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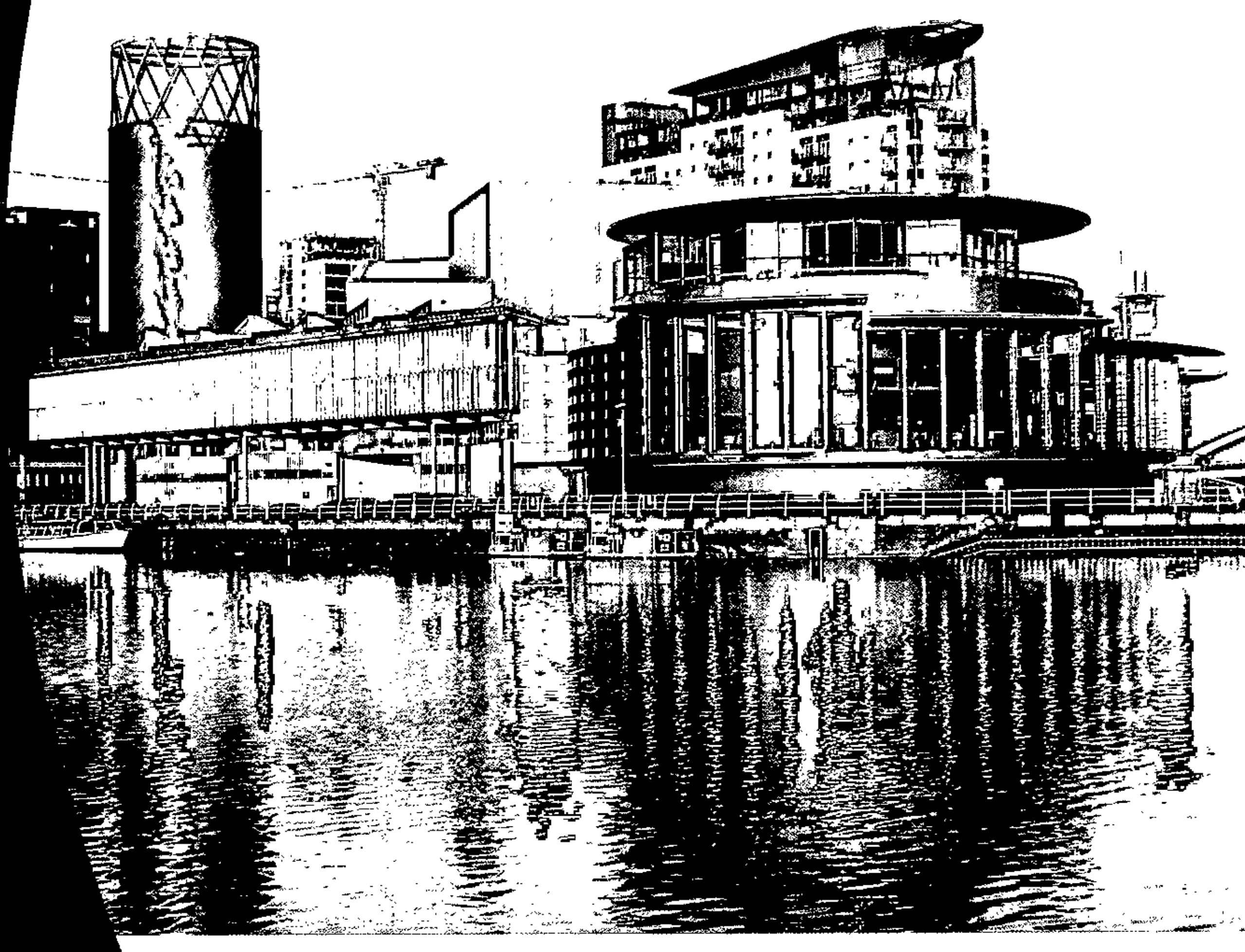
ACOUSTICS BULLETIN



in this issue… Whistling Gratings - case studies in wind generated noise reduction

plus… Noise and Vibration Diagnostics and Control in Aerospace Vehicles

ANASE: Unreliable - owing to design-induced biases

End corrections due to perforated pipes

Institute of Acoustics

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Contents

Front cover photograph: A car park at The Lowry, Salford, Greater Manchester was giving rise to a puzzling noise problem in new residential properties until acousticians from Faber Maunsell and Bureau Veritas investigated. Their findings are presented on page 18. (Photo courtesy of The Lowry, Salford Quays)

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.

Institute of Acoustics

The Institute of Acoustics is a nominated body of the Engineering Council, offering registration at Chartered and Incorporated Engineer levels.

The Institute has over 2800 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.

Dear Members

I ended the 2007 conference season by attending the Reproduced Sound 23 conference which was held in the spectacular setting of the Sage at Gateshead. Those involved in the area of acoustics covered by this conference series have the distinct advantage that much of their work is involved with enhancing entertainment sound. Few speakers missed the opportunity to exploit this, culminating in the final presentation, which included a demonstration of a novel concert sound system by using a professional band flown in for the occasion. I was delighted to see that there was a very high proportion of overseas speakers and delegates at the conference, showing the importance placed on this conference by the international acoustics community. We also managed to attract a large number of students to the conference, which is vital to the continued success of the life of the Institute.

The organisers of the RS 23 conference worked hard to introduce new ideas into the conference. In particular, an electronic voting system was used for the first time at one of our conferences, which allowed speakers to get near instant feedback on their ideas and demonstrations from an expert audience. I am sure that this new technology will be used again at future conferences.

The conference also provided me with the opportunity to present Dr Graham Bank with the 2007 Peter Barnett Memorial Award in recognition of his substantial contribution to the advancement of loudspeaker design, which included the novel use of laser interferometry to analyse the behaviour of loudspeaker cones.

I broke with the tradition of making award presentations at our conferences when I presented Professor Roland Dobbs with his Honorary Fellowship in December. His family had arranged a 'This Is Your Life' for him on the occasion of his 83rd birthday and when the story reached the IOA I was able to recall the pivotal role he had played in the formative years of our Institute before making the award. We all owe him a debt of gratitude for transforming the fledgling society into the professional Institute that it is today.

Last year saw the first full year of our e-newsletter and its undoubted success has ensured it a permanent place in our publications portfolio. We enter 2008 with the Institute's membership at an all time high and this continued growth will allow us to further develop our services. The first of these will be an update of our website, to include more web-based member services and introduce on-line payments.

Finally, may I wish you all a happy and prosperous New Year.

Colin English

PRESIDENT

Making a rating mandatory

Peter Rogers. Consultation Paper July 2007: The future of the Code for Sustainable Homes

Preamble

This review has been prepared on behalf of the institute of Acoustics (IOA) in response to an invitation to comment on the document entitled 'The future of the Code for Sustainable Homes: Making a rating mandatory', published by the Department of Communities and Local Government (DCLG) in July 2007.

The Institute of Acoustics is the leading professional body in the United Kingdom concerned with acoustics, noise and vibration and is active in research, educational, environmental and industrial organisations. The Institute is a nominated body of Engineering Council, and a member of the International Institute of Noise Control Engineering and International commission on Acoustics and a founding member of the European Acoustics Association. Members of the IOA are active in the development of UK, European and International standards.

The IOA also gives support to the development of legislation in the various disciplines in the field of acoustics and it response to consolation papers is based on this role. The IOA however represents a wide range of members and disciplines in acoustics and the comments presented here are comments that emerged from a review by an elected specialist selection of our members, who form a group known as the Building Acoustics Group. The response was then approved by a Senior representative of the IOA on behalf of the Executive and Council.

Response to the consultation questions

Q1: *Do you agree that a rating (not an assessment) against the Code for Sustainable Homes should be mandatory for all new marketed homes from April 2008?*

A1: No, there should be an assessment as well.

Reasons and discussion: A mandatory rating would indeed raise awareness for the buyer, but possibly would be sending the wrong message. A rating alone could serve to confuse buyers by rating a home that had **not** been assessed. It placed no added value in the information before buyers on such properties. For example if Robust Detail constructions were used, there would be likely to be a better than Document E standard of sound insulation, but it would be 'zero rated'. An assessment would at least point out the positives and negatives that could inform the choice by the buyer rather than simply be a black mark for the development. The simple act of forcing an assessment to be done may well add an extra cost for the buyer, but there is little incentive otherwise for a buyer to buy 'green' than to create an inclusive scheme rather than an exclusive scheme. An assessment would allow buyers to understand more of what they are buying, including the good elements of the building as well as the bad, even within the lowest quality homes. See also the additional section at point 5 for a further suggestion for the Economic incentives for buyers.

'Zero rating' does not in itself make any significant headway in **reducing** the impact of new housing on the global warming, as it does not require any action by the contractor. Instead it seems to provide house builders with a route to opt out by getting a zero rating rather than forcing the 'step change' that is the challenge. To hit the tough targets set by the government and make all new homes zero carbon by 2016 the IOA is not convinced that having a mandatory 'rating' will achieve the Governments objective. A mandatory 'assessment' may be a better vehicle to place the onus on the construction industry to tackle the problems presented by delivering sustainability.

What the extra cost of an assessment would provide for buyers is a breakdown of what their home actually does well or poorly. This would be worth the fee, and enable them to use it in such a way that still could minimise the effect on the environment.

Q2a: *Do you agree that where homes are not assessed against the Code for Sustainable Homes, potential buyers should be given a document which clearly states that it has not been assessed?*

A2a: Yes.

Q2b: *Would you prefer that this document is (a) a zero star certificate; or (b) a standard letter?*

A2b: Prefer (b).

Reason: A letter is preferred, because a certificate would seem to infer that it had been assessed. The wording of the sample certificate/ letter (Annex D of the consultation document) also requires clarification, as it may be misleading. It states 'New homes still have to meet minimum standards as set out in Building Regulations, but these are below the standards set out in the Code'. This is not strictly the case for the Health and Well-being section (including sound insulation), which are optional and although the minimum assessment level is a 3dB enhancement on Document E these are not minimum standards required by the code, but rather to be rewarded by credits. Perhaps clarification is all that is required, or a distinction drawn for the optional sections.

Q3: *Do you agree that, before we make rating against the Code mandatory, we should require that all Code assessor organisations (or self-employed individuals) are able to provide Code and EPC services as a single package?*

A3: This would make sense, although a rating does infer an assessment will take place, but it introduces that as an option. Obviously assessors would not be relevant to the process of rating, and letters could be downloaded as suggested on p11, where schemes are not assessed. Where they are assessed a single package would seem desirable.

Q4a: *Do you agree that the Home Information Pack would be an appropriate mechanism for ensuring homebuyers are provided with a rating against the Code for Sustainable Homes?*

A4a: Through these packs would seem appropriate, or equally some other way, but crucially enough information should be included to allow the occupant to understand where their home performs sustainably well, or poorly. Perhaps more resolution is needed to the Final Certificate (proposed in Annex D–4) to allow people to see how good the rating was for sound insulation for example. Not enough information is currently given.

Q4b: *Do you think it is necessary to have legislative powers to ensure that both design stage and post-construction certificates are given to homebuyers?*

A4b: Yes, for the post construction certificates at the very least, as HIP's would obviously leave a hole. They should also be put into context with what the figures actually mean for CO_2, for example. Perhaps against the One Planet Living principle or similar. For Sound Insulation it should be detailed if an enhancement of 3dB over Doc E standards has been achieved and what improvement this will have, for example. This seems unrelated to ratings but more to assessments however.

Q5a: *Do you agree there should be a transitional period for the introduction of a mandatory rating against the Code?*

A5a: No. If purely a 'rating' then it is simply an administrative challenge, where as mandatory 'assessments' would probably need a transitional period.

Q5b: *If there is a transitional period, should this come into effect for new homes that either: apply for planning permission after April 2008; or reach the Initial Notice, Full Plans or Building Notice stage of the building control notification process after April 2008?*

A5b: As this relates primarily to the performance of the building it would seem more appropriate to be the latter - linked with Building Regulations is the obvious answer. There would be conceivable difficulties by linking a buildings performance with the planning system, but there is the prospect of a more holistic view being possible of the internal and external amenity for occupants to be considered which be of interest to explore separately. The IOA would have concern that the planning system is not currently the right place in which to consider the buildings performance.

Q6: *Do you agree with our analysis of the likely demand for assessments, and that there will be sufficient Code assessors available?*

A6: Very difficult to say - might be higher. It must be considered that more assessors would mean an increase in the carbon footprint that will be created by them doing this work.

Q7a: *Do you agree with the principle that the Code for Sustainable Homes should be changed to reflect changes to the building and other regulations?*

Q7b: *Do you agree that the Code for Sustainable Homes should be revised in light of changing Building Regulations in 2010?*

A7a and A7b: Yes, these changes seem obvious and essential.

Q8a: *Do you agree that Lifetime Homes standards should be made mandatory in the Code?*

Q8b: *Do you agree that Lifetime Homes standards should be made mandatory at progressively lower levels of the Code, starting with level 6 in 2008, level 4 in 2010 and level 3 in 2013?*

A8a and A8b: Yes, this would seem a very good and essential approach to take as an important part of the lifecycle challenge. It is essential to not only provide a sustainable building, but also living environments will allow sustainable communities to flourish. Acoustical design is relevant in not only providing the internal protection, but also the provision of protecting and potentially enhancing external soundscapes. This should be considered as part of this review, focused on helping people to get a living environment that they will want to live in for their lifetime (just over three times the lifetime of a typical 25 year construction).

Acoustic design to allow flexibility through the use of lightweight partitions, made of low energy materials, could be a matter that of importance in this section to maintain the enhanced standards given on day one to the new occupants, and should be a matter for consideration in an future review of the Code for how to maintain and alter standards easily.

Further suggestions / matters arising

1) Should the code be urgently revised ?

The intentions of the code are applauded and strongly encouraged. However the following weakness should be considered to prompt an early revision as a matter of urgency.

Because the code is based on the BRE assessment system the requirements are heavily focused on environmental factors. Sustainability requires regard for the ecological/environmental, economic and social elements to be considered and the code is particularly weak in considering the social sustainability issues eg contribution to local social needs, neighbourhood privacy. However the inclusion of enhancing sound insulation in (Section Hea2) does give an optional chance to score credits through a degree of emphasis on internal aural protection.

The recent adoption of the principles of One Planet Living provides a good model for developing a more holistic approach by the code to correct the weakness in the social section, and if the code is to deal with a step change in delivering sustainability then this is essential. The risk of not doing so is that the buildings that are eventually produced as 'zero carbon' may not be suitable to sustain or meet the needs of the occupants. Early signs from occupant satisfaction surveys in the US are putting acoustics high up on the list of reasons why 'green buildings' are falling short. This would fundamentally conflict with the concepts of delivering sustainability, as the buildings are only one part of the process for making sustainability work over their lifetime. From the acoustical point of view the aural environment is very important to the health and wellbeing of the occupants, and a much stronger obligation on sound insulation and protection from external noise should be included in the short term whilst more is found to support good design for the enhancement of internal and external soundscapes.

As a consequence of the above points the questions in this consultations are therefore probably the wrong ones to be asking, in the IOA's view.

2) Increases in standards required under building regulations

The improvement of standards in sound insulation within homes has been identified as a matter of relevance to the health and wellbeing , as part of the social category of sustainability. Whilst this is the case a balance must be stuck between striving for ever increasing levels of separation, with no trade off against the additional materials required to achieve this in the construction. At this stage an 8dB upper threshold is considered to be an upper limit in this regard, and may need review in future revisions of the code. It is not just sound insulation alone that contributes to occupants well-being in the built environment, but achieving specific acoustic standards within bedrooms, for example should provide an additional credit in preference to an 8dB enhancement of sound insulation.

A substantial number of our members believe that the existing standard of 45dB $D_{nt,w}+C_{tr}$ is however inadequate for new housing in that it allows inappropriately high transmission of sound at mid-frequencies and high frequencies, and does not provide the level of protection expected by occupants. This comment echoes that of the Association of Noise Consultants in this regard.

There are also well-documented issues as to the decrease in certainty and reproducibility of measurements using the C_{tr} correction as the overall result is dominated by the performance in the 100Hz and 125Hz octave bands. The standards in Building Regulations took some account of this by reducing the standard to allow for the expected measurement uncertainties. This approach is, however, not valid for a rating system in which the measurement uncertainties are of the same order as the increments between standards for points under the Code.

Consideration of measurement indices may include extending the measurement range, and in particular increasing this upwards from 3150Hz to assist in identifying high-frequency 'leaks' which are currently not taken into account. This would also be expected to improve the reproducibility of the single-figure index.

We believe that a review is required both of the measurement indices used to assess sound insulation and of the values applied in both the Code and in Building Regulations, with the aim of increasing the minimum standard of sound insulation permissible in new homes and of reducing the measurement uncertainties in assessing these.

Further psychoacoustic research work to correlate subjective acceptability against various parameters is considered necessary to justify alternatives approaches.

3) Further research work funded centrally

The final point from above suggests that subjective correlation with improved sound insulation should be completed to support any changes to the parameters used to measure sound insulation, including impact noise.

This work should perhaps also extend to what people find helpful or indeed what they want to help enhance their internal and amenity living environments. At the moment there is a risk that standards will be set based on inadequate knowledge.

4) Introducing consideration of enhancing amenity spaces (aural environments)

Our response to the consultation on the Code originally spelt out why it is considered strange only to include assessment of the internal sound insulation of a building, when the protection from the external environment is equally critical and part of the building design. There is a suggestion that the code could be administered through the planning process, which would combine these two worlds, but the choice of which body does the administration should not be left to chance. Providing good aural environments through protection and enhancement of internal and external amenity spaces is something the Institute is currently looking at. We would urge you to consider this for inclusion. It is an area mentioned in the bid promises for the Olympics, and in the World Health Organisation's aspirations for living environments, so it should be a part of the Code.

5. Financial incentives to drive up standards

It would seem worth considering that designs with poor code ratings should attract a financial penalty or levy. This may encourage the buyer to choose more quickly to live in a higher rated home.

Prepared by **Peter Rogers** BSc(Hons) MSc MIOA

For and on behalf of the Institute of Acoustics

Meeting report: London branch

Ed Weston. David Hiller and Colin Cobbing: Vibration annoyance in buildings

On Wednesday 17 October 2007, David Hiller of Arup Acoustics and Colin Cobbing of ARM gave a joint presentation of their study investigating the human response to vibration in residential environments. Commissioned by DEFRA, the work on vibration annoyance was carried out by Arup Acoustics and Temple Group Ltd with the Transport Research Laboratory and the Institute of Sound and Vibration Research.

Motivated by a general lack of confidence in the vibration indicator and associated rating values in BS 6472:1992, the aim of the work was to develop robust survey tools which could be applied to a subsequent study to establish how people in residential environments respond to vibration from external sources, eg road, rail, industrial and construction.

A measurement protocol was established to assess vibration levels at people's houses specifically due to nearby rail and construction sources. A social survey questionnaire was also developed to yield objective information about residents' responses to this vibration. A pilot study was undertaken to test these, and the data gathered was analysed to validate the success of the methodology developed.

Various approaches were investigated to establish a suitable measurement protocol. The chosen approach involved small, self-contained data loggers acquiring data over 24-hour periods. One was located at a position near to the source, and others at dwelling positions selected such that vibration levels for intervening dwellings could be evaluated by interpolation.

The development of the questionnaire involved a literature review and the preparation of a number of drafts which underwent review by the project partners and the trained interviewers following a pre-survey exercise. The final questionnaire requested information on the dwelling and occupants, and addressed issues such as satisfaction with neighbourhood and home, vibration and noise (in general, and specific to the source under investigation), comparison of noise and vibration annoyance, and the interviewer's assessment of the noise and vibration sources, perception and any secondary effects.

The pilot study comprised obtaining a questionnaire response from a resident (by cold-calling), and then setting up the apparatus to measure vibration levels at the resident's property. This was undertaken for over 100 respondent/measurement pairs, at locations along the East Coast main line railway, and at a construction site where impact piling activities were taking place.

A Spearman's rank correlation analysis of the data tested for the presence and significance of a relationship between vibration and subject response. Significant correlations were found between annoyance and railway vibration which indicated an ordinal relationship, suggesting that the application of the pilot study methodologies in a larger study may achieve clear dose response relationships. Correlations were, however, not significant between vibration measures and annoyance ratings relating to the construction site. It was therefore considered that the methodology should be further developed for this type of source.

The event was well attended, and was followed by a stimulating question and answer session and further lively discussion which continued, as usual, at the Cittie of Yorke across the road.

For further information, the full report is available at:
http://www.defra.gov.uk/environment/noise/research/pdf/human-response-vibration-residential-environments.pdf

Ed Weston MIOA

Meeting report: Central branch

Richard George. Visit to Royal Air Force Centre of Aviation Medicine (RAFCAM)

On Tuesday 11 September 2007, 18 members of Central Branch attended RAF Henlow for a series of presentations from the Noise and Vibration Division of RAFCAM followed by an interactive tour of their facilities.

Although based at Henlow, RAFCAM is responsible for providing medical and scientific support and training for all RAF personnel in this country and abroad. Included in this remit are such elements as operational support, clinical support and research, pathology and occupational and public health.

"That they may fly safely" RAFCAM motto

An hour and a half of absorbing presentations began with a talk from Matt Peacock describing how the RAF dealt with the implementation of the European Physical Agents Directive with respect to the occupational noise and vibration experienced by pilots whilst in the air. Not surprisingly, the design and use of measurement equipment suitable for in-flight use presented some unique challenges.

The design brief for the measurement instruments was that they must be integrated into the pilot's uniform, be able to log noise and vibration levels for at least three hours, and weigh less than 400 grams.

Test flights on the prototype showed that recorded noise data became distorted at high aircraft acceleration levels, as the head of the DAT recorder was forced away from the tape above 4G. This is not a common problem for most of us!

Once these initial gripes had been solved, the results showed that some pilots were exposed to sounds in excess of 94dB at the ear (even with hearing protection). However, whole-body vibration levels were relatively low, with many pilots needing to be in the air for 24 hours before the vibration exposure limit was reached.

Dave Williams gave the second presentation explaining RAFCAM's training procedure for RAF personnel to undertake risk assessments as Environmental Health Technicians.

The third presentation from Tao Wu dealt with one of the solutions to the high noise levels discussed in the first talk: headsets. Both passive headsets and active noise reduction headsets were considered. The aim was to find which headset provided enough attenuation to bring noise levels at ear down to an acceptable level, whilst still allowing cockpit alarms and radio communications to be audible.

After a delicious lunch, we were treated to a fascinating tour of RAFCAM's facilities. These included the hypobaric test chambers (capable of reducing air pressure to the equivalent of that found at 60,000 feet and used for acclimatising pilots to these conditions); a short presentation on the work of the RAF's Environmental Health Officers; and hands-on demonstrations of the features and limitations of a pilot's helmet and night-vision goggles (the latter allows you to see a lit cigarette two miles away, but not the power lines right in front of you!).

The tour concluded with one lucky volunteer being spun round at high speed in a disorientation simulator, all in order to prove our reliance on visual cues as well as the balance organs when trying to stay upright.

All in all, this was a fascinating visit giving a rare insight into the work of the RAF's noise and vibration engineers and the unusual challenges they face, most of which we civilians will never encounter.

The Central Branch wishes to thank RAFCAM and RAF Henlow for making this visit possible.

Richard George MIOA

Meeting report: London branch

Nicola Stedman. Planning and the health effects of noise

With new research from the World Health Organisation (WHO) suggesting that long-term exposure to high noise levels can affect health, it was considered appropriate to invite a specialist in health impact assessment (HIA) to give a presentation to members of the London Branch. Andrew Buroni of RPS Group, an HIA specialist with six years of experience in civil aviation, transport, regeneration, waste and energy projects, offered to step forward and explain the fundamentals of HIA and the health effects of noise in a meeting held on Wednesday 19 September 2007.

Andrew began by explaining that HIA assessment is a multidisciplinary process designed to investigate the potential health outcomes of a project, policy or programme. The main objective is to maximise health gains and reduce or remove negative impacts or inequalities. Although HIA is not mandatory (yet!), a number of large scale projects are undertaking HIA as part of the planning process to demonstrate sustainable development, alleviate community concerns and to address human rights issues.

The main factors which affect health include income, employment, housing, education, social networks, access, health care, lifestyle and environment. There are known links between our environment and our health, noise being one of these. However, community, employment and income will always have the biggest impact on our health.

It has been known for some time that noise can result in health effects, but trying to prove that high noise levels can have a significant affect on health is not simple, especially as it is often difficult to separate the effects of noise from other environmental factors, such as air quality. However, the WHO research implies that it will be possible to quantify the effect in a similar way to exposure to air pollution, and this will have a major impact on planning, development, prevention and mitigation.

Andrew's presentation resulted in an active discussion on the implications of the soon to be published WHO document.

For further information on HIA please contact Andrew Buroni on **buronia@rpsgroup.com**

Nicola Stedman MIOA

Meeting report: Midlands branch

Presentation of Student Projects

A large audience attended our annual visit to Derby Univeristy to hear from the recent students. There were two excellent presentations on two very different aspects of the application of the Control of Noise at Work Regulations 2005.

Ian Grove – Noise exposure of a semi-professional rock musician

Ian reported on his own noise exposure from playing in a rock band for 18 years. From April 2008 the Regulations will apply to music/entertainment venues. Ian reported that many performers consider it a hobby rather than a job. Rock music is inherently loud with the majority of noise exposure for the performers coming from the fold back speakers, a situation made worse if poor venue design results in performers being too close together and competing to hear their instruments. His measurements show that CNWR action levels are likely to be exceeded. He discussed methods for reducing noise exposure on stage, but the use of hearing protectors is still generally considered taboo.

Kevin Emery – Noise exposure of window fitters

Kevin pointed out that it is traditionally considered that workers in heavy industry are exposed to the 'worst case' of noise exposure. However, this study considered the issue with regard to window fitters, generally self-employed workers. He described the typical activities carried out by the fitters. He found he had some difficulty in arranging to do noise measurements, as the fitters were reluctant to do anything that slowed them down. However, he completed his study successfully and the data he gathered showed that typical noise exposures could easily exceed the action levels under the Regulations.

An esteemed panel consisting of Brian Hemsworth FIOA, Mike Swanwick FIOA and last year's prize winner Rik Lewis (MIOA) judged the presentations. Midlands Branch Chairman and IOA President-elect John Hinton awarded the prize for the better presentation to Ian Grove.

Ian Grove receiving the prize for best presentation from Paul Shields of Scott Wilson

In addition to thanking the presenters and John Pritchard and Derby University for providing refreshments and use of the facilities, the Midlands Branch would also like to acknowledge the participation of Scott Wilson who kindly donated towards the prizes.

Attendance 36 (17 members, 19 non members)

Meeting report

Martin Armstrong.
It's *Practically* a Quality Measurement?

It was appropriate that The National Physical Laboratory at Teddington was the venue for the IoA Measurement and Instrument Group one-day meeting held on 17th July, which explored the question of "are your acoustic measurements fit for purpose?".

A wide ranging series of papers covering accreditation, calibration and survey strategies, uncertainties and the human interface were assembled by Susan Dowson of the NPL. Unfortunately Susan was unable to be present, having sustained injuries whilst on holiday, and the meeting was chaired by Martin Armstrong.

Kay Crittenden (UKAS) presented an overview of the relevance of UKAS Accreditation to BS EN ISO/IEC 17025/2005. The title of this Standard is "General requirements for the competence of testing & calibration laboratories", however it also covers the competence "applied to all organisations performing tests and/or calibrations". This standard is applicable if an organisation performs measurements at customer premises/sites. Kay explained the benefits that accreditation gives assurances to customers that your organisation, or the organisation being used, will carry out valid measurements.

Richard Lord (NPL) presented a paper entitles "Appropriate calibration strategies for acoustical measurement systems." A measurement programme will comprise generic elements of a system, the instrumentation, measurement methodology, the environment and the operator. Richard stressed that the most important fact to establish is "why are measurements being taken?" This will help to define the relative importance and necessary confidence levels and the required level of calibration and traceability. Scores can be assigned to the commercial risk and technical risk for different activities such as regulatory, routine monitoring or initial survey measurements. The importance of a calibration regime can then be assessed.

Ole-Herman Bjor (Norsonic AS) explored the "Uncertainty of measurements made with Sound Level Meters." A manufacturer's specification is normally restricted to the performance class of a product standard such as IEC 61672-1 and the uncertainties and limits contained in the standard. For a class 1 SLM measuring a broad spectrum signal, based on limits for the full environmental range, the expanded uncertainty would be 2.41 dB. The largest contributor was linearity. Ole then showed that in practice, by using data from 20 units of a class 1 SLM over a typical environmental range, the expanded uncertainty reduced to 0.52 dB.

Adam Buckell (Frazer-Nash Consultancy) presented a wide ranging view of "Acoustic calibration in the Telecommunications Industry". Technological advances have been astounding with better quality audio, greater bandwidth, amplitude and frequency linearity and more compact devices. The use of ear and pinna simulators and HATS are not always fully understood and present a challenge to meet future requirements. Currently knowledge transfer, and education in the use of the more unusual acoustic devices, is underway in the industry.

"Have you been Set Up?" **Richard Tyler** (AV Calibration) certainly showed this to be true in a practical multi-media workshop on the "Art of coupling an acoustic calibrator to a sound level meter." The selected couplers and the instruments employed were easily displayed using a camcorder linked to a computer. The effect of incorrect couplers on the calibration of a SLM was demonstrated to show considerable errors.

Dan Cartman (Cirrus Research) explored the subject "Noise dosimetry: Understanding parameters and practicalities". Many multi-national companies are required to follow both local law and global corporate policy. Dan highlighted the incompatibility of measuring with one setting, e.g. ISO, and trying to calculate the OSHA dose. The two most significant errors are due to the higher criterion level and the threshold in the OSHA settings. Instrument uncertainties for dosimeters, when calibrated properly are low, but the measurement position, to reduce uncertainties, is to site the unit midway along the shoulder nearest sound source and with the microphone vertical.

Dan Simmons (NPL) presented a study addressing the limitations, failings and gaps in knowledge summarised in "Problems in the industrial application of specific standards for measurement of machinery noise emission". Meteorological conditions and geographical locations relating to temperature, pressure, altitude, wind speed, and background noise were each addressed. In addition the uncertainties associated with source directivity, the reflecting surface and production standard deviation, as well as load or no load conditions, were considered in the context of a European working group on Directive 2000/14/EC.

Justin Adcock (Hoare Lea Acoustics) considered the quality of measurement entitled "Post measurement analysis – looking beyond the surface". Post measurement analysis must ultimately assess the reliability and plausibility of the data for decision making. A series of cases demonstrating the need to look more closely at recorded data were given.These covering short bursts of rain, change of wind direction pointed to other sources than a distant motorway, choosing the right parameters such as frequency and Ln. The aim of any measurement analysis is to determine if the set of data is fit for purpose.

Mike Wright (Atkins Acoustics) looked at "Unattended environmental noise measurements – a can of worms?". The advances in recent years with declining data storage costs have opened up the increased resolution in logged data. However quantity may not make up for quality of the noise data without additional information such as recording the sound. Examples of snow reducing traffic flow and speeds, bird song, early morning deliveries, intermittent operations and flight path changes were covered. A logging meteorological station should be mandatory. Lastly above all inspect all data before leaving site.

The AGM of the M&I committee took place after lunch. Richard Tyler, Chairman, gave a report on the past years activities and the retiring members on the committee were re-elected for a further 3 years. The NPL organised conducted tours of some of the acoustic facilities, which took place before the afternoon session. Thanks were expressed to NPL for the organisation on the day and to Susan Dowson for planning the meeting.

IOA certificate pass list

Certificate Name: Certificate of Competence in Environmental Noise Measurement
Exam Date: 5 October 2007 - Pass Candidates

Bel Educational Noise Courses
Black P D
Raffan A

University of Birmingham
Altaf K
Iles N E
Jindu Z P
Kelcey I J
Kiernan L
Roberts H A
Wild C J

University of the West of England
Shoemark R C

Colchester Institute
Brown M
Byrne L
Chandler H
Clifton M M
Cook T
Hunter D W
Labruyere R
Lewis S
McMeel S

Poths T
Southwood A T
Weston D S

University of Derby
Buchanan A J
Childs-Scott K
Edwards S P
Joy P R
Mackay J D
Olive S J
Rayns M C
Renshaw C
Shacklady L G

Sharrock L C
Stroud G

EEF Sheffield
Hemming A P
Jackson B
Lawless R E
Smith P C

Leeds Metropolitan University
Ackelbein M
Cavies R A
Hicks R A

Knowles P J
Mason C E
Taylor C

NESCOT
Attwood T E
Barker P
Bownds P
Casey D M
Chard M J S
Costa L P
Hitchens J
Lee G

IOA certificate pass list

Certificate Name: Certificate Course in the Management of Occupational Exposure to Hand-arm Vibration
Exam Date: 19 October 2007 - Pass Candidates

EEF Sheffield
Alcock R J
Cassidy C W
Cook P G
Marrison E W

Institute of Naval Medicine
Hall G
Gomina S B
West S M

Certificate Name: Certificate of Competence in Workplace Noise Risk Assessment
Exam Date: 9 November 2007 - Pass Candidates

University of the West of England
Adam L R E T
Atkins R
Bryant G R
Burrowson P
Court D J
Greenwood R P
Hill E P
Joyes H D
Kibblewhite A

University of Derby
Dunning K
Marshall W A
Pritchard W
Read D J
Smith A

EEF Sheffield
Anderson S L
Baird J L
Cook P G
Hewitt W

Holt M
Leyshon S
McCole K
Palmer R R
Smith S P

EEF East Midlands & Mid Anglia
Bennett P E
Clarke G
Shires D I
Wyllie M A

Institute of Occupational Medicine
Craig S
Edwards J G
Flower D R
Jackson R R
Lee O P M
Lewis C
Shearer J
Sutherland M J
Tinto K L

University of Derby
Hopkins O
McCawley Y
Mullins C
O'Donnell L
Russell L
Ryan A

Rapid Results College
Bonnen S
Chapman A J
Gbinije H
Jones S F
Mullis C C
Rutherford H
Webb R H

Bed time reading for members

Adam Lawrence.

If you are in the business of research, then it is as likely as not that you will have needed to refer to standards, journals, proceedings and a whole range of other published materials to establish the research baseline and the key findings in your area of interest. You may not be aware that as a member of the Institute you are able to make use of a wide range of library facilities across the country. Whilst some of these arrangements have been in place for a while, there is now a new acoustics collection available at Southampton University.

Institute Headquarters

At the Institute offices in St Albans there is a wide range of publications in the library to which members can have access. The available material includes:

- All IOA publications (Proceedings, *Acoustics Bulletin etc*);
- A range of journals (including JASA, JSV, Applied Acoustics);
- Acoustical standards and codes of practice;
- Some trade magazines, and a range of acoustics papers;
- A range of reference books stretching back into the mists of time.

Members need to telephone the Institute in advance of their visit. They are welcome to browse, but there a searchable database is also available. The library is managed by Sue Omasta who would be pleased to help members track down that all-important paper.

Acoustics Archive at Southampton

The Institute has acquired collections of papers from notable acousticians. The collections consist of working papers from:

- Dr Raymond W B Stephens and the British Acoustical Society (MS 337);
- (Philip) Hope Edward Bagenal (MS 340);
- Hugh Creighton (MS 341);
- Keith Rose (MS 342)

These papers are held in archive collections (the MS number given in brackets) in the library at the University of Southampton. The archives and manuscripts are open Mondays to Fridays between 09.30 and 17.00, by appointment: applications should initially be made in writing. A catalogue of each of the collections is held at the IOA offices in St Albans.

Details of the contact details and library rules can be found on the University web site at www.archives.lib.soton.ac.uk: click on 'visiting special collections'.

Access to other libraries

In addition to the above acoustical reference sources, members of the Institute are able to make use of the facilities at the following libraries:

- Aberdeen: Robert Gordon University
- Bath: University of Bath
- Birmingham: Aston University
- Bradford: University of Bradford
- Bristol: University of the West of England
- Colchester: Colchester Institute
- Derby: University of Derby
- Manchester: University of Salford
- Paisley: University of Paisley
- Portsmouth: University of Portsmouth
- Preston: University of Central Lancashire
- Sheffield: University of Sheffield
- Southampton: University of Southampton
- Stoke on Trent: Staffordshire University
- Newcastle upon Tyne: Northumbria University

Members should make themselves known to the librarian on arrival, and would need to abide by the rules of each library. Some of them only allow referencing, but others allow borrowing, and charges may apply. The Institute has full contact details for each library. In addition to the abundance of available published material, an opportunity is offered to allow members to observe how 'libraries were not like this in my day'. After all, when I was at Salford, the Library had 386s...

Adam Lawrence MIOA

New members

The following new members were approved by Council on 6 December 2007

Corporate Members

Akil, H
Hann Tucker Associates
(Sponsor Member)

Bailess, T D
Max Fordham LLP

Brightwell, M A
Hilson Moran
Partnership Ltd

Carr, S M
White Young Green

Carugo, D
Oxford Brookes University

Cawser, S J
Scott Wilson Ltd

Cook, J A T
Bureau Veritas Acoustics
and Vibration Group

Cooper, C E
White Young Green

Corker, G
Cheshire County Council

Cramond, D
White Young Green
Environmental Ltd

Di Rosario, S
Buro Happold Ltd

Girdziusz, E
Faber Maunsell
(Sponsor Member)

Halford, R W
R H Environmental Limited

Harrison, M J
Norman Disney & Young

Hinxman, G
Applied Acoustic Design

Hooper, L B
Environmental Noise
Solutions Ltd

Hunter, G J
Kingston University

Johnson, B
AWN Consulting

Kent, H G
Stansted Environmental
Services Limited

Keon, E
Enviros Consulting Ltd

King, G J
Sharps Redmore
Partnership

Lai, Y K
Aeolian View Consultants

Miller, S A
Faber Maunsell
(Sponsor Member)

Ngai, T Y
Hyder Consulting Limited

Nielsen, O W
Atkins Acoustics,
Noise & Vibration

O'Driscoll, L A
Atkins Acoustics,
Noise & Vibration

Oakton, C I
Cullum Detuners Ltd

Oldfield, A R
Faber Maunsell
(Sponsor Member)

Russell, N P
Hann Tucker Associates
(Sponsor Member)

Saunders, D K
Alan Saunders Associates

Shaddick, R S
Soundguard

Storey, R C D
Walker Beak Mason

Swales, R
Atkins Acoustics Noise
& Vibration

Walls, C
Munro Acoustics

Whitehead, D B
Rolls-Royce Naval Marine

Associate Members

Archer, N P
Hepworth Acoustics Ltd

Arden, S C
Capita Symonds Group Ltd

Armstrong, C E
Scenic Acoustic and
Vibration Engineering Ltd

Bangue, S
Acoustic Design
Consultants

Barnett, S A
Hann Tucker Associates
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Bass, D J
Peterborough City Council

Blaine, T
Bureau Veritas Acoustics and
Vibration Group

Brzezinski, G
Sun Studio A/S

Carrick, M J
Siderise Insulation

Carter, A
Atkins Acoustics,
Noise & Vibration

Carter, A M
Arup Acoustics

Castro Llach, C A
Adnitt Acoustics

Dunne, K
Integrated Acoustic
Solutions Limited

Edwards, M
Temple Group Ltd

Eugui, I
Hepworth Acoustics Ltd

Finch, A L
South Cambridgeshire
District Council

Garnett, M P
BAE Systems,
Submarines Ltd

Giudice, R
Bureau Veritas Acoustics
and Vibration Group

Grove, I P
Sandwell Council

Gully, T P
AMS Acoustics
(Sponsor Member)

Haseler, S P
STATS Limited

Hine, G R A
Acoustic Associates
(Peterborough)

Holmes, D W
Vita Technical Foams

Howat, C H
Rutland County Council

Landles, S L
Hartlepool Borough
Council

Lane, M J
Thurrock Council

Massey, N P
Birmingham City Council

Masterson, A J
Breckland DC

McEldowney, S
Newry & Mourne
District Council

Ngoka, O C
London Borough
of Tower Hamlets

Parkin, L
Colchester
Borough Council

Patel, D
London Borough
of Southwark

Payne, M J
SFL Group Ltd

Petrasso, S
Weston Homes Plc

Roberts, S J
The English Cogger LLP

Robson, L V
London Borough of Barnet

Ryan, D M
City of London

Sanavi, A
Buro Happold Ltd

Sarton, B S
SLR Consulting Limited

Singleton, J E
New Acoustics

Smyth, S
AWN Consulting Ltd

Symons, B D
Sound Barrier Solutions Ltd

Walsh, R A
Pendle Borough Council

Whitman, M P
Stansted Environmental
Services Limited

Wilson, L
Richmondshire
District Council

Yates, D
Buro Happold Ltd

Zafar, M

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NEC Group

Haigh, N J
Bureau Veritas Acoustics and
Vibration Group

Lewis, C
John Fellows
Acoustic Art Panels

Prosser, G
NEC Group

Technician Members

Ellesley, D M
Acoustic Design
Consultants

Iachetta, L A
Sound Acoustics Limited

Lee, M J
Custom Audio Designs Ltd

Sibson, J E
Wandsworth Council

Urquhart, S C
Philip Dunbavin
Acoustics Ltd

Student Members

Alavi, H

Barnard, R S

Chaplen, J T I

Cheong, S H

Cherel, M

Chung, G Y

Hills, T D

Jelfs, S

Knaggs, E J

Marsh, C

Pitts, H A

Reynolds, M J

Vignali, D

Yamakawa, N

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Sound Reduction
Systems Ltd

Jones, P
Acoustic Comfort Ltd

Wilkins, M
John C Wilkins
Acoustic Supplies Ltd

Former Welsh Woman of the Year wins Public Awareness of Acoustics Award

Wendy Sadler

A passion for promoting acoustics to school students and the general public alike, using music as a theme, has led to Wendy Sadler, Director of *Science Made Simple* being awarded the Institute's prestigious Award for Promoting Acoustics to the Public.

This is the second year of the award. With noise increasingly on the public agenda, and to encourage activity to create a greater awareness of its importance outside the acoustics fraternity, the Institute of Acoustics launched a new Award in 2006.

Since her graduation with a joint BSc honours degree in physics and music from Cardiff University in 1994, Wendy has made it her mission in life to excite people about science in general, and she specialises in the promotion of acoustics. Her work in this area began in 1995 when working with the Techniquest Science Centre in Cardiff Bay where she was responsible for the development of music shows for the theatre and workshops for visiting families on the topic of musical instruments.

She was awarded a BA/Royal Society Millennium Award to develop and deliver music technology presentations and workshops in south Wales. These presentations were aimed at using music as the hook to engage an interested, but non-specialist, adult audience in music technology and acoustics.

In 2002, Wendy established her own business called *Science Made Simple*. Wendy has also written popular articles on the science of sound, presented on local radio about how sound works, and also written books on the theme.

She has developed her own science of music show and has travelled widely with the show. An accomplished musician, Wendy uses various musical demonstrations to bring the shows to life. Performing the 'Last Post' on a corrugated tube, and making strange, vaguely musical, sounds from a dustbin and a bucket make for an entertaining and memorable performances.

Wendy has also engaged many young students through lectures, and in particular an Institute of Physics National Schools and Colleges lecture tour featuring her show Music to your ears with which she has travelled the world. The presentation covers the basics of sound production, frequency and pitch, amplitude and volume, the dangers of listening to loud music, tinnitus, resonance, harmonics, how an acoustical amplifier works, how analogue music is turned into digital signals, how electronics can be used to change the sounds of a voice and how voice synthesis works.

On being informed of her award, Wendy said that acoustics was a fascinating area of study and one that had a fundamental impact on many aspects of our everyday lives. She was delighted that she was able, by means of music, to encourage young people in particular to think more about the science of sound and hoped this could generate an interest later in life to consider acoustics as a possible career.

Colin English, President of the Institute added that the IOA was delighted to be able to give this Award to Wendy. Through live presentations, TV appearances, popular articles, children's books and through the training of the next generation of science communicators, she had promoted the science of sound to many thousands of people from diverse backgrounds over the last 11 years. This made her a worthy winner of the Promoting Acoustics to the Public award.

The Award, an engraved glass trophy, will be presented at the Institute's Spring Conference in April 2008.

Peter Barnett Memorial Award 2007

Graham Bank

Dr Graham Bank of Deben Acoustics Ltd has been awarded the Peter Barnett Memorial Award for 2007 by the Institute of Acoustics. Graham's contribution to the field of electroacoustics was recognised at the IOA's 23rd annual Reproduced Sound Conference which was held for the first time in its history at a live event venue, The Sage Gateshead, on 29 and 30 November 2007. The presentation was made by Colin English, President of the Institute of Acoustics.

Receiving his award, Graham said that he was thrilled to receive the Peter Barnett Memorial Award for 2007. Coming from his peers made it very special – receiving it from such welcoming people as the IOA Electroacoustics Group, made it even better.

Inaugurated in 2001 by the Electroacoustics Group, The Peter Barnett Memorial Award honours Peter Barnett, who died the previous year. This award recognises advancements and technical excellence in the fields of electroacoustics, speech intelligibility, and education in acoustics and electroacoustics and is awarded annually.

Peter Barnett had a wide range of interests in acoustics but primarily in the fields of electroacoustics and speech intelligibility, and was a stalwart of the Reproduced Sound series of conferences. Graham is an ideal candidate for the award, having contributed greatly to electroacoustic innovation and understanding not only in the UK but on a world wide basis.

The Peter Barnett Memorial Award Paper

Graham gave his Peter Barnett Memorial Lecture entitled *Resonances in Audio - They're bad things, aren't they?* on the first evening of the conference. Illustrating the concept of good and bad resonances, Graham showed the audience some of the early techniques used to study loudspeaker diaphragm resonances. The first scanning laser plots of loudspeakers enabled even the inexperienced user to identify problem areas.

Dr Graham Bank receiving the award

Although the traditional goal of loudspeaker designer is to remove all traces of resonance, a new loudspeaker was described which made use of them. Delegates were introduced to the balanced mode radiator (BMR), a loudspeaker which has a diaphragm in the form of a flat disc driven by a conventional coil and magnet assembly. By carefully positioning the active components in the loudspeaker it was possible to produce a flat frequency response which had an unusually wide directivity to very high frequencies.

The lecture concluded with a stereo demonstration of a pair of the BMR loudspeakers, using circular panels only 46mm in diameter. Built into very small enclosures (0.3 litres each) they were well received by the audience, who gathered around them: a long question-and-answer session finished the session off.

Biography

Graham Bank earned a degree in applied physics from the University of Bradford in 1969. After a period as a research assistant in the University, he received an MSc in 1973. Since 1974 he has worked for both Wharfedale and Celestion twice. He held posts as Technical Director and Research Director at both companies.

He has contributed greatly not only to the understanding of loudspeaker performance and design but also to the underlying technologies, and has been involved with many loudspeaker innovations over the past 30 years.

An interesting illustration of his wide interests and adoption/development of new technologies was that in the late 1970s, whilst working for Celestion, Graham helped develop one of the first laser interferometry measurement systems for measuring the behaviour of the vibration and movement of loudspeaker cones. He also used this equipment to measure the vibration of the eardrum for medical research purposes.

Following a loudspeaker research programme completed in 1997 on the theory and performance of ribbon tweeters, Graham was awarded a PhD in electronic systems engineering by the University of Essex.

In 1997, Graham joined NXT as Director of Research, a post he held for seven years, researching flat panel loudspeaker and driver unit technology for use in both the consumer and professional markets. He is the author and co-author of several loudspeaker technology patents. He left NXT in 2004 to set up his own acoustics consultancy business and has, over the years, presented several papers at Reproduced Sound on loudspeaker related topics. He has also presented many AES papers.

Previous winners of the Peter Barnett Award are:

2001	Dr Herman Steeneken	2002	Dr Wolfgang Ahnert
2003	Peter Mapp	2004	Dr Per V Brüel
2005	Prof James Angus	2006	Dr Evert Start

Citation: Roland Dobbs

Honorary Fellow of the Institute of Acoustics

Roland Dobbs, Emeritus Professor in the University of London has given a lifetime of service, extending over 60 professional years, to physics and physical acoustics. He joined the Admiralty in 1943, as a 19 year old, to work on radar and in 1946 became a research student at University College, London. Three years later he moved on to a lectureship in Physics at Queen Mary College, where he stayed for nearly ten years, before a change to Brown University, USA, first as a Fullbright Scholar and then as Associate Professor.

On returning to the UK in 1960, he worked at the Cavendish Laboratory, Cambridge for 4 years and then went to the newly established University of Lancaster as Professor and Head of Physics, building the Department up to a staff of 30. His nine years of energetic input helped establish the Physics Department on a footing which has enabled it to become the 5*A rated Department which it is at present.

Roland's professional activities were involving him in increasing committee work in London. Cooperative work with the University of Sussex also developed during the 1970's and 1980's,. Having put Lancaster on a firm foundation, in 1973 he moved south to Bedford College, London. During his tenure there, reorganisation of Physics Departments in the University of London led to amalgamations, and Roland had the task of combining his old department from Bedford College with that of Royal Holloway College, which he now led. At Royal Holloway he developed a Millikelvin Laboratory, delving further into the boundaries of low temperature physics. Roland retired from Royal Holloway College in 1990 and became visiting professor at Sussex from 1990 to 2003.

Professional work has included committees of the Faculty of Science at London University, including Dean during the 1980s. He has also served nine years as member of Committees of the Science Research Council / Science and Engineering Research Council.

His own research has been in physical acoustics and, in particular, the properties of liquid helium at extremely low temperatures. This culminated in the publication in 2001 of his 1000 page book *Helium 3*, which covers all the low temperature properties of helium-three as liquid, superfluid, and solid. This remarkable book is itself a tribute to Roland, but the Institute of Acoustics takes great pleasure in honouring him for both his services to low temperature physical acoustics and his services to the Institute. He was around at the very beginnings of the Institute in January 1974 with the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society. He was the Institute's President from 1976 to 1978, during a time when the Institute's rapid development required the firm and guiding hand which Roland applied so skilfully. It was during his Presidency that the fledgling Institute took major steps to become a professional body and introduced the corporate grades of Member and Fellow. Roland himself became one of the Institute's first Fellows.

The Institute is honoured to include Roland Dobbs on its distinguished list of Honorary Fellows.

the Honorary Fellowship is bestowed on Prof Dobbs at his home, by Colin English.

Meeting report: Irish branch

Sam Bell. Dr Gerry McCullagh Memorial Lecture - University of Ulster

In recognition of the time and effort that Dr Gerry McCullagh put into the promotion and education of acoustics throughout Northern Ireland and the Republic of Ireland the Irish Branch of the Institute decided to hold an annual lecture to which an eminent acoustician would be invited to present a talk on their area of expertise.

Geoff Kerry CEng FIOA, a good friend of Gerry's for many years, gave this year's lecture on 22 October 2007 at the University of Ulster, entitled *Sure you're sure* – a broad view on uncertainties in environmental noise measurements.

The chairman, Dr Martin Lester opened the meeting by especially welcoming Mrs Rita McCullagh, Gerry's mother Jean, his daughter Caroline and his grandson Robbie. Martin then introduced Geoff Kerry, IOA Past President.

Geoff began by saying that he had met Gerry back in 1974, the same year the Institute was formed. They had often met at the Autumn Conference at Windermere and he reminded us about Gerry's legendary bottle of 'Irish Spring' Water', always a welcome treat in Windermere in November.

Gerry had been a member of Council during Geoff's presidency and he had always brought a calm rational voice to the sometimes heated proceedings. Geoff also referred to Gerry's love of rugby and paid tribute to their friendship.

In introducing the lecture topic, Geoff explained that, since he had been trained as a physicist, he had realised at an early stage in his career the importance of estimating uncertainties in acoustic measurements, especially those carried out in practical environments but under difficult conditions. Statistics, as applied to uncertainties, used to put him off until he won a contract from DTI to provide a Good Practice Guide on Uncertainties in Environmental Noise Measurement.

Bearing in mind the fact that many in the audience would never have heard of the concept of measurement uncertainties, Geoff provided a little background information which included the definition from the Oxford Dictionary of 'uncertain' and the fact that all measurement quantities have an element of doubt due to accident, design or deliberate action: he illustrated the discussion with examples such as the variations in the size of shoes and the amount of froth above the line at the top of a glass of Guinness!

He explained that defining or quantifying uncertainties gives us a better understanding of measurements and their variables. Uncertainties are a measure of **doubt** but often they can also provide a measure of **quality**.

For environmental noise, uncertainties are more a measure of variability in the source and transmission path than in the measurements themselves, but a good understanding is required before comparisons can be made against either criteria or simply another set of measurements.

Geoff then described some of the practical work supported by the DTI. The University of Salford had set up a noise source on their cricket ground and teams, including some local consultants had collected measurements including façade reflections in a controlled exercise giving information on repeatability and reproducibility of A-weighted noise measurement.

Additional work had been carried out on an exercise involving assessments to BS.4142 giving a reproducibility of some 5dB. Changes in the weather during measurement could be significant, indicating that detailed measurement records were important.

A wind speed of less than 2ms^{-1} downwind was compared with zero wind conditions, the latter giving the greatest variability leading to uncertainty.

A checklist developed for the Good Practice Guide provided a handy way of ensuring that all possible uncertainties would be taken into account, and the Guide itself contains information on calculating uncertainties and on practical ways of minimising them. For more detailed information Geoff referred to publications provided by NPL and by UKAS.

Geoff provided a good rule of thumb and advised that if the estimated uncertainty was between one fifth and one twentieth of the total uncertainty, we should accept it.

If it was less than a twentieth of total uncertainty it was probably best to ignore it, but if it was over a fifth of total uncertainty then we should do something more than just worry about it!

Front row L to R: Gerry's grandson Robbie, Gerry's widow Mrs Rita McCullagh, Gerry's mother Mrs Jean McCullagh, daughter Caroline Taylor. Back row: Joan Kerry, Geoff Kerry, Kevin Macan-Lind, Linda Macan-Lind, Martin Lester.

Martin Lester, chairman of the Irish Branch, presenting Pamela Christie with her Certificate for achieving highest marks in Ireland in the IOA Diploma.

Finally Geoff explained that the Good Practice Guide was currently out of print, but that a PDF version could be obtained from the University of Salford (for a small fee).

There followed a question-and-answer session.

Martin thanked Geoff for this lecture, wished him well and hoped he and his wife Joan would return soon. He then presented Geoff with a certificate in recognition of his lecture.

The Chairman then congratulated Pamela Christie from Antrim Borough Council's Environmental Health Department and presented her with a certificate for the highest marks in the Diploma in Acoustics and Noise Control in Ireland for 2007, which gained her three merits. This Diploma award was to celebrate Dr McCullagh's involvement in Education throughout Ireland and will be awarded each year.

The Irish Branch was also pleased to have Kevin Macan-Lind, Chief Executive and his wife Linda attending this Lecture on behalf of the Institute.

Sam Bell MIOA

Underwater Acoustics Group

Judith Bell. Conference on Detection and Classification of Underwater Targets

The Underwater Acoustics Group organised the first international conference on Detection and Classification of Underwater Targets at Heriot-Watt University on 18 and 19 September 2007. The conference was attended by around 83 delegates with a truly international audience and included speakers from USA, Canada, France, Italy, Norway, and Germany as well as the UK.

The majority of the first day was devoted to discussion of algorithms for computer aided detection and classification of underwater targets, since with the increasing deployment of Autonomous Underwater Vehicles for mine countermeasures applications, the automated processing of large volumes of data gathered by these vehicles to detect and classify targets has become a critical task. Numerous techniques have been proposed for Computer Aided Detection (CAD) to detect all possible mines and Computer Aided Classification (CAC) to classify whether the detected object is a target or not. >

< The opening keynote presentation was given by Jason Stack from the Naval Surface Warfare Center in USA. He presented work on behalf of Gerry Dobeck, and illustrated their current state of the art in CAD/CAC algorithms as well as techniques for the fusion of algorithms to combat the problem of creating the "perfect" algorithm. He also showed images of targets highlighting the true complexity of the problem faced by the community. The session then continued with talks covering detection and classification in sidescan sonar imagery, video imagery and with Synthetic Aperture Sonar Imagery, image enhancement, 3D shape estimation from sonar imagery, fusion of CAD/CAC algorithms and multi-aspect classification.

The opening keynote address illustrated how the environment in which the targets are placed can determine the complexity of the problem, with targets lying on clear flat seabeds easy to detect and those in regions of seaweed or rock outcrops difficult, if not impossible, to distinguish from the background scene. The conference then moved on to consider the effect of the environment and seabed on the classification. One of the hardest environments in which to detect targets is shallow water especially in bubbly mediums. The effects of sedimentary properties were discussed and work presented on Rayleigh Mixture distributions for analysis of sea bottom reverberation.

The first day of presentations was concluded with the presentation of the AB Wood Medal to Preston Wilson from the Applied Research Laboratories at the University of Texas. The medal was presented by Colin English, the President of the IOA. Preston has worked in a range of areas including seismo-acoustics, acoustics of bubbly water and investigation of gassy-water-saturated sediments. Preston Wilson is true experimentalist who has mastered a wide range of techniques; he has also investigated the viability of Wood's Equation, named after A. B. Wood, to the low frequency properties of gassy marine sediments. It was therefore appropriate that he chose as this as the topic of his AB Wood lecture.

In the evening a reception and conference dinner was held within the conference venue at Heriot-Watt University. Tom Swean from the US Office of Naval Research and Colin English from the Institute of Acoustics provided after dinner speeches. Colin welcomed everyone on behalf of the Institute and thanked our sponsors for their valuable contributions to the conference. Tom Swean summarized his involvement in the field and his visions for future research and funding.

The second day extended the scope of the conference beyond algorithms and away from the classical view of a mine as the target. The initial session considered the scattering of acoustic energy from targets. This included talks on comparison of at sea experiments and tank experiments to measure bistatic scattering, characterization of specific targets, detection of buried targets and modeling of target scattering.

The second session moved onto the design of sonar transducers for improved target detection highlighting new materials for transducer design as well as novel architectures capable of scalability and modification without redesign and the potential of this for high performance sonar. The session also considered implementations of a real time reconfigurable broad band sonar beamformer which could meet the demands of compact and low power systems required for target detection sonar using Autonomous Underwater Vehicles.

The final sessions of the conference considered the detection of other types of targets including diver detection in harbour regions for increased security in busy ports and detection and localization of marine mammals. Also on the topic of harbour security, techniques for automatic ship hull inspection were presented. Two further papers considered deployment techniques for improved target acquisition, with a final paper on novel techniques to distinguish different targets using a human hearing model.

The conference was enjoyed by all, and provided an insight into the wealth of ongoing research which covers the entire process of detection and classification encompassing the sensor design, physical scattering processes by the targets, deployment strategies, signal design as well as CAD/CAC processing algorithms. The two days were very tightly filled with interesting presentations and a very full programme for delegates.

The conference was sponsored by the US Office of Naval Research (ONR), QinetiQ and the Edinburgh Research Partnership in Signal and Image Processing and the organizers wish to thank them for their contributions.

One small criticism – the acoustics of the conference room could have been better – but that's a topic for another IOA group!

Judith Bell MIOA

Whistling Gratings

Craig Scott and Eleanor Girdziusz. case studies in wind generated noise reduction

Introduction

This article presents the results of two investigations undertaken into separate incidences of noise generation caused by wind flow across car park grating. The noise produced in each case was tonal, and increased in amplitude with an increase in wind speed.

The occurrence of this phenomenon was investigated using different methods in each case. The results of each set of measurements are presented, with a commentary on the success of the adopted solutions and the conclusions drawn.

Case studies

(1) Lowry development, Salford Quays

Complaints were received from a newly built residential development located approximately 100m from the Lowry, related to an 'eerie' whistling tone that originated in the vicinity of the car park. The tone typically occurred during wind speeds of 10 to 15 ms^{-1}, with the tone increasing in volume with increasing wind speed.

Following an initial investigation into these complaints it was concluded that the noise was being generated by airflow across the perimeter grating installed to allow natural light and ventilation into the car park. To further pinpoint the source, third-octave band noise measurements were undertaken to establish the frequency content and absolute level. Figure 1 presents the results.

The results of the preliminary spectral analysis indicated a distinct tone in the 1.25kHz to 1.6kHz region (the relatively high levels of noise measured at low frequencies, up to 100Hz, were attributed to wind flow over the microphone itself and not to the specific tone generated by airflow across the grating). Given the lower and upper frequency limits of third-octave bands, the tone (or tones) that were audible under wind loading were identified to be between 1118Hz and 1789Hz. It was decided that further, more precise, measurements were needed in order to pinpoint the tonal frequency more accurately. Figures 2 and 3 present the results of the additional spectral analysis.

The additional results consistently show a distinct tone at around 1390Hz, almost exactly at the midpoint of the indicative measurement frequency range of 1118Hz to 1789Hz. Notably, the upper frequency limit of the 1.25kHz third-octave band (and the lower frequency limit of the 1.6kHz third-octave band) is 1414Hz. The tonal noise therefore contributes to the measured level in both bands (as shown in Figure 1).

Figure 3 shows that the dominant tone occurs at 1390Hz, and there are also two slightly less significant tones at 1546Hz and 1679Hz (these are evident in Figure 2 as intermittent lines above the 1390Hz line). These will also be audible and supported the claims from some residents that there were, on occasion, three tones.

(2) Asda, Sutton

As for the Lowry development, an investigation was conducted into the occurrence of wind noise generation at Asda, Sutton, following the receipt of a number of complaints from nearby residents. Again the tone was distinct and only seemed to occur during periods of windy weather. In this case the tone had already been attributed to airflow across the car-park perimeter grating.

Hypotheses

It was hypothesised that the tonal noise was generated by one of, or a combination of, the following mechanisms:

- Vortex shedding: this is an intrinsic feature of transverse flow over slender bodies, and regular pulsation is a feature of vortex shedding in the turbulent wake. It is a function of airflow speed and the size of an object, and is discussed in more detail below.
- Resonant vibration of the slatted panel: under certain weather conditions it could be possible that panel excitation was occurring and creating a strong, resonant tone. This can be classed as a 'structural resonance'.
- Acoustic resonance: this is the noise that is created as a result of air movement (wind) passing the slats. The air between the slats is forced backwards and forwards creating a tone.

Measurements and results

Vortex shedding

The method for predicting the vortex shedding frequency of an object is based on research carried out by Vincenc Strouhal. Predictions indicate that slats would need to be approximately 3mm thick and the wind speed around 45 to 55 mph (20 – 25 ms^{-1}) to create vortex shedding at a frequency of around 1.4kHz. The slats on the panels at the Lowry are approximately 3.5mm thick, and this noise has been generated by winds of significantly less than 55mph. The calculation assumes a Strouhal number of 0.2, based on a single cylindrical object in a clean air stream, but grating-shaped objects may alter the result. Nevertheless, a vortex shedding effect was a possible source of the tone.

Given the geometry of the grating, this mechanism was also believed to be the cause of the noise generation at Asda, Sutton.

Vibration response

Measurements of the impulse response formed the next stage of the investigation at the Lowry. These measurements were not conducted at Asda, Sutton. The weather during the vibration response measurements at the Lowry was such that the noise was generated only sporadically. In order to obtain appropriate vibration measurements to identify potential structural

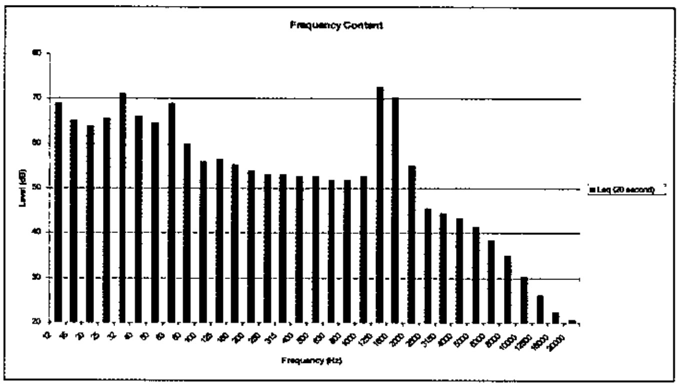

Figure 1

Frequency content of noise (third-octaves)

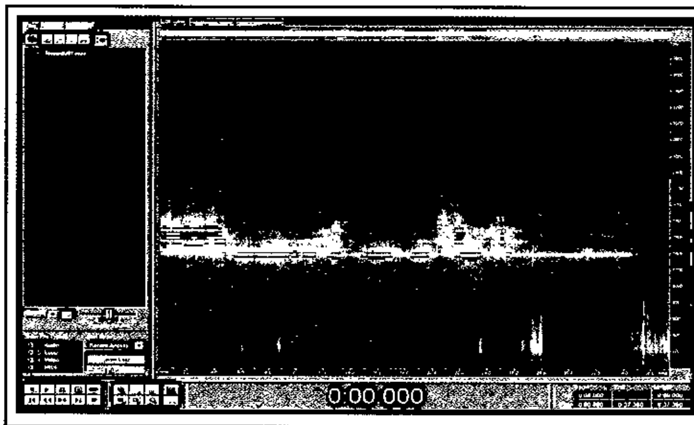

Figure 2

Spectral analysis of recorded noise

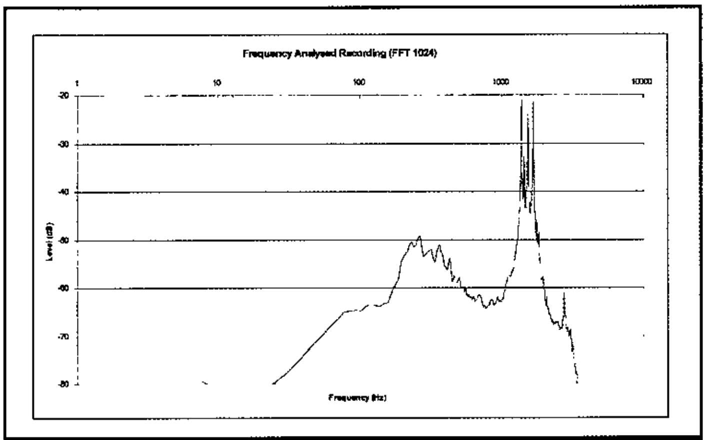

Figure 3

Graphical form of spectral analysis

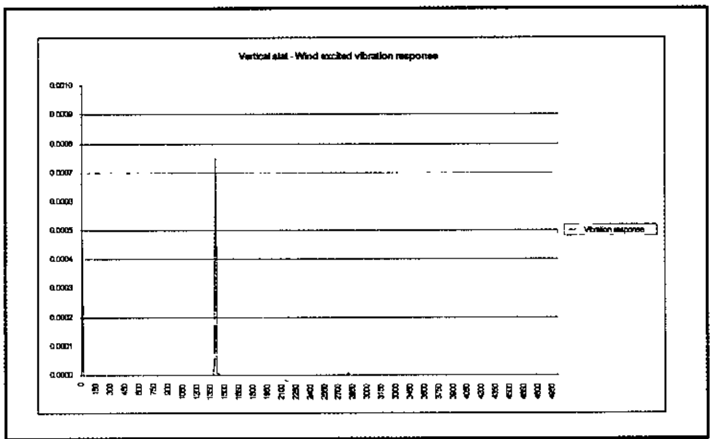

Figure 5

Vibration measured in slat due to wind excitation

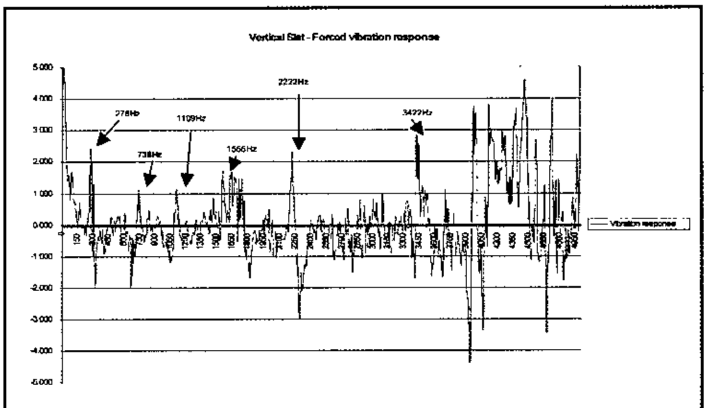

Figure 4

Typical 'forced' vibration response (structural resonance)

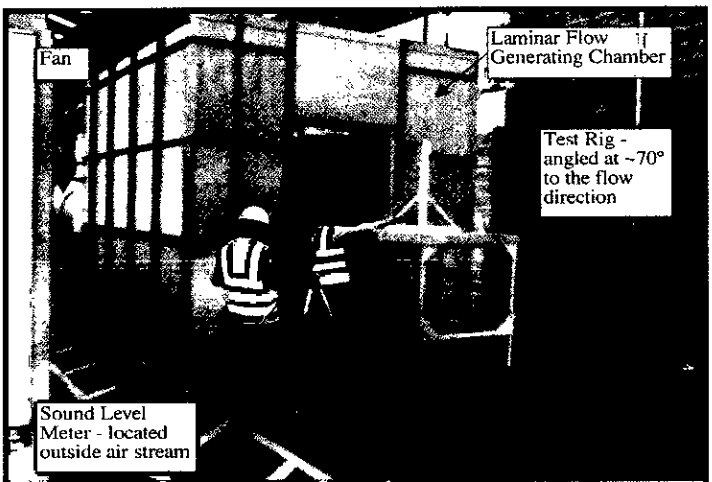

Figure 6

Photograph showing the wind tunnel test rig arrangement

resonance, therefore, measurements were first undertaken when the tone was not being generated, *ie* the resonant response due to broadband forcing frequencies (caused by the impact of a 'force hammer'). The results are shown in Figure 4. The equipment used for vibration measurement was a Diagnostic Instruments DI2200 analyser, force hammer and accelerometer.

None of the resonances visible in Figure 4 corresponded to 1390Hz. It is therefore considered unlikely that the audible tone was a structural resonance.

Following the above, vibration response measurements were also undertaken at the Lowry Development for periods during which the tone was generated. Figure 5 presents the results.

Figure 5 shows a distinct tone at exactly 1.4 kHz. This is unlikely to be the result of resonant excitation of the gratings, as the impact response test did not identify a resonance at this frequency. It was therefore concluded to be vibration resulting from sound waves incident on the gratings as a result of an acoustic resonance or vortex shedding effect in the air stream.

Proposed solutions

On the basis of the results of the preliminary investigations at both sites, it was proposed that disrupting the flow across the grating would either prevent vortex shedding or acoustic resonance, thereby alleviating the problem.

The following methods for disrupting the flow were proposed:

- Provide inserts between gratings: the noise is generated by wind exciting the air around the gratings as it passes across the front of them. If an insert is filled between gratings, a rubber bung for example, this could prevent the gratings from being excited under wind loading. It may also interrupt the establishment of acoustic resonances and prevent generation of vortices.
- Provide a 'rounder' edge to the gratings: if the generation of turbulence by the edges of the gratings can be reduced then this should prevent the noise being generated. This could be achieved by providing some form of rounding to the outer edge of the gratings. A rounder edge profile could be achieved by using a preformed pipe lagging section or similar.
- Install a mesh across the gratings: the geometry of the grating is a variable in the production of the tone, therefore if the geometry could be changed, the effect may not occur. The incidence of turbulence may also be reduced by the cure proposed for 'rounder' edges.

At the Lowry development, the option whereby the profile of the grating edges is rounded was trialled in-situ. To achieve this effect the edges of the gratings were covered in rubber strips similar to those around car doors. The treatment was fitted to a sample area, to allow a comparison between those areas with remedial treatment fitted, and those without. Vibration measurements were conducted of the resulting treated area.

At Asda Sutton, the solution whereby a mesh was installed across either the face or rear of the grating was tested in a wind tunnel. The tests were conducted using a sample of the existing grating, for which the tone was successfully recreated and measured using a NOR188. Third-octave band frequency measurements were then conducted for a number of different mesh types, fixed to each side in turn at different wind speeds. Measurements of the background noise generated by the fan when operating at the set wind speed were also recorded as a reference. Figure 6 provides an example of the test rig arrangement.

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Whistling Gratings - *continued from page 19*

Results

The vibration measurements undertaken at the Lowry, on a sample section of grating with rubber strips fitted and on an adjacent section without, were conducted during a period in which other areas of the grating generated the tone previously identified. The measurements were undertaken using a Brüel & Kjær type 2260 analyser, with the BZ7208 FFT analyser module, with the accelerometer placed on the face of a grating. Figures 7 and 8 show the results of these measurements. As can be seen, the presence of the rubber strips successfully reduced the tonal response. When the treatment was extended to the remaining grating areas at the Lowry, the tone could no longer be heard.

Figures 9 and 10 present the results of the spectral measurements undertaken during one set of wind tunnel tests for Asda, Sutton.

It was found that the whistling tone was generated by the car park grille at wind speeds of between approximately 11 and 15 ms^{-1} (around 20 to 25 mph) with the rig set up at angle of around 70° to the wind direction. At the lower wind speed the tone was generated at a frequency of around 2500Hz, and the frequency increased to 3150Hz at the higher wind speed.

The installation of a number of the mesh types installed to the rear face of the rig significantly reduced the audibility of the whistling at both wind speeds, so that it was indistinguishable from the background noise generated by the fan. One of the mesh types, however, subjectively had very little or no effect when applied to the leeward face in either orientation (with the ovals running horizontally or vertically). Having reviewed the results it appears that for some of the configurations for this mesh type, eg with vertical ovals and a wind speed of 15ms^{-1}, the sound pressure level of the produced tone was higher than that when the mesh was not present: the mesh increased the volume of the tone.

Conclusions

The following conclusions were drawn from the investigations.

The noise generated by wind passing across and around a series of gratings is not in this case a structural resonance. Treatment to the leeward face mitigates the noise generation, which makes sense if the boundary layer separates from the leeward edge of each grating. Calculations using the Strouhal number do not quite fit, because the grating geometries are different. It was concluded that vortex shedding was a source of the tone.

Disrupting airflow at the edge of gratings was a very effective means of limiting the generation of a distinct tone. Objective and subjective assessments of the 'rubber strip' solution and the covering mesh (subject to geometry), supported this idea. Both of these design options offer relatively cost effective solutions, although they may have implications on other aspects of the grating, eg light transmission, ventilation path, and maintenance.

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This article is based on a paper on the same subject given at the 2007 Institute of Acoustics Autumn Conference.

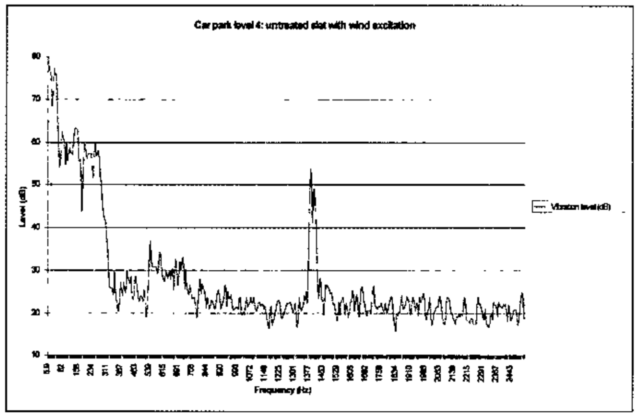

Figure 8

Vibration measurements for untreated grating

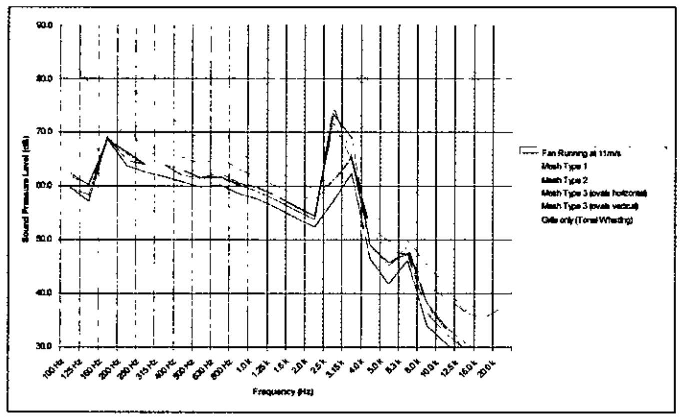

Figure 9

Graphical summary of noise levels generated by test rig at a wind speed of 11ms^{-1} (mesh installed to rear leeward face)

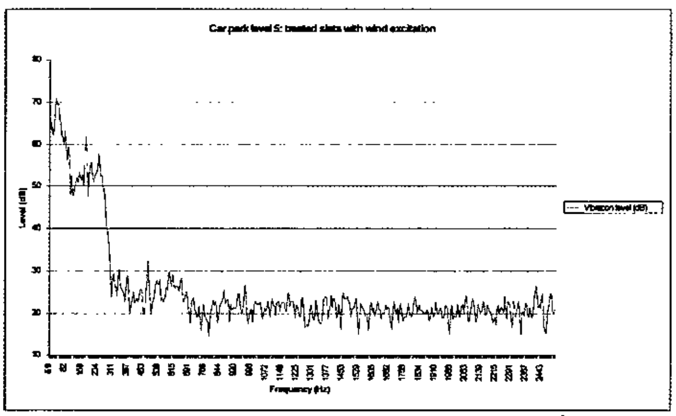

Figure 7

Vibration measurements for treated gratings (rubber strips installed)

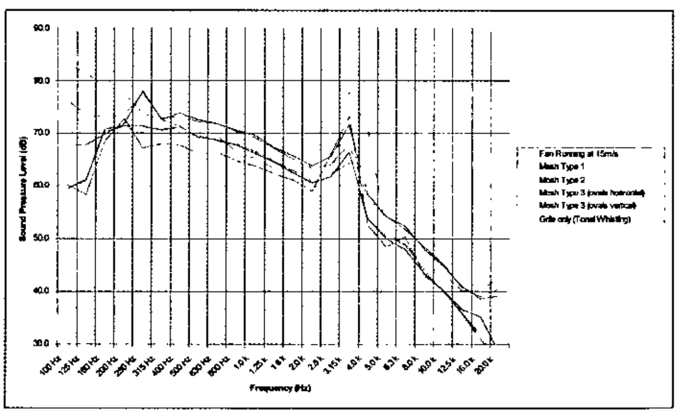

Figure 10

Graphical summary of noise levels generated by test rig at a wind speed of 15ms^{-1} (mesh installed to rear leeward face)

End corrections due to perforated pipes

Keith Peat.

Introduction

The acoustic performance of duct systems at low frequencies, below that of the lowest cut-on frequency of a non-planar wave, can be predicted very simply by a plane-wave analysis. Geometrical discontinuities in the duct system such as area expansions will, however, generate evanescent non-planar waves that generally have a minor influence on the acoustic performance of the duct system. The accuracy of a plane-wave analysis can be improved by the use of a discontinuity impedance that accounts for the generation of evanescent waves at a given geometric discontinuity. In the absence of any mean flow, the reactance dominates over the resistance and the effects of the entire discontinuity impedance are equivalent to a small increase in the duct length, a so-called end correction. Thus the effective acoustic length of a duct is the sum of its physical length and any appropriate end corrections at each end of the duct. Two classic cases of this are an open duct termination into free space[1] and a flanged duct termination into half-space[2]. At low frequencies, such that $ka < 0.5$, where k is the wavenumber and a the duct radius, these end corrections are 0.6a and 0.85a respectively. Within duct systems, geometric discontinuities often take the form of a change of cross-sectional area, see Figure 1. The full open or flanged duct end correction is then modified by a correction factor[3] based upon the area ratio at the discontinuity. The end correction is applied to the narrower duct only.

Within flow ducts, it is unusual to find an expansion box silencer of the form given in Figure 1. The reason for this is that there would be large flow resistance as the flow expands and contracts. Thus, in order to reduce flow resistance, a perforated tube is used to bridge the gap between the flow inlet and outlet, as seen in Figure 2. There is now a design compromise regarding the porosity of the perforate - the ratio of open area of the perforations to the total area of the tube. As the porosity increases so does the flow resistance, whereas as the porosity is reduced so is the acoustic effectiveness of the silencer, as less acoustic energy is transmitted through the perforate. Typically, perforates of 10-20% porosity are used in practice.

Given knowledge of the impedance of the perforate, it is possible to conduct an approximate plane-wave analysis of a silencer such as that given in Figure 2 by either a segmentation[4] or a decoupling[5] approach. However the purpose of the extended inlet and outlet of this silencer is to give quarter-wave resonance in the respective end cavities and hence the frequency of the resonance depends upon the acoustic length of the extended inlet and outlet. Thus, if the end correction for a perforate were known, a designer could precisely determine the physical length of extended inlet or outlet required to tune out a particular frequency without recourse to trial and error using a full plane-wave analysis of the system. Furthermore, both the segmentation and decoupling approaches to analysis are approximate in their physical representation of the perforate, let alone their assumption for perforate impedance, such that an 'end correction' approach is also likely to give a more precise estimate of resonant frequency.

This article presents an experimental investigation into the end correction of a plain duct that terminates in a perforated duct of the same cross-section. The effects of a mean flow are also considered. The only known previous work on this topic is based upon a finite element analysis[6] of a silencer of the form given in Figure 2. Mean flow effects were included, but the mean flow was assumed to be inviscid and non-rotational. General results were given from only one overall size of silencer box for the end correction in situ, but if these results are altered by the Karal correction factor[3] then the end corrections for a perforate alone become as shown in Figure 3. The dotted line in Figure 3 represents the theoretical value of end correction in the zero flow case without a perforate[1], namely the limit towards which the Mach number M = 0 results should tend as the porosity tends to 100%. The results indicate that the perforated tube has a significant effect on the end correction and one that increases as the mean flow increases.

Experimental setup

In a typical expansion chamber silencer for a vehicle exhaust system, the pipe radius a would be of the order of 20 to 25 mm whereas the lengths of extended inlet and outlet would be of the order of 100 to 200 mm, to give a resonant frequency in the low frequency region of major concern. Thus although the change in end correction due to a perforate would appear to be of significance, the relative change in acoustic length of the resonator and hence frequency of resonance would be quite small. However this is no longer the case if the perforate is attached to the neck of a Helmholtz resonator. Figure 4 shows a sketch of a typical triple-pass silencer box, the most common generic type of rear box silencer to be found on road vehicles.

The two flow reversal chambers at either end of the box form double-neck Helmholtz resonators that resonate at a theoretical frequency f of

$$f = \frac{c}{2\pi}\sqrt{\left(\frac{S_1}{L_1V} + \frac{S_2}{L_2V}\right)} \qquad (1)$$

where $S_{1,2}$, $L_{1,2}$ are respectively the cross-sectional area and acoustic length of necks 1 and 2, V is the volume of the reversing chamber and c is the speed of sound. The necks generally consist of short plain circular tubes of radius 20 to 25 mm and a physical length of similar magnitude. Thus the end corrections at each end of the neck can dominate the acoustic length of the neck such that in this scenario the change in end correction due to the presence of the perforate can have a very significant effect upon the resonant frequency of the chamber.

An experimental setup was chosen that would closely represent a single such flow reversal chamber and hence have a much greater

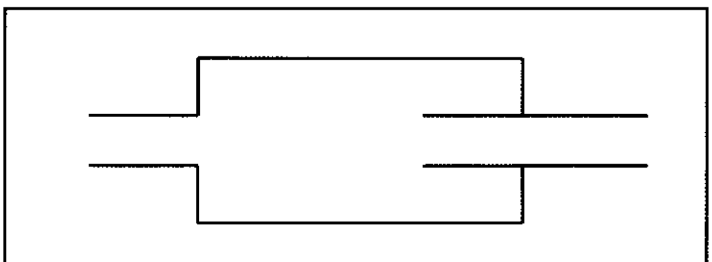

Figure 1

Simple expansion chamber silencer

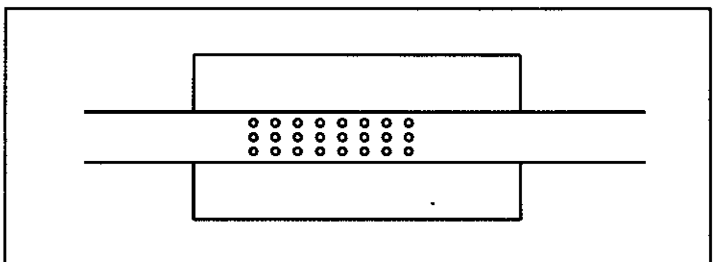

Figure 2

Typical flow-duct expansion chamber silencer

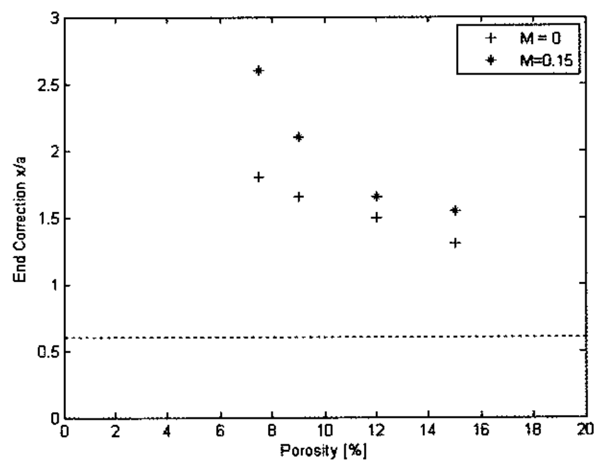

Figure 3

Numerical evaluation of perforate end corrections

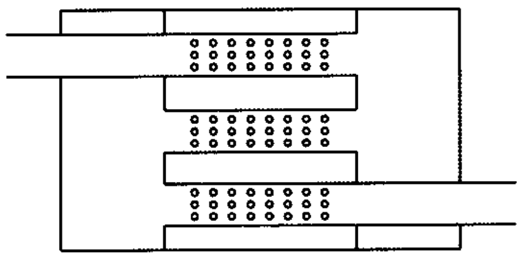

Figure 4

Typical triple-pass silencer box

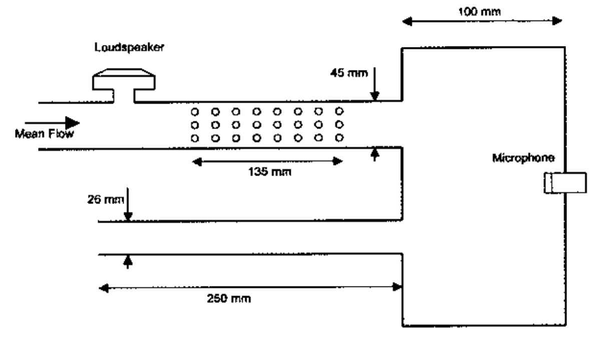

Figure 5

Sketch of experimental setup

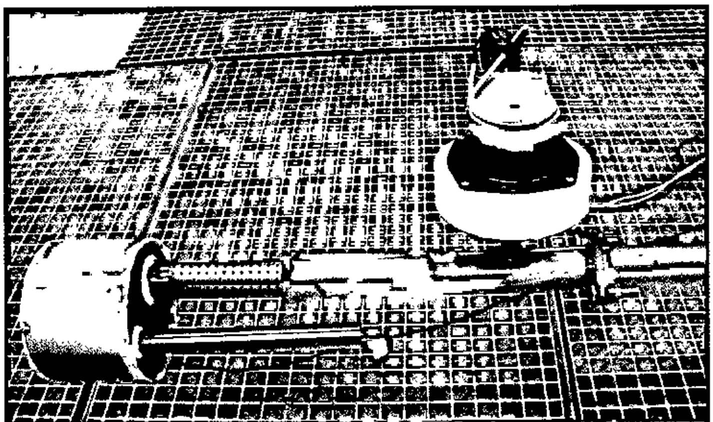

Figure 6

Photograph of experimental setup

sensitivity, namely change in resonant frequency for a given change in end correction, than that given by a system such as shown in Figure 2. A sketch of the experimental setup is shown in Figure 5 and a photograph of the corresponding actual system is shown in Figure 6. To simplify matters, a perforate was attached to only one of the necks. The second neck was made long and narrow such that any uncertainty over the end correction of this tube would have minimal impact upon the resonant frequency. Nine different tubes were used to form the first neck, as shown in Figure 7.

In all cases the plain length of neck was exactly the same at 33mm. Likewise the holes, 3.5mm diameter, the axial spacing between rows of holes, 10mm, and the total length of perforated section, 130mm, were kept constant in every case, as was the general rectangular pattern of holes. Only the number of equally-spaced holes at a cross-section varied, to give porosities of perforate ranging from 4.4% to 16.1%. In addition, a simple plain tube of length 33mm was also tested.

Results

Measured results of the resonant frequency of the double-neck Helmholtz resonator are shown in Figure 8 for different porosities of perforated tube. The dotted line shows the measured frequency of resonance of the plain tube, effectively the value for 100% porosity. Equation (1) was then used to determine the end correction of the wide neck at the perforate boundary, given the theoretical end corrections at the other three terminations of the two necks. In the case of the plain 33mm pipe wide neck, all four end corrections are known theoretically[1],[2],[3]. However the Karal factors[3] of the two flanged ends into the chamber are not known precisely, since the necks are not concentric with the chamber and the Karal factor does not include interference effects for more than one neck. Thus, the Karal factor was adjusted slightly to give an end correction of the plain pipe of exactly 0.6. The adjusted factor was then retained when evaluating the end corrections due to the perforates. These results are shown in Figure 9, together with the numerical values[6] given in Figure 3.

It is seen that although the trends are the same for both measured and predicted results, there is a large shift in actual value. Given the greater

continued on page 24

End corrections due to perforated pipes - *continued from page 23*

sensitivity of the experimental setup to changes in end correction and the repeatability of the measured results as apparent from Figure 9, the large difference between the two sets of results is presumed to be because of inappropriate values of perforate impedance, and imprecise modelling of the perforations in the numerical results.

A vast amount of both theoretical and experimental work has been done on the radiation impedance of a plain pipe with a flanged or unflanged termination when a mean flow of low Mach number exits the pipe. In a brief summary[7] of the key results the overall conclusion is drawn that the mean flow increases the resistance but has minimal effect upon the reactance, hence upon the end correction. The resonant frequency of the Helmholtz chamber was measured for the case of the 33mm length of plain pipe, with a mean flow through the remote flow pipe driven by a Roots blower. The exit velocity from the narrow neck was measured by a pitot-static tube and the Mach number of the mean flow in the wide neck was deduced from continuity. Figure 10 shows experimental values of the end correction of the plain 33mm at the open end, based upon the measured resonant frequencies of the chamber, on the assumption that the other three end corrections are unaltered by the mean flow. This assumption is invalid, as if there is any noticeable change of end correction due to flow it would be shared amongst all four neck terminations and would be expected to be greater for flow efflux rather than flow influx terminations. It is seen from Figure 10 that there is some noticeable change with flow from the no-flow value of 0.6 but that the trend is not uniform.

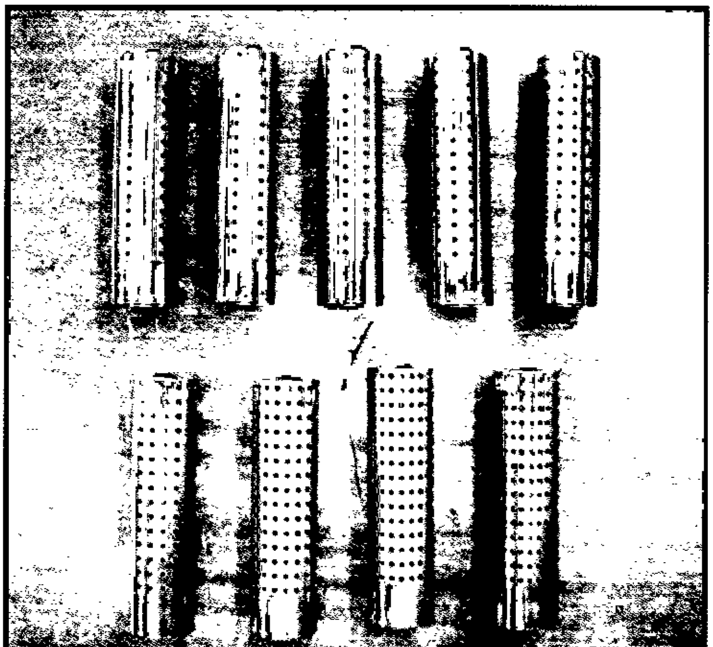

Figure 7

The resonator necks of different porosities

The resonant frequency of the Helmholtz chamber was also measured with various perforated tubes connecting the flow pipe and the inlet to the Helmholtz resonator, for variable amounts of mean flow. The total end correction at the perforate/inlet boundary required to give the measured frequency was then evaluated, using the same end corrections for the other three pipe terminations as was used without mean flow. The results are shown in Figure 11. It might be argued that the two flow efflux end corrections should be altered with flow in accordance with the results of Figure 11, before evaluation of the perforate end correction. However, given the relative values in Figures 10 and 11 this will not make a substantial impact upon the results. It is seen from Figure 11 that the influence of a mean flow upon the end correction at a perforate boundary is very substantial, the trend always being for increasing mean flow to increase the end correction. This is in agreement with numerical results[6], see Figure 3. At very low Mach numbers, the same trend for increased end correction with reduced porosity as was observed without mean flow is seen. This becomes less apparent as the mean flow increases, due mostly to greater scatter in the results.

As noted earlier, in the presence of mean flow the resistive part of the radiation impedance of a plain pipe termination increases over the zero flow value. This effect becomes far more apparent for transition into a perforated pipe. Thus without mean flow, the resonance peak of the Helmholtz resonator was very sharp. Mean flow through the plain pipe neck of the resonator, as for the results of Figure 10, gave a slightly more rounded and broader resonance peak, but the resonant frequency was still clearly defined. In the case of the basic measurements with perforates for Figure 11, the resistance was so high that the precise resonance peaks were very difficult to distinguish. This problem increases with increasing mean flow rate and reducing porosity. This has limited the range of flow and porosities for which results could be obtained as well as leading to larger uncertainty in the results for increasing flow and reducing porosity.

Conclusions

The effective end correction for a uniform circular pipe that terminates by transition into a perforated pipe of similar cross-section has been calculated from measurements of the resonant frequency of a dual-neck Helmholtz resonator, both with and without mean flow through the necks. The end correction increases as the porosity of the perforated pipe is reduced and as the mean flow velocity is increased. The effect is substantial in both cases and will dominate in the

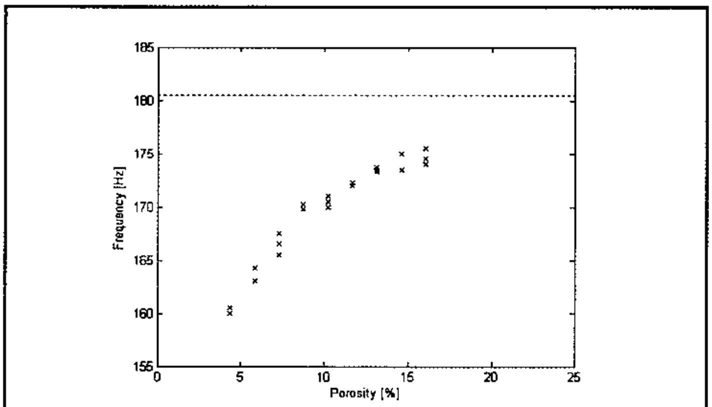

Figure 8

Measured resonant frequencies, no mean flow

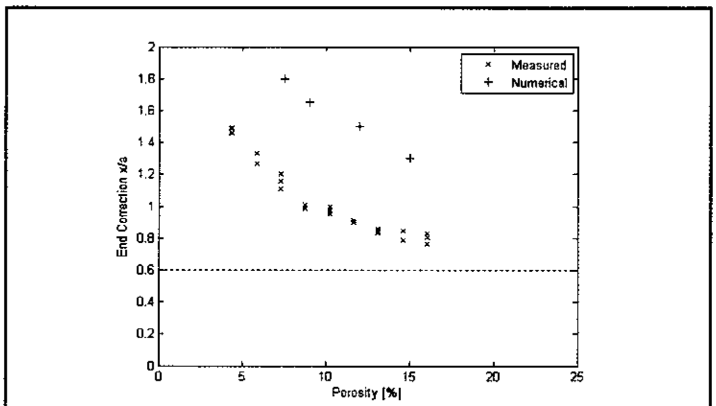

Figure 9

End corrections due to the perforated tube, no mean flow determination of the acoustic length of a duct whose physical length is of similar order to its diameter. The effective acoustic resistance at transition into a perforated pipe also increases as the mean flow increases to a much greater degree than is observed for a plain pipe termination into free or half space. Thus the given results on end corrections due to perforated pipes with mean flow are more error-prone than those for zero mean flow. Furthermore the effect becomes so great, even at low mean flow rates through highly porous pipes, as to dampen the resonance peak of a Helmholtz resonator to a degree which makes the resonator useless in practice.

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This article is closely based on his paper of the same name, presented at the IOA Autumn Conference in Oxford, October 2007

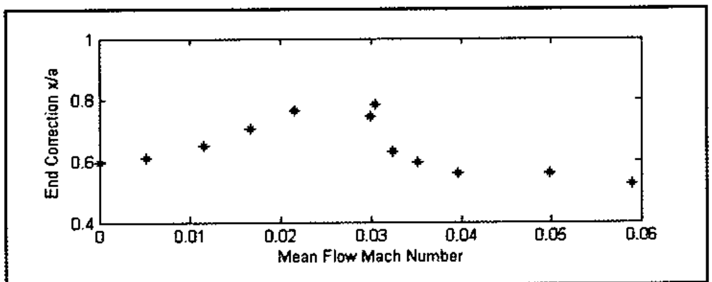

Figure 10

Equivalent end corrections of the open end of the plain pipe with mean flow

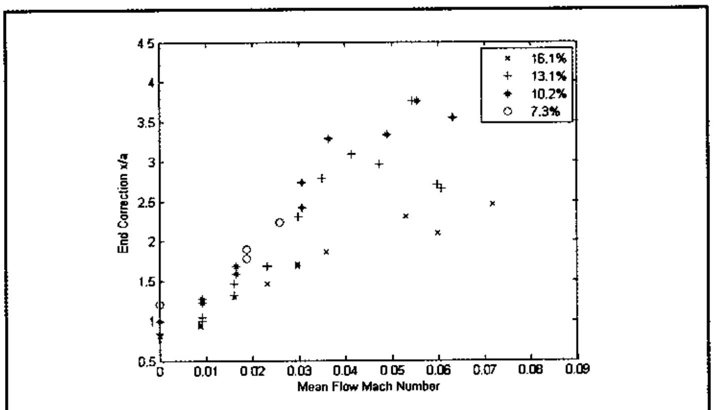

Figure 11

End corrections due to the perforated tube, with mean flow

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ANASE

Peter Brooker. Unreliable – owing to design-induced biases

Introduction

In November 2007, the ANASE (Attitudes to Noise from Aviation Sources in England) report was published. It claimed that people were increasingly annoyed by aircraft noise, and it estimated how much they would be 'willing to pay' to get rid of it. But its quantitative 'findings were rejected as unreliable by the Department for Transport [DfT]' (BBC web page). Immediately after the report's release, a DfT Minister (BBC Politics Show) said:

'The reason why it [ANASE] was delayed was that the scientists – the peers reviewing this major scientific study – said that it isn't up to standard...it isn't good enough for what the Government wanted, ie to formulate Government policy.'

About a quarter [sic] of the project's duration was spent on expert peer reviews. ANASE's website **(http://www.dft.gov.uk/pgr/aviation/environmentalissues/Anase/)** includes the report, its technical appendices and several of these critical reviews. In particular, DfT paid two objective and knowledgeable acoustics experts to review the ANASE draft material (Havelock & Turner, 2007). Their comments include:

'...in the first version of this review it was stated that there were sufficient technical and methodological uncertainties still remaining with the study to mean that reliance on the detailed outcome of ANASE would be misplaced. In view of developments since the review of the July 2007 version of the ANASE main report, the reviewers are even more convinced that their concerns are 'full'y justified...'

The DfT did not refer to these conclusions in its publicity material about ANASE, but this review is a key document.

The following article summarises the main ANASE claims, and then examines its design, methodology and statistical analyses as set out in published documents. Neither the history of the project, nor the managerial and professional issues in its conduct, is discussed. Brooker (2004, 2006) provides general background on past research and the technical issues explored here, particularly in the context of the earlier Aircraft Noise Index Study (ANIS – Brooker et al (1985)).

ANASE's objectives and claims

The 1985 ANIS study concluded that there was no better metric than the noise energy measure L_{Aeq} (L_{eq} here) in terms of correlation between aircraft noise and community annoyance. Following consultations, the Government decided to adopt the use of L_{eq} to describe noise, and decided that 57 L_{eq} (16-hour period) marked the approximate onset of significant community annoyance from aircraft noise.

In mid-2001, the DfT announced a major study into aircraft noise:

'...the new study underlines the Government's commitment to underpin our policy on aircraft noise by substantial research that commands the widest possible confidence';

and stated that conclusions from the ANIS research have:

'...been broadly confirmed by other studies here and abroad, and we have no reason to doubt their validity.'

Commercial contractors (led by MVA Consultancy Ltd) were commissioned to conduct the ANASE project in late-2001. The ANASE study has two aspects:

- Relationship between aircraft noise and annoyance
- Monetary valuation of annoyance by aircraft noise (Stated Preference [SP])

The following does not discuss the SP part of the work, but it does indicate how that component markedly affected the work on annoyance: note that the bulk of the DfT managers' attention was on the SP components.

ANASE adopted several basic ideas from ANIS. Social survey questionnaires were used to elicit respondents' annoyance from aircraft noise as well as socio-economic data. Fifty-six survey sites near nine airports were included in the study, with levels of aircraft noise from 36 to 68 L_{eq}. The study report makes a number of aircraft annoyance claims, including (slightly edited):

Claim: 'For the same amount of aircraft noise, measured in Leq, people are more annoyed in 2005 than they were in 1982.'

Claim: 'The modelling work also showed that respondents were less sensitive to changes in sound level below 42 L_{eq} and above 59 Leq, adding support to a logistic dose-response form. There was no threshold, or discontinuity, in the relationship between mean annoyance and L_{eq}.'

Claim: 'The results from the attitudinal work and the SP analysis both suggest that Leq gives insufficient weight to aircraft numbers, and a relative weight of 20 appears more supportable from the evidence than a weight of 10, as implied by the Leq formulation.'

These are dramatic claims. To meet the DfT criterion 'commands the widest possible confidence', they would need to be robust, technically reliable, and capable of withstanding scrutiny.

ANASE problems: questionnaire

When carrying out an attitudinal survey, choices must be made about question wording, response scale, question context, and data collection technique. All these choices can generate errors and biases. The responses to attitudinal questions may easily be affected by the way the issue is posed, the sequencing of questions, the particular wording of a question and its context.

Psychologists interpret attitudes as 'structures in long-term memory', and suggest a four-stage cognitive process needed to answer attitude questions:

(i) Interpret the question ('What is the attitude about?').

(ii) Retrieve relevant beliefs/feelings.

(iii) Apply these beliefs/feelings to generate appropriate judgement.

(iv) Use this judgement to formulate response.

This indicates that attitudes are 'evaluative judgements' formed at a particular time, rather than some kind of enduring personal view, waiting to be picked out of someone's mind. Each stage is likely to be influenced by psychological variables dependent on the questionnaire construction and data collection process.

Thus, attitude reports are highly context sensitive. All four stages above can potentially be affected by 'prior items': serious respondents may be building on their earlier thought processes, or they may aim to 'match' the earlier responses, ie try to be consistent with their answers. They are unlikely to want to mislead about their 'true' attitudes, but they may be motivated to help or 'please' the interviewer by providing answers that show that the interviewee is aware of the issues that he or she is to be questioned about. Reputable textbooks (eg Sudman and Bradburn, 1982) warn about context effects, as does UK governmental guidance on question order:

'Question order can affect the way in which survey respondents interpret survey questions and thus answer them. This is because the wording of preceding questions can help to shape the context in which respondents interpret the current question.' (GSRU, 2007)

'Such question-context effects may therefore bias prevalence estimates and invalidate comparisons across surveys where the same questions are asked but not in identical order.' (McColl et al, 2001)

Figure 1 shows a schematic comparison of the ANIS and ANASE questionnaire set-ups. Two potential context effects are worth noting.

- The installation of noise playback equipment precedes ANASE, but

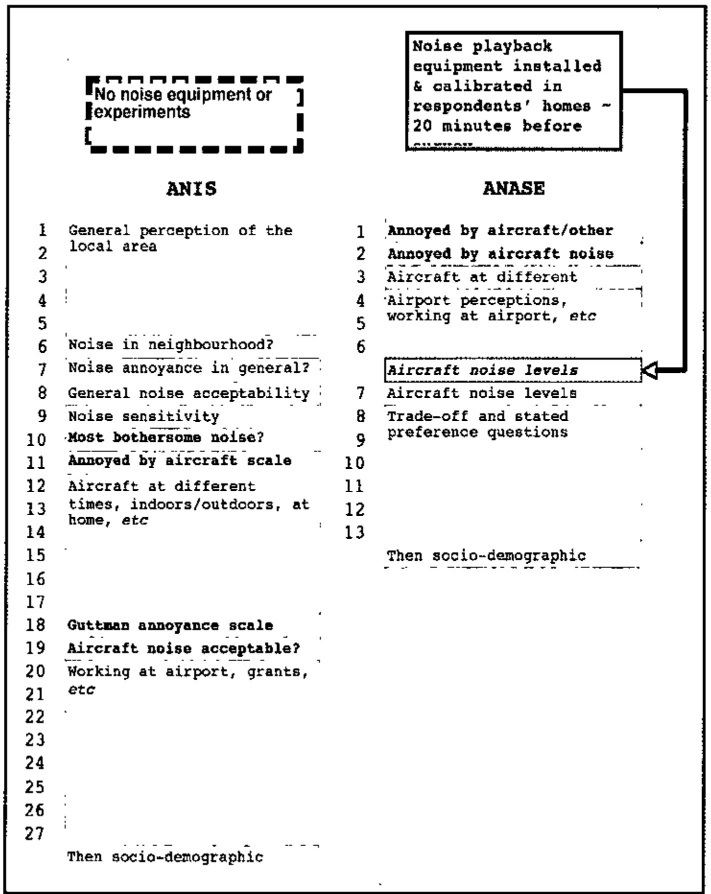

Figure 1

Comparison of key ANIS and ANASE Questionnaire context, question order and noise playback equipment differences.

Notes:
(i) The ANASE questions are in the order given, but the numbering starts at 6 rather than 1 – no explanation is given for this.
(ii) The bold text indicates where questions to provide 'aircraft disturbance' scales used in the statistical analyses were asked.

not ANIS. Thus, ANIS is a social survey and ANASE is a combination of a social survey and a foreshadowed laboratory experiment, as, later in the interview, noises are played to respondents.

- ANASE starts immediately with questions on aircraft noise annoyance, but ANIS leads up to them by asking about perceptions of the local area, and thus allows the interviewee to mention aircraft noise spontaneously.

Given the importance of context effects, both of these factors could affect annoyance ratings considerably, as discussed below.

Measured annoyance attitudes also tend to be very variable for other reasons:

- *Sampling fluctuations:* if for a particular noise climate, the true percentage of a proportion is (say) 30%, then a sample of 160 people will produce a range of values purely through sampling variations (the 95% confidence band is 23% to 38%).
- *Socio-economic variables:* few of these produce consistently detectable effects, but working at an airport or having a job dependent on airport activity usually show up as distinct 'confounding factors', and surveys do not consistently include or omit these respondents.
- *Media attention/trust:* there is great deal of research work on attitude measurement showing the importance of recent media attention at the airport in question on respondents' expressed attitudes. Related factors are people's trust in the airport company and national/local government policies.

Site	ANASE estimate	CAA / DfT published	Bias, ie difference (ANASE - CAA / DfT)	
R01	40.9	45.8	-4.9	
R02	41.6	46.2	-4.6	
R03	43.0	44.9	-1.9	
H3C	46.0	50.3	-4.3	
R06	46.5	51.4	-4.9	*ANASE: < 50 L_{eq}*
R09	47.2	52.2	-5.0	*Average bias -2.5dB*
R05	47.5	48.1	-0.6	
R04	47.6	48.5	-0.9	
R08	48.9	50.4	-1.5	
H5E	49.6	46.3	+3.3	
R10	50.4	52.6	-2.2	
H3A	50.4	52.8	-2.4	
H3B	50.5	53.2	-2.7	
H5A	50.9	53.5	-2.6	
H3D	52.7	52.8	-0.1	*ANASE: 50 – 57 L_{eq}*
H3E	53.0	54.3	-1.3	*Average bias -2.0dB*
H1P	54.7	57.6	-2.9	
R07	55.2	56.0	-0.8	
H5B	56.1	58.6	-2.5	
H5F	56.2	58.3	-2.1	
H5D	58.7	57.8	+0.9	
H5C	59.3	60.0	-0.7	
H1L	59.7	58.9	+0.8	*ANASE: > 57 L_{eq}*
H1M	59.8	59.4	+0.4	*Average bias +0.4dB*
H1K	60.3	59.8	+0.5	
H1J	61.7	61.8	-0.1	
H1H	**63.1**	**62.3**	**+0.8**	

Table 1

Comparison of published CAA / DfT London Heathrow Summer 2005 $L_{eq(16h)}$ with ANASE estimate. Data ranked by ANASE estimate.

ANASE problems: noise

ANASE used noise estimates for common noise areas (CNA) that do not match with official CAA [Civil Aviation Authority] / DfT published values. Table 1 compares the Heathrow site ANASE estimates and CAA /DfT values for L_{eq} (16 hour), adapted from Table 1 of Havelock & Turner (2007)). The table ranks the L_{eq} data in terms of the ANASE estimate. The fourth column shows the differences between the ANASE estimate and DfT value – the L_{eq} bias. Havelock & Turner explore the technical reasons for the estimation bias.

At the right of Table 1, the average L_{eq} bias is shown for three groups of ANASE L_{eq} estimate: <50, 50-57, and >57. The L_{eq} biases are respectively -2.5, -2.0 and +0.4 dB(A). The inference is that ANASE underestimates L_{eq} for CNAs under 57dB(A); thus, when ANASE analyses led to statements about 50.0 Leq estimates, they should be referring to 52.5 Leq on average.

ANASE problems: annoyance measure

The ANASE contractors' way of using annoyance scales is odd. First, compare the questions that ask how much a respondent is annoyed:

ANIS	ANASE	
Very much?	Extremely? Very?	Highly annoyed?
Moderately?	Moderately?	
A little?	Slightly?	
Not at all?	Not at all?	

Note that the ANIS version has no middle ranking choice, so the interviewee is not able to take the easy way out by choosing 'in the

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middle'. For the ANASE version, the combination of 'very' and 'extremely' answers is taken to represent the 'highly annoyed' category. The ANASE reports did not offer evidence-based reasons for the change.

There is no perfect recipe for determining 'good' attitude scales, but the key question is the extent to which a possible scale is cardinal in nature (*ie* corresponding to the properties of integers), rather than just 'ordinal' (ranking responses). If a scale is cardinal, then such results can be manipulated by all the rules of arithmetic, and hence analysed by the standard kinds of statistical testing.

ANIS used the responses above to construct a 'very much annoyed percentage' scale of annoyance at each survey site. This percentile method actually correlates well with average responses (using non-parametric statistical testing). The ANIS choice of scale is consistent with the great bulk of international research on aircraft disturbance (eg Fidell & Silvati (2004), a recent review paper of international social survey data into aircraft noise annoyance). In contrast, ANASE used the answers to its version of the annoyance question to construct a 'mean annoyance'. In its scheme, a rating of 'not at all' scored 10 points, 'slightly' scored 30 points, then up to 'extremely' scoring 90 points: each extra level of annoyance added twenty points. The mean annoyance estimate for the site was then simply the arithmetic average of the respondents' scores, so if half the people said 'not at all' and half the people said 'extremely', this would be a mean of 50 points.

ANASE's choices of weightings are, however, subjective value judgements. The ANASE contractors did not produce robust evidence to justify the relative numerical scorings (saying the scale is 'standardised' adds no content). Why are nine people saying 'not at all' equivalent to one person saying 'extremely', or three people saying 'slightly'? Rather than 10, 30, 50, 70, and 90, the analysis could have used any other set of monotonic numbers, with corresponding changes in the inferences made.

Arbitrarily-averaged attitude scales, with their unreliable statistical properties, were used very cautiously even before the ANIS work. It is puzzling why ANASE would need to change from the ANIS percentage scales. The following focuses on percentage scale data, as these enable comparisons with ANIS and international work.

ANASE problems: statistical analysis

ANASE used two kinds of survey sites. At one ("full") there was the noise playback equipment of Figure 1, and at the other ('restricted') there was no equipment. Thus, the context for the two was markedly different. If context effects are crucial in this study, then marked differences would be expected in the data from the two kinds of sites – and they are there.

Figure 2 shows the '% highly annoyed' response for the two site types at the 27 ANASE Heathrow sites. The Heathrow sites are selected because CAA / DfT higher accuracy L_{eq} values for these sites are available; because it is simple to approximate internationally-used DNL values (by adding 2.5dB to the L_{eq} value); and to avoid airport-dependent factors. DNL is the day-night average sound level used in the USA and several other countries: it is a 24-hour L_{eq} with night flight noise levels artificially increased by 10 decibels. Simple linear-fit trend lines are also shown for the two sets of data.

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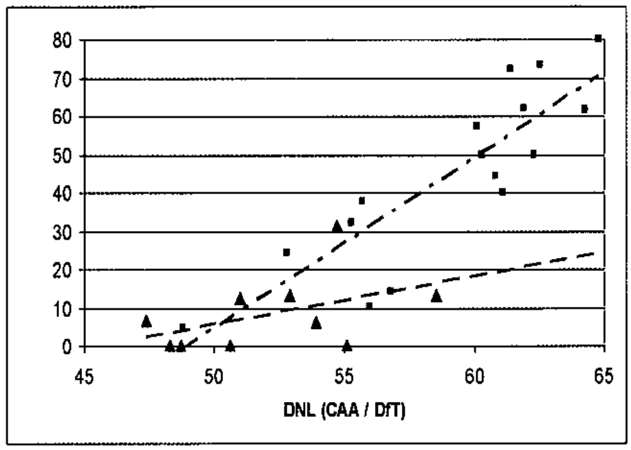

Figure 2

ANASE '% highly annoyed' Heathrow results: two distinct data sets. Red squares: 'full', blue triangles: 'restricted' (linear trend lines)

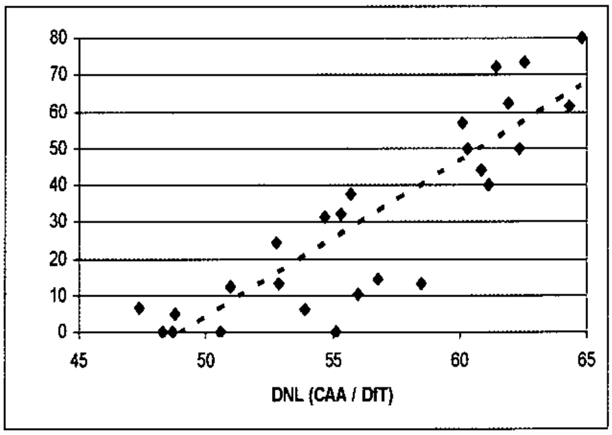

Figure 3

Erroneous ANASE-type fit for Heathrow results, with statistical test results disregarded

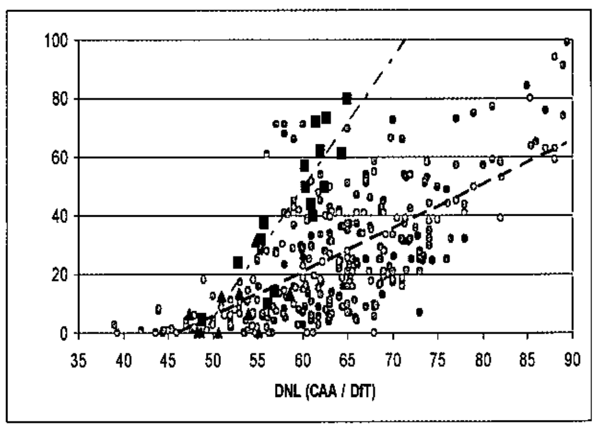

Figure 4

Compares Heathrow ANASE '% highly annoyed' with Fidell & Silvati (2004). Red squares: Heathrow 'full', blue triangles: Heathrow 'restricted', grey circles: Fidell & Silvati data set. Linear trend lines to 'full' and Fidell & Silvati data.

ANASE - *continued from page 28*

Figure 2 indicates that the "full' and 'restricted' scatter plots and trends are very probably different – in particular the trend line slopes differ. In comparing two regression lines, the most basic hypothesis is that of coincidence, to test whether the two underlying relationships are the same. The ANASE contractors carried out statistical testing to compare Heathrow 'full' and 'restricted' data – but only at the instigation of the reviewers (Havelock & Turner, 2007, p20). This rejected the coincidence hypothesis, finding that the differences were statistically significant (t statistic above the standard 5% level). It is therefore unlikely that the two samples came from the same underlying population. It implies that the introduction of noise equipment changed the aircraft noise annoyance dose-response relationship, by a roughly multiplicative bias here. The ANASE contractors decided to ignore these crucial results.

Only in circumstances when statistical testing accepts coincidence, as examined through (for example) analysis of variance techniques, is it permissible to fit a single overall regression line to both relationships. The ANASE statistical analysis wrongly combines 'full' and 'restricted' data sets (see Figure 3 for an example). To ignore the statistical testing by rejecting the coincidence of the data sets is not sound practice. A statistical textbook might offer this as an example of 'how to do it incorrectly'. It removes any possible sound foundations for subsequent ANASE modelling claims about annoyance onsets and the weighting of the number of aircraft.

Why do the data sets differ? It is not possible to offer precise reasons based on the ANASE documents, simply because the ANASE work did not investigate potential causes. One factor could be confusion between audibility or awareness of noise as compared with suffering a degree of annoyance. The presence, and presumed intended use, of the noise playback equipment is certainly a possible strong factor (would a police officer standing in the corner affect a crime survey?).

An even more telling illustration is a mapping of the Heathrow data in Figure 2 onto the Fidell & Silvati data set in Figure 4. This aircraft annoyance research collated international data from 326 site surveys with an average of 160 people per site. The figure shows a scatter plot of all the '% highly annoyed' data against DNL. The two trend lines are the linear fits to the Fidell & Silvati data and the ANASE Heathrow 'full' data. The ANASE Heathrow 'restricted' data lies roughly on the Fidell & Silvati trend line. The ANASE Heathrow 'full' data lies markedly above the trend line for the other data: it is hard to believe that it is a sample from the same underlying population.

Figure 5 shows the complete sets of 'full' and 'restricted' data from ANASE (using wholly ANASE data). This again shows that there are differences between the two data sets: having noise equipment present does make a difference – showing a roughly multiplicative bias at the 'full' sites. The figure also shows that ANASE 'restricted' sites were not wisely selected. The onus was on the ANASE contractors to select sites to be able to test effectively for 'full/restricted' differences – 'restricted' sites at higher L_{eq} values ('control group sites') should therefore have been included.

Figure 6 compares the '% highly annoyed' data from all the 'restricted' sites with a curve fitted to the ANIS results used in policy work (Havelock & Turner, 2007; Fidell and Silvati (2004) discuss curve-fitting). The ANASE 'restricted' data points are possibly slightly above the ANIS curve, but this could be a statistical sampling issue ('restricted' site ANASE samples were very small, typically 16 people) or a context effects related problem, because of the markedly different questionnaire ordering and a different annoyance question.

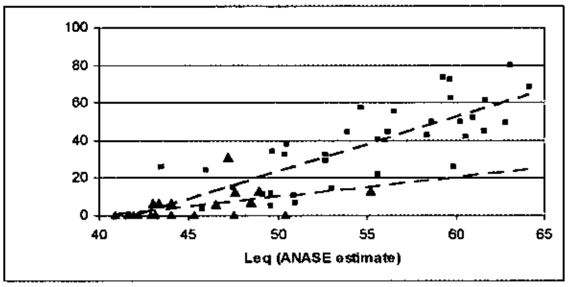

Figure 5

Compares ANASE 'full' and 'restricted' sites '% highly annoyed'. Red squares: ANASE 'full' sites, blue triangles: ANASE 'restricted' sites. Linear trend lines. Source: Technical Appendices, Table 10 (pages 250/1), Table 6.2 (pages 17/18). Site R17 excluded, as in ANASE analyses.

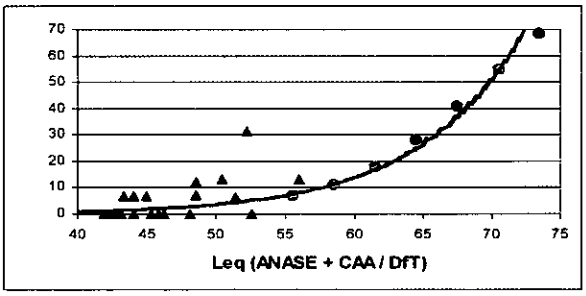

Figure 6

'% highly annoyed' at ANASE 'restricted' sites compared with ANIS curve. Blue triangles: ANASE 'restricted' sites (source above), sample size typically 16. The x-axis shows ANASE L_{eq} for non-Heathrow data, and CAA/DfT L_{eq} for Heathrow data. Green circles are standard ANIS values from Havelock & Turner Table 2, plus exponential fit.

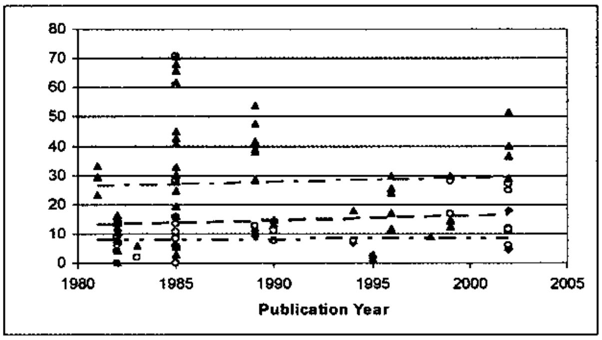

Figure 7

'% highly annoyed' from Fidell & Silvati (2004), post 1980 data. Red lozenges: ~50 DNL, black circles: ~55 DNL, blue triangles: ~60 DNL. Linear trend lines.

ANASE problems: international comparisons over time

There are comments in the ANASE reports that allude to non-UK studies suggesting that the annoyance dose-response relationship might be moving upwards, *ie* people are typically more annoyed for a given L_{eq}. This is not a new suggestion (Brooker, 2004): the test of this kind of hypothesis is to examine data.

As already noted, a recent review paper (in the peer-reviewed literature) is Fidell & Silvati (2004). Figure 7 extracts results from the Fidell & Silvati data set. It shows responses in the bands 47.5-52.5, 52.5-57.5, and 57.5-62.5: these approximately represent ~50, ~55 and ~60 DNL. The plots cover results after 1980, mainly because the interest is in changes since the early 1980s ANIS work. The figure plots these responses against the year the survey was published. Simple (unweighted) linear regressions on the data in the figure — the trend lines - do not show significant changes over time (none of the regression t-statistics is significant at even the 10% level). Thus, there is no strong evidence from this large international data set of a trend over time.

A simple analysis of even this large data set is not statistical proof. To be confident about the magnitude of possible trends over time, it would be necessary to carry out high-quality data collections and statistical analyses, with tight experimental controls on questionnaire context/design, annoyance scales, socio-economic variables, media attention/trust, and of course sampling variations.

Summary

DfT was wise to commission the peer reviews and to publish the material rather than be accused of a cover-up. No reliance, however, can be put on ANASE claims: they cannot 'command the widest possible confidence'. There are unrepairable major problems with questionnaire design and process, noise estimates, analysis techniques, and selective attempts to compare with international work.

The design of the ANASE questionnaire does not meet the necessary criteria set out in standard textbooks, by the Treasury's GSRU, or by responsible UK organisations such as the NHS. This damages the ability to make reliable comparisons with earlier work.

ANASE noise estimates are markedly biased at lower L_{eq} sites compared with official CAA / DfT published values, which distorts several of the analyses.

The analysis techniques used in ANASE do not recognise the problems of using average annoyance scales in parametric statistical analyses. ANASE's contractors presented no good reasons for changing from earlier, robust scales, *inter alia* preventing proper comparisons.

ANASE fails to meet minimum data analysis requirements for such a study, a critical examination of raw data to detect potential biases, always taking proper account of statistical testing results, is absent. The regression-based statistical modelling used in ANASE is invalid because it too quickly combines data from 'full' and 'restricted' (*ie* without noise playback equipment) site samples. This also reveals ANASE's poor design: the onus was on the contractors to test key hypotheses on these effects, and there are insufficient 'restricted' sites at higher L_{eq} values.

ANASE data suggest that the introduction of noise equipment changes the aircraft noise annoyance dose-response relationship by a roughly multiplicative bias factor. ANASE data for 'full' sites are markedly out of line with the results of reputable international and previous UK work. As data from ANASE's 'full' sites are unlikely to be representative of people's annoyance attitudes, the SP results that build from these distorted attitudes may similarly be distorted. ANASE 'restricted' site data are broadly consistent with international and ANIS results.

Thus, a straightforward factual explanation for the ANASE data set is that it has a design-induced multiplicative bias overlaying annoyance responses largely unchanged from past studies. The implication is that the ANASE contractors' claims - eg increased annoyance over time, additional aircraft number effects - are invalid because they mostly derive from the biased data.

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Noise and Vibration Diagnostics and Control in Aerospace Vehicles

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Introduction

Noise inside passenger aircraft impacts passenger comfort and crew communication. Prolonged exposure to high noise levels may cause permanent hearing loss and the airlines and operators are liable to damages. However, any noise control effort by adding treatment to the aircraft has associated penalties in terms of payload, range and cost. There are no regulatory interior noise requirements, but the requirements mostly result from passenger comfort, noise exposure and economic considerations.

The noise levels in the forward section are generally lower than in the aft section of the aeroplane. The interior noise control treatment is designed to provide a slow varying noise environment in the cabin. The aircraft acoustical models, based on Statistical Energy Analysis (SEA) and Finite-Element Method (FEM), are built and unitised to select treatment to maximise noise benefit with minimum weight and cost penalties. During the design and production stages, noise engineers have more treatment options, but they are generally left with add-on treatments at the later stages. In fact, for certain noise control treatments, retrofitting may not even be feasible or economically viable except during a major service.

During the testing phase or in-service noise and vibration concerns, noise engineers have the difficult task of identifying offending noise sources and their transmission paths. Once the source is identified, treating the source is generally more weight-effective and cost-effective than devising a global treatment or masking the noise. In this article, common noise sources and diagnostic techniques are discussed through several case studies.

Noise and Vibration Sources

Aircraft interior noise is a cumulative effect of several aerodynamic and noise and vibration sources, such as a turbulent boundary layer over the fuselage surface, an environmental control system (ECS) or air-conditioning, engines, hydraulic motors to drive airframe components, on-board equipment (such as the galley chiller, fans, *etc*), and special mission equipment for military aircraft.[1],[2] Noise from these sources enter the cabin and flight deck through air path, and is classified as 'airborne', whereas the noise radiated inside from fuselage vibrations is termed 'structure-borne'. A good example of structure-borne noise is fuselage vibrations caused by slight engine unbalance.

Boundary layer noise from turbulent air flow over the fuselage

Boundary layer noise is created by pressure fluctuations in the turbulent airflow over the fuselage surface. Noise characteristics (amplitude and frequency content) from this most significant noise source depend on air speed, altitude, and the fuselage station. In the front of the aircraft, the boundary layer is thin (*ie* the length scales are small) and high frequencies dominate the noise. The boundary layer becomes turbulent and is thicker towards the rear of the aircraft and lower frequencies are dominant.

The environmental control system and equipment cooling

The airflow through the aircraft's ECS creates turbulence due to duct branches, orifices in the duct, bends and outlets. This turbulence-generated noise travels along the duct and enters the aircraft cabin through the duct openings. The turbulence may also excite duct walls that radiate noise in the cabin. Increased ECS flow rates may be required for cooling requirements associated with special mission equipment or flight deck avionics cooling. The noise increases with flow rate in the ECS duct, therefore, the noise plays an important role in limiting flow velocities. In some cases, additional fans are needed for equipment and avionics cooling that add to the cabin and flight deck noise environment.

Engine related noise

Engine noise includes buzz-saw noise and exhaust noise forward and aft of the engine, and engine vibration related noise (EVRN) near the wing or aft cabin (for fuselage-mounted engines). Engine buzz-saw is transient noise, as it is heard during take-off and climbs[1]. Exhaust noise is heard as a low frequency noise rumble in the passenger cabin. Aircraft makers and engine companies have been successfully controlling engine exhaust noise by developing and integrating treatments in new engine designs. Additional noise reductions are achieved by extra treatment in the sidewalls resulting in weight penalties.

EVRN results from slight imbalances in low pressure and high pressure turbine rotors at spool frequencies. These low-frequency sounds are heard at low engine speeds (iat low altitudes when fuselage modes coincide with spool frequencies) in the forward part of the aircraft (for wing-mounted engines) and in the aft cabin (for engines mounted on the aft fuselage). During lift-off of the launch vehicle, engine noise may also impact payload inside the fairing[1].

On-board equipment and other noise sources

Noise generated by on-board and special mission equipment in the main deck and lower decks, and other mechanical equipment (such as hydraulic equipment needed for flight operations during take-off and landing such as landing gear deployment, outflow valve operation, *etc*) contribute to interior noise. Air leakage through doors can also impact the noise environment. Some of these noise sources may be short duration and may be considered as transients. However, very high noise levels or continuous noise sources may need to addressed.

Diagnostic Techniques

Flight test validation of the design is one of the crucial steps in any new aircraft programme. Various analysis tools available for acoustic treatment design, eg SEA and FEM codes, are frequently calibrated with flight test data, but the treatment design may still require some

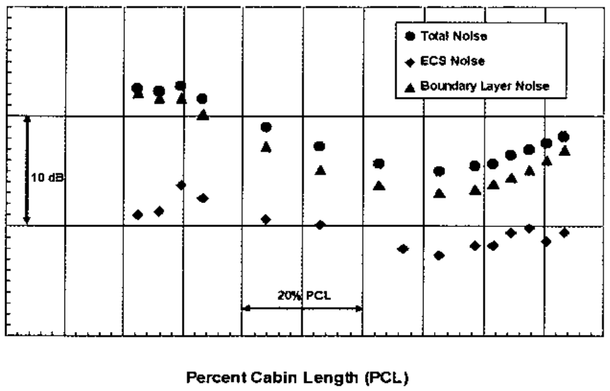

Figure 1

Boundary layer and ECS noise components

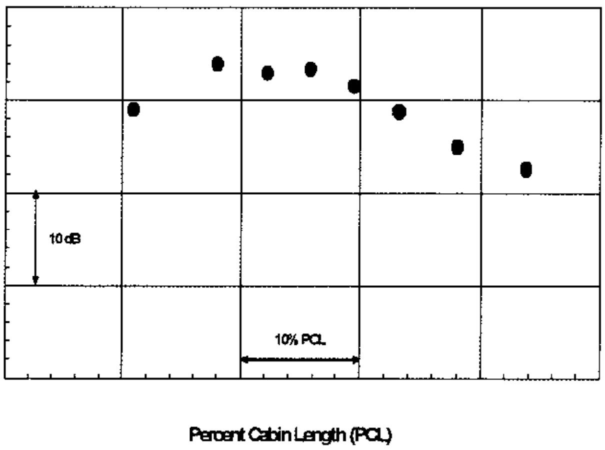

Figure 2

Noise measurements at standing height at a typical cruise condition

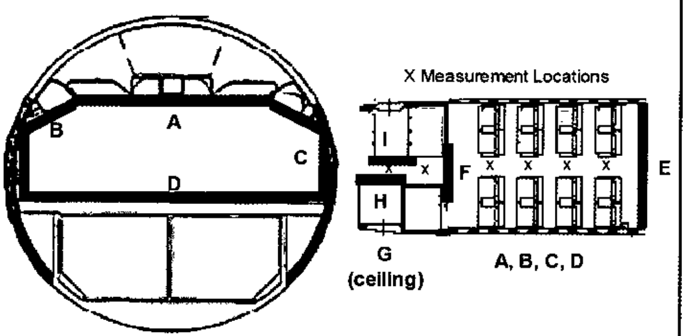

Figure 3

Noise blocking panel and measurement locations

adjustments during the validation flight tests. Ironically, as discussed earlier, the noise engineers may not by then have all the treatment options available. Noise treatment installed throughout the aircraft, such as thickening or increasing the density of insulation blankets, may not even address a particular area of concern. It is therefore necessary to identify the problem source or its transmission path for a most cost-effective and lighter solution. Noise levels of 2 or 3 dB above the background noise are detectable by the human ear, and if the source is highly localised, a subjective evaluation of the cabin might give some indication of the source location.

A cabin noise survey along the aircraft using microphones installed on passenger seats is normally conducted during the flight test programme on the ground and at take-off, landing and cruise conditions. If the noise levels exceed the customer requirements or the aircraft noise specifications, a noise engineer is entrusted with a difficult task of identifying the noise sources, treatment design and implementation, and the flight test validation. The following techniques are helpful in noise source and transmission path identifications: (a) source separation, (b) detailed spectral analysis, (c) sound intensity scans, (d) noise blocking panels, and (e) skin panel or equipment acceleration spectra.

Figure 1 shows higher Speech Interference Levels (SIL) in the forward cabin of an aircraft. Noise levels at higher frequencies or SIL are generally related to boundary layer noise or ECS. In order to separate noise sources, noise data was recorded at a cruise condition with the ECS off and the engines at idle. At locations away from the engines, this noise with ECS off will be closely approximated by the boundary layer noise. At cabin locations closer to engines, where the data may be affected by the engine noise, additional data at several different power settings will be required to estimate turbulent boundary layer noise[3]. The ECS noise component is obtained by subtracting the boundary layer noise component from the total noise. In Figure 1, the ECS noise component is 5 to 10 dB lower than the boundary layer noise and shows a peak in the forward cabin. The total noise in the forward section is only 0.5 to 1 dB higher than the boundary layer noise, so the noise reduction efforts were directed to treating only the boundary layer noise source. If the ECS noise is higher than or comparable with the boundary layer noise, then the ECS noise must be reduced for any further cabin noise reduction.

Sound intensity and noise blocking panel methods are very useful source isolation techniques. Sound intensity is the rate of acoustic energy flow and is a vector quantity (it gives the energy flow direction)[4]. The technique uses a dual microphone probe. An alternative to the standard sound intensity technique is acoustic holography[5] which uses an array of microphones in a two dimensional surface. As discussed earlier, treating a source is generally the most cost-effective and least weighty resolution to any noise control effort. With the use of sound intensity scans, a cabin location where acoustic energy enters the cabin can be identified. The test area is divided into several smaller areas of about 1m^2. The actual scanning time depends on the scanning speed, source type and the frequency of interest (a random source and lower frequencies will require relatively longer scanning time). All test areas are then compared and ranked in the order of acoustic energy entering the cabin: a negative sign will indicate acoustic energy flow from the cabin.

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Noise and Vibration Diagnostics... - *continued from page 33*

Noise blocking panels are made from heavy foam or insulation blankets. Interior noise levels are measured after systematically covering internal surfaces with these panels. Often noise blocking panel tests are conducted as a precursor to sound intensity, which better defines source areas in order to minimise number of scans. Analysis of signals from accelerometers attached to skin panels and equipment are also used to resolve noise concerns resulting from structural vibrations and on-board equipment. Owing to complexities associated with attaching accelerometers to the skin panels, acceleration measurements are not very often used.

Case Studies and Mitigation Strategies

The noise measurements at standing height are shown in Figure 2. The forward cabin noise is dominated by turbulent boundary layer on the fuselage surface. The separation of boundary layer and ECS components indicated that ECS added about 1dB to the total SIL (Figure 1). This confirmed that the ECS was not a major noise contributor. Based on these observations, further diagnostic tests were necessary to isolate the most dominant noise source.

Six sets of noise blocking panels (A to F in Figure 3) made from 75mm thick foam insulation (providing around 15dB of noise reduction at 1000Hz) were installed in the forward part of the aircraft. The blocking panels were systematically removed one at a time, and the sound pressure levels measured at standing height in the aisle and at locations forward of the aircraft (outside the tunnel formed by the blocking panels). Results in Figure 4a show that turning off the ECS provided an insignificant noise reduction. The noise blocking panels on the ceiling provided about 5dB SIL reductions and the sidewalls, stowage bins and baggage rack did not appear to be major noise contributors. No appreciable difference was noticed when the aft divider blocking panel E was removed, whereas an increase of 5dB was noticed with the removal of the front divider panel F. Noise increase with the removal of panel F was a little puzzling. Therefore another test was performed as shown in Figure 3, with four blocking panels installed forward of the previous measurement location (F to I, on the ceiling, passenger door, galley entry and aisle entry): the noise measurements are shown in Figure 4b. All blocking panels showed a little impact on noise levels, except at the aisle entry F. When this panel was removed, noise levels in the forward section in the blocking panel zone dropped by over 10dB.

Sound intensity measurements along the cabin ceiling (Figure 4b) and skin panel acceleration measurements (Figure 5) along the length of the aircraft showed sudden rise in level by about 10 and 5 dB, respectively. This confirmed the noise source at a location shown in Figure 4b. A visual inspection of the antenna at this location revealed a small step caused by its base plate. This suggested that the antenna installation might be causing flow disturbances locally (and therefore pressure fluctuations) which may be responsible for high sound pressure levels in the cabin at this location. Sound intensities at the ceiling in the forward section, baseline and with the antenna removed, did not show any appreciable difference (Figure 6).

Skin damping treatment[6] was applied to fuselage skin panels in the crown area (Figure 7) to treat this noise source. This weight- and cost-effective treatment was very successful in treating the noise source and resulted in 4-5 dB SIL reductions at seated heights as shown in Figure 7. It is noteworthy that SIL reductions continued about 20% cabin length beyond the area where the skin damping treatment was applied. This confirmed the noise source in the forward cabin was responsible for high noise levels due to structural vibrations that were transmitted far in the aft cabin. Sound intensities measurements along the ceiling after installing the damping treatment show very little lengthwise variation (Figure 6).

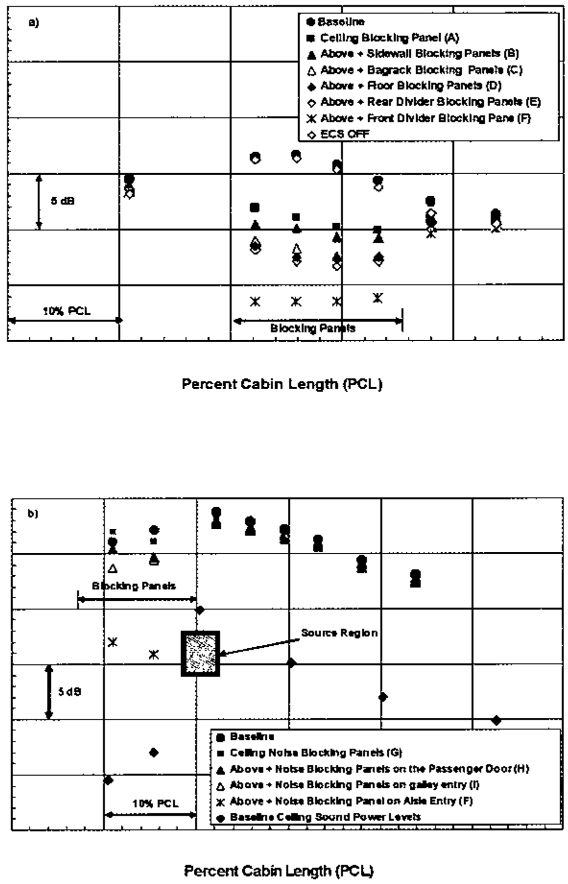

Figure 4

Noise measurements with noise blocking panels at a typical cruise condition

Two case studies from ECS and avionics cooling flow noise are shown in Figures 8 and 9. In the first case, noise levels in the forward galley near an ECS flow outlet were 7 to 8 dB higher. Flow measurements from this outlet indicated 30% to 35% higher than the requirement (noise varies as the sixth power of the flow velocity). To reduce the flow by 30% through the outlet, an orifice was installed in the ECS duct that resulted in 8dB noise reduction. The orifice location was carefully chosen, so that the orifice generated noise was not impacting the cabin. In the other case, high noise levels in the flight deck on the ground were traced to an

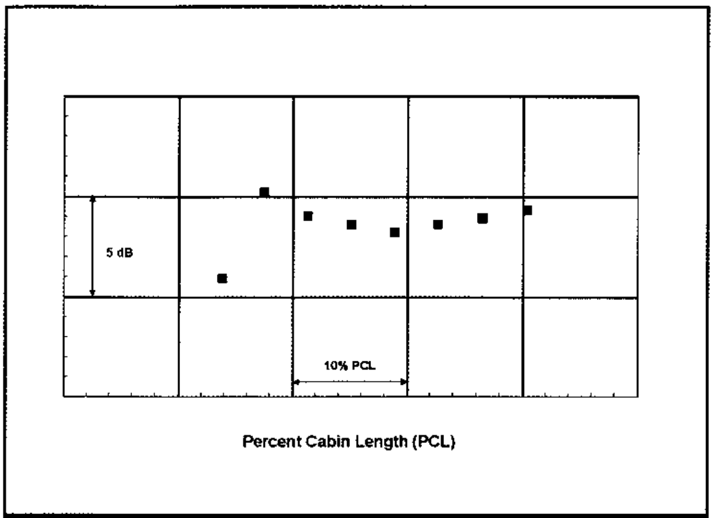

Figure 5

Skin panel accelerations

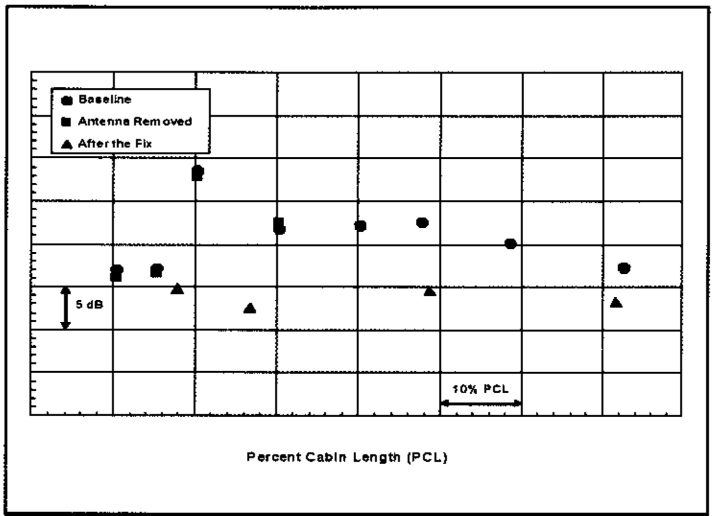

Figure 6

Sound intensity measurements along the cabin ceiling

avionics cooling fan. The fan capacity was about 40% higher than the cooling flow requirement and an orifice place was used in the exit duct to throttle the flow to the correct flow rate. It was discovered that the orifice was too close to the outlet and the noise reduction due to the reduced flow rate was compensated by the orifice generated noise that propagated through the duct outlet. A muffler used upstream of the fan did not result in any appreciable noise reduction. The existing fan was replaced with a new lower capacity fan with comparable case radiated noise. This resulted in 7dB noise reduction on the flight deck. Additionally, this option also resulted in weight savings with the removal of the orifice, muffler and other hardware.

On-board equipment cooling fans are often offending noise sources.

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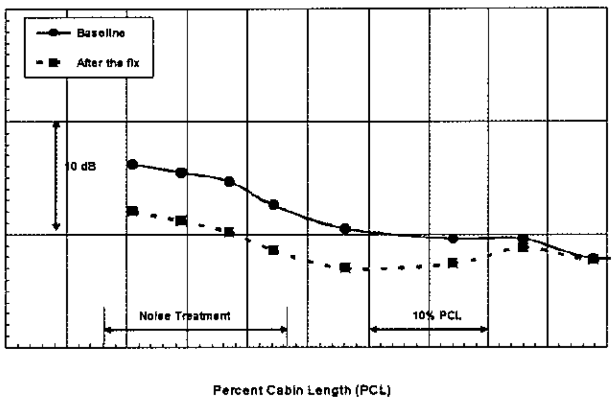

Figure 7

Noise levels before and after the fix

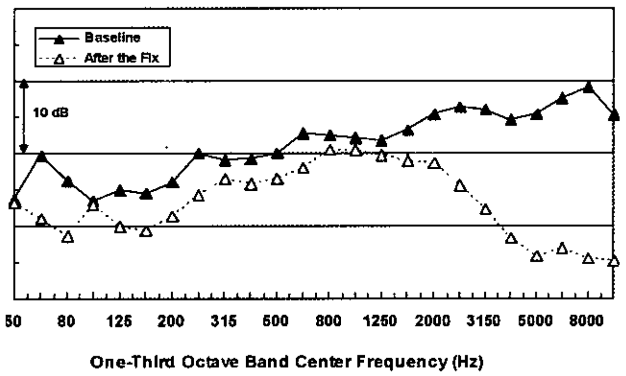

Figure 8

Sound pressure levels under an ECS duct at a typical cruise condition

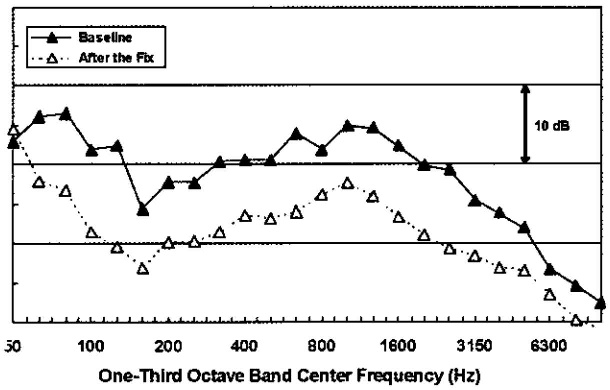

Figure 9

Sound pressure levels in flight deck at a typical cruise condition

Noise and Vibration Diagnostics... - *continued from page 35*

Noise is generated internally by high flow velocity or flow separation and turbulence through the air flow paths. In a case study shown in Figure 10, noise levels were 15dB higher than the requirement. It was obvious that re-design of the flow path to reduce flow separation and turbulence would have not resulted in 15dB noise reductions and it could only be achieved through significant reductions in the fan speed. In order to keep the same flow, a larger fan with twice the hub-diameter and half the rotational speed was used. The new fan resulted in about 15dB noise reduction. In the second case, it was not possible to accommodate a larger fan to get about 8dB noise reduction, and the fan was completely removed from the equipment. The required cooling for the equipment was achieved by using air from the aircraft's ECS system.

High levels of structural vibrations and noise (generally in 30-100 Hz range) can affect payload inside the space vehicle[7]. Noise reduction in cylindrical cavities at low frequencies is difficult to accomplish. Helmholtz Resonators (HR) are highly effective at very low frequency noise reductions that are the dominant noise

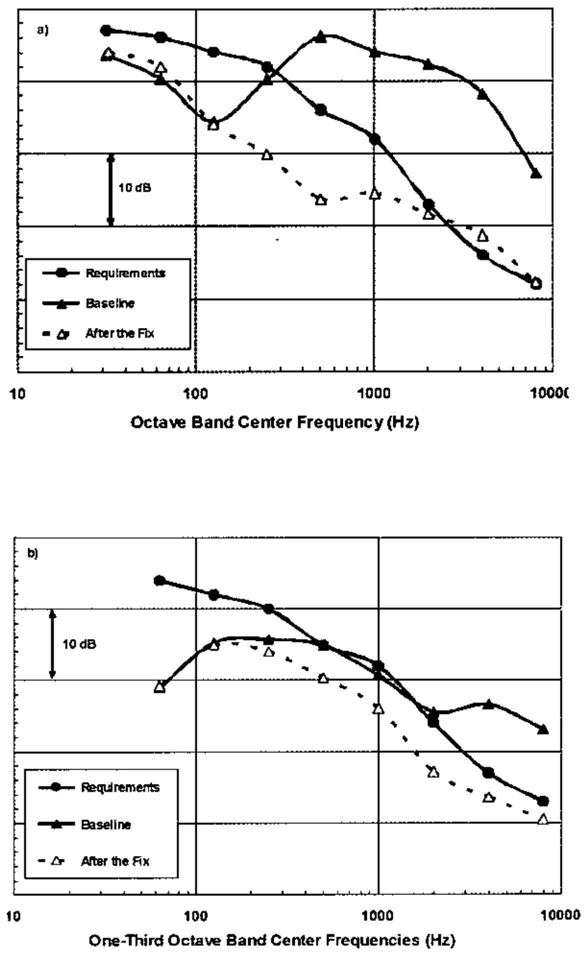

Figure 10

Equipment noise

sources during lift-off of vehicles (Figure 11). The HR size is comparatively large, but with possible active control a smaller size is possible: piezoelectric polymer polyvinylidene fluoride (PVDF) speakers inside the HR tubes may move air inside the cavity and the size may be reduced.

Concluding Remarks

In the review of common noise and vibration sources and diagnostic techniques discussed above, it is emphasised that treating the source is more cost-effective and weight-effective approach to address noise and vibration concerns.

Acknowledgements

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NK Agarwal is with the P-8A Poseidon Program, The Boeing Company, Seattle, USA.

This article is closely based on his paper of the same name, presented at the IOA Autumn Conference in Oxford, October 2007.

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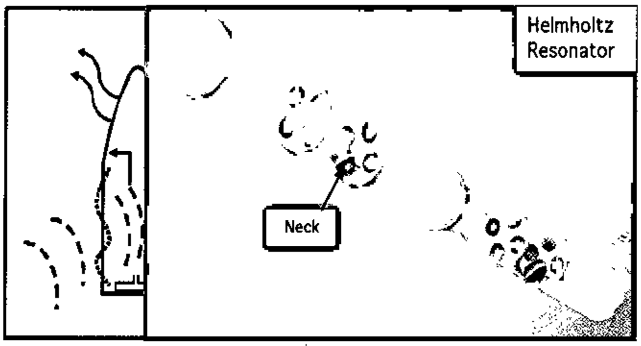

Figure 11

Rocket fairing and Helmholtz resonator

Examination dates 2008

DATE	EXAMINATION
7 March	Certificate of Competence in Workplace Noise Risk Assessment
11 April	Certificate of Competence in Environmental Noise Measurement
25 April	Certificate Course in the Management of Occupational Exposure to and Arm Vibration
12/13 June	Diploma in Acoustics and Noise Control
3 October	Certificate of Competence in Environmental Noise Measurement
17 October	Certificate Course in the Management of Occupational Exposure to and Arm Vibration
7 November	Certificate of Competence in Workplace Noise Risk Assessment

Institute of Acoustics

SRL

40th Anniversary Celebrations

In June 2007 Sound Research Laboratories (SRL) celebrated its first forty years in business. A whole weekend was dedicated to hedonistic pursuits for the staff and their families. Several retired staff also joined in, as did some famous names from over the years.

SRL dates back to Ian Woods leaving the family firm, now Fläkt-Woods, and starting up on his own. Shortly afterwards, in 1967, SRL was formed. The headquarters is still on the original site in rural Suffolk, although now there are additional consultancy offices in London and near Manchester. Clients are told that the laboratory needs to be in Suffolk, away from it all, because the low background noise and vibration level is necessary for accurate low frequency measurements. However, the fact that the staff like living there is equally important.

The weekend began with a gala dinner dance in a marquee erected in the grounds of HQ. Never have so many acoustic consultants looked so smart: they all scrubbed-up very nicely. Whilst we meet at work daily, it isn't nearly as much fun as letting your hair down at a party. However, decorum was maintained, perhaps by the presence of partners and spouses, who keep us all in check. After speeches with anecdotes of the last 40 years and corny jokes, we gathered outside for a fireworks display. Yes, we had warned the neighbours about the noise, and no, we didn't wear hearing protection. The evening finished off with dancing to a local live band. By the time that carriages arrived, many were ready, some more than others!

However, there was no respite, as early the next morning we all reported for a Thames barge trip. Most of us needed the sea air to blow away the cobwebs. However, after several gallons of champagne and some live jazz, everyone managed to come alive again for what was yet another successful event. By the time we had sailed to Felixstowe and back to Ipswich, everyone was in fine song.

Sunday was, not surprisingly, more subdued. We arranged a hog roast and garden games for families and friends. Only the strongest of constitutions was capable of keeping up the pace on day three, so we left it to the children. Some of SRL's old hands turned up, some of whom could remember the company's start-up, and others who joined very soon afterwards. We have given away several 'gold watches' to long-serving staff. It is surprising how quickly the fresh faced graduate becomes the old lag.

We had lots of fun over the weekend. It was great 'team building' to feel part of a long-standing and successful organisation. Monday morning came all too soon, the phone began to ring, and the next 40 years began.

Quack quack: a brilliant delivery by IAC's Boden to bowl out Allen Smails

One in the unmentionables for Richard Critchlow

The four captains

SRL chairman Ian Woods presenting the trophy to Steve Willsher of Flakt-Woods

Never had a career in acoustics looked so appealing

Has anyone seen my Sound Level Meter?

Ian and Suzanne Woods

Once the booze from the June weekend had worn off, the celebrations continued with a grand all-day cricket tournament held in September at Long Melford Cricket Club. SRL, Fläkt-Woods of Colchester, Industrial Acoustics Company (IAC), and a combined team from Sharps Redmore Partnership and Tendring District Council (SRT) were all keen to get their hands on the specially engraved glass trophy and to enjoy a beer-fuelled day. The IAC team were especially determined to have fun after a four-hour journey from their Winchester base, and their commitment to the cause was much appreciated.

The weather was perfect - warm and sunny - in the middle of the only real part of summer 2007. The draw paired Fläkt-Woods with SRT in the first semi-final, a hard-fought match deserving of the final. Fläkt-Woods scored a massive 103 for 7 in their 15 overs, with Simon and Stu both retiring, on 20 and 23 respectively. Their score was pegged back by the controlled bowling of SRT, with Taylor taking 3 for 20 and Metcalfe 2 for 17. SRT replied bravely, Taylor scoring 26 not out, but Fläkt-Woods' bowling restricted them to 86 for 9, Phil and Finchy took two wickets each, putting them through to the evening final.

Some of SRL's UKAS accredited sound insulation testing kit also made it to the cricket. In true Twenty20 style, snippets of appropriate cheesy-rock such as *'Another one bites the dust'*, *'Closing time'* and the *'Hallelujah Chorus'* accompanied wickets and boundaries, while SRL's resident springbok Andrew Wade was to be greeted to the wicket with the Spitting Image classic *'I've never met a nice South African'*.

A superb lunch of curry, rice, naan and pickles was enjoyed by all - a little too moreish for SRL and IAC who were to play in the second semi-final immediately after lunch!

IAC won the toss and invited the hosts to bat. Foster, Boden and Greg were the pick of the bowlers, taking a wicket apiece for an aggregate of only 41, but SRL capitalised on the other bowlers and closed their innings on 139 for 3. Critchlow, Budd, Wade and Way retired having made 20 each, and Clarke saw the innings through to a close with an unbeaten 19. A plucky reply by a keen but inexperienced IAC team saw them reach 90 for 8, with Boden retiring on 20 and Smith making 15 not out. Tight bowling by Swainston, Smalls, Bendy and Clarke put SRL through to the final, leaving IAC to face SRT in the third place play-off.

The combined Sharps Redmore and Tendring team bludgeoned 131 for 4, with Metcalfe, K Gayler and Redmore all posting twenties before retiring, while Boden, Bhatti, Foster and Greg all took wickets. Economical bowling by SRT restricted IAC to 69 for 6 in reply, and SRT had done

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SRL 40th Anniversary... - *continued from page 39*

enough to secure third place. The two teams then settled over their pints and hearty teas to see if SRL could pull off a miraculous (and unsporting!) victory in their own tournament.

However, SRL's dreams were short-lived, as Fläkt-Woods batted in gladiatorial fashion, with Willsher (21), Baker (24), Wenden (20), and Griffiths (20) all retiring unbeaten. Wade, Way, Budd and Clarke all took wickets, but those and a run-out were not enough to prevent the visiting finalists posting an impressive 134 for 7.

Needing nine runs an over in reply, SRL got off to a poor start and found themselves 4 for 3 after only two overs! Some entertaining resistance saw a mini recovery to 69 for 6, with Clarke posting 18, but penetrative bowling, including Walker (3 for 8) and Baker, and good fielding kept SRL behind the run-rate and they finally ended on 95 fpr 9, despite Calvert's 18 not out against his one-time colleagues.

Fläkt-Woods had won by 39 runs and walked off triumphantly to the clichéd strains of *'We are the champions'*. They were presented with the trophy by SRL's founder and chairman Ian Woods, who thanked all the teams for coming and rewarded IAC's long journey by wearing one of their caps for much of the afternoon!

Special mention must go to the two umpires who also travelled (from Kent) to stand in all four matches of the day. Evan Stirzaker (retired environmental health manager of Ashford BC) and Richard Woodcock (principal EHO, Ashford BC), contributed superbly with their efforts, and were presented with some liquid reward and best of all - an SRL cap! Evan promised to wear it next summer at the annual SRL and SRP match.

Desk space was at a premium following SRL's recent growth

The lack of champagne flutes was not a problem for the Langley family!

EAA

European Student Council

The European Acoustical Association (EAA) is launching a new Student Council, the aims of which are to establish a student community within the EAA and to provide a forum where students can communicate with each other and share problems and ideas. The Council will enable students to become involved in the organisation of meetings, and provide student representatives for technical committees. It will also act as a source of information on matters relevant to students such as grants, jobs, and exchange programmes. The Council will have its own pages on the EAA website for discussion and information. The Student Council will be launched at the EAA/SFA/ASA joint meeting in Paris in June 2008 with a programme of student activities planned jointly with the ASA Student Council.

Students (undergraduates and postgraduates) are needed to help organise meetings, design and maintain the website, sit on technical committees, liaise with other students, and coordinate activities. Anyone who would like to be involved with the Student Council in any way, or wishes to be on the email contact list, should email Bastian Epp at Oldenburg University in Germany at **bastian@aku.physik.uni-oldenburg.de** .

Schola

The EAA is also setting up a new initiative 'Schola', to provide support and information for students and young researchers. A Schola website is to be set up to include details of all acoustics courses, initially in Europe but possibly to include other areas in future, opportunities for research and industrial placements, funding/grant opportunities and so on.

For more information on the Student Council or Schola see the EAA website **www.eaa-fenestra.org** .

PLASA08 dates set

Professional Lighting and Sound Association's annual show

Interest in PLASA08 is running at an all-time high, with over two-thirds of exhibitors having already rebooked their stand space and further applications arriving at the PLASA Events' offices daily.

On the back of the success of PLASA07, many companies have increased their stand size and several have doubled their space, setting PLASA08 on course to be the major industry event of next year. The success of the 2007 show has also been a catalyst for drawing back former exhibitors and generating strong levels of interest from new exhibitors, impressed with the professionalism and energy of the event.

The show management team has identified a range of new initiatives to develop and strengthen visitor attendance and is also focusing on a number of key areas for further development.

One of the key messages that came across very powerfully from the research was how important the new products and developing technologies were to the success of the live business environment at PLASA. Visitors also placed considerable value on the networking opportunities, and the events team was studying ways to develop the networking experience. The show's special features will be extended to ensure delivery of a strong educational programme encompassing special industry topics, as well as intensive technical training in conjunction with key manufacturers.

The expansion into Earls Court 2 has been positively received, and there are new plans to develop the two hall layout, as well as making more stand space available for those who want to make the move into Earls Court 2 next year.

Plans are also under development for the provisionally titled 'PLASA North', which will be officially launched when PLASA Events takes over the A C Lighting North trade show immediately after the 2008 event.

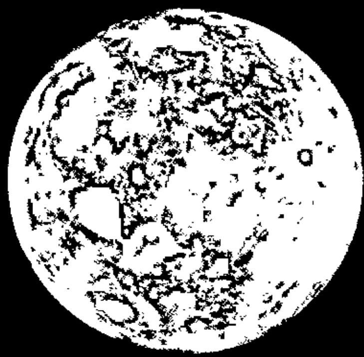
PLASA08 will run from 7 to 10 September 2008 at Earls Court in London.

www.plasashow.com

For more information contact Nicola Rowland, Director of Events

Tel: **+44 (0)20 7370 8662**

Email: **nicky.rowland@plasa.org**



100,000 Tests

Under the ANC's ADE Registration Scheme

In addition to testing for compliance with Part E of the Building Regulations 2000, ANC registered testers have also been conducting tests for Ecohomes assessments and are commencing conducting them under the Code for Sustainable Homes. This has swelled the number of tests being conducted under the registration scheme with the number in 2007 expected to be over 30% higher than the number in 2006. November 2007 was the busiest month to date and during this month the 100,000th test was registered.

The test took place on the Stratford Eye development constructed by Wates which includes a 19 storey tower and overlooks the 2012 Olympic Site. The test was conducted by Peter Davies and Rohan Ramadorai of Cole Jarman Associates and comfortably exceeded the minimum required by Approved Document E. As required by the ANC Registration Scheme the result of this test was entered into the ANC database with details of the construction from which the certificates are generated. A benefit of this system is that, as the construction details are also recorded, the performance of particular constructions can be monitored based on very large samples of test data. For example mean performances and pass rates can be determined. To date the overall pass rate is over 97%.

With the ANC Registration Scheme now firmly established, further developments are being undertaken. These include an application to UKAS to have the scheme accredited, and a joint research project. The latter involves the ANC, BRE and RDL and is concerned with the test method employed for source and receiving room measurement. To date measurements have been made in a building on the BRE site, these will be followed by site tests conducted around the country.

A list of all the ANC-registered testers for ADE throughout the UK can be found at the ANC web site, **www.association-of-noise-consultants.co.uk**

The Stratford Eye development

'Cathedral' sounds

celebrate £2.5m acoustic laboratories

It may sound as if they are singing in a vast cathedral but, at the official opening of Salford University's £2.5m acoustic facilities, the choristers' dulcet tones were actually emanating from a surprisingly small room.

To mark the official opening of the new laboratories on Thursday 25 October, eleven members of the Salford Cathedral Choir sang in the University's reverberation room – a place capable of transforming the quality of music so that it sounds like the interior of a church. The choir was fortunate in that they did not have to perform in the University's Anechoic Chamber, a room so quiet that the blood can be heard running through one's ears, and everything sounds strangely muffled.

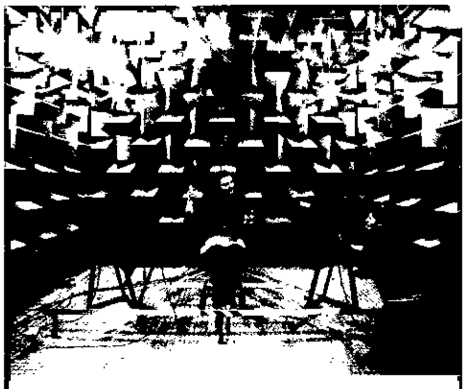
These were among the highlights set up for the grand opening of the state-of-the-art acoustic laboratories which also featured acoustical demonstrations and entertainment from the cutting edge of sound technology.

The laboratories have been used to test parts of world-famous buildings such as the Royal Albert Hall and Portcullis House. Research work in the facilities has led to international standards on rain noise measurement and the testing of theatre seating.

Dr Andy Bower, BBC Portfolio Manager, Digital TV, was one of 100 distinguished guests at the event including many past graduates who have gone on to work in the acoustics industry. Dr Bower led the day's debate – 'Is technology ruining TV?' – before cutting the ribbon and declaring the new facilities officially open.

Joining him at the debating table were Jamie Angus, Professor of Acoustic Technology, and Paul Sermon, Professor of Creative Technology, who spoke about research into the interactive phenomenon Second Life and how, for the first time in nearly 15 years, Second Life presented an entirely new interactive concept that exploited the full promise of the internet.

In the afternoon, Prof Andy Moorhouse was among the speakers, and demonstrated how to simulate the sound of a monsoon in Manchester.



The new anechoic chamber

The University's vice-chancellor, Prof Michael Harloe, and pro-vice-chancellor James Powell also attended the event.

Members of Salford Cathedral Choir

Parliamentary reports

From Hansard

Commons Written Answers

15 October 2007

Noise: Wind Power

Mr Paice: To ask the Secretary of State for Communities and Local Government if she will publish the guidelines for noise emission from wind turbines to be taken into account by planning authorities; and whether she has plans to review such guidelines.

Mr Iain Wright: Planning policies for renewable energy technologies, including wind turbines, are set out in Planning Policy Statement 22 (PPS22). PPS22 is supported by a companion guide which provides practice guidance on planning for renewables. Both documents are available at www.communities.gov.uk.

PPS22 expects local planning authorities to 'ensure that renewable energy developments have been located and designed in such a way to minimise increases in ambient noise levels'; and in doing so, assess and rate noise from wind energy developments using the 1997 report by the Energy and Technology Support Unit. This report is available on the BERR website (www.berr.gov.uk). There are no plans to review this guidance at present.

Wind Power: Planning

Mr Paice: To ask the Secretary of State for Communities and Local Government what guidance she has given to planning authorities on the minimum distances between wind turbines and residential accommodation; and what information she holds in relation to the equivalent guidance given in (a) Scotland and (b) Wales.

Mr Iain Wright: The companion guide which supports Planning Policy Statement 22 notes that 'fall over' distance (ie the height of the turbine to the tip of the blade) plus 10 per cent is often used as a safe separation distance; but advises that the minimum desirable distance between wind turbines and occupied buildings, calculated on the basis of expected noise levels and visual impact, will often be greater than that necessary to meet safety requirements. Guidance for Scotland and Wales is a matter for the Scottish Executive and for the Welsh Assembly Government.

22 October 2007

M3 Motorway

Mrs Maria Miller: To ask the Secretary of State for Transport pursuant to the answer of 27 June 2005 on the M3, what estimate she has made of the level of road traffic noise between junctions 5 and 7 of the M3 motorway calculated using her Department's traffic noise model for each year since 1995.

Mr Tom Harris: The following tables provide estimates of the level of road traffic noise between junctions 5 and 7 of the M3 motorway calculated using the Calculation of Road Traffic Noise, Department of Transport and Welsh Office (1988) for each year since 1995:

Section - M3 J5 to 6

	Estimate of traffic noise in dB
1995	79.7
1996	80.1
1997	80.2
1998	80.4
1999	80.3
2000	80.1
2001	80.2
2002	80.4
2003	80.3
2004	80.3
2005	80.4
2006	80.5

continued on page 44

Parliamentary reports - *continued from page 43*

Section - M3 J6 to 7

	Estimate of traffic noise in dB
1995	78.6
1996	79.3
1997	79.5
1998	79.6
1999	79.7
2000	79.7
2001	79.9
2002	79.8
2003	79.9
2004	79.8
2005	79.8
2006	80.0

These estimates are based on average traffic flows and the percentage of heavy goods vehicles but do not include other variable factors, such as obstacles and exposure. The estimated measurement point is calculated at 25m from the edge of the nearest carriageway and 2.5m above the carriageway.

16 October 2007

Aviation: Exhaust Emissions

Mr Hancock: To ask the Secretary of State for Transport what recent research she has (a) commissioned and (b) evaluated on the amount of emissions from each type of aircraft using UK airports; what plans she has to incentivise and penalise the worst offending operating companies; and if she will make a statement.

Jim Fitzpatrick: Individual aircraft are internationally certified according to their noise level, emissions of oxides of nitrogen (NOx) and emissions of particulates during landing and take-off. The Department uses the noise data of individual aircraft in models that build up a map of the total noise at designated airports. These are then published.

The project for the sustainable development of Heathrow is collating the total emissions inventory for different scenarios. The basic aircraft emissions data is derived from the publicly available certification data for each type of aircraft. We will be consulting on this shortly.

The Civil Aviation Act 2006 provides powers for all airports to introduce charges that reflect the noise and NOx generated by each aircraft type. In addition to these charges penalties can be imposed for exceedences of noise levels specified in the noise control schemes.

13 November 2007

Aviation: Noise

Susan Kramer: To ask the Secretary of State for Transport what the cost was of the Attitudes to Noise from Aviation Sources in England study published by her Department on 2 November 2007; and how much was spent on fees to MVA consultants.

Jim Fitzpatrick [holding answer 12 November 2007]: The current cost of the Attitudes to Noise from Aviation Sources in England (ANASE) project is £1,458,711 of which £1,401,517 represents fees to MVA consultants.

19 November 2007

Wind Power

Mr David Jones: To ask the Secretary of State for Business, Enterprise and Regulatory Reform what estimate he has made of the minimum distance from the nearest dwelling at which wind turbines should be located.

Malcolm Wicks: The Department has not set out any guidelines on minimum distance. The distance between occupied dwellings and a wind farm will depend on the particulars of each case and issues such as expected noise levels, visual impact and safety requirements will all need to be factored into determining whether a particular proposal is acceptable.

3 December 2007

Wind Power

Adam Price: To ask the Secretary of State for Business, Enterprise and Regulatory Reform whether his Department plans to revise ETSU-R-97 as it relates to existing and planned wind turbine installations.

Malcolm Wicks: The Government have published two independent studies on noise from wind turbines in 2006 and in 2007, both available on the BERR website at

http://www.berr.gov.uk/energy/sources/renewables/explained/wind/onshore/page31267.html and **http://www.berr.gov.uk/files/file40570.pdf** .

Based on the findings of these studies, the Government will not carry out any further research into noise from wind turbines at this time, however we will continue to keep the issue under review. We continue to support the approach set out in Planning Policy Statement (PPS) 22 - Renewable Energy. This approach is for local planning authorities to 'ensure that renewable energy developments have been located and designed in such a way to minimise increases in ambient noise levels', through the use of the 1997 report by ETSU to assess and rate noise from wind energy developments.

11 December 2007

Heathrow Airport: Noise

Mrs Villiers: To ask the Secretary of State for Transport what assessment she has made of the role continuous descent approach can play in mitigating noise from Heathrow airport.

Jim Fitzpatrick: Aircraft landing at Heathrow are required whenever practicable to follow continuous descent approach (CDA) or low power, low drag procedures, although the main noise benefits are outside the 57dB(A) Leq noise contour. This is consistent with the recommendations in the industry Code of Practice 'Noise from Arriving Aircraft; An Industry Code of Practice' on the benefits of CDA as a means of reducing both fuel burn and noise. The Code of Practice can be accessed on the Department's website **www.dft.gov.uk** .

Wind farms are designed to minimise increases in ambient noise

UK student awarded ASA prize

Georgia Zepidou

Georgia Zepidou, a student at London South Bank University, has been awarded the 2007 Acoustical Society of America Robert Bradford Newman Medal for Merit in Architectural Acoustics. The Robert Bradford Newman programme honours outstanding students at schools of architecture and architectural engineering throughout the world. Students selected for the award must have demonstrated excellence in this discipline and in the application of acoustical design principles in the course of their study. The medal, which is awarded 'for Excellence in the Study of Acoustics and its Application to Architecture' was for Georgia's MSc dissertation entitled 'Classical Orchestra Rehearsal Room Acoustics: Two case studies in Thessaloniki, Greece'. The dissertation was written as part of Georgia's MSc course in Environmental and Architectural Acoustics at London South Bank University. Currently, Georgia is studying for a PhD at LSBU on a project supported by Sound Research Laboratories and the Royal Academy of Music.

Georgia Zepidou with Leo Beranek Hon.FIOA

New boards of the ICA and EAA

Madrid Congress

The General Assemblies of the International Commission on Acoustics and the European Acoustical Association were held during the Nineteenth International Congress on Acoustics in Madrid in September. Both organisations elected new boards. New officers of the ICA include President Samir Georges (Brazil), Vice-president Sonoko Kuwano (Japan) and Secretary-General Marion Burgess (Australia). Phil Nelson remains on the Board as immediate Past President. The new board of the EAA includes: President Luigi Maffei (Italy, former General Secretary), Vice-president: Michael Vorländer (Germany, former President), Vice-president Peter Svennson (Norway), General Secretary Kristian Jambrosic (Croatia), and Treasurer Salvador Santiago (Spain).

LETTERS

I read with some interest the article on setting noise criteria in Acoustics Bulletin, vol.32 no.6 (November/December 2007). As a member living in NSW, Australia I thought I would point your members to the Industrial noise policy for that State **http://www.environment.nsw.gov.au/resources/ind_noise1.pdf** which does use a sliding scale to set noise limits outside a noise sensitive receiver (dwelling). This is a function both of the existing background noise level at the relevant time of day and the existing contribution of industrial noise at the dwelling

In quiet areas this normally equates to background (L_{A90}) + 5dB, subject to modifying factors. In already noisy areas this could be ambient (L_{Aeq}) - 10dB, rather than background (L_{A90}) – 10dB. The policy sets a procedure for determining the most appropriate criterion to apply, which I believe works very well with sensible outcomes.

I disagree with the author's comments that it is neither practical nor reasonable to set a criterion of 'background – 10dB' as he believes a noise level so low is not possible to measure. In the New Products section of the previous issue there was a piece about directional noise monitoring, a technique which does indeed allow measurement 10dB below the A-weighted ambient noise level within 1dB. Clearly if criteria that low need to be achieved there is now technically no excuse not to measure to determine compliance?

Neil Gross
Sound Science, Australia

NoiseLab

Delta's software comes to UK

AcSoft Ltd has been appointed UK distributor of the NoiseLab software package from Danish consultancy Delta Acoustics. Just released in version 3.0, the software makes a perfect partner for Svantek's range of hand-held sound level meters.

NoiseLab is a versatile acquisition and post-processing software package, designed to make preparation of noise reports an easy step-by-step process. The software handles the acquisition of up to 8 channels of data, and powerful tools allow the user to highlight and select significant parts of the signal for processing.

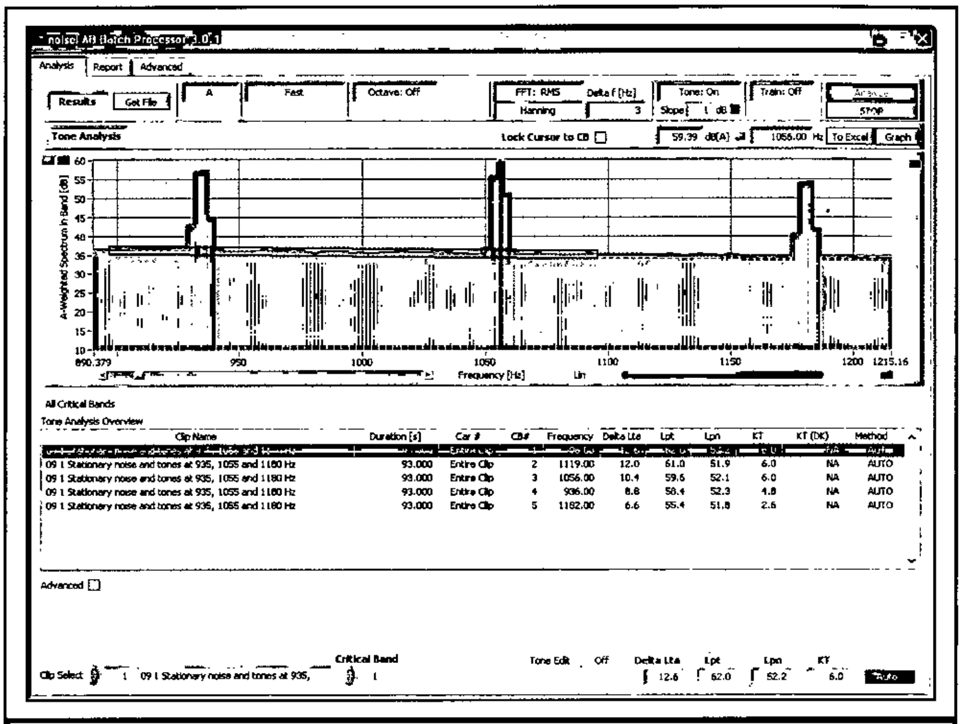
NoiseLab supports direct acquisition using USB hardware, equipped with microphone and preamplifier from GRAS, or alternatively, the Svan 95x series of instruments can be used as a front-end, via a free Windows-compatible driver.

Calibration is an easy matter, and depending on hardware used, NoiseLab meets the requirements of BS EN 61672:2 to Class I accuracy.

Alternatively, existing .wav files can be imported, calibrated and processed. This makes it easy to analyse .wav files recorded with popular sound level meters, such as the Svantek 959 or 957, as well as the B&K 2250.

NoiseLab is available in three packages, the Standard edition allowing measurement and processing of sound levels, with all necessary weightings including infrasound. The Advanced edition adds 1/3 octave analysis, FFT narrow band analysis and statistics. Tonal analysis to the latest ISO1996 Part 2 is also included, based on algorithms developed by Delta Acoustics themselves. The Professional edition adds frequency analysis down to 1/24 octave resolution, automated tonal detection, and powerful tools for analysis of trains and other transient events.

All versions include a batch processor, which allows fast automatic analysis of large libraries of .wav file clips, saving analysis time, and producing attractive reports. A free browser version allows viewing of results on any other PC, without licensing constraints.



Example screenshot

NoiseLab is likely to find many fans amongst users of the Svantek range of hand-held instruments, with their ability to record audio signals direct to a USB memory stick, but it is just as much at home with .wav files recorded via many other front-ends.

More information is available at **www.noiselab.dk**

Rytons

extend their 'Acoustic' range

Rytons' already extensive range of acoustic ventilation sets has grown even bigger with the addition of no fewer than four new sets for general ventilation, and for ventilating heat-producing appliances, and seven new sets for background ventilation.

BRE tested the sound reductions and equivalent areas. The AirCores provide effective sound reductions between 36 and 43dB. Rytons' range also includes '9x3' and '9x6' Acoustic AirLiner® Sets with sound reductions of between 36dB and 40dB.

The complete range maintains a high equivalent area to fulfil the requirements for background ventilation laid down in Approved Document F.

For information on all Rytons products, please phone **01536 511874** for a brochure. For instant information, visit **www.vents.co.uk**

The Rytons range

New book: The Little Red Book of Acoustics

Richard Watson. Acoustics made accessible

A new book has just been released which should assist those with a background in acoustics and need a ready-reference and an easy guide to current UK standards and regulations, and equally newcomers to the field who could do with a straightforward and accessible introduction to the basics.

The Little Red Book of Acoustics draws on the accumulated expertise and experience of the UK-wide Hepworth Acoustics consultancy, and is written by three of the staff. It is designed to provide a wide-ranging source of information on environmental and building acoustics, presented in a fresh, direct way accessible to the experienced and non-specialist. The book has eight sections spanning 225 pages and comes in two sizes, a pocketbook (designed for easy transportation) costing £19.99 plus p&p, and a slightly larger ring bound version (designed for office use) costing £24.99 plus p&p.

Co-author Richard Watson commented that the authors wanted the book to pick out the key principles and most important aspects of the various environmental and building acoustics regulations. There were lots of acoustics books covering different areas, but they wanted the book to be straightforward, direct and useful for everyday use.

The book is aimed at acoustic consultants, environmental health officers, other professionals and those studying or working in and around acoustics. The book is due to become a recommended text for the IOA Diploma course, and Hepworths are in discussions with various universities about its use on other courses. The firm has had a great deal of positive feedback from all of these groups of people. Value for money is widely commented upon.

The initial chapters of the book progress from a straightforward definition of 'sound' through decibel addition, subtraction and averaging, third octave and octave bands, to explaining commonly used parameters and descriptors such as dB(A), L_{eq}, SEL, L_{90}, NR curves *etc*, as well as distance attenuation, barrier attenuation, and sound insulation.

For more experienced practitioners, the book provides a handy reference to common acoustical formulae, data and criteria. The 'standards and regulations' section includes most of the current standards and regulations relating to acoustics and community noise issues which are currently in force in the UK, enabling the used to find relevant information quickly. A set of appendices gives the reader an extremely helpful set of tables as well as a range of examples of calculations on which to draw.

Co-author Peter Hepworth, Managing Director of Hepworth Acoustics says that the book developed from a simple idea, but often simple ideas are the best. The book has proved very useful, even to experienced acousticians, and all members of technical staff at each of the eight Hepworth Acoustics offices were given a copy so that key information was always to hand. The book was not covering new ground, nor was it intended to, but it was demystifying acoustics and making the subject more accessible than it had ever been.

All in all, whether you are looking for some standard formulae for averaging decibels or for a ready reference to common standards, then this little book (or its bigger twin) is likely to become an indispensable item. Both are available via the Hepworth Acoustics website at:
www.hepworth-acoustics.co.uk/redbook.htm

Richard Watson BEng CEng MIOA MAES MIEEE

Understandable confusion in the acoustical marketplace?

A comment on the state of the acoustic supply market

End-users, construction companies, developers, architects and acoustic consultants are increasingly bombarded with information from companies who either manufacture and sell or simply sell products for sound insulation and sound absorption. Yet the information coming out of these companies and the technical advice and support provided by them can be highly variable.

Why should it be like this? What do user groups require of the supplier companies? This should not be a difficult question to answer. Despite there being specific differences in their needs there are a number of common elements. All are looking for quality products, proven solutions and correct technical advice. Yet, what are the messages coming back from the recipients of this information?

The main complaint from end-users is of that of receiving technical information that creates confusion, leading to decision making being a real problem. There are many different methods and ways of expressing sound insulation performance and it is all too easy to confuse the layman, who may not have appreciated the difference between airborne and impact sound, yet alone, the difference between laboratory and site test results. Increasingly one hears of 'fairy-dust' solutions being offered with guarantees of peace and quiet that simply cannot be achieved.

One recent caller to our offices, Paul Hanrahan, site manager for CK Properties, complained of just this problem. Paul commented that he had recently been talking to another well-advertised sound insulation material supplier, who provided him with a solution to a particular acoustic problem they faced on a current project. The supplier advised that a particular product would guarantee compliance with Approved Document E of the Building Regulations 2000, and provided trade literature purporting to support this, as well as providing a sample. Believing this, the product was purchased and installed, only to get a significant failure at a pre-completion test. Subsequently, on taking the now-much-larger problem to Floorscan Acoustics, a distributor of SRS products, he was given much more information and made aware that the performance of these materials would differ from site to site, since they only form a part of the total floor or wall construction. Not only that, Paul was advised by Floorscan that the SRS product, of which the other product was a clone, would not fulfil the requirements of AD-E in this particular situation. An alternative SRS product was offered, and shown to provide compliance on site prior to purchasing the total quantity required. It had been a costly exercise, but CK Properties certainly knew who to go to next time, and why.

At the other end of the spectrum, of necessity, acoustic consultants are required to keep up to date with the latest developments in acoustic systems and products. The number of providers is now large with many new manufacturers and suppliers having appeared in the marketplace over the last few years. Not all employ experienced, qualified personnel with a knowledge of building acoustics and the necessary site experience. As a consequence, on many occasions these consultants find that they are faced with difficulties in ensuring proven products are used on sites. Erosion of specifications becomes all too common.

Duncan Templeton, of the leading practice BDP Acoustics, commented that he relied on the architect and engineer incorporating in design drawings and contract documents, acoustic requirements which he had carefully and scientifically defined based on laboratory and field test data. Too often this advice became generic rather than specific, when it came to product selection. The architect has to balance acoustic performance with other parameters - appearance, buildability, durability, fire rating, and fixing. The contractor is swayed by cost, availability via supply chain partners, and ease of site assembly. The result, all too often, is a compromise in product selection and installation.

A further example came to SRS's attention very recently, and it reinforces the problems outlined above. The Acoustilay product had been used successfully on a flat conversion in one street in Lancashire, where it had been specified following a diagnostic site survey. The good news spread, and a near neighbour wanted to follow suit. This time the site survey revealed that a more rigorous solution was required and a ceiling treatment was recommended in addition to the application of Acoustilay. Yet, what did the client and contractor do? Seeing that Acoustilay had worked further up the street they decided to omit the ceiling treatment and be satisfied with an acoustic underlay; not Acoustilay, but a cheaper clone. The result was a failure with the end result being increased costs for the necessary remedial action.

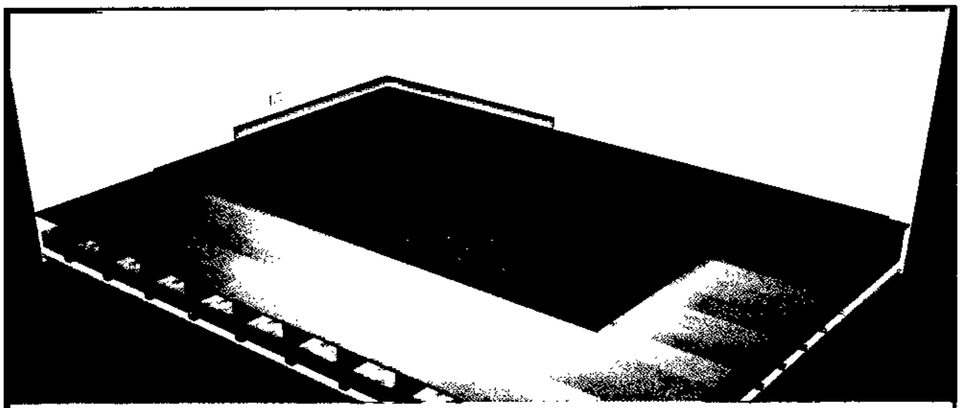
What can the specifier and end user of the information do to remedy this situation? One thing is certain: there is no one correct route to success. As illustrated above, just as every construction site is different, and the difference may result in a different acoustic performance from the identical product or system when used in it, there is no simple panacea. However, there are some simple guidelines that should be followed so that the recipient of the information can be assured that they are receiving the appropriate recommendations and the appropriate product or products for their particular noise problem.

What we are all seeking is confidence in the choice of the 'right' material or system for use in the 'right' place, and the key to gaining that confidence is that the advice, recommendations and ongoing support is coming from the 'right' people and is followed without specification erosion. The following points are likely to help.

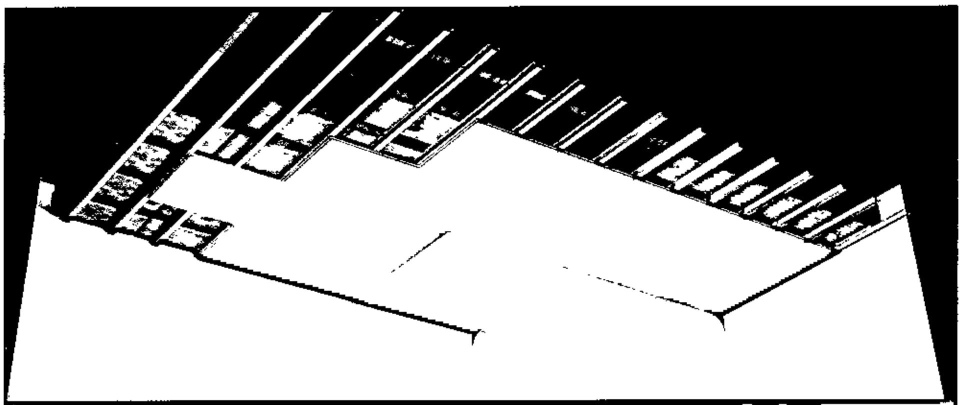
- Use proven products and solutions.
- Longevity of product indicates that it has a proven success rate. Look-alikes and clones may not have been subject to the same level of testing and will not have the same track record. Testing can be costly and some companies may not wish to incur these costs, gambling on similarities to proven well-established products and a lower price securing them the business. The holding of a patent for the product or seeing a registered trademark on the product can act as a good indicator.
- Longevity of a supply company indicates that they are likely to have a proven track record.
- Ensure that a supply company has appropriately qualified technical personnel: membership of the Institute of Acoustics is a definite advantage. New companies on the block are not precluded from this and may meet these criteria, but this is worth checking, as a graduate level qualification alongside practical experience and the support of appropriate IOA member referees are required for consideration for full IOA membership.
- When looking at companies' claims for products and systems, it is important to ensure that 'apples' are compared with 'apples' eg D_{nTw} with D_{nTw} (site recorded data under real conditions) and not R_w (laboratory data under perfect conditions). R_w figures will look significantly better than the D_{nTw} figures measured on site.
- If in doubt, ask for an acoustical condition survey to be carried out. Knowing the starting point makes recommendation of the appropriate solution simpler, with much greater guarantee of success.
- In the current age of increased sustainability and protection of the environment, a traceable audit trail is important. Ensure that the supplier can provide this for their product range.
- If still in doubt, simply ask! Reputable companies will certainly be willing to provide relevant information regarding the company and its personnel, as well as copies of laboratory and site test data.

Following this prescription should ensure that most of the pitfalls are avoided.

Dr Roger Manifold MIOA



An acoustic floor build-up using Acoustilay



The same system seen from the floor below

For further information on Sound Reduction Systems Ltd, its technical team, its testing policy, and its products please contact **Dr Roger Manifold** MIOA,
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tel: **01204 380074**
email: **roger@soundreduction.co.uk**

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Committee meetings 2008

DAY	DATE	TIME	MEETING
Thursday	10 January	10.00	Meetings
Thursday	24 January	10.30	Diploma Tutors and Examiners
Thursday	24 January	1.30	Education
Thursday	31 January	10.30	Membership
Thursday	14 February	11.00	Publications
Thursday	21 February	11.00	Medals & Awards
Thursday	21 February	1.30	Executive
Thursday	6 March	10.30	Engineering Division
Tuesday	11 March	10.30	Diploma Examiners
Thursday	**13 March**	**11.30**	**Council**
Thursday	3 April	10.00	Meetings
Tuesday	8 April	11.00	Research Co-ordination
Tuesday	22 April	10.30	CCWPNA Examiners
Tuesday	22 April	1.30	CCWPNA Committee
Thursday	8 May	10.30	Membership
Wednesday	21 May	10.30	CCENM Examiners
Wednesday	21 May	1.30	CCENM Committee
Thursday	22 May	11.00	Publications
Tuesday	3 June	10.30	CMOHAV Examiners
Tuesday	3 June	1.30	CMOHAV Committee
Thursday	5 June	11.00	Executive
Thursday	**19 June**	**11.30**	**Council**
Thursday	26 June	10.30	Distance Learning Tutors WG
Thursday	26 June	1.30	Education
Thursday	3 July	10.30	Engineering Division
Tuesday	8 July	10.30	ASBA Examiners
Tuesday	8 July	1.30	ASBA Committee
Thursday	10 July	10.00	Meetings
Tuesday	5 August	10.30	Diploma Moderators Meeting
Thursday	4 September	10.30	Membership
Thursday	11 September	11.00	Medals & Awards
Thursday	11 September	1.30	Executive
Thursday	18 September	11.00	Publications
Thursday	**25 September**	**11.30**	**Council**
Thursday	2 October	10.30	Diploma Tutors and Examiners
Thursday	2 October	1.30	Education
Thursday	16 October	10.30	Engineering Division
Thursday	30 October	11.00	Research Co-ordination
Thursday	6 November	10.30	Membership
Tuesday	11 November	10.30	ASBA Examiners
Tuesday	11 November	1.30	ASBA Committee
Wednesday	12 November	10.30	CCENM Examiners
Wednesday	12 November	1.30	CCENM Committee
Thursday	13 November	10.00	Meetings
Tuesday	18 November	10.30	CMOHAV Examiners
Tuesday	18 November	1.30	CMOHAV Committee
Thursday	20 November	11.00	Executive
Thursday	27 November	11.00	Publications
Tuesday	2 December	10.30	CCWPNA Examiners
Tuesday	2 December	1.30	CCWPNA Committee
Thursday	**4 December**	**11.30**	**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.

Conferences and meetings:

Diary 2008

29 January 2008
Speech & Hearing Group
Speech and hearing in learning environments
The Kohn Centre, The Royal Society, London

6 February
The improvement of the management of helicopter noise
The Lowry Conference Room, University of Salford

20 February
Soundscapes inside and outside future buildings
The Wren Room, RIBA, London

28 February
Wind farm noise
Armagh City Hotel, County Armagh, Ireland

5 March 2008
London Branch
Noise Nuisance
London

12 March 2008
Environmental Noise Group
Transportation noise update
Birmingham

10-12 April 2008
Spring Conference 2008 - Widening horizons in acoustic research
Reading

16 April 2008
Measurement & Instrumentation and Electroacoustics Groups
Playing safe – meeting the Control of Noise at Work Regulations 2005 in music and entertainment
London

16-18 September 2008
Underwater Acoustics Group
Underwater noise measurement, impact and mitigation
Southampton

Further details can be obtained from Linda Canty at the Institute of Acoustics
Tel.: **01727 848195**
or on the IOA website:
www.ioa.org.uk

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