Vol 40 No 5 September/October 2015

ACOUSTICS BULLETIN

in this issue... **Acoustically induced vibration: a review of industry best practice**

plus... **The propagation of low frequency sound through an audience, part 2**

Otoacoustic emissions, cochlea mechanics and hearing loss

BS 4142: 2014 Measurement planning and practice

Institute of **Acoustics**

ACOUSTICS BULLETIN

Vol 40 No 5 September/October 2015

Front cover photograph:
Acoustically induced vibration is a major concern in the oil, gas and petrochemical sectors

Contacts

Editor:
Charles Ellis

Contributions, letters and information on new products to:
Charles Ellis, Editor,
Institute of Acoustics,
3rd Floor St Peter's House,
45-49 Victoria Street, St Albans,
Hertfordshire, AL1 3WZ
tel: 01727 848195
e-mail: charles.ellis@ioa.org.uk

Advertising:
Enquiries to Dennis Baylis MIOA, Peypouquet, 32320 Montesquiou, France
tel: 00 33 (0)5 62 70 99 25
e-mail: dennis.baylis@ioa.org.uk

Published and produced by:
The Institute of Acoustics,
3rd Floor St Peter's House,
45-49 Victoria Street, St Albans.

Design and artwork by:
oneagency.co London
81 Rivington Street
London, EC2A 3AY
e-mail: london@oneagency.co
web site: www.oneagency.co

Printed by:
Newnorth Print
College Street
Kempston
Bedford MK42 8NA

FSC www.fsc.org MIX Paper from responsible sources FSC® C023802

Annual subscription (6 issues) £120.00
Single copy £20.00

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 programme 2015

17 September
Organised by the
Sustainable Design Task Force
and the Building Acoustics Group
Acoustic design for sustainable buildings
London

27-30 September
Organised by the Galpin Society
in association with the IOA
Musical instruments in science and history
Cambridge

15 October
Organised by the IOA
Acoustics 2015
Harrogate

29-31 October
Organised by the IOA
with support from the
French Acoustical Society (SFA)
Auditorium acoustics
Paris

10-12 November
Organised by the
Electroacoustics Group
Reproduced Sound
Moreton-in-Marsh

26 November
Organised by the
Measurement and Instrumentation
and Young Members' Groups
Sound sensing in smart cities
Salford

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

Dear Members

I hope you had an enjoyable summer break and enjoyed the wonderful weather. After the holidays and the inevitable catch up, our minds turn to the conference season. We have a number of local branch meetings with diverse topics, as well as national events, such as Acoustic Design for Sustainable Buildings, the Galpin Society conference on musical instruments in science and history, Acoustics 2015, Auditorium Acoustics, Reproduced Sound and Seabed and Sediment Acoustics. These events are supported by our volunteers to ensure that opportunities exist for our members to maintain their knowledge and CPD requirements, as well as opening up new educational opportunities for those not working in these specific disciplines. Please support these events and bring a friend to enjoy the wonderful world of acoustics.

I recently attended the RIO Acoustics 2015 in Brazil for its second year. It was fantastic to see the event develop where attendees now come from all over South America and the rest of the world. Papers given encompassed the newest techniques and technologies to solve challenges in underwater acoustics. Internoise 2015 also proved successful again, with more than 1,000 delegates attending, and it was supported by a comprehensive exhibitors' conference. Attendance at both of these international events bodes well for us in promoting ICSV 2017 in London, for which planning is well under way.

We recently sent a survey to members, as the Institute is keen to understand members' needs with regard to professional development, particularly in the near future, and how the Institute might better tailor – and enhance – its offer in order to take account of these needs. This is part of the strategic review of our education provision and forms part of the basis of the report we will be expecting shortly. My thanks go to those of you who have responded as your input will prove invaluable. The report will be presented and reviewed at our education strategy workshop day in St Albans on 14 September, where we will have Council and invited attendees from key groups both inside and outside the Institute. These findings will be used to help formulate and shape our learning and development strategy and provision.

Unfortunately our AGM on 9 July in Kingston was not quorate. However my thanks goes to those of you who did attend despite the London Underground strike. Even the best laid plans go awry when late outside developments impact the event. The meeting will now be held on 14 September at 4pm in the Quality Hotel, St Albans, directly after the education strategy review at the same location.

As we move from one year to the next, regrettably we have to say goodbye in Council and Executive to those whose terms end and who have given extended continuous service to the Institute. One such individual is Dr Martin Lester who has served on Council for eight years and as Honorary Treasurer for six years. My thanks go to Martin on behalf of the Institute for his support and dedication to the Institute, Council and Executive through a time of transition, during which he gave us the financial oversight that has enabled us to have the stable and transparent finances we have today.

William Egan, President

Amplitude modulation consultation responses go under the microscope

By Gavin Irvine and Richard Perkins

The Institute's working group formed to develop an AM metric (AMWG) has been very busy over the past few months and is looking forward to updating delegates at the Acoustics 2015 conference in Harrogate on 15 October. A summary of recent activities is shown below.

AM workshop

The IOA held a one-day workshop in Newcastle on 11 June during the consultation process on the three preferred metrics that closely meet the criteria as set out in the group's terms of reference.

The meeting was attended by around 40 people and there was a good lunch followed by some presentations and then a lively debate on AM issues in general and rating methods.

Dave Coles from 24 Acoustics gave a live demonstration of the software and Tom Levet from Hayes McKenzie showed AM noise rated with different metrics. Matthew Cand from Hoare Lea also reported some interesting results regarding the mitigation of AM at two wind farms using modifications to the blades and changes to the turbine pitch control.

Consultation responses

The consultation has now closed. Twenty responses were received from IOA members and other interested parties, including two from researchers overseas.

The group is now considering the responses and will issue the final document in time for Acoustics 2015. A summary of the consultation responses will be published together with the individual responses for those who gave permission for this.

DECC contract finally under way

The long-awaited research contract that the Department for Energy and Climate Change (DECC) tendered in March to look into the setting of an appropriate limit by the Government for AM based on the metric that the IOA will propose is under way.

It has been let to a team led by WSP | Parsons Brinckerhoff, including Colin Grimwood, Bernard Berry and Stephen Stansfeld.

The AMWG will be liaising closely with the DECC team to keep them up to speed with the latest developments with the AM metric.

The IOA AM document will be issued in October

Hearing impairment and the enjoyment and performance of music

By Mike Wright

Kingston University in south west London hosted the first ever joint one-day meeting by the Musical Acoustics and the Speech and Hearing Groups. The focus of the meeting was to address a longstanding need to explore better ways to improve the musical experience for listeners and performers with hearing loss, including those with tinnitus and hyperacusis.

Michael Wright, Chairman of the Musical Acoustics Group, introduced the meeting by stating that his own hearing loss had affected his appreciation of music and that work was needed to improve hearing devices and performance venue facilities. He set the scene by explaining that there were fine musicians across all musical genres with varying degrees of hearing loss. Some were either born with loss while others have developed loss in their early years. They may have never heard or performed music with anything like perfect hearing. Indeed, there were some brilliant musicians who were profoundly deaf. There were also many who have developed hearing loss over the years as a result of inevitable presbycusis. Some may also have been affected by noise-induced hearing loss, where there were large differences in individual susceptibilities. Well-known percussionist Dame Evelyn Glennie, who has been profoundly deaf from a young age, neatly summed up the issue on her website: "Deafness is poorly understood in general. For instance, there is a common misconception that deaf people live in a world of silence. To understand the nature of deafness, first one has to understand the nature of hearing."

At the start of the meeting, it soon became clear that improvements were needed in transmitting the sound from the presenters to some members of the audience! The need for hearing loops at all IOA meetings was very clear.

Graham Frost, technical consultant at the British Society of Audiology, described the consequences of hearing impairment on the perception of music. He demonstrated the effects of impairment, where a 60dB loss at 4KHz affected a significant part of the "audible area" in musical sound. He went on to explain the various types of loss including conductive, where sound waves passing along the route through the outer ear, tympanic membrane (eardrum), or middle ear (ossicles) are affected. He then described sensorineural loss (SnHL) where the inner ear, the nerve that runs from the ear to the brain (auditory nerve), is damaged. He then briefly mentioned non organic hearing that is unexplained by anatomic or physiological abnormalities and auditory processing disorder. Any of these problems may be combined. The consequences of hearing impairment are complex. It can affect perceived loudness and Graham described "recruitment" where there is a change in the perceived loudness growth, i.e. dynamic range. Thresholds are raised and the effects of masking noise. Damage to hair cells which provide narrow band filtering due to different sensitivities to response can affect their "tuning curve". Graham then explained various signal processing strategies that could address some issues. However, his conclusions did not hold hope for a "magic solution". Unlike visual impairment which can be compensated for by lenses, most hearing losses cannot be fully compensated. Whilst amplification and DSP algorithms may help, capabilities are still limited.

Peter Mapp, principal specialist in architectural acoustics, electro-acoustics sound system designs, described assistive listening systems for music and speech for hearing impaired listeners. He outlined the problems faced by hearing aid users including the direct to reverberant sound ratio, background noise, amplification levels and frequency acuity. He reminded the audience that whereas the general range for speech lay between 100Hz and 8 kHz, the range for music was greater, from 40Hz to 10 kHz. He illustrated the effects of presbycusis and some "typical" hearing losses showing that losses may be up to 80-90dB and highly frequency dependent. Compensating for this in a domestic environment could include increasing the volume, tweaking the tone controls: all with limitations and side effects. In public spaces and auditoria, hearing aids should cover the required frequency range but can suffer from poor dynamic range ratio, leading to too much reverberation and potential noise. Digital aids are usually optimised for speech but can employ some "beam forming" to improve dynamic range at high frequencies. However, hearing aids are not binaural and ear-brain cross correlation cannot be used. He outlined the pros and cons of using headphones and moved on to assistive listening systems (ALS) including hearing aid loops, infra red and wireless systems, the latter not common in the UK. He explained the need for signal limiting, compression and gain control which may assist people to hear the overall sound. However, this will be monophonic and thus of limited benefit.

The morning session concluded with a session on interactive performance for musicians with hearing impairments using the vibrotactile mode, presented by Carl Hopkins from the University of Liverpool, with acknowledged contributions from R Fulford, J Ginsborg, Royal Northern College of Music. He began by indicating that there were an estimated 10 million people with some form of hearing loss. There were more than 45,000 deaf children in the UK and more than 800,000 people severely or profoundly deaf. Carl gave an insight into recent research on the potential for using vibrotactile feedback to facilitate musical performance for deaf musicians. This included the perception of musical notes via vibration on the fingertips and feet and showed a useable dynamic and pitch range. However, this was confined to pitches between C1 and C6, i.e. 32.7 to 1046.5 Hz. As a result of the experiments, he concluded that there were no significant differences between the perceptions of non-hearing impaired participants and those with severe or profound impairment. There was a useable dynamic range for music that would avoid adverse health effects. There were problems identifying pitch at and above A5 because continuous vibration was not felt. Discrimination gets easier as intervals increase, with a semitone not easily identified. Basic training improved perception. Appropriately, he rounded off the presentation with an interactive instrumental performance of a Beatles number, *Day Tripper*.

After lunch, Christina Rocca from the Mary Hare Music Therapy Centre, talked about the developments of musical pitch perception and production in children with cochlear implants. Her study demonstrated the pitch-related development of pre-lingually deaf, cochlear implanted children participating in a habilitation programme, *A Musical Journey*. She also noted that psychoacoustic tests of electrical hearing have tended to show disappointingly poor performance on pitch-related tasks. This was not the case with the structured habilitation programme and she concluded that this had value which was often overlooked.

Janet McKenzie, a paediatric rehabilitationist from Addenbrooke's, Cambridge University Hospitals, followed with a paper on paediatric music appreciation and expression category scales. Cochlear implants were not originally designed for listening to music but provided an unexpected outcome regarding musical appreciation, regardless of age. Implants are targeted for people with more than 90dB hearing loss at 2 and 4 kHz and those who would not benefit from hearing aids. In this, a pilot study, she defined music appreciation (MAC) and music expression scales (MEC). The results were encouraging. In the case of MAC, as the duration of listening experience increased, children moved through to the higher musical appreciation categories. A child achieving a higher category of auditory performance (CAP) was likely to achieve a higher MAC rating. It had led to further development of the MEC scale which required further calibration.

After a tea break, Dr Stephen Dance, Reader in Acoustics in the Department of Urban Engineering at London South Bank University, and no stranger to the Musical Acoustics Group, presented an interesting comparison of the hearing acuity of classical music students. His work over the last eight years, which is ongoing, has involved automated audiometric tests on almost 2,600 students on entry to the Royal Academy of Music in London and, so far, 120 on exit. His project described hearing loss categories, hearing loss by instrument group, hearing loss analysis at 10%, 90% and 98% of the students tested. So far, 33 students have been found to have "referral levels" of hearing loss as described by the Control of Noise at Work Regulations. However, he also found 24 students with a hearing acuity beyond the capability of the instrumentation used to conduct the tests. He also looked at hearing loss asymmetry – i.e. the differential loss between each ear. Early findings have shown that 6 kHz is the prevalent "hearing notch" for all 19 instrument groups, higher than normal. Overall results showed the left ear to be worse than the right ear for musicians.

P8

Mike Wright opens the meeting

◄ P7

Whilst Ludwig van Beethoven had been mentioned by previous speakers, his findings actually showed that composers are the most likely type of musician to have the worst hearing acuity.

The final paper was by Dr Robert Fulford, a Research Fellow in Music Psychology at the University of Leeds, who gave preliminary insights into a questionnaire study on hearing aids for music. Robert acknowledged the fact that music was an important part of people's lives and that it was also likely to be true for people with impaired hearing. He cited anecdotal evidence on issues relating to digital hearing aids that are generally optimised for speech. This newly funded project is designed to explore how hearing aids affect music listening experience and behaviours. Robert's presentation gave initial findings based upon a short questionnaire distributed to NHS patients and a private audiology clinic. A prior interview study showed musicians with hearing loss adopt a variety of strategies to improve music listening, ranging from reprogramming digital aids, using older analogue devices to simply not using a hearing aid. The questionnaire data showed a prevalence of music listening issues among hearing aid users. This study will inform the design of a large-scale national survey.

The day finished with a very lively Q&A discussion workshop. In addition to the formal sessions, there were two posters. One, by Neil Summerfield, Salford Royal Foundation Trust, concerned the case of the lone piper and his new hearing aids which has left him uncomfortable to continue playing his bagpipes. The other, by Elizabeth Hough, Cambridge University Hospitals NHS Trust, described musicians in the audiology clinic – an individual management approach. She cited the challenges of adapting to hearing loss and the use of hearing aids. She provided a number of case studies to highlight ways to help musicians to continue to enjoy and perform music.

Environmental noise course numbers hold up but demand for workplace noise training remains low

By Keith Attenborough, Education Manager

In May 2015 there were 95 candidates at 13 centres for the Certificate of Competence in Environmental Noise Measurement (CCENM) of whom 85 passed. The number of candidates is comparable with the number who registered in autumn 2014 but fewer than registered last spring. Nevertheless CCENM continues to be the most popular of the IOA's short courses. Recently the CCENM Management Committee has had to consider how to respond to the 2014 revision of BS 4142 and the withdrawal of PPG24. The Education Committee has a policy in respect of the IOA Diploma in Acoustics and Noise Control of requiring changes in standards and legislation to have been in force for 12 months before changing the syllabus and course notes accordingly. However, a greater currency is considered important for the short courses. Since the emphasis of CCENM is on measurement rather than assessment and interpretation, it has not been found necessary to change the CCENM syllabus in respect of BS 4142. On the other hand consideration is being given to replacing "noise" by "sound" in its title.

There were 18 candidates at five centres for the Certificate of Competence in Workplace Noise Risk Assessment (CCWPNRA) in March 2015, of whom 15 passed. The number of candidates is comparable to those for the autumn and spring presentations in 2014 but the demand for the course continues to be low. Progress is being made on an agreement between the IOA and the British Occupational Hygiene Society (BOHS) in respect of mutual recognition of courses for membership purposes. A new examiner is needed for CCWPNRA following the resignation of Tim Ward (who now works for a consultancy rather than HSE) and the current chairman of the management committee (Dave Lewis) also wishes to resign as soon as a successor can be found. So far the CCWPNRA committee have not been able to identify replacements.

All 16 candidates (including one resit candidate) for the Certificate of Competence in Building Acoustics Measurements (CCBAM) passed in April 2015. CCBAM has been delivered so far only at Southampton Solent since the number of candidates remains small. Nevertheless an Irish version (CCIBAM) is to have a trial run in September 2015.

The Certificate of Proficiency in Antisocial Behaviour etc. (Scotland) Act 2004 Noise Measurements (ASBA) was delivered at Strathclyde University in May 2015 for the first time in two years. Out of a total of 15 candidates (including two resits from Bel Noise Courses) only one failed. After serving as one of the providers since its inception Bel Noise Courses Ltd has been wound up and a new partnership Bel Noise Courses (Alistair Somerville and Lillianne Lauder) has taken over.

Antisocial Behaviour Act 2004 noise measurements

Bel Educational Noise Courses

Stewart A
Stewart L

University of Strathclyde

Cuthbert J M
Eldessouky M E
Hazlett K
Hood G R
MacNeil M
McKnight J
Miller P
Morris E I
Murchison K
Roy C J
Ryan A
Westwater L
Wilson N T

Building acoustics measurements

Southampton Solent University

Andrade A F
Baumgartein S J
Cousins J
Gonzalez Sanles R A
Jackson-Callen N
Loughlin B
Pickering M A
Pidsley A C
Porteous D
Price R K
Rioperez J L
Sharpe A
Van Empel W
Walker S C
Winman A
Wood B J

Environmental noise measurement

Bel Educational Noise Courses

Chapman F M
Farquharson K
Fraser P
Harshaw P
MacDonald K
McBride M V
Nicholl M E
Parry M R
Sibbald C D

University of Birmingham

Ahmad I M
Davy L
Ejale E E E
Hartridge K
Mohamed H A O
Senior S M
Simpson C

University of the West of England

Baish D P
Bright M D
Carter L
Chibalabala K
Evans E
Flynn R T
Groves G R
James E S
Lethbridge R J
Mordecai G M
Perez S
Spellissy N B
Vernon D N

Colchester Institute

Abraham T W
Adekanle A
Callaghan P
Christofis C
Collins A M
De Silva K R A
Debbage-Philp T S
Gardner A
Holmes S J
Hyslop S J
Marshall S B
Miles A J R
Nixon J
Poucher A J
Senior J A
Smith C M

University of Derby

Beddows B J

P10 ►

◄ P8

EEF Sheffield
Beech O
Bromby D
Hughes D R
Richards J

Liverpool University
Bates C J
Bigley R E
Brincat B
Charlton W S J
Copeland D
Deed C
Fraser J G
Harrison A M
Karaiskos A E
Wright C A

London South Bank University
Cawley A
Georgieva P
Hicks R M
Liu S
Loran T
Serghides M A

Shorcontrol
Carroll G
Coogan P

Management of occupational exposure to hand arm vibration

Leeds Beckett University
Allen M
Bilton K M
Churchman S A
Eacott L
Jenkins A
Storey C R

Institute of Naval Medicine
Brookes K
Fowler S C
Halford J V
Hefford D
Radford D M
Woodcock P

Workplace noise risk assessment

Citrus Training
Dwyer G
Gopauloo R
Trayhurn B

University of Derby
Fox S G
Middleton D J

EEF Sheffield
Ashley W G
Bromby D
Cardiff W R
Creasey S J
Faulkner D
Harley A J

Rapid Results College
Gallego C
Jeffrey K A

Shorcontrol Safety
Brosnan P
Ferry G N

Back in chime – a visit to the historic Whitechapel Bell Foundry

London Branch report

By Nigel Burton

In May a group of 21 Institute members visited the Whitechapel Bell Foundry in London.

The foundry is listed in the *Guinness Book of Records* as Britain's oldest manufacturing company, having been established in 1570 during the reign of Queen Elizabeth I, and being in continuous business ever since. This said, a link has been established through the research of bell historian George Elphick back to one Master Founder Robert Chamberlain, thus tracing an unbroken line of founders in the Aldgate and Whitechapel area back to the year 1420; during the reign of Henry V, and 72 years before Columbus set sail for America.

The foundry's business remains to this day focused solely on the manufacture and refurbishment of bells and their associated fittings. Around 80% of its work involves large bells for change ringing in church towers, single tolling bells, carillon bells, and their complete range of accessories such as frameworks, wheels, clappers and their assembly in church towers. The remaining fifth of their work lies in the manufacture and servicing of hand bells for turn and change ringing and other small bells.

A number of world famous bells have been made at the foundry. These include the original Liberty Bell (1752), the Great Bell of Montreal and London's very own Big Ben located at the Palace of Westminster. Cast in 1858, this is the largest bell ever cast at the foundry, weighing 13½ tons.

The tour began with an explanation of how the larger bells are moulded and cast. Our guide also demonstrated the process by which the bells were electronically tuned. In the double height space at the rear of the premises, we were shown examples of the bells that had been returned to the foundry and were currently being refurbished.

In the beginning: learning how the process starts

Moving upstairs, via some steep and narrow stairs, we were shown the carpentry and hand bell workshops, which were cramped to say the least.

It was an interesting and enjoyable visit and our guide gave us a great insight into the history of the company and processes it employs.

Ring my bell: members enjoy the foundry visit

Skill, care and good practice in acoustics

Eastern Branch report

By Hugo Cass

Adrian James took us for an amiable and informative tour through various factors that influence how acoustics consultants work, successfully or otherwise.

The talk was illustrated by anecdotes and experiences of good and bad practice, explaining along the way how the wording of commercial contracts might be unrealistic (and dangerous for the consultant), and what "reasonable skill" means in reality.

Many of us were surprised to learn that there is actually no formal definition of "good practice" in acoustics although the IOA Code of Conduct and the ANC Code of Ethics do cover much of the subject.

Adrian went on to talk about skill and good practice in the context of the role of the acoustics consultant as an expert witness, where the overriding duty is to the court, not to the client.

Various examples of good and bad practice were discussed, without being at all contentious, including how not to baffle clients with technicalities, why complex computer models are not always helpful, inappropriate use of BB93 as a design standard, and how always thinking about special educational needs in schools is good practice.

Adrian then presented a number of interesting examples of good and bad architectural acoustic design, including one of his own which illustrated how being honest with your client is good practice.

By the end of the presentation we learnt that skill, care, diligence and best practice are not just legal terms, and how we have an ethical and professional duty to the public as well as our clients and, ultimately, that "commercial" should not mean "unethical".

Midlands Branch stalwart Kevin is honoured for his work for the Institute

Kevin Howell, a key figure in the growth and success of the Midlands Branch since its inception, has received an Award for Services to the Institute. The presentation was made to him by Branch Chairman Paul Shields at a recent branch meeting. Below is his citation.

After graduating with a Masters from the Institute of Sound and Vibration Research (ISVR) Kevin continued as a research assistant, followed by a short spell with Telford New Town Corporation. In 1977 he moved to Bickerdike Allen Partners and worked on a range of environmental and building acoustics projects. In 1980 he returned to ISVR as Senior Research Fellow before joining British Gas Research & Technology where he worked for 12 years supervising a team carrying out research into reducing noise emissions from industrial gas burners and plant. In 2000 Kevin moved to Birmingham City Council where he supervised a small acoustics team. Kevin took redundancy from the council and between 2011 and 2014 he worked on a part-time basis as an independent consultant.

Allied to his long and varied career in acoustics, Kevin has been an active member of the Midlands Branch from its inception in 1994 and has attended nearly every branch meeting, often travelling considerable distances in the process. Throughout its history Kevin has been a strong supporter of the branch, and for most of this time a committee member. One of Kevin's key contributions has been his excellent reports on the presentations, which he has produced for many years. These consistently high quality reports have provided an invaluable record of the branch activities and useful CPD to those who could not attend the event, but could still obtain an overview of the meetings by reading these reports afterwards in the Bulletin.

Kevin joined the committee as treasurer and later stepped down when the role was no longer required. He re-joined the committee as secretary in 2011 and held this post until retiring from the committee in December 2014. In his role as secretary Kevin helped organise the programme of monthly branch meetings and generally ensured that the branch ran smoothly, whilst all the time continuing to write meeting reports.

This consistent, selfless and high quality support to the branch spanning 20 years is, to the best of my knowledge, unique in IOA branch history, and certainly so for the Midlands Branch.

It should be noted that both in his career and his work with the branch, that Kevin, like many of the people who are attracted to technical disciplines, has chosen to avoid the limelight. This has in no way detracted from his achievements and more importantly his selfless service to acoustics and to the Institute.

The IOA is delighted to present Kevin Howell with an award for Services to the Institute 2015.

Kevin (right) receives his award from Paul Shields

BS 4142: 2014 why zero is not the new 10

Southern Branch report

By Peter Rogers

Branch members crammed into the Guildhall in Winchester in July to hear the latest on BS 4142, in particular the practical aspects of implementing character corrections.

Richard Collman gave a talk to set the scene and was supported by Derek Nash who talked about the approaches that can be taken. Then Dan Saunders and Ed Clarke conducted a subjective experiment with the 70-strong audience using audio files of different sources of noise, and an audience response system was used to gather live responses and compare them with the calculated ratings.

The results were, in some case, surprising, and others agreed well for different types of sources. It was felt that some further analysis could be presented at a later point. It was also agreed that clear guidance was required when practically implementing the correction process, to achieve repeatable consistency and that you cannot always trust your ears alone when on site.

Derek Nash finished by introducing the ANC's BS 4142 checklist, which he was involved in developing, and which will be available to members in the near future to help provide a useful prompt during BS 4142 assessments.

Thanks go to all the speakers and to Clarke Saunders for the format, which was really engaging, useful and created an entertaining meeting. Also thanks go to Southampton Solent University for use of its audience response system.

Successful year for Musical Acoustics Group

The Musical Acoustics Group held its AGM at Kingston University in July and reported that it had been a successful year.

There had been a number of small meetings, including a very well-attended visit to Henry Willis and Sons Ltd (organ builders) in Liverpool. The group had also contributed to excellent musical acoustics sessions at the IOA 40th Anniversary Conference in Birmingham in October 2014. Thoughts were now turning to the forthcoming joint IOA/Galpin Society conference in Cambridge on 27-30 September and the IOA's Acoustics 2015 conference in Harrogate on 15 October.

The following members were elected unopposed to join the management committee: Stephen Dance and Jemma Jones (Young Person's Representative). Mike Wright (Chairman) and David Sharp (Secretary) were re-elected. The other continuing committee members are: Sam Wise, Owen Woods, Chris Turner, David Howard, Murray Campbell, Chris Stanbury and Stephen Parker. Lisa Greenhalgh (formally Young Person's Representative) stood down on account of maternity leave.

Instrumentation Corner

BS 4142:2014 Measurement planning and practice

By Mark Dowie MIOA, Environmental Applications Specialist at Brüel & Kjaer

This article is based on a presentation at the Measurement and Instrumentation Group's BS 4142 workshop in May. It is a guide to planning and making a measurement for BS 4142:2014 with suggestions on how to report and support assessments. This article has been split into two parts, the first of which appeared in the previous issue of *Acoustics Bulletin*.

Making measurements

When on site BS 4142 recommends making measurements at height of 1.2 to 1.5m above ground and at least 3.5m from any reflecting surface. In some situations it may not be possible to get far enough from walls or fences or you may need to measure outside a flat well above ground level. In this case measurements should be made at 1m from a facade, then the measured level can be adjusted to a free-field level by subtracting a 3 dB correction factor.

Take a photo of the measurement location and note the measurement position, height and the distance from any reflecting surface.

Make measurements of the weather conditions. Some manufacturers have weather stations that will plug in to their sound level meters to synchronise the weather and noise data. This will simplify your reporting and is most valuable in unattended assessments. For shorter attended assessments the use of handheld anemometers and local weather data from the web should be sufficient.

Weather conditions must always be measured

The sound level meter should be calibrated with a matching calibrator before every series of measurements. It should then be checked (not re-calibrated!) after every series of measurements. Make a note of these checks; if the level has varied more than 0.5dB you may need discard your measurements as this would suggest a fault in your measurement system.

BS 4142 requires a more detailed accredited calibration of the complete measurement system. The sound level meter must be calibrated every two years provided it is checked with a calibrator that has calibration no older than 12 months.

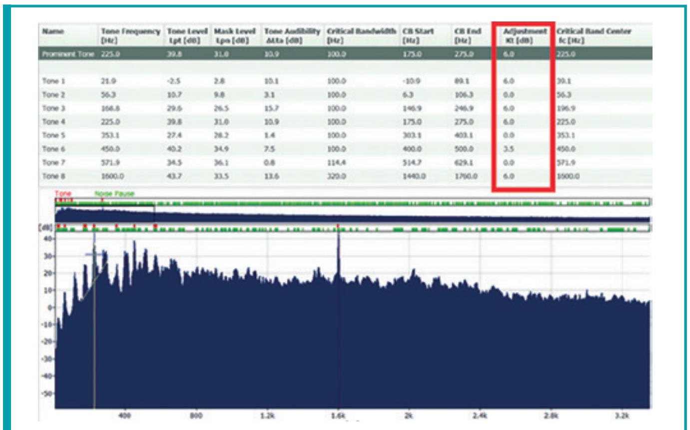
Processing your results

Check with your measurement equipment supplier as to what their software can do for you so you don't have to reinvent the wheel. Ideally you should be able to:

- View measurements and listen to recordings
- Exclude periods with adverse weather conditions or unrelated sounds
- Recalculate logged periods to give 15 or 60 minutes periods
- Select sections as specific or residual periods
- If appropriate for your assessment export periods of background sound to a spreadsheet for statistical distribution of the LA90 values
- Listen to recordings to help make a subjective assessment of the acoustic correction features (Ideally this would have already been assessed on site and you should be considering character at receptor location – which may not be the measurement location).

In order to produce a more robust assessment of the acoustic features you may wish to use the objective or reference methods.

- Identify periods with tonal and impulsive noises, your software may be able to do this automatically
- Take note of how long each tonal noise is present during the measurement period
- If you use the objective tonal assessment method bear in mind that it only takes account of tones that would incur a 6dB penalty, therefore there is a risk that less prominent tones could be ignored



Name	Tone Frequency [Hz]	Tone Level Lpt [dB]	Mask Level Lpn [dB]	Tone Audibility ΔLta [dB]	Critical Bandwidth [Hz]	CB Start [Hz]	CB End [Hz]	Adjustment Kt [dB]	Critical Band Center fc [Hz]
Prominent Tone	225.0	39.8	31.0	10.9	100.0	175.0	275.0	6.0	225.0
Tone 1	21.9	-2.5	2.8	10.1	100.0	-10.9	89.1	6.0	39.1
Tone 2	56.3	10.7	9.8	3.1	100.0	6.3	106.3	0.0	56.3
Tone 3	168.8	29.6	26.5	15.7	100.0	146.9	246.9	6.0	196.9
Tone 4	225.0	39.8	31.0	10.9	100.0	175.0	275.0	6.0	225.0
Tone 5	353.1	27.4	28.2	1.4	100.0	303.1	403.1	0.0	353.1
Tone 6	450.0	40.2	34.9	7.5	100.0	400.0	500.0	3.5	450.0
Tone 7	571.9	34.5	36.1	0.8	114.4	514.7	629.1	0.0	571.9
Tone 8	1600.0	43.7	33.5	13.6	320.0	1440.0	1760.0	6.0	1600.0

Figure 1. FFT analysis with tonal penalties

- Using the Reference (FFT) method will provide an absolute value for acoustic feature correction for a tonal noise. However, you should still subjectively consider how long the tone is present and if the full correction value should be applied
- Objective assessment of Impulses using 10 or 25 millisecond LAF data will need the same consideration. The Joint Nordic method will provide an exact correction value but if that impulse only occurs occasionally should it incur the same penalty as a period that has many impulse events? Show how often Impulses occur to back up your chosen correction feature.

Your software may also be able to perform the rating calculation by allowing you to choose which figures are used.

Reporting

When you produce your report be sure to include the following information:-

Ambient sound LAeq
Containing the specific sound, 15 minutes (night) or 60 mins (day) at the most representative period

Residual sound LAeq
15 minutes (night) or 60 minutes (day) measured at a time as similar as possible to the ambient period but without the specific sound present

Level correction
Calculated from the difference between ambient and residual, subtracted from ambient to give the specific level

Acoustic feature corrections
Tonal (up to 6dB), impulse (up to 9dB), intermittent (3dB) and other, in the absence of Tonal and Impulsive (3dB)

Background LA90
15 minutes (night) or 60 minutes (day) chosen as the most representative from a suitable range

Rating over background
Corrected specific sound level plus acoustic correction features minus background

Context
Include any factors which could influence your conclusions such as local attitude to the site, the residual acoustic environment characteristics (other noises including transport noise), the terrain and how it could vary throughout the year.

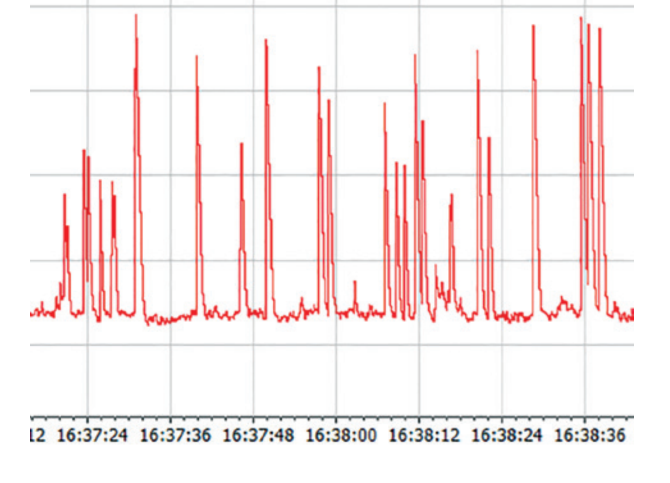


Figure 2: Short measurement period with a very high number of impulse events

State the effect of uncertainty on result
See Richard Collman's article in the Jan/Feb 2015 *Acoustics Bulletin*.

Additional information that will help validate your conclusion and could be invaluable if you have to justify your findings court:

- Photos of the noise source, the proposed site, the measurement location and nearest dwellings
- Map showing Industrial site with measurement locations
- Details of how acoustic correction features were calculated (Screen shots of software or exports of data could be useful)
- Justification of chosen LA90 period and distribution graph if appropriate
- Annotated time history, audio recordings and weather data
- Calibration certificates
- Details of your experience and qualifications to demonstrate competence.

To conclude

Every BS 4142 assessment will be different and not all of the above will be appropriate or practical but hopefully this will act as a useful guide to ensure your results as robust as possible. BS 4142:2014 checklists are becoming available which could prove to be very useful, Derek Nash of Acoustic Central has produced one for the ANC and some IOA regional branches are developing them with their local authorities. If all parties involved are able to agree on a methodology before an assessment takes place then this should lead to greater consistency in conclusions.

Entries for Association of Noise Consultants' awards rocket to an all-time high

By Robert Osborne

This year's ANC awards attracted a record number of 37 entries across the five categories.

The judges, drawn from academics, consultants and other professions, and chaired by Sue Bird, had a major challenge to reduce these to a shortlist of 15.

The judges did not visit any of the projects or hear the results and so their decisions were based on review of paperwork only. In a number of cases the projects are not built and so it is not possible to validate the results.

All the shortlisted entrants gave five-minute presentations at the association's annual conference, which was held in Birmingham in June. These presentations have become one of the conference highlights as they provide a rapid insight into some of the varied and innovative projects being undertaken by acoustic consultancies.

The awards were presented by TV presenter Philippa Forrester, the guest speaker.

A copy of the brochure giving further information is available on the ANC website http://www.association-of-noise-consultants.co.uk/anc-awards/

The Tyneside Cinema café bar

Architectural Acoustics: Commercial Buildings (sponsored by Ecophon)

Winner: *Tyneside Cinema café bar – Apex Acoustics*

The developers sought to create an acoustic environment that had never been achieved elsewhere. This is a well explained project with, in some ways, a deceptively simple solution for a significant acoustic challenge. The project is more complex than merely placing a small screening area next to a bar, it has to be flexible enough to use the space in a variety of ways and as one open space and this project demonstrates that flexibility. This type of solution and approach could be adopted in other building design contexts where there is an adjacent conflict in acoustic requirements at the same time as a fluid space. The judges were interested to see that the venue frequently screens silent films with the curtains open, as they find that the big screen helps draw in passing trade. The judges considered it was a challenging location in which to achieve good acoustics. This was the first time they had seen TripAdvisor used to validate the acoustic performance of a building!

Highly commended: *The Hub, Sky, London – Arup*

Commended: *Cathedral Court, Birmingham – Cundall*

Wallscourt Farm Academy, Bristol

Architectural Acoustics: Education Buildings (sponsored by Rockfon)

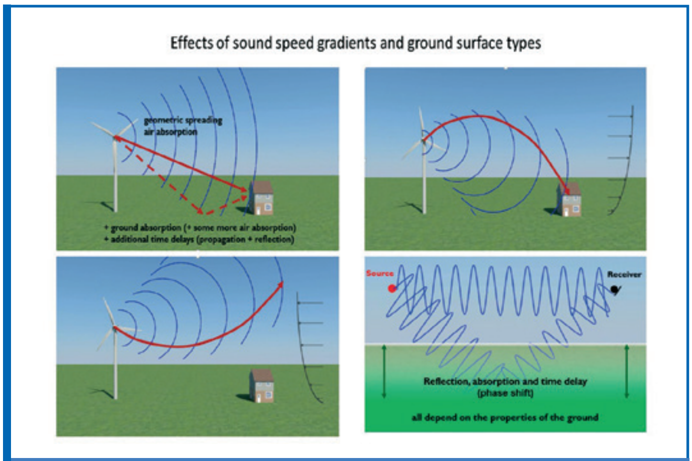
Winner: *Wallscourt Farm Academy, Bristol – Mach Acoustics*

This is a fine example of how to create an inspirational educational environment through an understanding of the requirements and characteristics of an open plan space. These principles have been developed from attending and observing the behaviour and workings of various different open plan schools, as well as through data analysis from on-site measurements and CATT Acoustics models. The removal of walls meant that the consultants focused on STI as a key design parameter, and on communication as their tool to ensure that the open plan spaces are correctly designed. Their logic being that if the acoustic design is not bought into, it will not be implemented, resulting in a space that is not fit for purpose. The judges noted this project was both innovative and different and, most importantly, identified solutions that could

Jack Harvie-Clark (centre) of Apex Acoustics with the Architectural Acoustics – Commercial Buildings Award pictured with Philippa Forrester and Page Hodsman of Ecophon

Max Reynolds (centre) of Mach Acoustics with the Architectural Acoustics – Education Buildings Award pictured with Philippa Forrester and Tim Spencer of Rockfon be used elsewhere. They were impressed that the consultant was keeping in touch with the school and so continuing to learn how the building functions over the next few years.

Highly commended:
Notre Dame Catholic College, Liverpool – SRL
Commended:
Sandwell College, Central Sixth Form campus – Arup



Effects of sound speed gradients and sound surface types

Environmental Noise (sponsored by Cirrus Environmental)

Winner: *Numerical Environmental Noise Modelling – Hoare Lea Acoustics*

The project comprises original, self-funded research to better understand potential shortcomings of noise propagation prediction methods currently applied across the UK. These current methods are typically based around empirical observations and engineering assumptions. The judges agreed that this project is an


Jonathan Sims (centre) of Hoare Lea Acoustics with the Environmental Award pictured with Philippa Forrester and Craig Storey of Cirrus Environmental

excellent example of UK consultants funding research and development, which draws on the skills and knowledge of academics, and applies this in a practical and innovative new way in order to push forward the current state of the art. It was the clear winner in terms of innovation and originality, as well as being both pioneering and inspirational, and making a significant contribution to advancing acoustics and improving public perception. The work should also contribute to genuine sustainability if it enables wind farm proposals to be better assessed, and in many other situations where modelling long distance propagation in varying atmospheric conditions would be a significant gain. It also scores well on complexity and makes a genuine contribution to the industry.

Highly commended:
BAE Birtley, Gateshead – WSP|Parsons Brinkerhoff
Commended: *Albert Wharf, Hammersmith – MLM Acoustics*

P18

◄P17

St James Centre, Jersey

Sound Insulation (sponsored by CMS Danskin and Regupol)

Winner: *St James Centre, Jersey – Hoare Lea Acoustics*

This was an ambitious project where heritage and acoustics had to be combined. The design required the separation of amplified music spaces from a performance venue within a common listed building structure. The client had very high expectations for sound insulation performance between all rooms, yet in delivering the acoustic design to achieve such expectations the listed balcony's timber panelling, arched ceilings and steel columns all had to remain untouched and exposed. The way the consultant was prepared to work outside the usual design recommendations to achieve subjective and therefore potentially risky targets was noted by the judges, as was the use of auralisation to establish client expectations. A very high standard of sound insulation was required, especially at low frequencies and the consultants persuaded the client to accept a more realistic target by simulated listening demonstration. The building also provided an opportunity in which public perception of good acoustics could be demonstrated and this was a major factor in the judges' decision to select this as the winner.

Highly commended:

Everyman Cinemas, Birmingham – RBA Acoustics

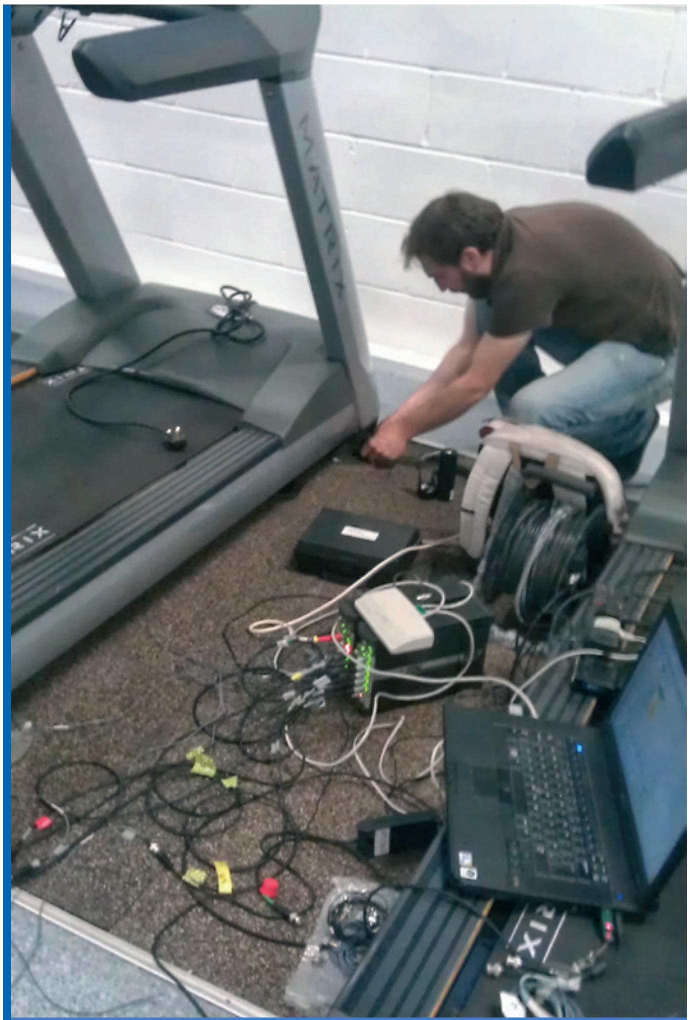
Commended: *North West Cambridge Development – AECOM*

Gael Vilatarsana (centre) of Hoare Lea Acoustics with the Sound Insulation Award pictured with Philippa Forrester and Paul Absolon of CMS Danskin

Vibration (sponsored by Mason UK)

Winner: *Advisory Role to Gym Group – Hoare Lea Acoustics*

The project deals with the problem of assessing potential locations for commercial gym facilities: a "low-profile" problem but one that deals with complex vibro-acoustic behaviour, and which can have significant economic and social consequences for the people concerned. This work demonstrates a significant advancement in analysis methods for the assessment and prediction of vibro-acoustic sources within existing structures, with the advantage that the technique can be extended to many other fields of application.



Assessing gym facilities

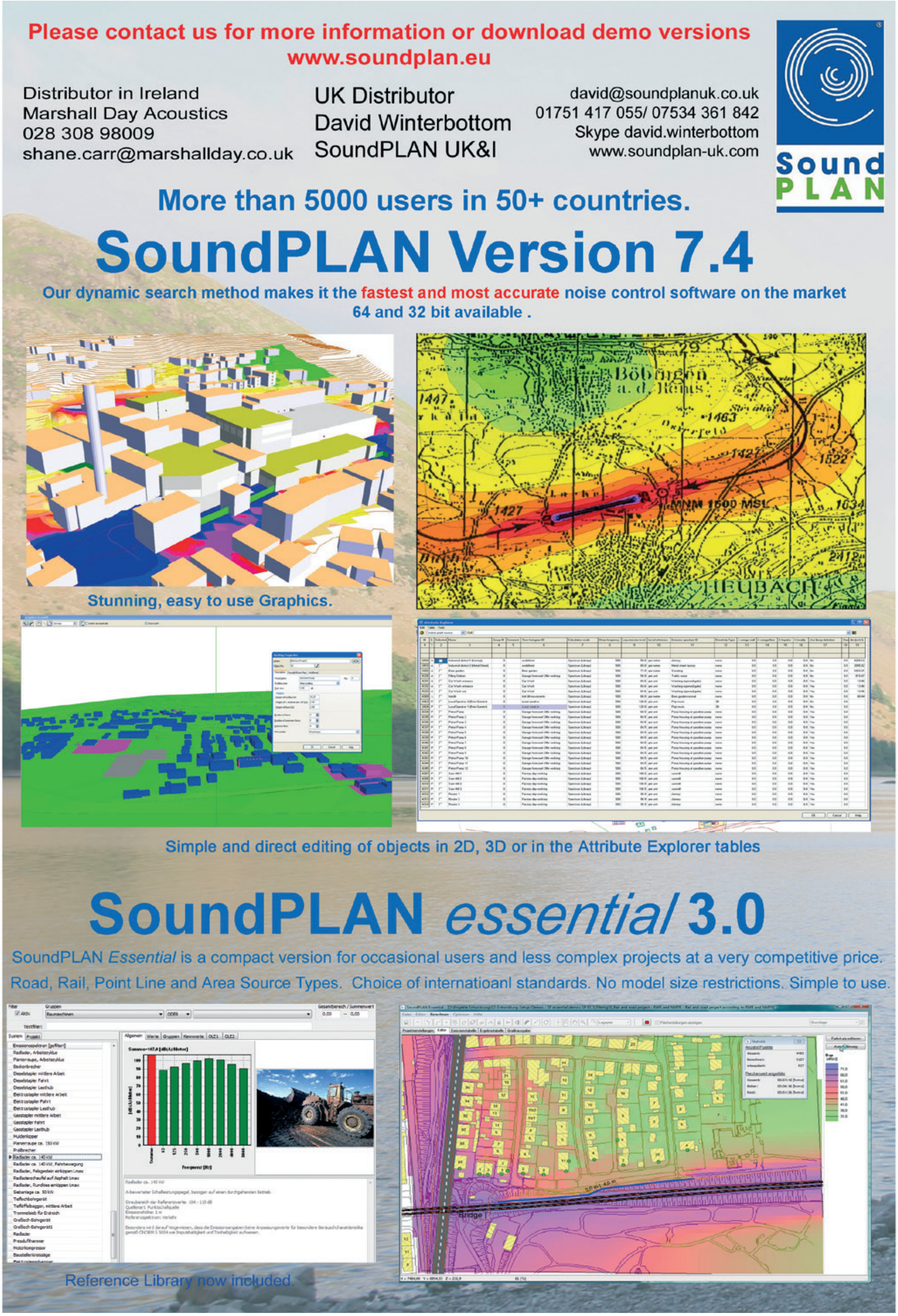
The project summarises a new method for the prediction within existing buildings in scenarios where source items cannot be directly tested in the receiving structure. A technically challenging piece of work, it is an excellent example of collaboration between industry and academia, which has applied current research and experience from other industries. The judges considered this a practical, validated solution that would be of wide benefit and that the method could be applied to many other applications. As such the economic benefit is notable, and a simple replicable test could replace more usual testing.

Highly commended:

Hertsmere House, Canary Wharf – WSP|Parsons Brinckerhoff

Commended: *Crossrail, Eastern Tunnels – SRL*

Martin McNulty (centre) of Hoare Lea Acoustics with the Vibration Award pictured with Philippa Forrester and Bob Pratt of Mason UK


Please contact us for more information or download demo versions
www.soundplan.eu
Distributor in Ireland
Marshall Day Acoustics
028 308 98009
shane.carr@marshallday.co.uk
UK Distributor
David Winterbottom
SoundPLAN UK&I
david@soundplanuk.co.uk
01751 417 055/ 07534 361 842
Skype david.winterbottom
www.soundplan-uk.com
Sound PLAN
More than 5000 users in 50+ countries.
SoundPLAN Version 7.4
Our dynamic search method makes it the fastest and most accurate noise control software on the market
64 and 32 bit available .
Stunning, easy to use Graphics.
Simple and direct editing of objects in 2D, 3D or in the Attribute Explorer tables
SoundPLAN essential 3.0
SoundPLAN Essential is a compact version for occasional users and less complex projects at a very competitive price.
Road, Rail, Point Line and Area Source Types. Choice of internatioanl standards. No model size restrictions. Simple to use.
Reference Library now included.

Schools acoustics put in the spotlight at the ANC's annual conference

By Miles Woolley

Andrew Parkin, ANC Chairman, opened the Association of Noise Consultants' annual conference to a packed seminar space at the prestigious Crown Plaza, Birmingham. Indeed his early comments included his delight in seeing such a huge turnout for the event.

The morning's session focused on schools and was split into two halves separated by a coffee break. The first part focused on ventilation for schools then the newly issued section 2 of Building Bulletin 93 (BB93) Acoustic Design for Schools drafted by ANC and IOA members. A lively question and answer section followed with many questions, ranging from noise from window actuators and meeting noise targets with respect to laptops and other audio visual equipment.

The second half of the morning focused on the (very) recent draft of the ANC Good Practice Guide and the ANC Schools Testing Certification Scheme. More questions followed and, like the first session, most questions were fielded by Jack Harvie-Clark.

After a delicious lunch representatives of the ANC, CIEH and IOA gave their overview of the Professional Practice Guidance (ProPG): Planning and Noise Part 1: New residential development with a fascinating overview by Colin Grimwood and concluded by Richard Greer, ANC Vice Chairman.

Following a break for coffee, all 15 shortlisted entrants for the ANC awards (see pages 16-18) gave five minute presentations on their projects. The audience voted for the best presentation and the winner was Gael Vilatarsana from Hoare Lea. The awards dinner and announcement of the winners followed in the evening.

Question time: (left to right) Ian Rees, Miles Woolley, Jack Harvie-Clark and Andrew Parkin

Strong call to include acoustic education in the music performance curriculum

By Luis Gomez-Agustina of London South Bank University Acoustics Group

Introduction

Acoustics can be considered as the underlying phenomenon and vehicle of music production, perception, performance and composition. The acoustics of the space greatly affect the perception of the instrument by the performer, the listening of other performers and the perception of the conductor and audience (figure 1). Therefore it is in effect another link in the music production and perception chain.

However until today this essential connection between acoustics and music seems to have been ignored or taken largely for granted by the music performance education community. Performance musicians, composers and conductors around the world (and specifically in the UK) complete their extensive musical training without basic understanding of the fundamental acoustics concepts behind their practice, making their instruction arguably incomplete and improvable. In an exhaustive search in the literature, no research or publication has been found regarding the topic here presented.

In the UK, only three higher education (HE) institutions (including universities, music colleges and conservatoires) provide some form of brief acoustic education to some music performance students. However this instruction largely focuses on aspects of instrument acoustics neglecting other essential topics such as room and psycho-acoustics.

A novel initiative has recently been initiated by the author with the aim of promoting the introduction of basic acoustic education in the HE music performance curriculum in the UK.

It is initially suggested that an introductory course could cover the following topics: the nature of sound, the auditory system, hearing conservation, psycho-acoustics, acoustics of performance

P22

Figure 1. Two different acoustic environments used in music performance

◂P20

spaces and musical acoustics.

The author has completed a study with the purpose of gathering relevant evidence, insights and recommendations.

The main part of the study was dedicated to identifying and evaluating the perceived value, suitability, and attitudes towards the prospective introduction.

This article presents a summary of the most salient aspects of the study.

Methodology

Demographic and attitudinal data was collected from a target group deemed to encompass the performance music and HE music education community in the UK. This group was composed of graduate students, teachers, trained musicians, performers, academics, researchers, conductors, composers, institution management and acousticians trained in music or with music performance background. The three data collection methods included an UK-wide online survey questionnaire, semi-structured interviews and documentary analysis. The semi-structured interview method was incorporated to collect detailed descriptive and experiential information to supplement information found from the online questionnaires.

In the UK there are 71 HE institutions which offer courses in music and music performance. In the 2013-14 academic year there were 24,640 under- and postgraduate students enrolled in music performance related courses in the UK.

Thirty-one music performance related institutions (including the most prominent ones in the UK) participated in the online survey questionnaire and interviews which had been open collecting data for seven months. Institutions comprised of universities, music departments, academies and conservatoires of music as well as music education, music research and music professional associations.

The online questionnaire and semi-structured interview were carefully designed in two sections. The first obtained demographic information of the respondents. The second obtained attitudinal information related to the initiative. Thoughtful, intensive and systematic promotional techniques involving email distribution lists and relevant online fora, were employed to achieve a statistically representative number of responses.

Results

In total, 464 valid completed questionnaires were received (sample size) and 22 interviews were completed. Post-processing validation and cross-analysis of the data evidenced the robustness and high reliability of the data collection methods. The high volume of valid responses received allows inferences to be asserted for the entire population.

Online survey questionnaire

Ninety per cent of the online questionnaire respondents agreed with the statement that basic acoustics education can be beneficial in the training of performance musicians, composers and conductors. Only 1% disagreed and 9% did not agree or disagree.

Twenty-nine per cent of the respondents believed that the introduction of basic acoustic education in the performance music syllabus is necessary, 59% thought it should be complementary, while 12% consider that it is not a priority. Only 0.4% believed that introduction is not suitable and 0.2% that is irrelevant.

Eighty-seven of the respondents agreed with the provision of the proposed introduction in some way and only 0.4% believed that the introduction should not be integrated in the syllabus.

A less unanimous opinion was observed on the question about the prospective duration of the introduction.

Semi-structured interviews

All interview respondents believed that the introduction of basic acoustic education would be beneficial in the training of performance musicians, composers and conductors. The majority of respondents considered the introduction very important while five of them believed this to be of moderate importance.

Below there are some illustrative quotes from respondents commenting on the importance of the proposed introduction (How important do you consider the potential introduction of basic acoustics education into the performance music syllabus?)

"Extremely important. I wish this subject had been available to me during my studies. Musicians create sound for a living. It's shocking that we are not better educated in the science of sound" (Senior performer and teacher, MMus)

"It is in fact remarkable that acoustics haven´t been incorporated into the curriculum earlier" (Head of guitar studies)

"I think it is a great idea, I really do .It should been thought earlier!" (Musical director, pianist and vocal coach)

"This is a very important idea…" (Prof Emeritus and world authority in musical acoustics, author of seminal musical acoustics book and musician, PhD)

" Yes, very useful, very important " (Lecturer, performer and head of music undergraduate programmes, Mus PhD)

"… that would be beneficial as so far not too many musicians (including the professional ones) are not aware of the acoustic possibilities of their instruments or the environments that they are performing" (Director of artistic and academic programmes, conductor, Mus PhD)

"Yes I strongly believe it is very important, for composers especially" (Area leader in postgraduate composition, lecturer, senior composer, conductor, performer, Mus PhD)

Some comments on the moderate importance view are provided below:

"Moderately important. Not essential, but could be a useful option particularly for composers" (Senior piano performer, PhD)

"Not so important because professional performers have limited control over their acoustic environments so it is not worth squeezing this into their packed curricula; composers/conductors might benefit more because they might have more control" (Music lecturer, researcher, manager, Mus PhD)

"Moderately important. Musicians have gotten by without it for a long time" (Lecturer in music acoustics, amateur musician, PhD in acoustics)

From comments on the question *"What benefits and drawbacks could be expected ?"* there seemed to be a clear agreement among respondents in that there are many benefits and few or no drawbacks. The only significant drawback mentioned was that *"… if it is not well designed and taught it could be a waste of time for students"*.

The recurring themes on the perceived benefits question were related to the practical and cognitive benefits to the student and that these will lead to the development of better and more rounded musicians. Below are reproduced some representative responses to this question:

"Understanding even the basics of acoustics would change the way musicians use the spaces they play in and how musicians physically arrange themselves in these spaces" (Senior performer and teacher, MMus)

" …making them more employable within the music industry" (Teacher, performer, researcher, PhD)

"Benefits: Students would understand the physical reasons for the characteristics of the instruments that they play which should enrich their musical experience and explain some of the problems of ensemble performance in unsympathetic acoustic conditions.

▸

Drawbacks: I cannot think of any" (Former lecturer on acoustics to music students, world leader acoustic academic, Professor Emeritus, PhD)

"The learner will develop an understanding of how acoustics can affect and influence their performance. Also the historical significance that acoustics have had in shaping musical development. Musicians being able to utilize a performance space better".(Multi -instrumentalist, music engineering producer, PhD student)

"Understanding the ingredients of music is bound to be beneficial to the people serving it up. Lots of benefits – e.g. Composers would understand more about orchestration, performing musicians would understand concepts like loudness and tuning. No drawbacks" (Composer and scientist, MMus, PhD in applied physics)

The recurring themes found in answers to the question *" What could be the potential barriers to implementation? "* were the lack of perceived value (awareness), potential cost/revenue implications, crowded syllabus, lack of expertise to teach the subject.

Discussion

Findings obtained from the online questionnaire agreed closely with those obtained from the interview thematic analysis.

During the course of the study, it has been observed the general unawareness by the relevant target group of the existence of acoustics as a scientific discipline closely related to music performance. This lack of awareness is possibly one of the main contributors for this type of education not to be present the current curriculum.

In the past few years traditional institutions have started to modernise the curriculum by introducing some non-musical subjects with the aim to provide a broader general education to the student. These subjects include psychology of music, physiology, well-being, music technology and professional skills. The author argues that basic acoustics education could be also considered as key complementary understanding in the education of well-rounded musicians.

Key benefits identified from the prospective introduction included:
- gain an understanding of how the acoustics of different spaces can affect the performance on stage and on the audience
- understand the historical significance of acoustics
- prevention of hearing loss
- increase sensitivity and awareness of the nature and characteristics of instruments, improve communication/ appreciation of other related professionals
- expansion of musicians' world view
- facilitate the improvement in aural skills and performance particularly in composing and operatic practice
- enrichment of musical learning experience
- show acoustics as a related industry for potential career change.

No significant drawbacks derived from a prospective introduction were identified in the study.

The following barriers to implementation were identified:
- initial lack of appreciation of the potential value and benefits
- lack of qualified staff
- crowded syllabus
- cost/revenue considerations.

Conclusions

Findings from this study clearly and conclusively showed that the large majority of the HE performance music community in the UK believe that the introduction of basic acoustics education in the instruction of performance musicians, composers and conductors would be very relevant and beneficial. Also the large

P24

◂P23

majority of that community support the actual implementation of this education.

The results from the study strongly support the argument that there is a perceived knowledge gap in the education of music performance students and that there is a potential demand for the introduction of acoustics knowledge into musical education.

The evidence and arguments presented in this study will be used to raise awareness of the education value of this initiative and support the incorporation of basic acoustic education in the curricula of relevant HE institutions in the UK and around the world.

It is hoped that this initiative will promote the engagement of the scientific field of acoustics with the wider public through the art of music.

Further work

To introduce this initiative into a perceived crowded curriculum will require a process of gradual education on the value and benefits as well as challenging other identified barriers and preconceptions. This could be implemented as a programme to raise awareness at relevant institutions involving extra-curricular seminars and workshops promoted as continuing professional development.

After a promotional and education phase, the following phase of the initiative will involve the design, implementation and evaluation of a pilot introduction in a selected group of music institutions.

The findings and insights of this study will be disseminated through the publication of an article in an international music education journal and presentations at national and international conferences with the aim that the initiative is also embraced internationally.

Research funding from relevant institutions will be sought to support the next phases.

Acknowledgements

I wish to thank all the music institutions and individuals who kindly participated or helped by promoting participation on the research. I also wish to thank Mike Wright of the IOA Musical Acoustics Group for his kind support on this initiative.

Government will not introduce WHO guidelines for community noise

The Government has no plans to introduce the World Health Organisation's (WHO) guidelines for community noise, Transport Minister Robert Goodwill has announced.

In answer to a question from Zac Goldsmith, MP for Richmond Park, if he would bring forward proposals to safeguard people's health from aircraft noise, he replied: "The WHO guidelines do not refer solely to noise from aviation, but refer to noise levels from any of various sources including other transport sources such as road, rail, and non-transport sources such as construction, industry and the neighbourhood.

"It is not possible to have a single objective noise-based measure that is applicable to all sources of noise in all situations because effect levels are likely to be different for different noise sources, different people and at different times.

"As such, the Government has no plans to introduce the WHO guidelines for community noise. At a national level, the Government aims to promote good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development."

No WHO guidelines for community noise

Better acoustics needed in green buildings, say scientists

Acoustics in green buildings need to be improved. This is one of the key conclusions of a report on the health benefits of green buildings by researchers at the Harvard T H Chan School of Public Health in the US. The findings are reported in *Current Environmental Health Reports*.

In carrying out the review, which included 15 studies, the team concluded that their occupants were far more satisfied than those in non-green ones.

However, building acoustics were consistently the one aspect that did not score better in green buildings, as participants in several studies were not satisfied with the noise levels experienced.

Where green buildings scored well were in air quality, workspace, building cleanliness and maintenance, with occupants having less exposure to allergens, pollutants, and environmental contaminants, such as formaldehyde.

This translated into better physical and mental health, with workers in such buildings taking less time off for sickness and being more productive.

Dr Joseph Allen, who led the study, noted that research on green buildings was still in its infancy, with most studies relying on self-reported measures collected through survey or questionnaires that were subjective. Future monitoring will include the use of mobile health sensors.

Acoustics in green buildings need to improve

Giancarlo Liguori / Shutterstock.com

Pioneering optical method for direct measurement of free-field sound pressure up to 20 kHz

By Ben Piper of the National Physical Laboratory

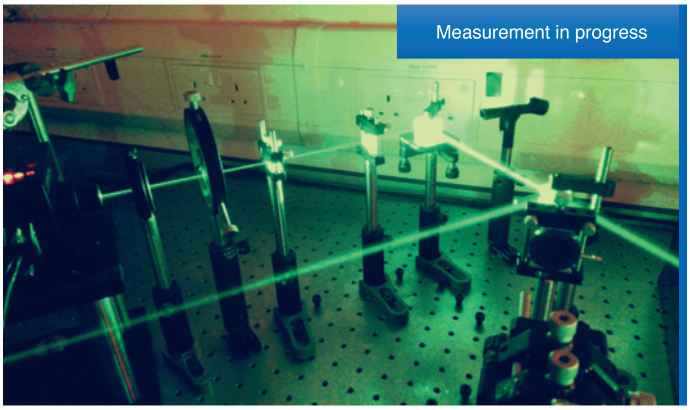
A recent paper in *Applied Physics Letters*, written by researchers at the National Physical Laboratory (The UK's national measurement institute), has described a new method for the free-field measurement of sound pressure covering frequencies up to 20 kHz. This method is based on a remote optical technique that provides direct traceability to the SI base units and allows for any microphone type to be calibrated in principle.

Accurate measurements of sound pressure in air are needed for many applications such as health and safety, environmental impact assessments, commercial development and device specifications. Confidence in the accuracy of a measurement is achieved through a traceability chain which is based on primary standards but includes several steps along the way such as accredited testing laboratories and quality control departments.

The current primary standards are based on the principle of reciprocity. In this method three microphones, with unknown sensitivity and which can be operated reciprocally (used as transmitters as well as receivers), are used to generated three transfer functions. These transfer functions are used in conjunction with accurate knowledge of the acoustic transfer impedance between a transmitter and receiver pair to derive the sensitivity of all three microphones. There are pressure field and free field versions of this standard for of which the former provides the most accurate results.

A new optical method for directly measuring sound pressure has been developed by scientists at NPL. The method allows for the determination of the sensitivity of any acoustic receiver with direct traceability to the standards for length, through the wavelength of the laser light used.

The optical method measures the sound pressure at the crossing of two coherent lasers beams within an anechoic chamber by using an adaptation of an optical technique known as photon correlation spectroscopy, which is normally used for measuring particle sizes. The crossing of two beams of coherent laser light creates an interference fringe pattern, similar to comb filtering, which can be thought of as an optical ruler. As airborne particles cross through this pattern photons are scattered from the light regions.



Measurement in progress

The scattered photons are collected using a single-photon counter. If a sound field is present then these particles will oscillate across the interference fringes generating scattered photons that have a periodicity related to the acoustic particle velocity. By measuring the autocorrelation of the photons collected by the counting device the acoustic particle velocity, and hence pressure, can be found. This procedure can be repeated at a number of frequencies and acoustic devices can then be calibrated against these direct measurements of sound pressure.

This method provides an alternative to the current primary standard that allows for the calibration of any microphone type and has direct traceability to SI base units. Crucially it allows for the calibration of acoustic measurement devices based on MEMS technology which have a significant role to play in the future of acoustic measurements. Now that the method has been shown to be applicable to the upper frequency limit of the audio range, research to turn this method into a standard can be carried out including a full breakdown of the measurement uncertainties associated with the technique and improvement of the infrastructure to increase the method's reliability.

New 'accessiblity' system will help hearing impaired students

Students with hearing impairment will be able to access a greater number of educational facilities and follow classes by way of tablets, SmartPhones or intelligent glasses. This is thanks to an accessibility system developed by Aptent Soluciones, a spin-off of the Universidad Carlos III de Madrid (UC3M).

The project, called Accessibility for deaf and hearing-impaired students via mobile devices and glasses, has been promoted by Madrid's regional government through the programme of pre-commercial public procurement. This technological solution makes educational facilities more accessible and eliminates the communication barriers that hearing-impaired individuals face.

The prototype, whose trial period will begin next academic year at several schools in the Madrid region, uses automatic speech recognition techniques. The professor is equipped with a microphone for her class. The system transforms this signal into subtitles in real time, and the subtitles are sent to mobile devices used by students, who also get sound through magnetic induction loops. In addition, the content is recorded, and its interpretation into sign language can be incorporated, which makes it easy to review these classes in a later viewing.

"First of all, the student can receive all the information she needs on her SmartPhone or tablet in class, and later, as everything is recorded on a YouTube channel, she can access this platform and see everything that happened in the classroom," said Diego Carrero, Technology Director at Aptent.

The results of this project will benefit the nearly 300 hearing-impaired students enrolled in one of 26 special schools in the Autonomous Region of Madrid. These schools have sign language experts and consultants and teachers specialised in hearing and language.

Scientists clinch £500,000 grant to develop a lip-reading hearing aid

A hearing aid equipped with a camera and lip-reading software is being developed by researchers at the University of Stirling.

The device is designed to help users in noisy environments, and can switch between audio and visual cues.

A multi-disciplinary team of scientists and clinicians has been awarded almost £500,000 to develop the technology.

They said it had the potential to "significantly improve" the lives of millions of people with hearing loss.

More than 10 million people in the UK suffer from some form of hearing loss, with the number estimated to rise to 14.5 million by 2031.

The team, led by Professor Amir Hussain, has been working on a prototype "next generation" hearing aid, and the funding from the UK government's Engineering and Physical Sciences Research Council (EPSRC) will allow dedicated work to take place over the next three years.

Professor Hussain said: "This exciting world-first project has the potential to significantly improve the lives of millions of people who have hearing difficulties.

"Existing commercial hearing aids are capable of working on an audio-only basis, but the next-generation audio-visual model we want to develop will intelligently track the target speaker's face for visual cues, like lip reading. These will further enhance the audio sounds that are picked up and amplified by conventional hearing aids.

"The 360-degree approach to our software design is expected to open up more everyday environments to device users, enabling them to confidently communicate in noisier settings with a reduced listening effort."


Professor Amir Hussain

The hearing aid's camera could be mounted inside a pair of glasses, a necklace or even an earring.

Professor Hussain and his team will collaborate with colleagues in the university's psychology department, a team at the University of Sheffield, international hearing aid manufacturer Phonak, and the Institute of Hearing Research.

The institute's Dr William Whitmer said: "We are excited about the potential ability for this new technology, which takes advantage of the similar information presented to the eyes and ears in noisy conversation, to aid listening in those difficult situations, a consistent issue for those affected by hearing loss."

Doctors warn that living near noisy road traffic may lower your life expectancy

Living in a neighbourhood with noisy road traffic may reduce life expectancy and increase the risk of stroke, doctors have reported in a study.

Researchers compared noise levels and data for deaths and hospital admissions across London, they reported in a paper published in the *European Heart Journal*.

In places where daytime road traffic noise exceeded 60 decibels there were 4% more deaths than in quieter areas where the noise was 55 decibels or below.

The World Health Organisation (WHO) sets 55 decibels as the threshold of community noise beyond which health problems are possible.

Residents of noisier areas were also 5% likelier to be admitted to hospital with a stroke – a figure that rose to 9% among the elderly.

Significant night-time noise from road traffic, ranging from 55 to 60 decibels, was also linked to a 5% increased stroke risk but only among the elderly.

The paper took into account factors such as smoking habits, socio-economic status and ethnicity.

The survey, led by Jaana Halonen from the London School of Hygiene and Tropical Medicine, covered districts within the M25 motorway that rings London. The study spanned 2003-2010.

More than 1.6 million out of London's 8.6 million inhabitants were exposed to daytime traffic with noise above 55 decibels, it found.

Outside commentators said the increased health risk was small but clear. The findings matched other research showing that noise increases blood pressure and stress – contributors to cardiovascular disease.

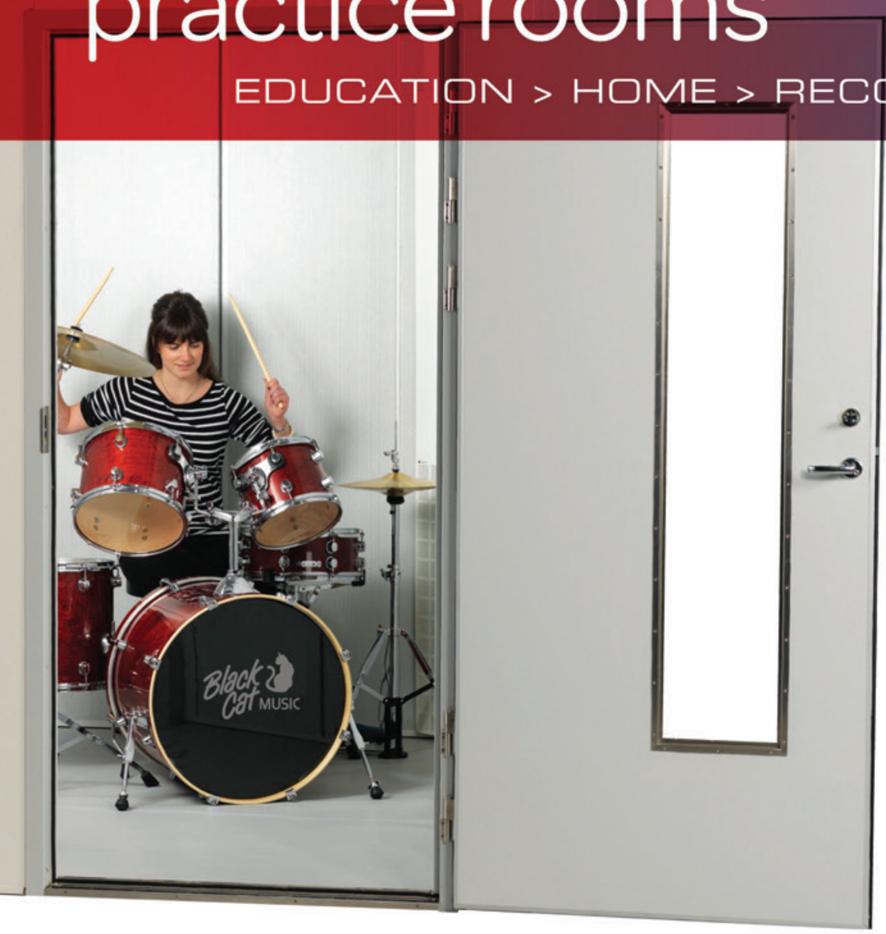
"Public health policies must pay more attention to this emerging evidence," Francesco Cappuccio, a professor of cardiovascular medicine at the University of Warwick, told Britain's Science Media Centre.


Living near a busy road can increase stroke risk

Sound-isolating practice rooms

EDUCATION > HOME > RECORDING

MUSIC
practice rooms.com



Having enough space to practise is often an issue in music departments; our modular, relocatable Music Practice Rooms provide an excellent solution to this problem. Each module offers an individual space for solo or ensemble practice, whilst providing an effective acoustic barrier to avoid disturbing other classrooms.

Head of Music at Lancaster and Morecambe College, Pete French, was delighted with the new sound-isolating practice rooms installed by Black Cat Music: "The facility used to be a lecture theatre. It was just one space we could use; now we've got three spaces. The modules are being used every day with all three year groups time tabled in, so they are getting maximum use."

The rooms, from MusicPracticeRooms.com, use a prefabricated panel design that is affordable, easy to install and allows rooms to be custom configured to suit available space. "We are very happy having them here," continued Pete French.

"The music practice rooms have changed the whole nature of the course, because they are so sound-proofed. The students love them and yes, they work very effectively."

To watch the video of this interview scan here or go to youtube.com/musicpracticerooms

Pete French - Head of Music, Lancaster and Morecambe College

"The Music Practice Rooms have changed the whole nature of the course, because they are so sound-proofed. The students love them and yes, they work very effectively."

Brought to you by

Black Cat MUSIC

Get in touch

Telephone: 0844 846 9740

www.musicpracticerooms.com

How owl wings hold the secret to help making wind turbines and planes quieter

Researchers have created a prototype coating for wind turbine blades which, in mimicking the intricate structure of an owl's wing, dramatically reduces the amount of noise produced by turbines and other types of fan blades, such as those in computers or planes.

Since wind turbines are heavily braked in order to minimise noise, the addition of this new surface would mean they could run at much higher speeds – producing more energy while making less noise. For an average-sized wind farm, this could mean several additional megawatts of energy.

"Many owls – primarily large owls like barn owls or great grey owls – can hunt by stealth, swooping down and capturing their prey undetected," said Professor Nigel Peake of Cambridge's Department of Applied Mathematics and Theoretical Physics, who led the research.

Research into owl feathers may help reduce turbine noise

"While we've known this for centuries, what hasn't been known is how or why owls are able to fly in silence."

Along with collaborators at Virginia Tech, Lehigh and Florida Atlantic Universities in the US, Professor Peake used high resolution microscopy to examine owl feathers in fine detail.

They observed the flight feathers on an owl's wing have a downy covering, which resembles a forest canopy when viewed from above. In addition to the fluffy canopy, owl wings have a flexible comb of evenly-spaced bristles along their leading edge, and a porous and elastic fringe on the trailing edge.

"No other bird has this sort of intricate wing structure," he said.

"Much of the noise caused by a wing – whether it's attached to a bird, a plane or a fan – originates at the trailing edge where the air passing over the wing surface is turbulent.

"The structure of an owl's wing serves to reduce noise by smoothing the passage of air as it passes over the wing – scattering the sound so their prey can't hear them coming."

In order to replicate the structure, the researchers looked to design a covering that would "scatter" the sound generated by a turbine blade in the same way. Early experiments included covering a blade with a material similar to that used for wedding veils, which, despite its open structure, reduced the roughness of the underlying surface, lowering surface noise by as much as 30dB.

While the "wedding veil" worked remarkably well, it is not suitable to apply to a wind turbine or aeroplane. Using a similar structure, the researchers then developed a prototype material made of 3D-printed plastic and tested it on a full-sized segment of a wind turbine blade. In wind tunnel tests, it reduced the noise generated by a wind turbine blade by 10dB, without any appreciable impact on aerodynamics.

Their next step is to test the coating on a functioning wind turbine.

'Mind-blowing' clothes dryer that uses vibration instead of heat

A clothes dryer that uses vibration rather than heat to remove moisture is being developed in the US.

"It consumes almost five to 10 times less energy," said Ayyoub Momen, a scientist at Oak Ridge National Laboratory, Tennessee, which conducts research into clean energy and national security problems for the U.S. Department of Energy,

The dryer works by using ultrasonic transducers to dry the fabric. The vibrations turn the water into a cold mist.

"I realised how cool that is and how much mist it can create with such a little amount of energy," Mr Momen said.

The modern-day tumbler dryer was developed in the late 1930s and came into wider use after World War II. Today about 85% of households in the US have a dryer, and they account for 6% of the energy used there.

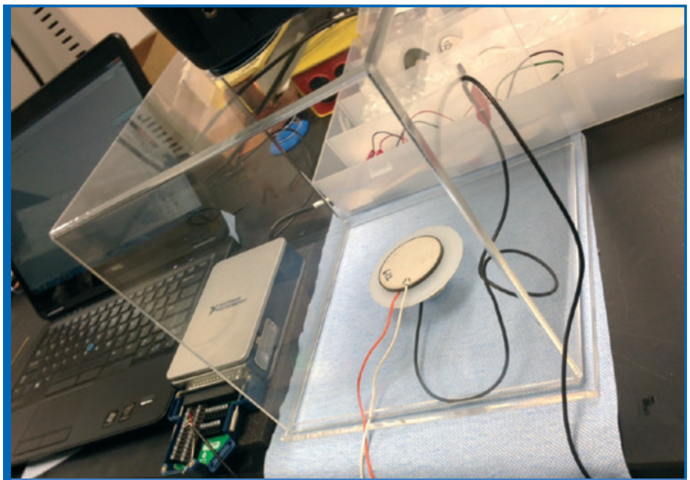
The current prototype works only on small pieces of fabric, but it dries the material in seconds.

"When I put a very small piece of fabric on top of these transducers, the results were like amazing and mind blowing," Mr Momen said. "In just 14 seconds I could dry fabric from completely wet to completely dry."

Drying times for a full load are expected to be reduced to 15 to 20 minutes.

"We think that with this technology, since we are not heating up the fabric, the amount of lint generated would be significantly less," said Edem Kokou, an intern working on the project.

The laboratory, which partnered with General Electric Appliances for the project, is now applying for a patent for the invention. It hopes to have a working full-sized prototype by this autumn.



The prototype dryer in action

Heavy fine for bus builder which ignored multiple HAVS warnings

National bus and coach builder Alexander Dennis has been fined £100,000 and ordered to pay £18,643 in costs after it ignored multiple warnings about dangers to its workers' health from overuse of hand-held power tools.

For several years, the Edinburgh-based company persistently failed to heed expert advice, specialist reports and complaints from workers of pain, discomfort, numbness and whiteness in their fingers.

These symptoms are typical of the type experienced by workers suffering from the permanent debilitating condition known as hand-arm vibration syndrome (HAVS).

Sheffield Crown Court heard that nine workers at Plaxton's, an Alexander Dennis after sales, repair and refurbishment depot in North Anston, South Yorkshire, were diagnosed with HAVS in 2012.

The Health and Safety Executive (HSE) found there was uncontrolled exposure to hand-arm transmitted vibration in the case of up to 25 staff in the Plaxton motor vehicle repair workshops in Ryston Road. There were no restrictions on the type of hand-held power tools employees used or the length of time they were allowed to operate them.

In addition Alexander Dennis had no system to replace those tools that were old or worn out – one tool was 28 years' old and a lack of maintenance meant tools were not running at the optimum level to minimise vibration. Workers were not provided with any information or instruction on how to minimise the risk from vibration and there was no health surveillance programme to check for early signs of HAVS among the workforce.

Alexander Dennis, trading as Plaxton of North Anston, Sheffield, pleaded guilty to breaching Section 2(1) of the Health and Safety at Work etc Act 1974.

The judge described the company's failings as inexplicable and highly culpable in their failure to follow the advice and the warnings given.

In another court case, a facilities management company has been fined a total of £14,000 and ordered to pay full costs of £1,943 for safety failings that contributed to a worker sustaining HAVS.

Nottingham Magistrates' Court heard how, between 2007 and 2012, an employee of UPP (Broadgate Park) operated mowers, strimmers, and a leaf blower as part of his work for the company, and was regularly exposed to levels of vibration which were above the Exposure Limit Value and Exposure Action Value. He reported ill health symptoms to his line manager but no action was taken.

UPP (Broadgate Park), of Gracechurch Street, London, was prosecuted by the HSE and pleaded guilty to Section 2(1) of the Health and Safety at Work etc. Act 1974 and Regulation 5(1) of the Control of Vibration at Work Regulations 2005.

Acoustics, the invisible architecture at an Australian children's hospital

By Jessica Shannon

The Lady Cilento Children's Hospital (LCCH) in Brisbane is Australia's largest and most advanced paediatric hospital. Its innovative and colourful design incorporates leading edge diagnostic and treatment facilities which provide specialist health services for children.

The importance of acoustics was recognised very early in the project with innovative acoustic treatments integrated from master planning to final design.

The LCCH was a very special project from the start as it combined the widest range of potentially conflicting uses in one structure. Responsible for meeting this challenge were the architects, a Conrad Gargett and Lyons joint venture and acoustic consultants, ASK Consulting Engineers.

Balancing and respecting the requirements and expectations of its users, the hospital had to be engaging yet comfortable: a building of specialities and extremes that had to feel homely and safe. The local context, a busy road corridor with the extreme noise intrusion associated with emergency vehicles and helicopters landing on the roof, had to be treated in a cost effective manner that allowed for rest and recuperation. A balance was negotiated and achieved with the thermal and acoustic requirements of the facade and roof.

In the LCCH there are many internal neighbouring environments with conflicting objectives. An example of two extremes is the contrast between quiet bedrooms and the objective of the public areas acoustically lively in an attempt to normalise the environment.

A significant challenge in finding the balance with the building envelope was the acoustic design of the public zones. These zones are passively ventilated and have an active and welcoming feel. An acceptable reduction in noise level from the external transport zones into these public areas, whilst allowing for a reasonable standard of communication was achieved by adding acoustic absorption in the form of perforated plywood on wall and ceiling surfaces to minimise noise build-up and noise transfer deeper into the public zones.

At the opposite end of the background noise spectrum was the requirement to allow for peaceful healing and recuperation in the in-patient bedrooms. The challenge in these areas was the potential for them to become too quiet. Although this sounds counter intuitive, a reasonable level of background noise is important to assist with providing acoustic privacy and masking of corridor noise associated with nursing activity and visitors.

A specified noise level from mechanical services was an important acoustic design parameter. The limitation was to also ensure the noise levels were not so high they may adversely impact on service delivery, causing distraction of staff and potential mistakes.

There was also the challenge of accommodating the hygienic design requirements of hard reflective stainless steel benches, vinyl floors and painted impact resistant wall linings dealt with by providing strategic acoustic to achieve the appropriate ambient sound levels.

Healing is greatly enhanced if patients are relaxed rather than stressed and if clinicians are working within a comfortable environment. These two aspects were considered in designing the LCCH acoustic environments.

The role of the acoustics was not just about excluding external noise but in controlling the sound generated within the hospital so the noises generated were appropriate to each environment. The sensitive healing and treatment spaces such as wards, sleep study rooms, intensive care units, consulting rooms, audio booths, operating rooms and specialist equipment spaces such as MRI facilities were in direct conflict with the high noise generating spaces such as music therapy, Radio Lollipop, specialist plant rooms and the roof top helipad. Extensive room acoustic modelling and design was undertaken to provide acoustic treatments that met all requirements.

The project diversity also incorporated specialist education spaces which included an auditorium and seminar rooms which were finished with acoustic reflective and absorptive wall panels for reverberation control and flexibility of the space.

Consultation spaces necessitated yet another set of acoustic considerations – in this case, acoustic separation – which was realised with a combination of ceiling and partition performance, soft furnishings for noise reduction, and controlled background noise levels.

The closely associated impacts of vibration were integrated with the acoustic analysis. ASK incorporated treatment addressing impacts of surrounding vibration from vehicles and construction onto instrumentation rooms for MRI, CT and microscopy. MRI rooms especially required a high level of acoustic and vibration isolation as they generate high noise levels yet are sensitive to vibration. Internal absorptive wall surfaces were used to reduce reverberation.

The acknowledgement of the importance of the acoustic design was built into the construction process and included many acoustic specific site visits to confirm the acoustic design intent was being appropriately coordinated into the construction. Noise from mechanical plant was modelled to allow a selection of appropriate plant and inform the team on constraints associated with choice of locations. Sources included lifts, laundries, loading dock, garbage compactor, chillers, suction pumps, compressors and smoke exhaust fans. The loading dock canopy was treated with absorptive material on the underside of the soffit.

Emergency smoke exhaust fans were treated to allow for communication during evacuation and to prevent substantial impact during testing. Hydraulic systems were treated by the selection of a lower noise generating system and lagging pipes with additional void treatments in ceilings of highly sensitive spaces including boxing-in with multiple layers of plasterboard and diverting risers. Noise from the video camera fans in a sleep lab were reduced by recessing into the ceilings. Even rain noise was addressed in the roof system design.


The Lady Cilento Children's Hospital


One the hospital's public areas

Bendy liquid metal coils could make stretchable loudspeakers

Coils of liquid metal could be used to make stretchable loudspeakers and microphones, potentially leading to new kinds of hearing aids, heart monitors, and wearable and implantable devices, researchers say.

Increasingly, researchers worldwide are developing flexible electronics, such as batteries, video displays and solar panels, that could one day make their way into clothing and even human bodies.

However, developing flexible devices that can record and play back sound has proved challenging, because scientists have had trouble developing audio components that can remain mechanically stable after they are stretched.

Acoustic devices often rely on rigid metal coils that can both emit and detect sound. Now scientists in Korea have created a stretchable acoustic device by replacing this rigid coil with a deformable, liquid metal coil.

The new coil was made of Galinstan, a highly conductive liquid metal alloy of gallium, indium and tin. The researchers used a syringe to inject Galinstan into a spiral channel in a thin film of flexible silicone rubber.

They then attached copper wires to the end of the coil and a neodymium magnet (made from an alloy of neodymium, iron and boron) to the centre of the coil.

The scientists operated the device by electrically charging the liquid metal coil, turning it into an electromagnet that could push back and forth off the neodymium magnet to either detect or emit sound. They were able to record sounds, such as the human voice and a beeping alarm clock, and play them back while the device was attached to the wrist or was being stretched by hand.

The researchers found the device can be stretched up to 50 per cent its length 2,000 times without any noticeable loss of acoustic performance. It could also play back sounds across the frequency range of human hearing.

Further research is needed to improve the device so that it can more efficiently convert electricity into sound, the researchers said.

This article is based on one that first appeared in *Live Science*.

Scientists develop new tool to assess impact of underwater noise on sea mammals

A team of scientists from the University of St Andrews has developed a new computer modelling tool for assessing the impact of noise from human disturbance, such as offshore wind development, on marine mammal populations.

The team, led by Professor John Harwood, of the School of Biology, has created the interim Population Consequences of Disturbance (PCOD) framework for assessing the consequences of human-induced noise-disturbance on animal populations. The study is published in the journal *Methods in Ecology and Evolution*.

The news follows a study by the university which found that construction noise from offshore wind farms could damage seals' hearing.

Recently a coffer dam was completed at the Dundee V&A project ahead of a summer embargo on works on the River Tay to avoid any impact on the harbour seal breeding season.

Changes in natural patterns of animal behaviour and health resulting from animals being disturbed may alter the conservation status of a population if the activity affects the ability of individuals to survive, breed or grow. However, information to forecast population-level consequences of such changes is often lacking.

The project team developed an interim framework to assess impacts when evidence is sparse. Crucially, the model shows how daily effects of being disturbed, which are often straightforward to estimate, can be scaled by the duration of disturbance and to multiple sources of disturbance. One important application for the PCOD framework is in the marine industry. Many industries use practices that involve the generation of underwater noise. These include shipping, oil and gas exploration, defence activities and port, harbour and renewable energy construction.

For example, offshore wind turbines are installed using a method called pile driving. This effectively involves a large hammer driving foundation posts into the seabed, which generates short pulsed sounds every few seconds. The potential risk of injury and/or disturbance to marine mammals during these noise producing activities has been identified as a key consenting risk for offshore wind projects in UK waters, but many other noise sources are less stringently regulated.

Possible consequences of exposure to underwater noise include: disturbance that could cause marine mammals to either move away or change behaviour e.g. stop feeding, suffer temporary hearing damage or permanent physical injury. The PCOD model assesses what the longer term and larger scale impacts of these consequences on individual animals are to the population as a whole.

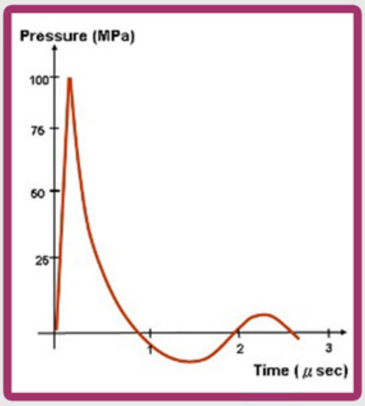
The tool has been designed to use the kind of information that is likely to be provided by developers in Environmental Statements and Habitats Regulations Assessments, and currently covers five key priority species in the UK – bottlenose dolphins, harbour porpoises, minke whales, and harbour and grey seals. However, the approach can be applied to other marine and terrestrial species.

At risk from human noise: sea mammals

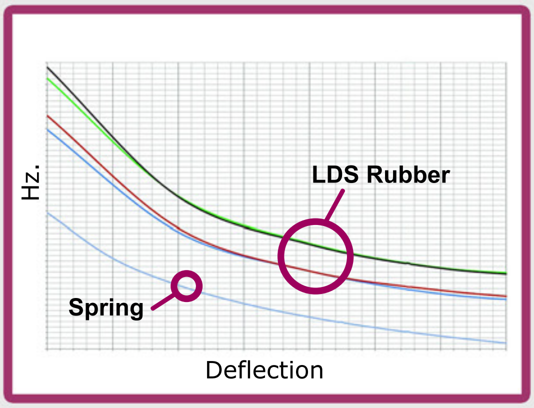
Engineering for Impact Noise
Engineered by Mason

It can be challenging to install gymnasia within existing buildings. The most effective solution is to construct a high mass concrete floating floor, isolated with high deflection springs. This is the only viable option to prevent impact energy from reaching the structure, as with this project in Westfield Stratford for free weights up to 300kg. The existing floor could not accept the weight of this, so we worked with the structural engineer to add steel beams, which reinforced and stiffened the existing structure.

Construction phases of a spring floating floor



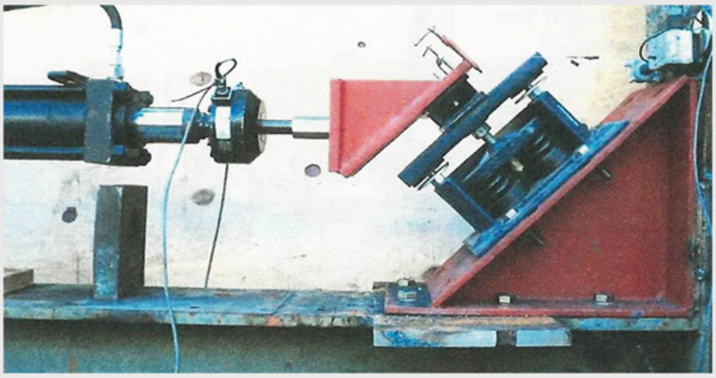
Shock Pulse



LDS / Spring Dynamic Stiffness Curves

Rubber or foam is not effective against shock pulses. Such layers can absorb the higher frequencies but are too dynamically stiff to react and absorb the problematic lower frequencies. These pass through and can easily travel throughout the building. Springs react virtually instantly, allowing each coil to absorb energy –the physical displacement of the shock pulse needs to be absorbed. The higher the deflection spring the more effective coils are available and the lower the frequencies which will be absorbed.

Mason UK regularly test our elastomers and other products in independent laboratories. As part of the Mason Industries group, We also have access to extensive testing facilities. As well as taking responsibility for our own design and engineering, we often have to fabricate bespoke solutions, some of which require very specific testing and certification. Whether a standard solution or a problem never tackled before, Mason UK can help.



Spring Mount testing

Major report calls for better wind farm noise prediction

Call for new noise prediction methods

Experts have called for a revamp of the methods used to predict the amount of noise generated by onshore wind farms, saying that the current system of modelling is failing the public.

A two-year study into the visual and aural impact of turbines at 10 sites in Scotland found that more care should be taken to identify noise issues, and that more consideration should be given to its impact on people living nearby.

The report, carried out by SLR and Hoare Lea for climate change research group ClimateXChange, is the first of its kind to compare the predicted effects of wind farm developments with what happened after the banks of turbines were switched on.

It found that Scotland's wind-powered renewable energy sites met with current planning regulations, but suggested that these should be reviewed to ensure that future developments achieve consistency in future.

The research used two sources of information:

- How local residents experience and react to visual, shadow flicker and noise impacts
- How the predicted impacts at the planning stage compare with the impacts when the wind farm is operating, as assessed by professional consultants.

The main findings are:

- The majority of assessments presented at planning stage for the 10 case study wind farms identified and mainly followed extant guidelines.
- However, for some of the case study wind farms, extant guidelines were not consistently followed and/or the impacts predicted in the documentation submitted with developers' planning applications were not consistent with the actual impacts as assessed in this study or as reported by some local residents.
- Assessments and public engagement activities had not always adequately prepared residents for the impacts of the operational wind farm in terms of visual, shadow flicker or noise impacts.

Ragne Low, Project Manager for ClimateXChange, said: "As the study has focussed on issues relating to the planning process, we are confident that the findings will feed into improved practice in measuring the predicted impacts of proposed wind farms, and in communicating this to decision-makers and those likely to be affected.

"The findings point to several possible improvements in planning guidance and good practice. Some have been implemented in the time between the case study wind farms being planned and built, and the present. The study will contribute to building on these improvements.

"It is very encouraging to see that the project has been overseen by a broad steering group, and we urge everyone involved to continue this inclusive process to develop the impact assessment process."

Linda Holt, spokeswoman for Scotland Against Spin, the national organisation which campaigns for reform of Scottish wind energy policy, welcome the report's publication

"This study is the first of its kind in the world to put the experience of people living near wind farms at its heart. For too long, people who have complained about wind farms have been dismissed as nimbies.

"The recommendations show that the planning system is ill-equipped to address potentially adverse impacts on wind farm neighbours, and we urge the Scottish Government to lose no time in implementing them. For too long, decision-makers on wind farms have been asked to determine applications while blind-folded about the true impacts of placing enormous industrial machines near people's homes."

"We share the disappointment of the hundreds of residents who completed a survey for the study that the contractors refused to undertake new noise monitoring. We are not surprised that the contractors found the modelling in past and current noise assessments to be inadequate."

The full report can be obtained from ClimateXChnge at **http://goo.gl/w522V5** .

Low frequency noise test findings could affect the future siting of wind farms

Scientists have discovered that humans can hear sounds at a far lower frequency than previously assumed.

Brain scans on test volunteers showed that even infrasound as low as 8hz – a whole octave below the traditional cut off point for human hearing – was still being picked up by the primary auditory cortex, the part of the brain which translates sounds into meaning.

Their findings could eventually have important implications for the future siting of wind farms, whose critics often complain of the detrimental impact on health of low frequency sound emitted by turbines.

The research, part of the European Metrology Research Programme (EMRP), was co-ordinated by the Physikalisch-Technische Bundesanstalt (PTB) in Germany and involved experts in acoustics, biomagnetism (MEG) and functional magnetic resonance imaging (FMRI).

In the tests, volunteers were asked about their hearing experience when subjected to infrasound down to 8hz and their statements were compared by means of imaging procedures.

Everyone concerned explicitly stated they had heard something and in addition the scientists observed a reaction in certain parts of the brain which play a role in emotions.

The debate over the effects of wind turbine noise on people living nearby is still raging. Wind farm opponents say it can lead to deafness, nausea, dizziness and migraines, while some experts have concluded that these symptoms are simply imaginary.

Dr Christian Koch of the Max Planck Institute for Human Development in Berlin, who is leading the EMRP project, said: "Neither scaremongering nor refuting everything is of any help in this situation. Instead we must try to find out more about how sounds in the range of hearing are perceived. We're actually at the very beginning of our investigations. Further research is urgently needed."

www.pcbpiezotronics.co.uk/Acoustics

When You Need to Take a
Sound Measurement

Special Purpose Microphones

377B26
High Temperature Probe
Microphone & Preamplifier

130B40
Prepolarized ICP®
Surface Microphone

Acoustic Microphones

377B02
1/2 inch free-field,
prepolarized
condenser microphone

377C20 NEW!
1/2 inch random
incidence, prepolarized
condenser microphone

Preamplifiers

426E01
1/2 inch ICP® preamplifier
(for prepolarized condenser microphones)

HT426E01
High temperature 1/2 inch preamplifier
(for prepolarized condenser microphones)

Microphone & Preamplifier Systems

378B02
1/2 inch free-field prepolarized
condenser microphone,
with 1/2" ICP® preamplifier and TEDS

378A14
1/4 inch pressure microphone cartridge,
a mated preamplifier with TEDS,
and system calibration.

Acoustic Array Style Microphones

130E20
ICP® microphone
with integral preamplifier

130A23
Prepolarized ICP® High Amplitude,
Enhanced Frequency, Array Microphone
and Preamplifier Combination

Just a Selection from PCB's Broad Range of Acoustic Products

High Quality ▪ Exceptional Value ▪ Fast Delivery ▪ Best Warranty

PCB PIEZOTRONICS INC.

7 Paynes Park, Hitchin, Herts SG5 1EH, UK
Tel: 01462 429710 ▪ **Fax:** 01462 429712
E-mail ukinfo@pcb.com ▪ **www.pcbpiezotronics.co.uk**

Check Out Our Prices
www.pcbpiezotronics.co.uk/buymics

Acoustically induced vibration: a review of industry best practice

By Richard Palmer

Introduction

Failure of piping systems in the oil, gas and petrochemical sectors can lead to asset damage, environmental impacts and potentially loss of life. The UK's Health and Safety Executive for offshore industry calculated that 20% of all process pipework failures in the North Sea are due to vibration induced fatigue[1]. High levels of acoustic energy is one of the prime causes of such failures in the piping system and is known as acoustically induced vibration (AIV).

This technical paper provides the reader with a better understanding of the phenomenon of AIV, a review of available screening and analysis methods in the public domain and a viewpoint on the interpreting of the Energy Institute Guidelines of "should" and "shall".

Acoustically induced vibration

In a system in gas service, common in a refinery or offshore platform, high frequency acoustic energy (typically, between 500 Hz and 2,000 Hz) can be generated by a pressure reducing device, such as a safety valve or control valve. It is the result of high pressure drops and high mass flow rates across the valve that generate acoustic energy in the system. The result is the potential for high dynamic stress levels at branch connections in the downstream piping. Potential fatigue issues are concentrated at locations where the downstream piping is circumferentially asymmetric, such as at:

- Tees / branch connections
- Small bore connections (vents, drains, instrument or sample points, typically 2 inches or less in diameter)
- Welded piping supports and anchors.

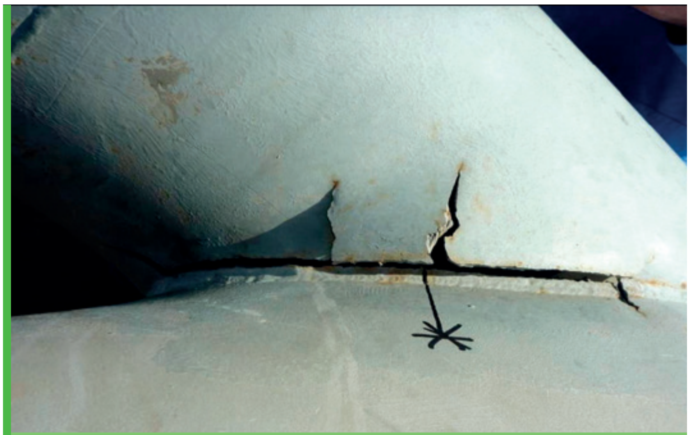


Figure 1- 20x16 Inch flare header unreinforced branch after failure (Source: Society of Petroleum Engineers, Oil and Gas Facilities June 2013)

Failures (similar to the one detailed above), are caused by peak cyclic stresses that occur at the welded connection (discontinuity), where the vibrating pipe wall is abruptly restrained by the asymmetric discontinuity. Axisymmetric discontinuities such as flanges do not experience AIV because the pipe wall vibrations are gradually dampened out as they approach the branch line due to the cylindrical shell stiffening effect.[2]

In recent years there has been an increasing incidence of vibration related fatigue failures in piping systems, on and offshore[3]. The main reason for this is the demand for increased flowrates and a greater use of thin walled pipework. In the 1980s, flowrates were in the region of 175,000 kg/hr discharging into 28 inch diameter headers, whereas today it is quite common to find flowrates in excess of 1,000 000 kg/hr discharging into a 48 inch diameter headers. The resultant increase in system energy is one hundred fold. This has led many operators to specify in their General Engineering Specifications that AIV screening studies should be undertaken at the design stage of project.

The Energy Institute (EI) *Guidelines for the Avoidance of Vibration Induced Fatigue in Process Pipework* (2008) is fast becoming the de facto industry best practice guidance for the assessment of AIV in high pressurised gas systems across Europe, the Middle East and east Asia. It provides a standardised approach that can be adopted during the design phase of the project.

The EI Guidelines provide a screening procedure that enables the user to categorise the level of risk the system is exposed to from acoustic energy, which is presented as a likelihood-of-failure (LOF) score. A LOF of equal to 1 indicates that corrective measures shall be implemented and a score of between 0.5 and 1 indicates that corrective measures should be implemented. A LOF of below 0.5 means the system is acceptable.

It is the interpretation of these terms, "should" and "shall" that often causes confusion on how and where to apply corrective measures within vulnerable piping systems.

In order to understand when corrective actions should be applied it is fundamental to have a wider appreciation of the technical reference material available for the assessment of AIV.

A review of AIV assessment guidelines

In 1982, Carucci and Mueller published an ASME paper highlighting the issue of AIV in high capacity pressure reducing systems in the oil and gas sector. The paper identified a relationship between the amount of acoustic energy within the piping system and a fatigue limit at which point the pipe would fail. This research was based on actual data from industry and included 36 cases where high vibration levels had resulted in either pipe failure, non-failure or no abnormal experience.

The outcome of the study was the development of a design limit curve, which plotted internal sound power level versus nominal pipe diameter. Subsequent industry screening methods are based on the same set of known AIV failure cases and emphasises the limited amount of data in the public domain on known AIV failure cases.

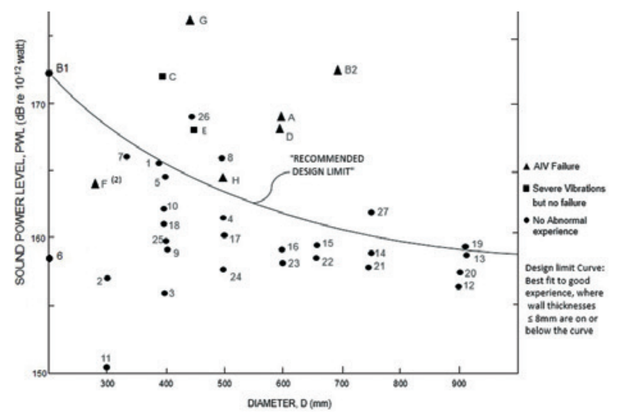


Figure 2

Of the 36 cases, nine were accredited to AIV, which are denoted with letters A-H and the 27 non failures with numbers 1-27. However only seven of the nine AIV cases can reliably be attributed to AIV. The reported failure on the 12 inch line (Point F) was due to a severe weld undercutting; no abnormal experience was reported after the weld had been repaired and Point B1 and B2 only refer to one failure on a 28 inch x 10 inch branch connection. As noted earlier, it is the weld on the parent pipe that is at risk to AIV and therefore, in this case, the failure that should be plotted is the failure on the 28 inch pipe (B2). There is an argument that Point B1 should also be removed from the curve. This would suggest the Carucci and Mueller design limit curve is conservative and should be realigned closer to Point C.

In 1985, the European Oil Company Organisation for Environment, Health and Safety (CONCAWE) conducted its own study into known AIV failure cases within industry. As the only information in the public domain at the time was from the 36 cases report by Carucci and Mueller, the CONCAWE Task Force wanted to enquire from refineries whether cases of acoustic fatigue had occurred which had not been reported. The results were published in Report No. 85/52; Acoustic Fatigue in Pipes. Unfortunately, due to a lack of response from industry, the CONCAWE report could only base its paper on the original 36 cases of high vibration levels.

The CONCAWE report presented the Carucci and Mueller design limit curve as well as a means of predicting the internal sound power level, based on mass flow, differential pressure, temperature and molecular weight. The report also identified control measures that could be applied in order to minimise the risk of AIV.

Although Carucci and Mueller provided a method of identifying the potential for pipe failure by means of the AIV design limit curve, it did not provide guidance on how to assess different types of depressurisation systems. Fatigue failure of any pressure system depends on time or the number of cycles to failure, therefore the treatment required for a system in continuous service may not be justified for one in short term service.[4] This prompted oil and gas companies in the mid to late 1980s[5] to develop their own in-house criteria and assessment methods based on the Carucci and Mueller design limit curve.

Continuously operating pressure reduction devices were defined as being in use for more than five to12 hours during the lifetime of the plant (the time variance being due to the individual Guidance Note), and were considered to include control valves, whereas valves in operation for less than this time period were classified as in short term service, such as safety valves discharging into a flare header system. Making the distinction between short term and continuous service was considered necessary in order to make the proper selection among system design alternatives.

Another important factor that operators considered was the level above which the design limited curve was exceeded. If the predicted sound power level was lower than the design limit curve, no further action was required. However, if it was exceeded the required control measures were dependent on by how much it was exceeded and typically were split into bands of 3 dB, 5 dB and 10 dB or more. The higher the exceedance, the more stringent the recommended control measures. This would suggest there is some flexibility in the tolerance of the applied design limit curves and it is dependent on the type of valve and its service.

In 1997, Eisinger F.L sought to develop the original work conducted by Carucci and Mueller and explore the relationship between pipe diameter and pipe thickness (D/t) and the corresponding sound power level at which failure could occur. The design limit curve developed by Carucci and Mueller was based on a nominal pipe thickness and therefore did not account for changes in pipe wall thickness. The magnitude of dynamic stress caused by vibrational forces within the piping system is very much dependent on the diameter and thickness of the piping system. The thicker the pipe, the greater the resilience to AIV and consequent failure.

Eisinger developed a straight line D/t versus calculated internal pipe sound power level 'Fatigue' and 'Allowable' design limit curves. The allowable design limit curve is 3 dB lower than the fatigue limit curve. From these curves an allowable sound power level can be calculated for a particular D/t ratio.

P40 ▸

◀ P39

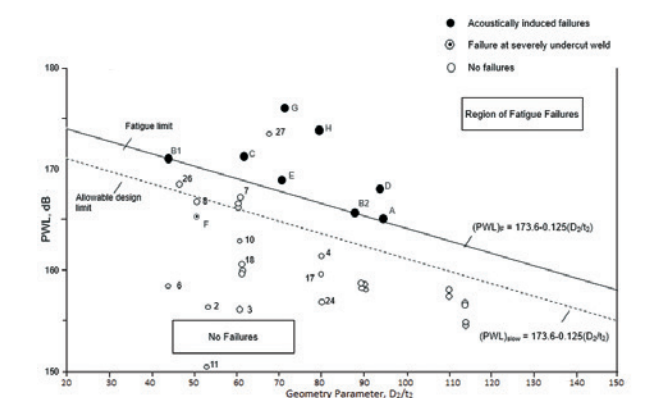


Figure 3

If you exclude failure point B1 from Eisinger's D/t curve, due to the reasons noted above, then Eisinger's curve would indicate a D/t<64 in high energy systems is considered desirable. This is consistent with Carucci and Mueller's curve where only Points B1 and F have a D/t ratio <64, however as discussed, these points should arguably not be included in the design limit curve.

The Energy Institute Guidelines

In 2008, the Energy Institute (EI) published the 2nd Edition of the *Guidelines for the Avoidance of Vibration Induced Fatigue in Process Pipework.* The first edition was published by the Marine Technology Directorate (MTD) in 1999. The guideline was based on the outcome of a Joint Industry Project, which was initiated in response to a growing number of onshore and offshore process piping failures. The original publication was intended principally for use at the design stage and in the period since the first issue, more experience was gained in practical application and a number of improvements were identified.[6] It should, however, be noted that the EI methodology is based largely on the original research conducted by Carucci and Mueller.

The EI Guidelines provide the sound power level calculation value as detailed below, which is the same calculation as Carucci and Mueller; the only difference being that the EI uses International System of Units (SI) rather than imperial. It also introduced the concept of the sonic flow factor (SFF). SFF is a correction to account for sonic flow. If sonic conditions exist then SFF = 6, otherwise SFF = 0.

$$PWL(source) = 10log\left[\left\{\frac{P1-P2}{P1}\right\}^{3.6} W^2 \left\{\frac{Te}{Mw}\right\}^{1.2}\right] + 126.1 + SFF$$

Symbol	Metric
P1 = Upstream Pressure (absolute)	Pa
P2 = Downstream Pressure (absolute)	Pa
W = Mass Flow Rate	kg/s
Te = Upstream Temperature	K
Mw = Molecular Weight	Grams/mol

The sound power level calculation used in AIV assessments do give a different prediction to the International Electrotechnical Commission (IEC) method, which is the standardised approach for determining noise from valves. The EI equation predicts higher sound power levels than the IEC method at higher pressure drops; there is also a difference in the mass flow rate index between the two. The Carucci and Mueller method was used in the EI document to keep consistency with the earlier CONCAWE method and failure/non-failure data. The IEC method, whilst it appears more accurate, should not be used in AIV screening assessments as the relationship between the failure cases and the Carucci and Mueller sound power level has been empirically derived.

The EI Guidelines state that the LOF assessment only needs to be conducted for valves where the calculated sound power level is greater than 155 dB. This cut-off point makes reference to the Carucci and Mueller failure cases, where none of the AIV cases had occurred with a sound power level of less than 155 dB. Therefore for valves in gas service a sound power level in excess of 155 dB is cited as the point where AIV assessments should be conducted and is the starting point for the EI assessment.

The EI approach systematically assesses each discontinuity (branch connection) downstream of the valve to either the flare knock out drum, large vessel, vent to atmosphere or until the sound power level falls to below 155 dB. At each discontinuity the sound power level is recalculated, taking into account noise attenuation along the pipe and a LOF score predicted. The attenuation correction is based on the original analysis conducted by Carucci and Mueller and subsequently presented in the CONCAWE report. The sound power level is reduced by 3 dB per 50 pipe diameters. This method may overestimate the noise attenuation (especially in short pipe runs), however it is consistent with the original work conducted by Carucci and Mueller and CONCAWE.

If the LOF score at the discontinuity scores below 0.5 then it automatically defaults to 0.29. If it scores between 0.5 and 1.0 then the actual value will be shown and if the score is equal to 1.0 or greater it will default to 1.0.

Factors that can influence the durability of the discontinuity and which are used in calculating the LOF score, not only include the D/t ratio, but also the diameter ratio between the parent pipe and the branch connection (D/d). The closer the diameter ratio between the two pipes, the greater the amount of stress the discontinuity can withstand. This emphasises the vulnerability of small bore connections (SBCs), where the abrupt change in pipe diameter causes greater vibrating forces at the welded connection. The other two important factors that influence the LOF score, are whether the connection type is an olet (such as a weldolet or sockolet) and if the pipe is made of duplex material, both of which increase the LOF score.

In broad terms, a LOF of 0.5 conforms to the Carucci and Mueller design limit curve and a LOF of 1.0 is approximately 7 dB greater than the Carucci and Mueller design limit curve. The EI method would seem to follow a similar approach to that of the oil and gas operators own assessment methodologies of the 1980s; that the application of the design limit curve is not a pass/fail approach, but must take into account a number of factors that may improve the durability at the discontinuity or accelerate its potential failure.

It is clear that corrective actions are required if the LOF scores 1.0, however it is not so clear when to apply corrective actions when the LOF score is between 0.5 and 1.0. The EI Guidelines only state that good engineering judgement should be used. Based on this discussion, factors that could be taken into account when deciding if a discontinuity with a LOF of between 0.5 and 1.0 requires corrective actions include:

- If the D/t ratio is greater than 64
- If the valve is in continuous or short term service
- If the discontinuity is an SBC (i.e. high D/d ratio).

Conclusion

The oil and gas sector, to a large degree is still relying on the 36 cases first identified by Carucci and Mueller in the assessment of AIV. Since their publication in the early 1980s, in-house guidance notes have been developed based on the original Carucci and Mueller design limit curve. It was not until the end of the 20th century that the Energy Institute (MTD) developed an alternative assessment method, which ranks the potential risk using a Likelihood of Failure scoring system. The EI Guidelines appears to now be becoming the industries assessment method of choice.

The EI is, however, not without its critics and raises questions over its use of the terms "shall" and "should" and how to address design issues at discontinuities with a LOF score between 0.5 and 1.0.

In 2014, the EI launched a new joint venture with industry to improve the industry's understanding and management of AIV. This will primarily be achieved through the means of physical testing and analytical modelling. The findings will aid in refining the EI approach and will subsequently be published in a later revision of the EI Guidelines.

Richard Palmer MSc BA Hons is the Abu Dhabi Office Manager and Company Partner at WKC. He has more than 14 years' experience, specialising in acoustics and Environmental Impact Assessments (EIAs). His prime focus is on the management, preparation and delivery of acoustics studies in the oil and gas, petrochemical, manufacturing and mining sectors. He is responsible for overseeing and providing noise services in the form of environmental and occupational noise assessment, acoustically induced vibration and flow induced vibration studies, permit applications, modelling for major international oil and gas developments, particularly in the Middle East, Caspian region and West Africa.

Bibliography

- Carucci & Muller 'Acoustically Induced Piping in High Capacity Pressure Reducing Systems', ASME 82-WA/PVP-8 (1982).
- CONCAWE 85/52 'Acoustic Fatigue in Pipes' (1985).
- F.L. Eisinger (Foster Wheeler) 'Designing piping systems against Acoustically Induced Structural Fatigue' (Aug 1997).
- MTD 99/100 'Guidelines for the Avoidance of Vibration Induced Fatigue in Process Pipework' (1999).
- Energy Institute 'Guidelines for the Avoidance Induced Fatigue Failure in Process Pipework' (2008).

References

1. EI 2008
2. Carucci and Mueller 1982
3. MTD 1999
4. Exxon 1985
5. *et al*; Exxon; Shell; BP
6. EI Guidelines 2008

The propagation of low frequency sound through an audience, part 2

By Elena Shabalina, d&b audiotechnik

Introduction

Frequent concert or open-air festival visitors might have noticed that at large events subwoofers, the dedicated low frequency loudspeakers, are often placed in a row in front of the stage as an evenly spaced array (Fig. 1). The reason for this is the directivity control that can be achieved by using beamforming techniques. Opposite to the standard left/right set-up which creates strong interference throughout the listening area, a carefully designed subwoofer array provides an even sound pressure level distribution across the listening area, and keeps the sound away from the stage and the neighbours.

However, at large outdoor events the audience often stands tightly packed in front of the stage (Fig. 2) and the sound from the subwoofer array propagates partly through the crowd and partly

P42

◄ P41
above it. Live sound engineers notice the difference in the tonal balance in an empty venue and with the audience present, but they have different opinions on the topic. Some say the bass becomes louder when the audience is present, some say it is quieter, so we've decided to find out how much of the low frequency energy is actually coming through the crowd. The question is: does it make any sense to work on the beamforming algorithms for subwoofers, if all the sound is absorbed by the audience anyway?

In the part 1 of this article (*Acoustics Bulletin* July-August 2015) we discussed the diffuse field absorption of the human body at low frequencies and a mathematical model of an audience as a porous medium. Part 2 covers a Boundary Element simulation of an audience as a set of hard cylinders along with a scale measurement, and a series of live concert measurements of the sound propagation through a crowd of people.

BEM-simulations

To verify the analytical solution presented in part 1, a computer simulation was conducted. If people in the audience are modelled as upright rigid cylinders on a rigid surface, the propagation of sound through an audience can be represented as a boundary problem and can therefore be modelled using the Boundary Elements Method (BEM).

The foundations of BEM are extensively described in literature, for example in [2]. For the modelling presented in this chapter the software Virtual Lab from LMS is used [3] with the following simulation parameters:

- Nodes and Elements: 40664 Elements and 21785 nodes
- Mesh type and size: Triangular mesh (TRI3) made of linear elements with a maximum length of 250mm
- Software: Virtual.Lab version V11-SL2
- Computer: 64-bit Windows 7 PC with Intel Core i7-2600 CPU 3,4 GHz,
- 16 GB RAM memory, 1 core in use
- Frequency range: 20-120 Hz in 1 Hz steps
- Simulation: Indirect harmonic BEM
- Boundary properties: Z=infinite (acoustical hard boundary)
- Ground: Simulated by a symmetry plane
- Air absorption: Is neglected
- Source: 1 Monopole with source strength of 1kg/s. which corresponds to 1 Pa at 1m distance
- Medium: Air, with c = 340 m/s
- Simulation time: 21 hours.


Fig. 1 An array of subwoofers in front of the stage

Fig. 2 Tightly packed audience in front of a subwoofer array

BEM-simulation layout

Three hundred and fifty hard upright cylinders of an average height of 170 cm and an average radius of 25 cm were placed randomly within an audience area of 17m x 10m with a constant concentration. A point source was located at the height of 0.3 m from the floor 2 m before the audience.

The frequency range of the simulations was 20 -120 Hz. The limiting factor for every simulation was the maximum number of boundary elements and the corresponding number of cylinders that the BEM-solver could handle.

BEM-simulation results

The following figures present the sound pressure level distribution within the audience and above it. Fig. 4 shows the sound pressure distribution on the surfaces of cylinders. Fig. 6 presents the sound pressure level drop over the distance within the audience and above it vs. sound pressure level drop in the absence of an audience. Below 80 Hz an interference-like picture is formed with the distance between peaks about half of the wavelength. The minimum at the rear boundary of the audience (L = 17 m) indicates a soft boundary between the audience and the air.

The same simulation was conducted for the concentration of 1.3 pers./m² with similar results.

The BEM-simulation results were confirmed by a scale measurement: the exact model shown in the Fig. 3 was reproduced in wood in a scale of 1:21.7. The odd scale factor comes from using broom sticks to make the cylinders (Fig. 5). Details can be found in [4].

Live concert measurements

Live measurement set-up

The next step to evaluate the influence of presence of an audience

P44 ►

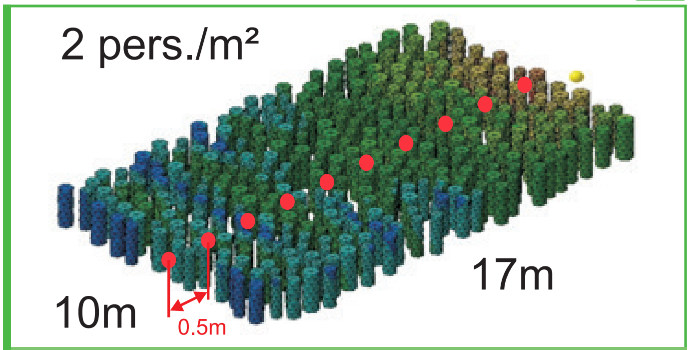


Fig. 3 The layout of the first BEM-model. The audience occupies an area of 10x17 m. The source is 2 m before the audience, microphones are located on the central axis at 0.5m distance from each other.

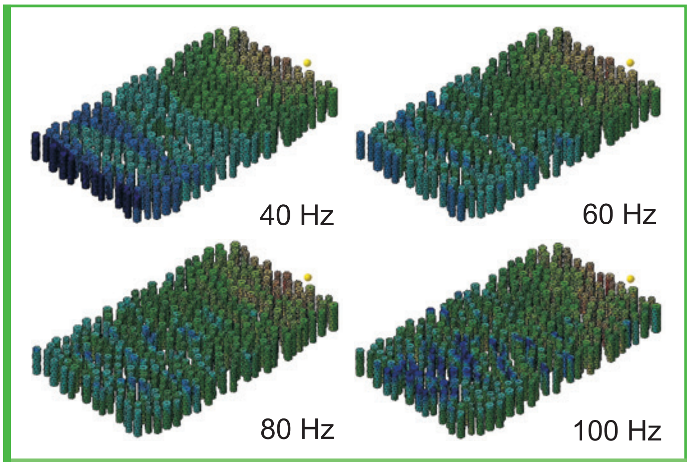


Fig. 4 Sound pressure level distribution over the audience, concentration 2.6 pers./m?, colour scale: 2.5dB/division

◂P42

on low frequency sound propagation is to compare the sound pressure level distribution in a venue with and without an audience. The easiest way is to measure the frequency response on the middle axis of the sound system at different distances from the stage, first without and then with an audience present. The typical layout for this measurement is shown in Fig. 7. The PA system consists of flown arrays of broad-band loudspeakers (so-called tops) and ground stacks or a horizontal array of subwoofers. We are interested in the signal from the subwoofers on the ground since they produce the wave going through the audience. At first measurement positions are marked on the centre line of the venue, usually with 5 m steps. Then frequency responses of the subwoofers are measured after the sound check in the empty venue with the system already set up for the show. This reference measurement is done with sweep signals; then the frequency responses of the subwoofers are measured at the same positions several times during the show, using program material as the measurement signal [1, 5]. Then the sound pressure level decay with the distance from the stage is plotted in frequency bands and compared with an empty and filled venue. The next step is to evaluate the density of the audience. This can be done only very roughly: at the beginning of each measurement a photograph of the audience is taken from the front of house tower, then the number of people is counted manually and divided by the area (also measured before the show). During one measurement the density stays almost constant, but it changes a lot with the distance: the crowd is much denser in front of the stage and becomes sparse at the last measurement position.

Fig. 5 Scale model

Results for diferent densities

Measurements according to the above described procedure were performed at several different events several times during a concert. The average density of the crowd varied from approximately 0.3 pers./m² to 1.2 pers./m². The measurement results for the densities 0.345 pers./m², 0.683 pers./m² and 1.18 pers./m² are presented in the Fig. 8.

The results of live concert measurements of sound propagation through an audience show a similar tendency for different densities of the audience: the decay of sound pressure level with the distance is less in the presence of audience than in free field. The effect seems to increase with the density of the crowd. However, it is very diffcult to measure the effect quantitatively: a dedicated measurement session is diffcult to arrange due to the large number of people that need to be involved, and live measurements contain large uncertainties that can hardly be eliminated. First, the exact measurement

▸

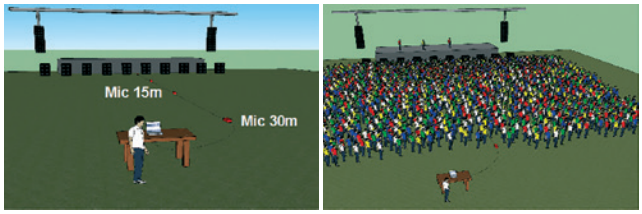


Figure 7: Typical layout for live measurements. Left: measurements in an empty venue, right: measurements in a full venue at the same positions

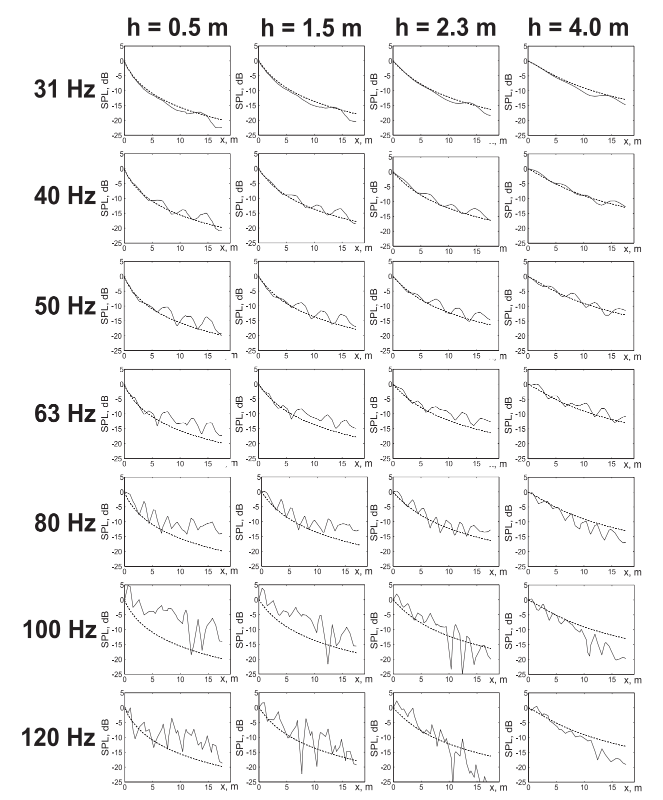


Fig. 6 Sound pressure level distribution over distance at different heights and different frequencies with and without the audience. Solid line represents results with the audience present, dashed line – without audience.

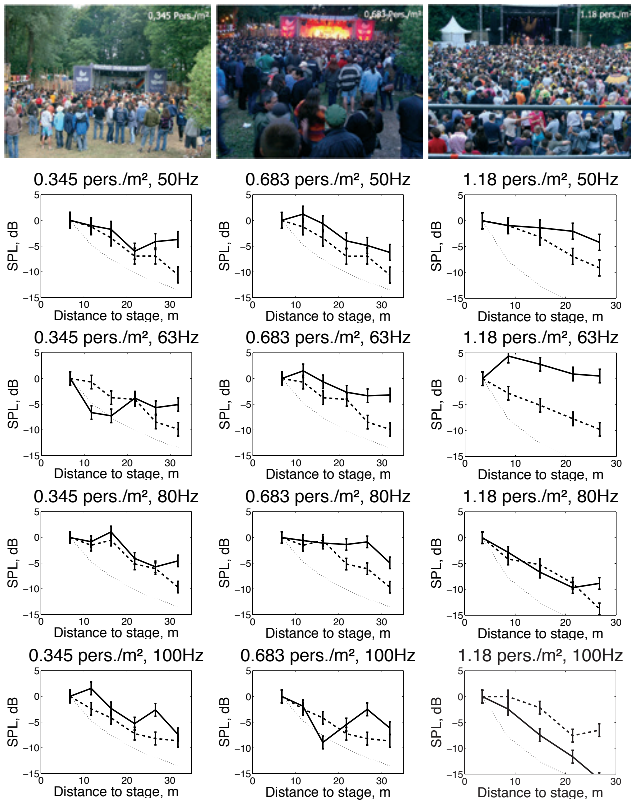


Fig. 8 Live measurements results. Solid line – filled venue, dashed line – empty venue, dotted line – ideal point source.

positions are hard to find in the presence of the audience, the error lies within 0.5 m. Second, the sound engineer might change the setting of the system during the measurement (the volume of the whole system or its component; or the frequency response by equalization) if it is required for the show, and third, the density of the crowd is not constant and hard to evaluate correctly.

Comparison and discussion

Let's have a closer look at the results shown in the previous sections and their meaning.

BEM-simulation vs analytical solution

Analytical and BEM-models do not allow direct comparison since plane waves were used for the former and spherical for the latter. However, both results show interference effects (Fig. 10 and 11 of Part 1 and Fig. 6), where the distance between the peaks is half of the wavelength in the corresponding medium. It does not depend on the type of wave and can therefore be compared. The wavelength $\lambda = 2\pi/k$ of the analytical model is calculated from the known speed of sound (Eq. 5 in Part 1) for the two given values of the concentration ν. The wavelength of the BEM-model is estimated from the distance between peaks on the Fig. 6. This estimation is possible only at 40 Hz, 50 Hz and 63 Hz, where the interference peaks are clearly visible, and gives an uncertainty in the wavelength of $\Delta = \pm 0.5$m due to the size of cylinders.

However, within the given uncertainty the calculated wavelengths of the BEM-models match the analytical model quite well. Also, the wavelength in a less concentrated audience is generally longer than in a concentrated audience, which corresponds to the decrease of the speed of sound with the increase of concentration shown in Fig. 7 of Part 1.

Verification through live measurements

Live measurement results are hard to compare with BEM-simulation or analytical solutions: the distance of 5 m P46

f, Hz	λ,m			
	v=2.6 pers./m²		v=1.3 pers./m²	
	Theory	BEM	Theory	BEM
31	11.75		13.25	
40	9.11	9.5	10.27	9.1
50	7.29	7.1	8.21	7.7
63	5.78	5.4	6.52	6.2
80	4.56		5.13	
100	3.64		4.12	
120	3.04		3.42	

Table 1: Wavelength, calculated according to the analytical model and BEM-simlations

◄ P45

between microphone positions does not allow us to see the interference effects, and the field of the concert subwoofers in an empty venue is far from a field of an ideal point source. However, the tendency of a smaller decrease of the sound pressure level within an audience than in an empty venue is still present.

Fig. 9 and Fig. 10 show both a BEM-simulation result (left) and a live measurement result (right) at 50Hz and 63Hz. All the plots demonstrate a smaller decrease of the sound pressure level in the presence of audience, but the BEM-simulation result shows interference dips that can not be visible in the live measurement due to the large distance between the microphone positions. Still, the live measurements need a lot of improvement to be correctly compared with the simulation.

Summary

Here in short are the main results of the study:

We have found out that the diffuse field absorption of the human body is from 0.025 to 0.07 m^2 per person in the frequency range from 30 to 100 Hz, which is not much in comparison with high frequencies. Despite that, there is a measurable difference between the sound pressure level distribution in an empty venue and in the presence of audience, and the sound pressure level decay with the distance tends to be less in the presence of audience.

At low frequencies an audience forms a medium with its impedance significantly different from the impedance of the air, which leads to the reflection of sound waves from the boundaries back into the audience and therefore the increase of the sound pressure level. The wave impedance of the medium and, correspondingly, the propagation of sound through it, can be calculated using the porous medium theory.

The findings might find use in sound system design or event planning: knowing the influence of an audience of given concentration on the sound pressure level distribution, one can find a better placement of subwoofers and listener areas, along with optimal concentrations of listeners for every zone of the listening area. Decrease of the concentration from the front to the back of an audience can, for example, prevent reflections from the back and eliminate interference peaks.

References

1. W. Ahnert, S. Feistel, and E. Finder. "Software Based Live Sound Measurements". In: Audio Engineering Society Convention 121. 2006, Preprint 6988
2. S. Kirkup. The Boundary Element Method for Acoustics. 2007.
3. LMS Virtual Lab. http://www.lmsintl.com/virtuallab.
4. E. Shabalina. The propagation of low frequency sound through an audience. Logos Verlag, Berlin, 2013.
5. E. Shabalina, M. Kaiser, and J. Ramuscak. "Live measurements of ground-stacked subwoofers' performance". In: Audio Engineering Society Convention 128. 2010, pp. 1–6

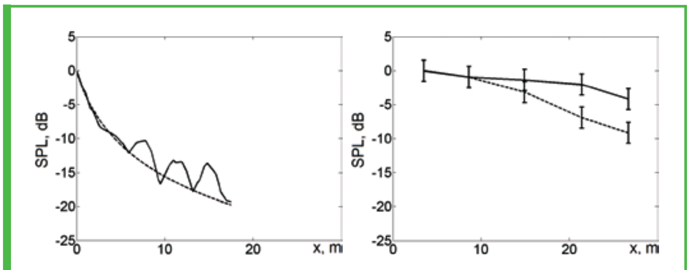


Fig. 9 BEM-simulation (left) and live measurements (right) results at 50 Hz. Solid line – filled venue, dashed line – empty venue

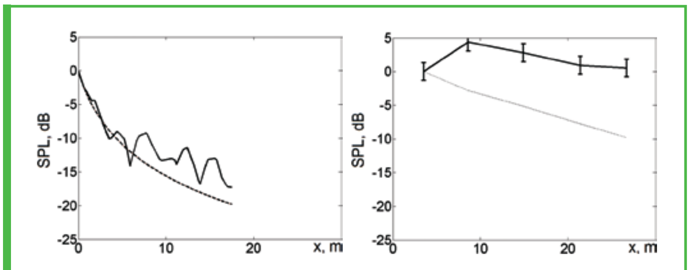


Fig. 10 BEM-simulation (left) and live measurements (right) results at 63 Hz. Solid line – filled venue, dashed line – empty venue

Otoacoustic emissions, cochlea mechanics and hearing loss

By Oliver Brill of Otodynamics

Otoacoustic Emissions (OAEs) are sounds produced by the ear. The phenomena was discovered in 1977 by Dr David Kemp and their discovery was initially controversial as it contradicted the existing understanding of cochlear mechanics. Since then OAEs have changed our understanding of the mechanics of hearing and have become an established method of testing hearing. To understand the contribution OAEs have made we need to understand a little about our auditory system.

The auditory system translates sound into an electrical signal that is transmitted to the brain. The outer part of the system (the ear drum and the three small bones of the middle ear) translates air pressure changes into fluid pressure changes inside the cochlea.

The cochlea is a spiral shaped structure embedded in bone. Along the length of the cochlea runs the basilar membrane. This membrane separates two fluid filled spaces held at different electrical potentials. The middle ear transmits sound vibration into the upper space creating a travelling wave along the length of the basilar membrane.

The inaccessibility of the cochlea makes it very difficult to study. The founder of the study of cochlea mechanics was Georg Von Bekesy. He designed ground-breaking experiments that enabled

P48 ►

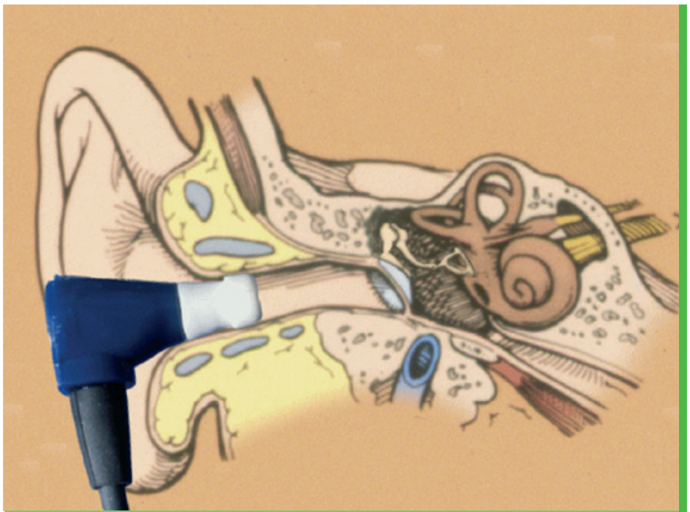


Figure 1: the outer, middle and inner ear, with the probe used for recording OAEs in place in the ear canal

◀ P46

him to observe the travelling wave in the cochleae of dead animals. He saw that the wave travelled along the basilar membrane until it reached a peak and then died away. How far the wave travels depends on the frequency of the sound; high frequency waves travel a short distance while low frequencies travel further. This is because the stiffness and width of the basilar membrane vary along its length so that each part has a different resonant frequency.

On the basilar membrane sit sensory cells called hair cells, so called due to the hair-like stereocilia sticking up from the top. The hair cells are of two types: inner and outer. The basilar membrane wave movement pushes fluid across the hairs bending them. This bending opens ion channels within the hairs which changes the electrical potential in the cells. This change causes the inner hair cells to fire, sending an electrical signal towards the brain.

Only the cells in the resonant region for the sound, where the wave is at its biggest, are triggered, so different nerves are triggered for different frequencies. This is the basis of our ability to discriminate frequencies.

Von Bekesy's experiments were only able to record the travelling wave for very loud sounds. The dynamic range of hearing is very wide: the quietest sound we can hear is equivalent to a sub atomic displacement of the ear drum, the loudest is more than a million times greater.

The output of the system is the frequency of nerve firing, which can vary only in a much narrower dynamic range, maybe from one to 100 spikes per second.

The outer parts of this system, are essentially linear; movement of the ear drum is proportional to movement of the stapes (the bone resting on the entrance to the cochlea).

The cochlea is where the acoustic signal is translated into an electrical signal and it is here that the dynamic range compression takes place.

Different types of hearing loss reflect these different functions; problems in the outer parts of the system (known as conductive hearing loss) are very different from problems with the inner part of the system (sensorineural hearing loss).

Conductive hearing loss makes all sounds quieter. Amplification of sound can completely restore hearing. We have all experienced conductive loss as a result of colds, air pressure change in airplanes or wearing earplugs.

Sensorineural loss is very different. Quiet sounds are lost but loud sounds can be heard just as loudly (often becoming uncomfortably loud) as they would be with normal hearing. The dynamic range of hearing has been narrowed because the compression that takes place in the cochlear has been lost. Modern hearing aids use sophisticated compression strategies to try to restore the dynamic range of hearing.

A major problem with Von Bekesy's passive model was that it was not able to explain this dynamic range compression. Among the critics of Von Bekesy's model was astrophysicist Thomas Gold. In the late 1940s he published papers suggesting that there is a mechanical resonator within the cochlea, which actively amplified the travelling wave, allowing quiet sounds to be heard. The Von Bekesy model could explain the transmission of intense sounds, but the drag caused by the fluid movement within the cochlea would extinguish the travelling wave for quieter sounds. Some kind of amplification of the travelling wave was necessary.

Gold predicted that, like feedback buzz from an amplifier, this resonator might actually produce sound.

Inspired by Gold, Dr David Kemp was able to record these sounds coming from the ear in 1977 and named them Otoacoustic Emissions (OAEs). Because the presence of OAEs contradicted the Von Bekesy model, acceptance of the discovery was slow. Unable to find a manufacturer willing to produce equipment to record OAE, Dr Kemp founded Otodynamics and started production in his garage.

Once accepted, the discovery triggered the search for the mechanical basis of the emissions and function of the process producing them. This search led to the other type of sensory cells in the cochlea – the outer hair cells – as experiments showed that damage to them eliminated OAEs.

The cochlea amplifier and the origins of OAE

The inner hair cells which send auditory signals to the brain are far outnumbered by the outer hair cells (OHC). OHCs are not able to send signals to the brain but do receive signals. In Von Bekesy's era the role of these cells was not clearly understood. OHCs are the most sensitive part of the auditory system; they are the first structure to be lost when the cochlea is damaged. When OHCs are lost, both hearing and Otoacoustic Emissions are also lost. A natural conclusion was that the OHCs are part of cochlea's amplifier – but how does this amplifier work? Some 30 years after the discovery of OAEs this remains a hot topic, but there has been much progress.

A key discovery was that OHCs move in response to sound. A protein called Prestin, which changes structure with electrical potential, was discovered in the walls of the OHCs. Movement of the hairs on the top of the cells opens ion channels in the hairs, changing the potential in the cells and therefore the length of the cell.

One popular theory is that the length change of each hair cell produces a tiny wave on the basilar membrane. With the correct arrangement of cells these tiny contributions can sum up to produce an amplification of the travelling wave. Small imperfections in the arrangement of the cells mean some of the energy produced travels backwards, down the cochlea and through the middle ear to produce sound (OAE) in the ear canal.

Other studies have shown that the stereocilia (hairs) on the top of the cells themselves 'twitch' in response to stimulation. This movement could also amplify the travelling wave and produce OAEs.

Detailed studies of OAEs show that there are several sources and so there may also be several mechanisms generating them.

P50 ▶

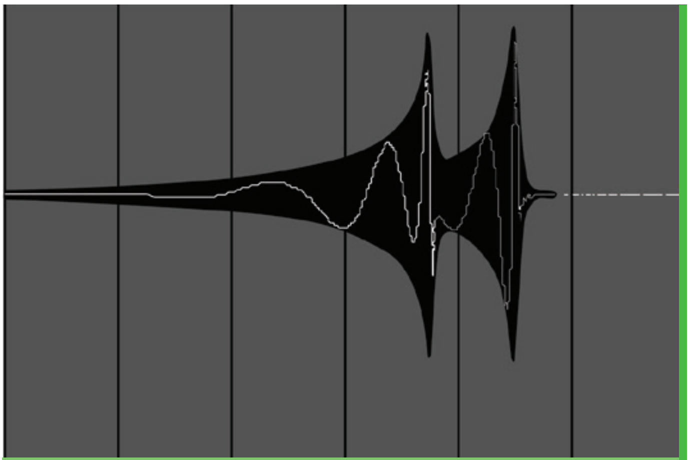


Figure 2: The travelling wave generated by two quiet tones of different frequencies in a healthy cochlea. The waves reach distinct large peaks with the lower frequency travelling further than the higher frequency

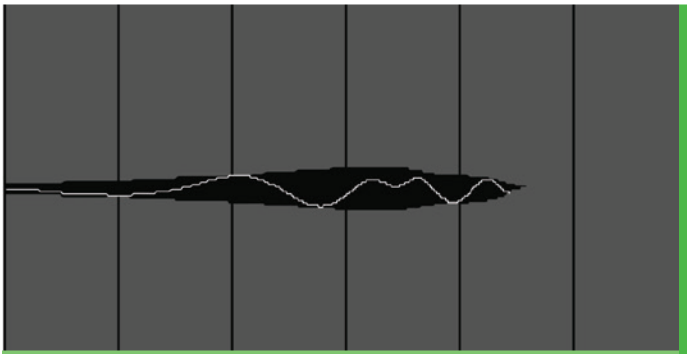


Figure 3: The travelling wave generated by two quiet tones in a cochlea with damaged OHCs. The peaks of the two tones are smaller and are indistinct. These changes in the shape of the travelling wave reflect typical patterns of hearing loss. Frequency discrimination is worse because the peak of the wave is broader and quiet sounds are lost because the peak is smaller. The travelling wave for loud sounds (as studied by Von Bekesy) is relatively unaffected by OHC loss.

◄ P48

From a clinical standpoint how OAEs are produced is not important. What matters is that they are a good indicator of cochlea health. The cochlea is such an inaccessible structure that although they are obscure epiphenomena of the hearing process, they have become a standard tool for audiologists.

Recording OAEs

OAEs are recorded by sealing a probe with a microphone and loudspeakers into the ear canal. Sometimes the microphone can record emissions with no evoking stimulus (known as spontaneous emission), but clinically they are always recorded in response to a stimulus from the loudspeaker.

The key problems in the recording of OAEs are:

- Distinguishing the emission, which is very small, from environmental noise which is generally much larger
- Distinguishing cochlea emissions from artefacts from other sources including the stimulus used to evoke the emission.

The first of these problems is tackled by averaging many responses. The response to each stimuli will be identical whereas environmental sounds will not be synchronised with the stimuli and will tend to cancel one another out. But synchronous averaging does not insure that these sounds originate in the cochlea. They could simply be responses to the stimulus from the ear canal or middle ear. This second issue is tackled differently by the two types of recording methods:

Transient Evoked OAEs (TEOAE)

TEOAE recording involves presenting repeated click stimulus to the ear. This stimulates the cochlea over a wide frequency range. Recording of the OAE response only begins when the evoking click stimulus has ended; the stimulus is separated from the response in time.

TEOAEs are recorded in two interleaved averages which allow us to compare the correlation between them. Correlations between the two waveforms are taken to indicate a reproducible signal while differences are evidence of noise.

The signal from the OHCs saturates at high levels as they act to amplify quiet sounds, but have little impact on loud sounds. Other artefacts of the stimulus (echoes) grow proportionately with the stimulus. Recording at different stimulus levels allows the artefacts to be cancelled leaving only the emission.

Distortion Product testing

The action of the outer hair cells will distort the waveform of sounds presented to the cochlea. Distortion Product OAEs (DPOAE) measure this distortion.

If two pure tones (at frequencies F1 and F2) are presented to the ear at the same time, then distortion in the cochlear produces further tones at specific frequencies (which are products of frequencies F1 and F2). Recording the sound level at these frequencies allows us to monitor the distortion. DPOAEs are recorded during the presentation of the stimuli and are distinguished from it because they occur at specific discrete frequencies. While TEOAEs separate stimulus and response in time, DPOAE separate them by frequency.

Multiple distortion products are produced but the strongest is produced at 2f1-f2 and it is this frequency which is measured clinically. Pairs of tones at a range of frequencies can be applied to build up a picture of function over a wide frequency range.

Distortion products were known long before the discovery of OAEs. They were originally discovered by musicians in the 18th century. Violinist and composer Guiseppi Tartini first heard additional sounds in his own ears when he played certain combinations of two notes on his violin. Once Tartini convinced himself that these sounds were being created by the ear, he started using them in his compositions. He would include two notes to be played together that he knew would create the sensation of a third note.

What can OAEs tell us about hearing?

OAEs inform us about damage to the cochlea which is the most common cause of hearing loss. They rely on a clear pathway to and from the cochlea so they are also affected by any damage to the middle ear.

However, because they are a side effect of the process of hearing, rather than a result of hearing itself, their presence only confirms normal hearing, they cannot accurately measure the extent of any hearing loss. Despite this they have found multiple uses in Audiology.

New born hearing screening

In the UK (and many other countries) all newborns have their hearing screened in a programme relying on the use of TEOAEs. OAE testing is quick, low cost and does not rely on any conscious response from the baby.

Newborn screening has drastically lowered the age at which children are diagnosed with hearing loss from years to weeks after birth. Development of neural pathways for hearing depends on stimulation from the ears in the first years of life, so early identification of loss, together with early hearing aid fitting (or cochlea implantation) has vastly improved outcomes for children with hearing loss.

Monitoring hearing loss due to Ototoxic drugs or noise exposure

Both TEOAE and DPOAE have been used with some success in measuring hearing damage prior to it becoming apparent as a hearing loss, allowing changes to be made in treatment or behaviour before communication difficulties arise.

Future directions

Testing of cochlea efferent pathway

Although they cannot send signals to the brain, OHCs do receive nerve signals from the brain. The purpose of this efferent pathway is not well understood, but its effect on OHCs can be measured by recording the suppression of OAE levels when the pathway is active.

Weak OAE suppression has been associated with difficulties understanding speech in noise and to vulnerability to noise-induced hearing loss.

Using our understanding of cochlea mechanics

The discovery of OAEs has played a part in revolutionizing both our understanding of cochlea mechanics and the lives of children born with hearing loss.

The advances that have been made in our understanding of cochlea mechanics have given us new insights into the causes of hearing loss. Future developments may create tests that can separate different mechanisms of OAE production and diagnose different types of hearing loss based on these mechanisms.

However, currently hearing aid fittings, practically the only intervention we can make for cochlea hearing loss, are unchanged by this new understanding.

They still use only our hearing thresholds and the loudest sounds we can tolerate across a range of frequencies. The signal processing power of hearing aids has grown rapidly over the last 30 years, while the information used to programme them is unchanged. Users with whose hearing is identical on these measures can have very variable benefits from using hearing aids, suggesting the tests do not give the full picture.

Our improved understanding of cochlea mechanics, together with the information available from tests including OAEs should enable us to fit hearing aids according to our knowledge of the area of damage in a particular ear. A first attempt to do this is the “BioAid” (bioaid.org.uk) which uses a mathematical model of the cochlea to create a hearing aid (downloadable free as an iPhone app). The parameters for fitting it are based on the design of the ear, rather than on the physical design of the aid. Hopefully this approach will improve the lives of people who are getting limited benefit from current hearing aids.

Pioneering acoustic technology company prepares for big expansion

St Andrews (SA) Instrumentation, one of the UK's leading designers and manufacturers of innovative acoustic technologies, has invested in a new headquarters and test centre as it advances its global production ambitions.

The company – a wholly owned subsidiary of the University of St Andrews – has taken a lease on two units at Mill Court Industrial Estate in Tayport, Dundee, effectively tripling the size of its premises.

The moves comes after three years of research and development and around £1 million of investment by the University and the SOI Group.

SA Instrumentation are pioneers in real-time autonomous acoustic detection, and have designed and manufactured a portfolio of products with a growing range of applications, from marine mammal detection to advanced human diagnostics equipment. Its in-house capabilities allow it to customise solutions where required.

The company's range of products include the bespoke Decimus, which is used in support of environmental assessments, mitigation measures and scientific research. Applications include marine renewables, oil and gas, decommissioning, marine civil engineering and infrastructure projects by the Government, security and defence contractors, as well as the scientific community.

Earlier this year, SA Instrumentation launched its data acquisition (DAQ) card, a new and revolutionary solution for acoustic processing including, marine mammal research and noise monitoring. Easy to integrate, it allows for the detection of acoustic data over a wide frequency band width that allow user control over the gain and filtering on all its analogue inputs combined with small size and power requirement.

The new premises will accommodate the company's five research and development engineers, as well as administrative staff. In addition to office space, there will be a new workshop area comprising design, test and despatch areas.

SA Instrumentation CEO Derek Watson said: "Having all of our personnel and facilities located together on one site is of huge benefit; the move supports the continuation of our growth and significant research and development activities.

"This is crucial to our success as we develop and improve existing and new technologies and services to lead the way in this area."

Derek Watson

Decimus in action

Model plane enthusiasts fly high with Svan 971

The British Model Flying Association (BMFA) is using a SVAN 971 sound level meter to help clubs with environmental noise-related issues and to ensure the long-term protection of model aircraft flying sites.

Andy Symons from the BMFA said: "As we are mostly monitoring environmental noise impact of model aircraft, our main requirement was the ability to integrate the sound level meter with 1/3 octave real-time analysis. This means readings can be made quickly and none of the octave bands miss any of the noise during the measurement period."

A model plane takes off

Xodus wins major Middle East oil pipe vibration contract

Xodus Group has secured a contract for the vibration assessment and analysis on the oil train piping and structures for Zakum Development Co. at Zirku Island, 140 km northwest of Abu Dhabi.

The work, valued at more than US$600,000, will pull in services from Xodus' process, piping, instrumentation and structural teams. The 24-week project will include a front end engineering design (FEED) scope of work

With its advanced oil and gas installations, Zirku is considered the main industrial base for the processing, storage and export of oil from the Upper Zakum, Umm Al-Dalkh and Satah fields.

In recent months, Xodus' vibration engineering team has also won a number of other contracts in the Middle East.

The company secured a three-year contract to deliver rotating machinery condition monitoring services with rotating machinery vibration analysis and risk management.

Xodus has also been awarded work to investigate two vibration issues on sulphur recovery units in Abu Dhabi.

The work will be split into two phases: phase one for the site survey vibration investigation and phase two to engineer solutions to eliminate or reduce the vibration concerns once the root cause has been identified.

Acoustic consultancies go head to head as they vie for Stirling Prize glory

Acoustic consultants Sandy Brown and Hann Tucker are celebrating seeing two schemes in which they played key roles shortlisted for the UK's most prestigious architectural award, the Stirling Prize.

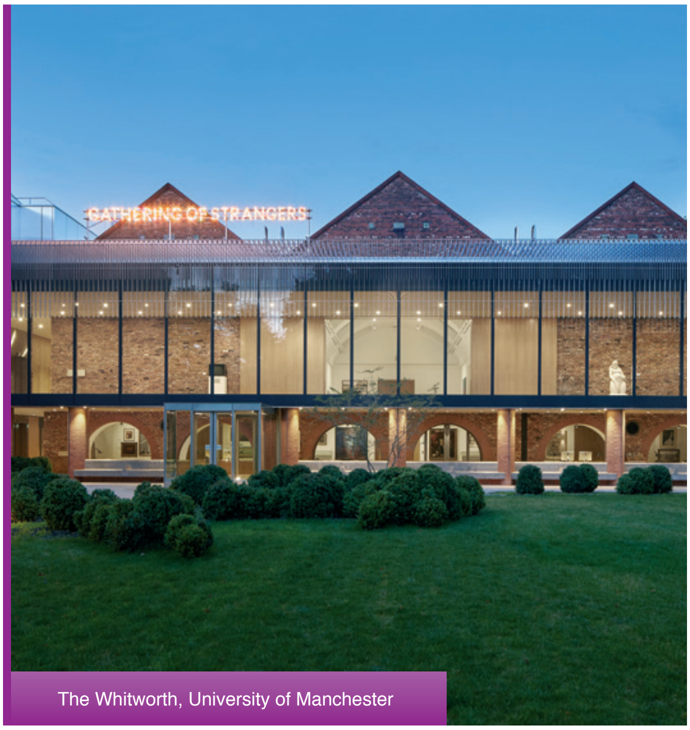
Sandy Brown was the acoustic engineer on a scheme designed by Heneghan Peng Architects to provide a new building at Stockwell Street, Greenwich for the University of Greenwich. In awarding it a national award, the judges described the acoustics as "remarkable".

Hann Tucker was the acoustic consultant on a MUMA-designed scheme to extend the Whitworth Gallery at the University of Manchester, which also won a national award.

Both schemes have been chosen, along with four other RIBA national award winners, for the shortlist for the Stirling Prize, the winner of which will be announced at RIBA on 19 October.

The prize, which began in 1996 and is named after Sir James Stirling, is judged against a range of criteria including design vision; innovation and originality; capacity to stimulate, engage and delight occupants and visitors; accessibility and sustainability; how fit the building is for its purpose and the level of client satisfaction.

Sandy Brown provided acoustic services for a scheme designed by Lifschutz Davidson Sandilands to provide a new building for Bonhams in Mayfair, London, which also won a RIBA national award.



The Whitworth, University of Manchester

The Stockwell Street Building

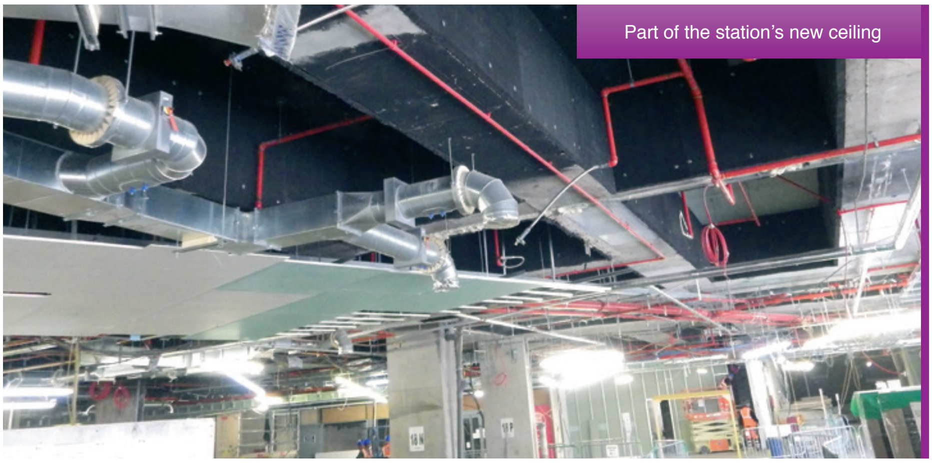
Fireseal 'just the ticket' at Birmingham New Street station refurbishment

Fireseal, an acoustic and fire retardant flexible foam, has been used extensively in a major project to transform Birmingham's New Street station.

The polyurethane foam, manufactured by Carpenter, was used to line the areas above the ceilings in the station shopping centre's new concourse to reduce reverberation levels for the 140,000 shoppers and commuters who will use it every day.

Justin Richards of Haskoll, the design-led architectural practice, said: "The foam has great acoustic absorption values, is easy to use and dark enough to not show through the ceiling system."

For further information ring **01457 892418** or email **sales.uk@carpenter.com**



Part of the station's new ceiling

Noise test system 'sound investment' at vehicle proving ground

A new noise measurement system has been installed at the Millbrook proving ground in Bedfordshire which is used as a test bed for new vehicles.

The investment, which follows a number of other upgrades across the business, enables Millbrook to test, investigate and develop way beyond the basic regulatory requirements.

The new noise facilities will be particularly prevalent in the development of new technologies, including electric and hybrid vehicles, enabling engineers to measure acoustics and vibration inside a vehicle and syncing it with data recorded outside. The system itself is ideal for, but not limited to, sound source localisation and contribution analysis, it states.

Ravi Bal, Senior Engineer at Millbrook, explained: "Noise, vibration and harshness (NVH) testing is a key area of development for Millbrook and we are working with many of our customers to conduct a variety of objective measurements in a repeatable test environment.

"This will enable us to assist our customers with investigation and development tasks, not just for regulatory purposes but also for improvements in refinement.

"In 2012, we introduced the UK's first commercially available ISO 10844:2011 specification noise surface, providing the most advanced facilities for investigating and understanding vehicle noise.

"Whilst the anticipated update to legislative type approval requirements did not go ahead as predicted in 2014, Millbrook is keen to remain at the forefront of the latest technology for the test and development of noise, and has invested in state of the art data acquisition hardware, and software, to provide a wide range of capabilities."

Noise testing at Millbrook

Hospital tiles aim to be 'just the tonic'

Armstrong Ceilings Bioguard Acoustic mineral tiles were extensively used in the building of the new South Glasgow University Hospital and Royal Hospital for Children.

Officially opened by the Queen in July, the hospital has been renamed the Queen Elizabeth University Hospital. It is expected to treat 750,000 patients, including 110,000 A&E patients, every year.

Bigger home for Wakefield Acoustics as business continues to boom

Wakefield Acoustics has substantially expanded its business and manufacturing operations by moving to a new 40,000 sq ft factory in Heckmondwike, West Yorkshire.

The switch follows a £4 million management buyout at company at the end of last year. Founded in 1980, it designs, manufactures and installs industrial and environmental noise control systems, servicing the needs of such sectors as power, oil, gas, water waste and general manufacturing.

Employee numbers have risen significantly in recent years, with the company now employing 40 staff, up from 25 in 2012. Five new manufacturing staff have been recruited in recent months and the company is still hiring as part of its growth plans.

The business recently announced a 50 per cent increase in turnover since 2012, with plans to double it by 2018.

Managing Director Lee Nicholson said: "We are absolutely delighted with our new factory which represents a significant milestone in the company's continued growth and development.

"Our enhanced capacity, facilities and resources further underpin our capability to design, manufacture and install high quality noise control products and services for our customers worldwide. We are very pleased that we have been able to expand our business locally and create new local jobs as part of the move."

Jane Dawson, Executive Director, and Lee Nicholson, Managing Director

New Yorkshire operating base for Ionix Advanced Technologies

Ionix Advanced Technologies has moved its main operating location to the 3M Buckley Innovation Centre in Huddersfield.

A spin-out from the University of Leeds, Ionix specialises in the creation of proprietary high performance piezo-electric materials that can operate in high temperature, high work environments.

Piezo-electrics have many applications: as actuators and motors in fuel injectors and robotics, as transducers employed in both medical and naval sonar ultrasonic platforms. They can also be used for active vibration dampening, electronic frequency filters, transformers and as acoustic/vibration sensors.

In 2014 the company received a funding award from the UK's innovation agency, Innovate UK, to co-fund a project to design, build, test and demonstrate a new prototype of ultrasound transducer that can be used in high temperature environments.

Dr David Astles, Chief Executive Officer, said: "This relocation allows us to expand our manufacturing and technical development team and lay out a production capability to meet the opportunities presented to the company over the next few years in materials and device component supply."

Going bats: how sound technology is used to assess condition of sewers

Lanes Group is claiming to be the first utilities contractor in the UK to commercially deploy pipe inspection technology that uses sound to assess the condition of sewers.

The company is working with Thames Water using the SewerBatt acoustic inspection device, which uses the same echo-location principles that bats use.

The SewerBatt inspection programme has been in operation across the Thames Water region since the start of May, following an 18-month development and trial phase.

For planned sewer maintenance, the technology is already reducing the number of CCTV drainage surveys required by 33%. The target is to reduce overall CCTV costs by £1.2m per year.

Lanes Utilities managing director Conrad Ashby said: "SewerBatt has significant benefits in terms of improving the overall operational efficiency and sustainability of our underground investigations. It allows us to identify blockage and pollution issues in drainage assets much more quickly than with traditional methods."

The UK-designed and manufactured device works by sending multi-frequency sound waves along sewer lines. Their interaction with chambers, lateral connections, cracks, deformities or blockages sends unique echoes back to the device, which are displayed on a digital graph.

Within 30 seconds, the system's software analyses the data from each length of pipe, and provides a simple output assessment of its condition as being green, amber or red. Green is clear, amber requires further analysis, and red denotes a problem that requires remedial action.

Lane's trials, during which a CCTV drainage survey was carried out to back up each SewerBatt inspection, showed the system was 97% accurate.

Paracoustics: Sound and the Paranormal

Edited by Steven T Parsons and Callum E Cooper

Review by Dan Pope, Atkins

Parsons and Cooper are well aware of the problems with research in the field of the paranormal. This is hinted at in the blurb on the reverse, where the tongue-in-cheek quote "An uplifting read!" is credited to Daniel D Home, a medium known for his alleged ability to levitate who died in 1886.

The book collects together writings on sound in the paranormal, covering the sound of ghosts and spirits, electronic voice phenomena (EVP), infrasound and the paranormal, spontaneous music and voices, and the acoustic properties of unexplained rapping sounds, among other related topics. It is a field that until now has not been covered specifically in any collection.

Parsons is best known as a ghost hunter, with a string of TV appearances to his name, and is currently studying a parapsychology focused PhD that examines the role of infrasound as a possible cause for various haunting experiences. Cooper is a lecturer at the University of Northampton at the Centre for the Study of Anomalous Psychological Processes (CSAPP) where he specialises in parapsychology and thanatology (dying, death and bereavement). As well as contributing several chapters to the book themselves, they have pulled together specialist sections from other contributors and compiled an appendix full of background reading.

It would be fair to say that the intended audience is those with a paranormal interest rather than acousticians, but there may be some overlap between the two. Personally I've always enjoyed the problem solving aspect of magic and the unexplained.

Acoustic terms are explained for the lay audience but are by no means complete. A notable exclusion here is an absence of discussion on temperature inversion, which is relevant when discussing "unexplained music from the sky", despite references to occurrences in the early evening when the effect would be the most likely explanation.

There is a detailed analysis of Vic Tandy and Tony R. Lawrence's *The Ghost in the Machine* infrasound research, which is included as an appendix. For further background into this I would recommend Richard Wiseman's *Quirkology*. As a quick explanation of this Tandy discovered that infrasound could account for some ghostly experiences when he traced resonance of a fencing foil in a vice to a newly installed fan. When the fan was on, the sword blade resonated, when the fan was off, it stopped. This may seem like enough information on the face of it but for Parsons the lack of information provided on room dimensions and the resonant frequency of the blade cannot rule out that the fan may have been interacting with other infrasound sources too.

Parsons asks the question; are paranormal researchers measuring infrasound properly? Given examples elsewhere in the book, it is clear that many in the field are still struggling with basic audio recording technology, so the answer is clearly no. He goes on to propose a "rough and ready test for ambient infrasound" based on comparing measurements with A-weighted and C-weighted filters. If the C-weighted value is greater than the A-weighted value it can be assumed that there is low frequency sound present. It is worrying that he refers to doing this with "inexpensive" sound-level-meters or even – the horror! – smart phone apps albeit "with a reduced degree of accuracy", without warning as to the potential issues with poor microphone sensitivity at low frequencies.

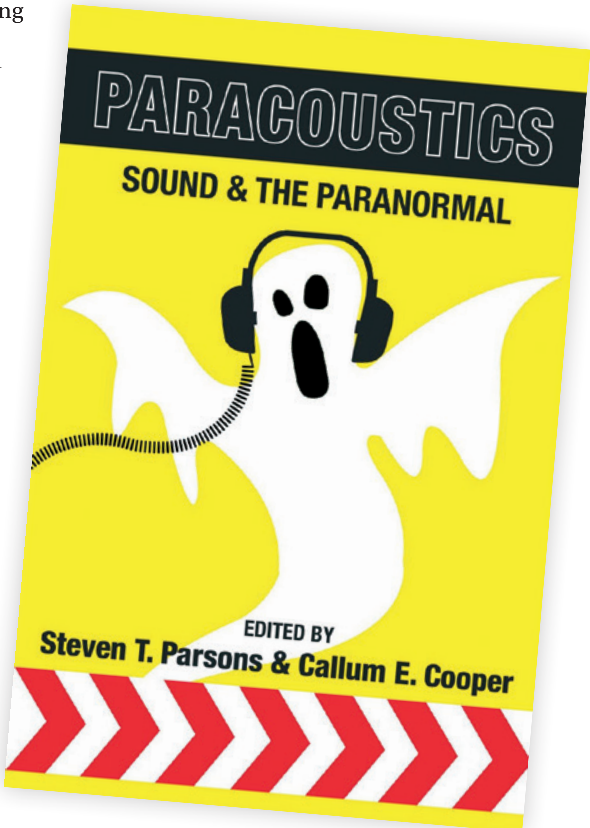
A similar issue occurs when discussing the acoustics of rapping sounds from poltergeists. (That's knocking/hitting sounds, not spoken or chanted rhyming lyrics, although a rapping poltergeist character sounds like something Kool Keith would dream up.) Reference is made to the Fox sisters in Hydesville, New York State, who in 1848 kick-started the Spiritualist movement with the spirits in their house who would respond to questions with a series of rapping noises. The sisters later admitted how they faked this using their clicking toes to rap on the floor but when destitute in later life attempted to retract the admission. To me, I would read this as proof the entire field was built on glass foundations but that doesn't stop many. Cognitive dissonance appears rife in paranormal studies.

The most interesting and useful chapter in the book is Ann R Winsper's contribution on The Psychology of EVP. This section summarises reasons people may hear voices in audio recordings that are not there. These include suggestion, paranormal belief, schizotypy, auditory hallucination, reality testing, dissociation, fantasy proneness, death anxiety, narcissism, "the big five personality traits", the nature and neuropsychology of "pure" white noise, auditory and speech perception, and practical auditory tasks. Of these the Openness personality trait discussed fits the tone of several of the contributions, where writers seem too quick to draw the conclusions they want to find.

Stephen Law's book *Believing Bullshit: How Not to Get Sucked into an Intellectual Blackhole*, refers to "piling up the anecdotes", where with enough data, once sorted into bins of possible cause, still leaves enough cases for speculation to take hold. Combined with Winsper's chapter this can add question marks to many of the cases.

One referenced study into unexplained telephone calls showed that the recently bereaved were more likely to attribute these calls to communication from the dead, whereas those with an interest is UFO spotting were more likely to attribute calls to communication from aliens.

If you are interested in looking for possible acoustic explanations to paranormal phenomena you'll like this. Not a lot, but you'll like it.



Peter Thompson takes over as new CEO of NPL

Peter Thompson

Dr Peter Thompson has been appointed the new Chief Executive Officer for the UK's national measurement institute, the National Physical Laboratory (NPL).

Previously the Deputy Chief Executive of the Defence Science and Technology Laboratory (Dstl), he replaces Dr Brian Bowsher who retired in June.

Dr Thompson spent the early part of his career applying niche technology ideas to national security challenges, particularly in intelligence, surveillance and reconnaissance fields. He has held various positions in Dstl and the wider MOD including: Head of MOD's Counter-Terrorism Science and Technology Centre; Dstl Programme Director (Research and Technology); and Strategic Advisor to the MOD Chief Scientific Advisor, where he led the S&T strand to UK Defence Reform.

Dr Thompson was appointed Dstl Deputy Chief Executive in 2013 and in January 2015 combined this with leadership of Dstl's technical and strategy directorate, responsible for technical, customer and organisational strategy.

Justin Barker appointed Sales Manager at ACSoft

Justin Barker

AcSoft, a specialist in sound and vibration instrumentation and sensors, has appointed Justin Barker as Sales Manager.

He brings a 15-year sales track record and wide acoustics industry experience to AcSoft. Prior to joining the company, he was Sales / Business Development Manager at Cirrus. Earlier roles include Acoustics Consultant at Eckel Group and UK Sales Manager at Campbell Associates.

John Shelton, AcSoft Managing Director, said: "Justin is a highly motivated and experienced sales manager with an excellent strategic understanding of the acoustics industry and occupational and environmental noise monitoring in particular.

"This is a key appointment for us at an important time as we are seeing a surge in demand right across our wide product portfolio."

Improvements added to Brüel & Kjær's Measurement Partner

Brüel & Kjær has expanded and updated Measurement Partner, its suite of solutions that supports sound level meter customers through the sound measurement process.

The updates include Wi-Fi capability for its sound level meters and cloud storage for its post-processing software. New capabilities include a smartphone field app, a learning centre and an online community.

The app for IOS/Android smartphones remotely controls sound level meters without disturbing the sound field. The app also captures GPS position, location photographs, background audio clips, video of nearby noise sources, text-based notes and other metadata.

All information can be sent to the Measurement Partner Cloud for storage and sharing, as well as for use with the Measurement Partner Post-Processing Software.

In addition, the company has launched two online initiatives: the Measurement Partner Learning Centre and the Measurement Partner Community. The learning centre brings together user manuals, application notes and training material. The community includes a blog and discussion board to connect Brüel & Kjær sound level meter users across the globe.

Learn more at **http://www.bksv.com/**measurementpartner

Dust and weather added to LivEnviro monitoring system

ANV's LivEnviro line-up has been completed with the addition of particulate and weather monitoring to that of noise and vibration on a single, secure web platform.

Users can see whether noise, vibration or dust limits are being, have been or are in danger of being exceeded on a Google Maps-based user interface. They can also choose how much information they want to share with other stakeholders.

LivEnviro uses site-proven and certified monitors. Live and historic data are available on the secure website and can also be downloaded as csv files.

The Live Leq Noise Monitor is based upon the Rion NL-52 IEC 61672 Class 1 Sound Level Meter which can also be used as a hand-held sound level meter.

Similarly, the Live PPV Noise Monitor is based upon the DIN 45669 Profound Vibra+ which can also be used as a GPRS enabled, BS 7385:2/BS 5228:2 compliant monitor independently.

ANV worked with Environmental Technology in choosing the Met One ES 642 as the sensor for the Live PM10 web-based particulate monitoring system. The ES 642 has MCERTS for both PM10 and PM2.5 and has a digital output enabling system health to be monitored – not just the analogue output of the sensor.

ANV has integrated the Lufft WS 600 multi-parameter weather station into LivEnviro. The WS600 monitors wind speed and direction, precipitation (rate, type and total), temperature, pressure, humidity and dew point and it has no moving parts. It also has a built-in electronic compass so it doesn't have to be manually orientated on site.

For more information call **01908 642846** or email **info@noise-and-vibration.co.uk**

HSL and 3M launch e-learning noise training package

The Health & Safety Laboratory (HSL) and 3M, the hearing protection specialists, have linked up to develop an innovative e-learning package to help health and safety professionals address noise risk at work.

Hearing Conservation is a flexible, interactive online series of four 20-minute learning modules aimed at demystifying noise, helping organisations understand their legal duties, and providing simple, practical suggestions to help deal with noise issues.

Written by technical experts, but delivered in language and bite-sized chunks that are accessible to all, this e-learning package aims to give health and safety personnel the confidence to begin to tackle noise issues in their place of work.

The four modules cost £99. For full details go to **http://www.hsl.gov.uk/products/hearing-conservation-e-learning-from-hsl-and-3m**

Brüel & Kjær simplifies earphone noise tests

To simplify testing the effects of earphone noise for audio and telecom engineers, Brüel & Kjær has modified the structure of the ear pinna simulators used with its Head and Torso Simulator (HATS).

Designed as replicas of the human ear, the new pinnas (Types DZ-9773 and DZ-9774) have been altered to a conical shape merged with a cylinder within the ear canal entrance, making it easier for engineers to seal earphones into the pinna during tests.

The symmetrical pinnae are utilised with Bruel & Kjaer's Head and Torso Simulator (HATS), Types 4128C and D, which consists of a dummy with built-in ear and mouth simulators, to provide a realistic replica of an average, adult human head and torso.

Bruel & Kjaer's HATS system is used to investigate the external acoustic effects from headsets, microphones, headphones, hearing aids, audio conference devices and hearing protectors. The mannequin also has an adjustable neck making it ideal for testing mobile and cordless telephone handsets.

More information about HATS is available on **www.bksv.com**

Ear testing


Invictus
Portable noise monitoring
For Long-term Noise Monitoring
Leave it to Invictus
Cirrus Environmental's purpose designed noise monitor for outdoor noise measurement.
• Reliable: Purpose designed for short, medium and long term environmental noise measurements
• Informed: Real-time alerts via SMS, email and twitter with automated reporting
• Control: 7" colour touch screen for simple, accurate setup and deployment
• Connected: 3G, GPRS, Wi-Fi and Ethernet connections to suit all locations and applications with GPS location data and optional weather measurement
• Flexible: Sophisticated calendar based measurements with multiple periods and alerts available for different days of the week and times of the day
• Manage: Web based noise management with live noise data on your phone or tablet
• Performance: Class 1 performance with 200mm dual layer windshield as standard
Cirrus Environmental
Call: 01733 667100
Email: sales@cirrus-environmental.com
Visit: www.cirrus-environmental.com

Institute Sponsor Members

Council of the Institute of Acoustics is pleased to acknowledge the valuable support of these organisations

Key Sponsors: Brüel & Kjær; Cirrus Research plc

Sponsoring Organisations

Acrefine Engineering Services Ltd
Acsoft Ltd
AECOM
AMS Acoustics
ANV Measurement Systems
Armstrong World Industries Limited
Arup Acoustics
Campbell Associates
Clement Acoustics
CMS Danskin Acoustics
Cole Jarman Ltd
Echo Barrier Ltd
EMTEC Products Ltd
Farrat Isolevel Ltd
Gracey & Associates
Greenwood Air Management
Hann Tucker Associates
Hilson Moran Partnership Ltd
Icopal Ltd
Industrial Acoustics Co Ltd (IAC Ltd)
Isomass Ltd
KP Acoustics Ltd
Mason UK Limited
Mott MacDonald
Noise.co.uk
NPL (National Physical Laboratory)
Peter Brett Associates
RBA Acoustics
Rockfon
RPS Planning & Development Ltd
Saint-Gobain Ecophon Ltd
Sandy Brown Associates
Sharps Redmore Partnership
Siderise Group
Sound Reduction Systems Ltd
Spectrum Acoustic Consultants Ltd
Wakefield Acoustics
Waterman Energy Environment And Design Ltd
WSBL Ltd
WSP Acoustics

Applications for Sponsor Membership of the Institute should be sent to the St Albans office. Details of the benefits will be provided on request. Members are reminded that only Sponsor Members are entitled to use the IOA logo in their publications, whether paper or electronic (including web pages).

Committee meetings 2015/2016

DAY	DATE	TIME	MEETING
Tuesday	**15 September**	**10.30**	**Council**
Monday	28 September	11.00	Research Co-ordination
Wednesday	7 October	10.30	Engineering Division
Thursday	22 October	11.00	Publications
Tuesday	27 October	10.30	Diploma Tutors and Examiners
Tuesday	27 October	1.30	Education
Wednesday	28 October	TBA	CCWPNA Examiners
Wednesday	28 October	TBA	CCWPNA Committee
Wednesday	28 October	TBA	CCENM Examiners
Wednesday	28 October	TBA	CCENM Committee
Wednesday	28 October	TBA	CCBAM
Thursday	29 October	10.30	Membership
Tuesday	10 November	10.30	ASBA Examiners
Tuesday	10 November	1.30	ASBA Committee
Tuesday	17 November	10.30	Executive
Thursday	19 November	11.30	Meetings
Tuesday	**1 December**	**10.30**	**Council**
Thursday	7 January	11.30	Meetings
Thursday	21 January	10.30	Membership
Thursday	4 February	11.00	Publications
Tuesday	9 February	10.30	Medals & Awards
Tuesday	9 February	10.30	Executive
Tuesday	1 March	10.30	Diploma Tutors and Examiners
Tuesday	1 March	1.30	Education
Tuesday	8 March	10.30	Diploma Examiners (London)
Tuesday	**8 March**	**10.30**	**Council**
Wednesday	6 April	11.00	Research Co-ordination
Thursday	7 April	11.30	Meetings
Tuesday	12 April	10.30	CCWPNA Examiners
Tuesday	12 April	1.30	CCWPNA Committee
Thursday	28 April	10.30	Membership
Tuesday	10 May	10.30	CCHAV Examiners
Tuesday	10 May	1.30	CCHAV Committee
Thursday	12 May	11.00	Publications
Tuesday	24 May	10.30	Executive
Tuesday	14 June	10.30	ASBA Examiners(Edinburgh)
Tuesday	14 June	1.30	ASBA Committee (Edinburgh)
Tuesday	**14 June**	**10.30**	**Council**

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

Institute Council

Honorary Officers

President
W Egan MIOA
Teledyne RESON

President Elect
L J Webb FIOA
Arup Acoustics

Immediate Past President
Prof B M Shield HonFIOA
London South Bank University

Hon Secretary
Russell Richardson MIOA
RBA Acoustics

Hon Treasurer
Dr M R Lester FIOA
Lester Acoustics LLP

Vice Presidents
Dr W J Davies MIOA
University of Salford
R A Perkins FIOA
Parsons Brinckerhoff
G Kerry HonFIOA
University of Salford

Ordinary Members

A L Budd MIOA
New Acoustics
K R Holland MIOA
Institute of Sound and Vibration Research
Dr P A Lepper MIOA
Loughborough University
R Mackenzie FIOA *RMP Acoustic Consultants*
H Notley MIOA
Defra
G A Parry MIOA
ACCON UK
P J Rogers FIOA
Sustainable Acoustics
A W M Somerville MIOA
City of Edinburgh Council
D L Watts FIOA
AIRO

Chief Executive
Allan Chesney

List of advertisers

Please mention Acoustics Bulletin when responding to advertisers

ANV Measurement Systems

SALES - HIRE - CALIBRATION

UKAS accredited calibration facility, see UKAS website for scope of UKAS accredited calibrations offered:- **www.goo.gl/9kVpY3**

UKAS CALIBRATION 7623

WEB-BASED NOISE, VIBRATION AND DUST MONITORING

Live nviro

- Site proven and certified monitors
- Strategic and Practical Control of Noise, Vibration and Dust using your Computer, Phone or Tablet;
- Real-Time Levels and Alerts
- Current and Historic Levels Available on the Website
- Current and Historic data downloadable as csv files which import directly into Excel
- Range of Permanent and Semi Permanent Enclosures Available
- Data on a secure Raid 10 Server in a UK Data Centre

All at a realistic price and backed by industry-leading Customer Support

Live Leq

- Independently Type Tested to IEC 61672 Class 1
- Up to 5 Simultaneously Applied Noise Limits during any measurement period
- Maximum update rate 1 minute
- LAeq, LAmax, and up to five percentiles
- Calculates Effective Remaining Limit (ERL) for Leq Limits and generates Amber Alert when this indicates the limit is likely to be exceeded at the end of the period
- Live Audio Streaming
- Audio Snapshots Recorded when limits exceeded

Live PPV

- Based on the Profound Vibra + DIN 45669 Vibration Meter
- Multiple limits and alarms can be applied simultaneously
- BS 5228: Part 2 “Perception” and “Complaints” Limits
- BS 7385: 2 Frequency - Dependent PPV Limits and Displacement Limit < 4 Hz Limits
- Maximum update rate 5 minutes with down to 1 second resolution data
- DIN 4150: 3 Building Damage Limits
- Up to 3 user-selectable broad-band PPV limits
- Multiple User-Specifiable Frequency-Dependent Limits
- User definable Amber and Red Alert Levels
- PPV, dominant frequency, and Displacement < 4 Hz shown on the website

Live PM10

- Based on the on the MCERTS+ Compliant Met One ES-642
- Up to 5 Simultaneously Applied Concentration Limits during any measurement period for each particle size
- User definable Amber and Red Alert Levels
- MCERTS+ PM10 as Standard
- TSP and MCERTS+ PM2.5 (Options)
- Smart heater on inlet (rather than continuously heated) - minimises burning off of volatile particulates (no requirement for x 1.3 multiplier)

Live Met

- Based on the WS600 manufactured in Germany by Lufft
- Precipitation Amount and Type measured by Doppler Radar
- Windspeed and direction measured using ultrasonic sensors
- Automatic self-orientation using in-built electronic compass
- Temperature
- Pressure
- User selectable alerts for windspeed, direction and precipitation

www.noise-and-vibration.co.uk | info@noise-and-vibration.co.uk | tel: 01908 642846

RION Sound and Vibration