used for floating ceilings

## Floating ceiling

◀P43 Similar to a floating floor, an air gap can be created between the ceiling and mechanical room. A floating ceiling is installed by using resilient mounts, namely elastomeric, spring or combined hangers as shown in Figure 4. Typically the construction is a suspended frame with gypsum boards attached to it. All HVAC equipment and piping, ducting installations that are supported from the ceiling should be mounted directly to the structure and resilient mounts should be used where required. Most commonly these systems are used to isolate two vertically adjacent spaces. In these situations mechanical equipment should be installed below the floating ceiling so that the performance is not compromised. Sometimes these are used to isolate sound transmission from suspended equipment to the space below. In both cases ceiling penetrations should be avoided or, if this is not possible, all penetrations should be properly sealed.

## Floating wall

These are walls that create an acoustical air gap on the mechanical room's walls. They are installed with special brackets that include elastomeric elements to provide resilient mounting.

Figure 5 shows a typical mounting bracket and wall brace that are used in installing flooring walls. Mounting brackets are attached directly to the main wall of the room a support frame is then used to mount gypsum boards. Again the purpose of the floating wall is to create an air gap and not carry loads. Hence any wall mounted equipment should be supported directly through the main walls of the mechanical room.

Very high levels of acoustical performance can be achieved when the above systems are used together and constructed properly. It is important to point out that acoustical performance depends on the resilience of the system. Therefore all penetrations and intersections with other surfaces must allow the floating system to float and have no rigid connections.

## Results

Creating an air gap by using resilient mounts provides a very effective way to reduce noise and vibration transmission from a mechanical room to the surrounding area. The natural frequency of the system depends on the natural frequencies of the resilient mounts and air gap and typically 15Hz can be achieved.

The main benefit of floating rooms is the airborne noise reduction. Sound Transmission Class (STC) in the range of 75-80 is possible for floating floors with 150mm solid concrete floor and 100mm isolated concrete slab.

Using resilient mounts provides the added benefit of vibration isolation. Structure-borne vibration transmission is reduced from equipment mounted on the floating floor.

## Conclusions

Floating rooms allow architects and HVAC system designers the flexibility to locate mechanical rooms in noise sensitive areas and so use space much more efficiently. Especially in high-rise buildings space can be allocated for mechanical rooms on middle or top levels. With this type of flexibility designers can reduce costs and create much more effective HVAC systems. Lowering energy consumption reduces running costs and results in sustainable buildings with less carbon emissions.

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# Recreational noise – the ticking time-bomb?

*By Richard V Harrison, Senior Scientist, the Hospital for Sick Children, Toronto, Neuroscience and Mental Health Program; Professor, Department of Otolaryngology – Head and Neck Surgery and Department of Physiology, University of Toronto*

Today, we live in a noisy world, not least because of electronic amplification and the wide-scale use of sound entertainment devices. In some domains there are rules and precautions to prevent over-exposure to loud signals (e.g. in military and industrial environments). However, in the private realm of audio entertainment devices there is very little regulation, and in any case individuals are ultimately free to make a choice about how much noise exposure they subject themselves to.

## Noise-induced hearing loss: is there really a problem?

Yes there is, and this is the simple logic we can apply: [1] We know from many studies, both in humans and animal models, the levels and durations of acoustic signals that can cause damage to the cochlea. [2] We know the levels of acoustic signals that are generated at various entertainment venues, or can be produced by personal entertainment devices. And we also know from a number of surveys the levels that individuals set for listening to their MP3 players, as well as their duration of usage. [3] These levels and durations are often well ABOVE those that we know can cause cochlear damage!

This article reviews very briefly how noise can damage the inner ear and provides an overview of some of the evidence that noise induced hearing loss is problem now and is also a ticking time-bomb. Finally some ideas about prevention are discussed.

## How does sound damage the cochlea?

We now have decades of research data that reveal how loud acoustic signals can damage the cochlea. Much of the earlier work was based on audiometric studies in humans exposed to noise in heavy industry and the military. We also have considerable basic science work, in which the damaging effects of high intensity ▶

◄ sound have been explored at the mechanical, physiological and biochemical levels in the cochlea. We know that ways in which the ear can be damaged by acoustic trauma are many fold and very complex, and that there are no simple rules that relate the type or level of noise exposure with the degree of cochlear dysfunction. For example, intense ballistic noise can directly damage the cochlear very differently from a low long-term noise exposure. Intense noise greater than 130 dB SPL can directly cause mechanical damage to the cochlea, including the organ of Corti and tectorial membrane; haircell and neuronal degeneration will follow. Damage to the sensory epithelium can directly cause haircell damage, and any mixing of endolymph and perilymph, which will produce more extensive lesions. Cells that are damaged may release cytotoxic agents, for example free radicals. Importantly, degenerating haircells can release excessive amounts of neurotransmitter that will damage cochlear afferent neurons (excitotoxicity).

Milder acoustic exposure for extended periods of time can result in biochemical changes in haircells, for example, "metabolic depletion". The anatomical evidence for such metabolic stress includes damage to the mitochondria and vacuolization of the endoplasmic reticulum, which indicate changes to both cell metabolism and protein synthesis. Other typical intracellular changes are swellings within the haircells and an increase in lysosomal bodies, which are precursors to apoptosis (cell death).

One of the most obvious signs of acoustic trauma is a change in the structure of the stereocilia. These are part of a delicate micro-mechanical system, and very minor damage will render a haircell ineffective and likely lead to cell degeneration. I have included here in figures 1-3, some electron micrographs showing various stages of damage to the stereocilia of hair cells as a result of acoustic trauma. These images also serve as useful visuals to give some "reality" (shock visuals?) to the damage that can be caused by loud noise exposure!

After noise exposure, in addition to the obvious disarray of the stereocilia, more subtle changes have been observed in the (intracellular) roots of the stereocilia, and in the links that hold adjacent stereocilia together in a bundle. Most importantly, there can be disruption of the tip-links and the function of mechanically gated ion channels that are essential for haircell depolarization (excitation).

Acoustic trauma only starts at the cochlea. It is essential to note that when haircells of the cochlea are damaged there are secondary effects. As previously mentioned, excessive release of glutamate neurotransmitter from inner haircells will result in damage to cochlear afferent neurons.

## Temporary Threshold Shift (TTS)

Sometimes after noise exposure, hearing sensitivity change is temporary, a common experience after a long bus journey or following a loud music concert. Whilst there is an impression that hearing thresholds fully recover after such noise exposure, it is likely that repeated episodes of TTS will eventually result in permanent damage. If there is a tinnitus associated with the noise exposure, then this is certain evidence that the ear has been damaged. The immediate ringing in the ears after acoustic trauma is almost certainly the result of an injury discharge in cochlear neurons, which are in the process of dying. As with all other mammals we are born with a fixed number of cochlear haircells and they do not regenerate. If we kill haircells by noise exposure, they are lost forever.

## Is noise-induced hearing loss a problem? What is the evidence?

We all have concerns about hearing loss that can result from sound exposures at concerts, in bars, and through the use of personal entertainment devices, including video games and MP3 players. But is it really a big problem? As healthcare professionals we seek the evidence, but it has to be said that high level evidence is missing. "Level A" evidence would be that provided by a prospective, randomized, control trial. However, it is very difficult to conceive carrying out such a study for obvious ethical reasons. Therefore we are left with lower levels of evidence, but this is quite extensive and convincing.

There are a number of large scale population studies in which hearing loss in school aged children has been examined, and surveys in the US, Canada and some European communities generally indicate that 12-15% of school-aged children have a hearing deficit, much of which is attributable to noise exposure. Then there are many smaller scale studies carried out in tens or hundreds of subjects that also reveal that 10-16% of teenagers have some form of hearing loss that can be attributed to noise exposure. Of note, there have been a few studies in which adolescents have been seen by a hearing healthcare professional because of tinnitus, and in these cases the majority have described the cause as being the result of recreational music. It is of interest here that the damaging effect of noise exposure has revealed because of the tinnitus rather than any sensorineural hearing loss that perhaps the patient has not yet become aware of. See the reference list for more details on these studies.

## The ticking time-bomb

The title of this article implies that a hearing loss due to noise induced damage hearing can be delayed by many years, as is yet to be revealed. Mention above was made of individuals P46 ►

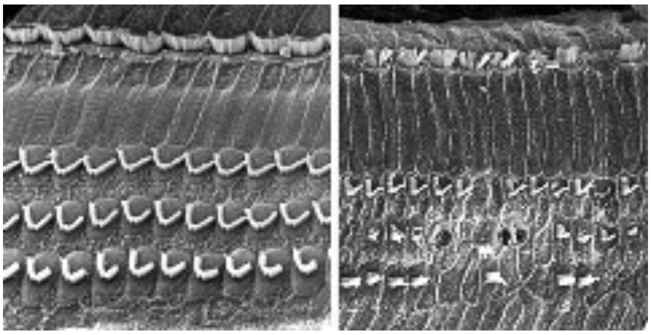

Figure 1. Normal cochlear hair cells (left), and after intense noise exposure (right).

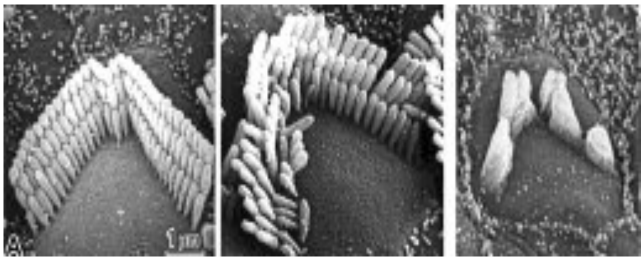

Figure 2 Changes to cochlear hair cell resulting from acoustic over-stimulation. Normal structure (left); disruption of stereocilia bundle (centre); hair cell death (right).

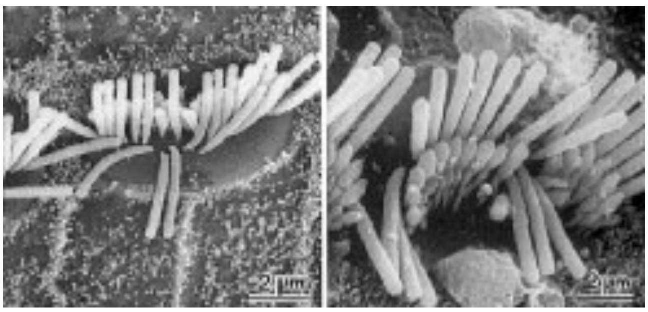

Figure 3 Hair cells that have lost the integrity of the stereociliar bundle as a result of acoustic over-stimulation. These cells will not recover and eventually die!


Figure 4 Sound Sense poster from the Hearing Foundation of Canada [78,79].

◂P45 seeking healthcare attention after acoustic overexposure not because of hearing loss, but because of tinnitus. It is quite clear that very mild levels of sensorineural hearing loss are often not apparent to individuals. Evidence suggests that mild acoustic trauma repeated during early adolescence may not "become a problem" until much later in life. This reinforces the notion that perhaps noise exposure effects are cumulative, and that many episodes of damage are required to result in a clinically significant hearing loss. A very important point here is related to the redundancy of haircells in the cochlea. We are born with many thousands of haircells, many more than we need at any one time. There can be many sensory elements lost through noise exposure with little effect on hearing because of the redundancy in the system. However, repeated insults will gradually deplete the haircells. Acoustic overexposure in young people may not be manifest as hearing loss until much later in life when the final remaining haircells are lost. In this respect, some argue that the noise trauma can accelerate the natural age-related hearing loss (presbyacusis). Rather, I would suggest that the noise trauma can significantly pre-deplete the haircell population, such that there is little to start with when age-related degeneration starts.

## Practical advice about prevention of noise induced hearing loss

Legislation, guidelines and rules can help to prevent noise induced hearing loss. For example, some jurisdictions (notably the European community) have requested manufacturers of MP3 players and other personal entertainment devices to limit sound level output levels. However there is really no control over the type of earphone or other external amplification devices, and it is clear that many young people can and will ignore or circumvent these impositions. I am of the opinion that is really up to society, i.e. parents, teachers, healthcare professionals, to educate children regarding the dangers of noise induced hearing loss. Fortunately, there are many public awareness campaigns, and there are some educational programs in schools that teach children the risks of listening to loud sounds. There are a number of excellent educational websites (listed at the end of this review) that are useful tools providing information for children, as well as teachers and parents about the risks of noise induced hearing loss. Figure 4 shows a poster for "Sound Sense", an educational programme set up in Canada by the hearing Foundation of Canada, to promote awareness about noise induced hearing loss in school-aged children.

Perhaps one of the most persuasive sources of information comes directly from the manufacturers of MP3 players for example. In the packaging for most devices there are pamphlets or warnings about the risks about noise induced hearing loss. Young children and adolescents should be made aware of these manufacturers' warnings. Often they provide detailed guidance on levels and durations of use that are safe. Regarding the intensity levels, one important problem is the tendency to turn up the volume on an MP3 player when in a high noise environment. Here is useful to suggest (to a child) that the device volume be set in a relatively quiet environment, and not further increased when in a noisy setting. There is some evidence that breaking up periods of exposure to loud music may allow the ear to "recover". Thus for every few hours of listening, there should be a break.

One of the most important factors relating to noise exposure risk is the type of earphone or headphone used. Here there is no single answer to what is best. The least risky in terms of potential to do damage are loose fitting ear buds that do not insert tightly into the ear canal. These are typically small transducers and are not transmitting acoustic energy into a confined space. On the other hand, these ear buds do not insulate the listener from environmental noise, and there is likely a tendency to increase the volume output under such conditions. Larger headphone type transducers may be useful for reducing the environmental noise, and thus allow a lower volume setting for listening to music. However large headphones typically have transducers that are capable of generating high levels of acoustic signal and need be used with caution. Some might recommend noise-cancelling headphones or earphones as a way to avoid environmental sound level issues. These are a nice luxury for the serious music lover, however, for younger people, the isolation from the acoustic environment may have danger factors associated with it.

In summary, the cochlea can be damaged by high-intensities of noise exposure. High-intensities of noise exposure can be generated by personal entertainment devices. When hair cells die, they are not replaced. There is no treatment for noise induced hearing loss that will restore normal function. This being the reality, it is our collective responsibility as hearing healthcare professionals to pay much attention to the issue of acoustic trauma in children.

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**For a full version of this article, with references see:**


- Robert V. Harrison, "The Prevention of Noise Induced Hearing Loss in Children," International Journal of Pediatrics, vol. 2012, Article ID 473541, 13 pages, 2012. doi:10.1155/2012/473541.
- This can be accessed free online at: http://www.hindawi.com/journals/ijped/2012/473541/


**Websites with more information on noise induced hearing loss**

- SOUND SENSE website, http://www.soundsense.ca
- WISE EARS, https://www.nidcd.nih.gov/Pages/default.aspx
- IT'S A NOISY PLANET, https://www.nidcd.nih.gov/health/wise/Pages/Default.aspx
- KEEP IT HEAR, "A noise induced hearing loss awareness campaign," http://www.keepithear.com
- LISTEN TO YOUR BUDS, "Keeping Kids Safe in Sound," http://listentoyourbuds.org
- HEAR-IT (YOUTH), http://www.youth.hear-it.org
- DANGEROUS DECIBELS website, http://www.dangerousdecibels.org

# Gwyn Mapp puts himself on new 'frequency'

Gwyn Mapp, formerly of Extrium, has launched his own acoustics consultancy, Amledd Consulting, in the Cardiff area.

Gwyn, chairman of the IOA Welsh branch, said Amledd – it is Welsh for frequency – "brings together technical, legal and technological expertise to offer an innovative approach to noise and vibration management".

The consultancy's website (**www.amledd.com**) hosts an active Twitter feed that provides an up-to-date account of news stories relating to noise and noise management. It also contains a periodic blog that will discuss important and/or interesting topic relating to noise that have featured in the news in recent times.

For more information, contact Gwyn on **gwyn.mapp@amledd.com**.

Gwyn Mapp

# Jonathan scoops Arup acoustics bursary

Jonathan Scheaffer, from the University of Salford, is the winner of Arup's acoustics bursary for 2013.

His submission "Wave cloud! An open source room acoustics simulator using the finite difference time domain method" was considered to be of great interest and potential great benefit to the industry by the international panel of judges.

The bursary is a global competition that recognises the importance of further study into acoustic design and engineering.

It is open to students, graduates, post-graduates and people not currently in full-time employment. It provides funding for the applicant to present a paper related to the theme of room acoustics at a conference of their choice anywhere in the world in 2013/14. The award is to the value of US$3,500 and covers expenses associated with attending and presenting at the conference.

Jonathan is proposing to present his paper at the 167th meeting of the Acoustical Society of America in Providence in May next year.

# ASK Alex as he launches his own consultancy

Alex Krasnic has launched his own acoustics consultancy, A.S.K. Acoustics, following the demise of his previous employer, Zisman Bowyer & Partners, earlier this year.

"Obviously it was a hard time for me and my former colleagues as a result of the operational difficulties of our industry-respected former employer," he said.

"Nevertheless, some good has come of it as I've been fortunate enough to retain links with a significant number of contacts within the construction industry, many of whom have requested I be novated to a number of high-profile projects.

"Hopefully, this will allow the consultancy to grow organically at a steady pace, as the economic outlook surrounding the industry is predicted to improve over the coming years."

Alex said he has the project expertise and knowledge to take on almost any commitment, from smaller planning and licensing applications to larger-scale acoustic design and commissioning projects.

He is also available on a contract basis for consultancies requiring an extra pair of "acoustic hands", or working with other acoustic consultants keen on forming a collaborative team to bid on larger projects.

Alex can be contacted at: **krasnica@hotmail.com**

Alex Krasnic

# Michael Delany 1934–2013: distinguished acoustician and twice IOA vice-president

## Obituary

Michael Delany was born in Chelsea on 30 June 1934 and was brought up in Roehampton. He won a scholarship to Emanuel School, Wandsworth Common, and went on to gain a BSc 2(i) degree in physics from Battersea Polytechnic. After three years' research at Imperial College into sound generation due to absorption of modulated infra-red radiation, working under Dr R W B Stephens, he was awarded a PhD and DIC in 1958 for his thesis entitled The Optic-Acoustic Effect in Gases. He was also awarded a National Research Council of Canada Post-doctoral Fellowship and spent a year at Dalhousie University, in Halifax, Nova Scotia, investigating the effect of a magnetic field on the propagation of sound in electrically-conducting media.

On his return to the UK he took up a Leverhulme Research Fellowship in the Department of Audiology & Education of the Deaf at Manchester University, investigating the performance of hearing-and-speech-training-aids for severely deaf children. In 1961 he joined the Applied Physics Division of the National Physical Laboratory as a Senior Scientific Officer, where he was to remain for the rest of his scientific career, researching a wide range of topics in acoustics. Significant publications covered the impedance of human ears, leading to the design of an artificial ear; the stability of auditory threshold; the primary calibration of microphones; propagation of sound in porous absorbent material; sound propagation in the atmosphere; prediction of traffic noise levels based not only on empirical data but also including theoretical and model studies; and the design & performance of free-field rooms. Michael Delany was an important member of several British Standards Committees and became the UK expert of several Working Groups of TC29C (Electroacoustics) of the International Electrotechnical Commission. He was the first recipient of the John Tyndall Medal of the IOA in 1975, following which he published a review of sound propagation in the lower atmosphere; this included an extensive account of historical investigations of the speed of sound in air.

Michael Delany served for a period as joint honorary secretary of the Acoustics Group of Institute of Physics, and as a member of the committee was instrumental in bringing together other interest groups to form the IOA prior to organising the International Congress on Acoustics held in the UK in 1974. He established *Acoustics Bulletin*, serving as editor for a number of years, and also served two terms as IOA vice president. He was made an Honorary Fellow of the IOA in 1990.

At NPL he was promoted to Senior Principal Scientific Officer responsible for all acoustics and ultrasonic work then being carried out in the Division of Radiation Science & Acoustics. In 1983, following three years' part-time study on the Southwark Ordination Course, Michael Delany was made deacon in St Paul's Cathedral by the Bishop of London and was priested the following year, serving as a non-stipendiary minister based in his home parish in Hampton, south-west London. By 1987 he felt called to full-time ministry and resigned from NPL to serve as Rector to two parishes in the New Forest. In 1994 he retired to Winterslow, near Salisbury, with his wife Roberta and, after completely refurbishing their bungalow, he pursued his long-term interest in furniture and cabinet making.

Sadly, a few years later the effects of Parkinson's disease became apparent, forcing Michael to find a new hobby which required less physical exertion, and from then on he spent much of his time tracing his family history.

His wife and children (Stephen and Janet) survive him.

Bernard Berry, a former Institute President, adds: "I recall very well how, in October 1970, I met Michael when I went for an interview at NPL for my very first 'proper job' in acoustics. After postgraduate studies at ISVR, I had just returned from Canada, where I had been a guest worker in the Applied Physics section at the National Research Council laboratories in Ottawa.

"Senior staff at NRC in Ottawa who had also worked at Imperial College under R W B Stephens, such as Edgar Shaw and Tony Embleton, had spoken very highly of Michael's work. In fact Michael showed me around the acoustics laboratories at NPL, in the Rayleigh Building, and I found then that he too had made a similar transition from working in Canada, in his case 10 years earlier. When I started work at NPL, a few weeks after the interview, in November 1970, I was greatly helped in my own transition by Michael's kindness and support. Although in subsequent years at NPL, before he left in 1987, he and I worked on very different aspects of acoustics, I continued to benefit greatly from his extensive knowledge, and I feel honoured to have known him."

# Two awards for ISVR's Matthew for research in acoustics metamaterials

Matthew Reynolds, a PhD student at the Institute of Sound and Vibration Research, Southampton, has been awarded two acoustics awards for his research in acoustic metamaterials.

He won the best student paper award in the structural acoustics and vibration category at the 21st International Congress on Acoustics held in Montreal.

More recently he received the Sir James Lighthill prize for the best student paper at the 20th International Congress on Sound and Vibration (ICSV) held in Bangkok. There were over 150 submissions for this year's prize from PhD students from a range of institutions around the world.

This is the second year running that an ISVR student has been awarded the prize; Jordan Cheer won the award last year in Vilnius.

Matthew said: "It is a great privilege to win these awards. To have my work acknowledged by the international scientific community is very flattering and affirming.

"I must extend the credit to the University, the ISVR and my supervisor, Professor Steve Daley, for giving me the opportunity and unique environment in which to carry out this research."

# Roger on right track with Crossrail award

IOA member Roger Dentoni, a noise and vibration consultant engineer, has won a Network Rail delivery award for "outstanding work on delivering the noise and vibration requirements on the Crossrail project".

More than 200 engineers from a wide range of disciplines are working on the delivery side of Network Rail's programme for Crossrail, most of whom were competing for the award.

Roger with his award

# Marshall Day in Irish wind farm noise study

Marshall Day Acoustics has been commissioned by the Sustainable Energy Authority Ireland (SEAI) to carry out a major study of wind farm noise.

The aim is to obtain evidence upon which to evaluate the appropriateness of the wind energy development guidelines in relation to noise impacts and, if considered necessary, suggest changes.

The study is due to be completed by the end of 2013 after which a report will be released for public consultation. It involves:

- reviewing available relevant peer reviewed scientific and other authoritative literature on wind turbine noise and its impacts on noise sensitive locations
- examining the different types of wind turbine noise
- reviewing best practice noise measurement methodologies in their application to wind turbine noise assessment and determining what methodologies for the measurement of noise are most appropriate
- examining the impacts of various relevant factors, including separation distance, topography etc, on the character and levels of noise experienced at sensitive locations in the proximity of wind farms
- reviewing wind farm noise standards, regulations and control/management approaches adopted in various other European countries and set by certain relevant bodies
- reviewing, and assessing selected submissions received in response to the recent call by DECLG for submissions on the noise and distance aspects of the current guidelines
- setting out recommendations for amending the current guidelines, should amendments be deemed to be necessary and appropriate.

# EADS takes Brüel & Kjær shaker system

Global aerospace expert EADS – the parent company of Airbus – has expanded its vibration test capabilities with a new electrodynamic shaker and controller system made by Brüel & Kjær.

The system is located at EADS's Structural Test Laboratory in Getafe, Madrid. This facility is where aviation started in Spain in the very early 20th century and is the current location for Airbus Military engineering, whilst production is carried out in their Andalucía site.

The new vibration test system enables EADS to carry out sine, random, and classic shock testing on flight elements of aircraft including the A400M, CN295, MRTT, according to procedures and standards in RTCA-DO-160 and MIL-STD-810.

For propeller aircraft applications, sinusoidal (sine) testing can be used to simulate phenomena such as wind-milling, where a stopped engine is turned by the airflow.

For jet aircraft applications, random vibration is used to simulate the vibration environment. It is ideal for production, durability and fatigue testing of electronics and components in helicopters and military vehicles.

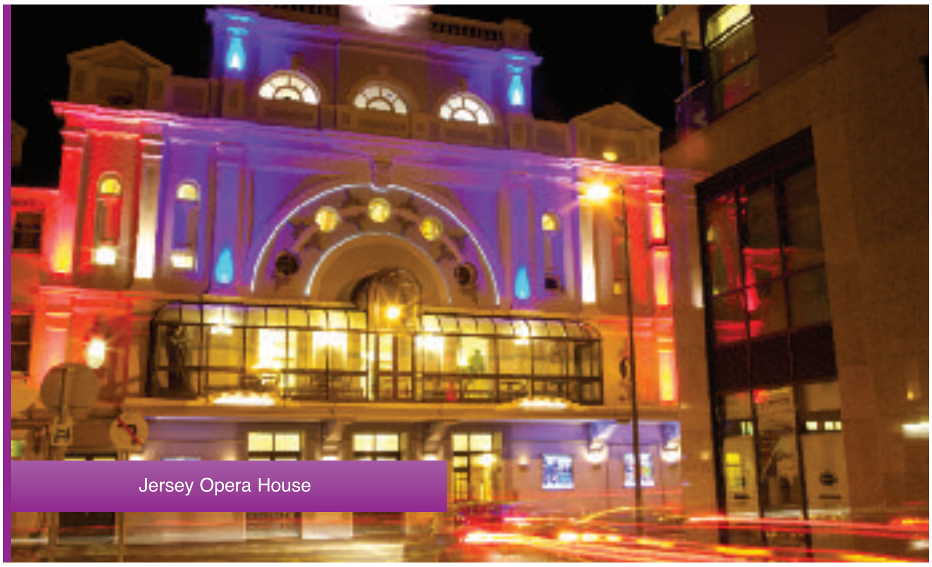
The system comprises a large LDS-V875 shaker together with a Laser USB Controller.

For more information on Brüel & Kjær's aerospace applications see **www.bksv.com/aerospace**

A V875 shaker

# Jersey Opera House puts Optimus Red in the spotlight

Jersey Opera House has turned to Cirrus again in its quest to deliver the best sound quality and level.



Jersey Opera House

Technical Manager Chris Wink, who has used Cirrus products for a number of years to monitor and record sounds level within the 625-seater auditorium, chose the Cirrus Optimus Red sound level meter when he needed to upgrade his equipment.

"We need to comply with all the health and safety regulations but we also need to respond to customer comments about the quality of sound during performances," he said.

"The opera house is used at least four days every week and features every type of show, from rock bands to one-man performances. In every show the sound is critical for the audience's enjoyment. We have to comply with all the guidelines and we want to make sure the noise is at a comfortable level for the audience, for example, if it's a children's show then we want to ensure that noise levels are much lower than for an adult audience."

The opera house has to keep its noise data for up to five years as it will be asked to produce noise level evidence on a specific show as part of an Health & Safety Executive inspection.

"We can use the Optimus in any part of the auditorium, on stage or back stage, so we can be very accurate in the data we collect across in every area."

Jersey Opera House was built in 1865 and enjoyed a £7 million refit and renovation between 1998 and 2000.


# Invictus

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# Arup 'on song' at Guildhall School's new training and concert building

Arup is celebrating the opening of the Guildhall School of Music & Drama's new state-of-the-art training and concert facilities.

The company was appointed to provide acoustic consultancy services to ensure the highest-quality sound in all performance and studying spaces at the £89 million Milton Court development close to the heart of the City of London.

The building boasts a 608-seat concert hall plus two theatres (223 seats and studio), three rehearsal rooms, TV studio suite, departments for costume, wigs and make-up, office space, tutorial rooms and public foyers. This will allow the school to increase its programme in terms of variety, scope and volume, whilst continuing to attract the most highly regarded teachers and best students internationally.

Milton Court concert hall
Picture: Morley von Sternberg

Arup worked closely with RHWL Arts Team during the design and held rigorous acoustics trials to test the acoustics in the concert hall, theatres and rehearsal rooms.

Philip Wright, lead acoustician, Arup said: "The performance and rehearsal spaces are in intimate proximity to each other, and so the concert hall is a totally isolated 'box-in-a-box' construction. It has an extremely flexible platform configuration and adjustable acoustics, to suit each type of performance. Detailed analysis and modelling, and immense care during construction, have resulted in a hall of the highest quality, exhibiting an ideal blend of clarity and warmth."

The concert hall will also host a year-round programme of classical and contemporary music as part of the Barbican's renowned music programme. This includes performances from the Barbican's two new associate ensembles – the Academy of Ancient Music and Britten Sinfonia – alongside one-off special events, artistic and commercial hires, and programmes from the Barbican and Guildhall School's joint creative learning division.

For more information on the venue and its programme of events, visit the Guildhall School website **www.gsmd.ac.uk**

## Product News

# New accelerometer range from Brüel & Kjær

Brüel & Kjær has created a range of CCLD accelerometers for vibration measurements in harsh industrial environments.

The new Type 4533-B and Type 4534-B accelerometers feature a high signal output-to-weight ratio and very low sensitivity to environmental influences.

This, says Brüel and Kjær, makes them ideal for general vibration measurements for a range of different applications, such as automotive parts, aircraft, and industrial machinery.

The new units have output sensitivities from 1 mV/ms–2 to 50 mV/ms–2 and a non-destructive (shock) limit of 10 000g, making them more robust than normal CCLD accelerometers, which typically have a limit of 5000g.

Both accelerometers automatically self-identify and supply calibration information using TEDS technology (Transducer Electronic Data Sheet).

Each unit features lightweight, robust, hermetically-sealed titanium housing, an insulated base (avoiding ground-loop problems) and a 10–32 UNF thread mounting hole, suiting use in harsh environmental conditions.

Brüel & Kjær has also updated its transducers and conditioning catalogue, which provides a comprehensive guide to its full range of microphones, accelerometers and accessories.

One of the new accelerometers

This latest version has quick links to the different sections, a matrix to simplify choosing the right equipment, and service/repair information.

More information about 4533-B and 4534-B is available at **www.bksv.com**

# German certification for Rion NL-52 and Rion WS-15

ANV Measurement Systems has announced that PTB in Germany has independently certified that the Rion NL-52 and Rion WS-15 Double-Skin Windshield achieve IEC 61672 Class 1.

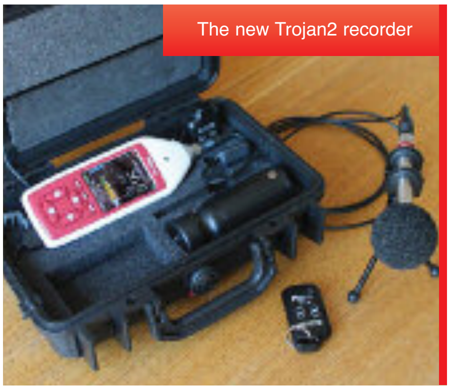
ANV believes that the WS-15 (in combination with the NL-52) is the first Double Skin Windshield to achieve independent type testing to this class. The WS-15 Double Skinned Windshield is applied directly to the Rion UC-59 pre-polarised microphone which is supplied as standard with the NL-52. This, says ANV, is very cost-effective compared with having to purchase a separate outdoor microphone.

The NL-52 and WS-15 are used extensively for long-term unattended monitoring for wind farms and other applications (especially construction noise). In addition to the Double Skin Windshield, the NL-52 has extremely low power consumption and will run for 10 days or more on a single 12 ah battery and 20 days on a pair of 12 ah batteries. ANV supply outdoor kits for use with the NL-52 and WS-15 and these can be deployed with one or two 12 ah batteries. Additionally, when equipped with the NX-42WR audio recording option, the NL-52 can record a two minute audio sample every 10 minutes, making it, says ANV, the perfect tool for collecting data for wind farm compliance monitoring.

They and other accessories are available from for hire and purchase from ANV Measurement Systems (**info@noise-and-vibration.co.uk** tel: **01908 642846**).

The Rion NL-52 and WS-15 with enhanced outdoor kit

# Launch of Trojan2 noise nuisance recorder



The new Trojan2 recorder

Cirrus Research has re-launched its Trojan noise nuisance recorder with many new innovations included as standard.

The Trojan2 software has also been revamped to allow measurements to be made over longer periods of time as well as making download of measurements quicker.

The key features are:

- High resolution colour OLED screen with backlit keypad
- Repeating measurements for environmental noise monitoring120dB dynamic range in a single span
- 4GB memory with 32GB option
- Simultaneous measurement of all parameters
- 16bit/16kHz or 32bit/96kHz audio recording
- Option of real-time 1:1 & 1:3 octave band filters from 6.3Hz
- AuditStore™, Acoustic Fingerprint™ and NoiseTools as standard
- Compatible with the CK:670 Outdoor Measurement Kit.

James Tingay, Cirrus Research Marketing Manager, said: "It has been designed to meet the needs of environmental health officers, housing associations and anyone who needs to measure, monitor and record noise nuisance."

For more details go to **www.cirrusresearch.co.uk**

# New Vexo vibration meter from Castle

Castle Group has launched its new Vexo S vibration meter dedicated to industrial monitoring on machinery and manufacturing equipment.

The Vexo S is a single axis vibration meter with a dedicated accelerometer attached via an ultra-robust cable. It has a colour OLED display, simple three-button operation and memory for storing 1,000 test results. Once a measurement has been made, colour coded results are given according to ISO 10816 for machinery condition or a dedicated bearing mode will give an indication of the condition of shaft or motor bearings.

One unique feature is that it is capable of taking a short average measurement rather than the normal instantaneous test. This, says Castle, increases the accuracy and repeatability of measurements, which is essential for trending applications. Graphical trending can be viewed using VibdataPRO PC software for Castle vibration meters.

For more information, visit **www.vexo.co.uk**

The new Vexo S meter

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# Committee meetings 2013/2014

| DAY | DATE | TIME | MEETING |
|---|---|---|---|
| Thursday | 7 November | 11.30 | Meetings |
| Thursday | 14 November | 11.00 | Executive |
| Wednesday | 20 November | 9.30 | CCBAM Committee |
| Wednesday | 20 November | 10.30 | CCENM Examiners |
| Wednesday | 20 November | 1.30 | CCENM Committee |
| Tuesday | 3 December | 10.30 | CCWPNA Examiners |
| Tuesday | 3 December | 1.30 | CCWPNA Committee |
| **Thursday** | **5 December** | **11.00** | **Council** |
| Thursday | 9 January | 11.30 | Meetings |
| Tuesday | 21 January | 10.30 | Diploma Tutors and Examiners |
| Tuesday | 21 January | 1.30 | Education |
| Thursday | 23 January | 10.30 | Membership |
| Thursday | 6 February | 11.00 | Publications |
| Thursday | 13 February | 11.00 | Medals & Awards |
| Thursday | 13 February | 1.30 | Executive |
| Thursday | 27 February | 10.30 | Engineering Division |
| Tuesday | 4 March | 10.30 | Diploma Examiners |
| **Thursday** | **6 March** | **11.00** | **Council** |
| Monday | 7 April | 11.00 | Research Co-ordination |
| Tuesday | 8 April | 10.30 | CCWPNA Examiners |
| Tuesday | 8 April | 1.30 | CCWPNA Committee |
| Thursday | 10 April | 11.30 | Meetings |
| Thursday | 1 May | 10.30 | Membership |
| Thursday | 15 May | 11.00 | Publications |
| Wednesday | 21 May | 10.30 | CMOHAV Examiners |
| Wednesday | 21 May | 1.30 | CMOHAV Committee |
| Thursday | 22 May | 11.00 | Executive |
| Tuesday | 27 May | 10.30 | ASBA Examiners |
| Tuesday | 27 May | 1.30 | ASBA Committee |
| Thursday | 29 May | 10.30 | Engineering Division |
| **Thursday** | **12 June** | **11.00** | **Council** |
| Wednesday | 18 June | 10.30 | CCENM Examiners |
| Wednesday | 18 June | 1.30 | CCENM Committee |
| Thursday | 19 June | 10.30 | Distance Learning Tutors WG |
| Thursday | 19 June | 1.30 | Education |
| Thursday | 17 July | 11.30 | Meetings |
| Tuesday | 5 August | 10.30 | Diploma Moderators Meeting |
| Thursday | 14 August | 10.30 | Membership |
| Thursday | 4 September | 11.00 | Executive |
| **Thursday** | **11 September** | **11.00** | **Council** |
| Thursday | 25 September | 10.30 | Engineering Division |
| Monday | 29 September | 11.00 | Research Co-ordination |

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.

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