Vol 33 No 5 SEPTEMBER/OCTOBER 2008

ACOUSTICS BULLETIN

in this issue… **Variability in the results of pre-completion testing in dwellings**

plus…

Introduction to the acoustics of ducts, resonators and silencers

An Australian guideline for the assessment of low-frequency noise

NATS Terminal Control North: IOA response to consultation

Institute of **Acoustics**

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ACOUSTICS BULLETIN

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Contents

Front cover photograph: The recent Acoustics '08 conference in Paris was attended by several members and by some of the principals behind the forthcoming Acoustics '09 conference to be arranged by the IOA in Edinburgh. The cover photograph shows an iconic landmark from a slightly unusual angle - the middle of the Seine!

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

Since writing my initial President's Letter I have chaired my first Executive Committee and Council meetings. As a consequence, I now feel that I have really got my feet under the presidential table.

I have also had the pleasure of attending the Acoustics '08 conference in Paris, which took place from 30 June to 4 July. The event attracted around five thousand delegates and, consequently, presented quite a challenge for the organising committee. However, I am pleased to report that the event was undoubtedly a success. A short article on the conference is included in this edition of the Bulletin.

Our Chief Executive also attended the conference where he did an excellent job promoting the Institute and, in particular, Euronoise 2009. This was done mainly from a stand shared with the European Acoustics Association (EAA) in the conference exhibition area. He was ably assisted by Dennis Baylis who managed to sign up many of the conference exhibitors for Euronoise 2009.

In addition, good contacts were made with representatives of other national institutes, especially L'Association Belge des Acousticiens, who are keen to hold a joint conference on environmental noise with us in 2010, and La Société Française d'Acoustique who would like to organise a joint event in 2012. The latter is likely to include the European Conference on Underwater Acoustics.

Bernard Berry took the opportunity presented by Acoustics '08 to organise a short meeting between representatives from the IOA and the EAA to discuss the organisation of Euronoise 2009. Several issues were discussed and resolved and it was clear to me that significant progress is now being made in the organisation of the event.

A number of consultation documents have recently been circulated for comment including the Terminal Control North Airspace Change Proposal. Our response to this consultation is provided in this issue of the Bulletin. My thanks are offered to Steve Mitchell and Stephen Turner who did the majority of the work on this response. Other consultation documents that have been received and are currently being reviewed concern noise action plans for Scotland and for Wales.

Finally, I recently attended a meeting of IOA young members' representatives. I was greatly encouraged by the positive attitude of these representatives who are very keen to become involved in the work of the Institute. The possibility of setting up a young members' group was explored, as was the role of the proposed group. One of its tasks could be to organise an annual meeting specifically for young members. Keynote speeches from older members could be included, but there would need to be a strong emphasis on papers given by young members from a wide range of acoustic disciplines. Louise Beamish, the young members' representative on Council, will present some proposals to the next Council meeting.

At the time of preparing this letter, many of you will have already started your holidays. By the time you read it, most of you will have finished them. I hope you had a good time!

John Hinton

John Hinton
PRESIDENT

Meeting report

London Branch Evening Meeting

Uncertainty in Noise Measurement & Prediction

Dani Fiumicelli's presentation on 16 April 2008 was aimed at raising awareness of issues and provoking debate relating to uncertainty associated with the measurement and prediction of noise levels.

The presentation:

- Highlighted the fact that environmental sound fields are inherently variable in both space and time;
- Identified some of the sources and magnitudes of variability associated with environmental sound measurement and prediction;
- Pointed out that the use of noise levels to inform decision-making processes could result in a risk of an incorrect assessment owing to this inherent variability;
- Defined variability, uncertainty, and risk, and examined how they interacted;
- Suggested that the risk of inappropriate assessment could be managed by adopting a structured approach to the design of measurement surveys and prediction which recognised the relationship between variability, uncertainty and risk;
- Highlighted that many standards and guidance documents focused on minimising the variability associated with measurement and prediction methods, rather than on study design, and that the variability associated with the competent use of precision grade instruments was usually insignificant compared with the inherent variability of environmental sound fields and human response.

Dani went on to suggest that in practical environmental sound studies it was frequently more important to understand the causes and magnitude of the variability of measured or predicted sound levels than it was to minimise this variability. Understanding variability in this way was frequently the most effective means of averting the risk of incorrect assessment outcomes.

Dani acknowledged the strong influence of Dr Andrew Bullmore, Geoff Kerry and the work of others in this field, and concluded by posing two questions.

In acoustics, how confident are we that that we can know the precise sound level at a specific location all the time?

Is the best we can aim for an estimate of the probable noise level most of the time at some locations?

The meeting then opened into a debate with many participants airing their views: some strong opinions were expressed and interesting ideas articulated.

Meeting report

Ed Clarke. London Branch

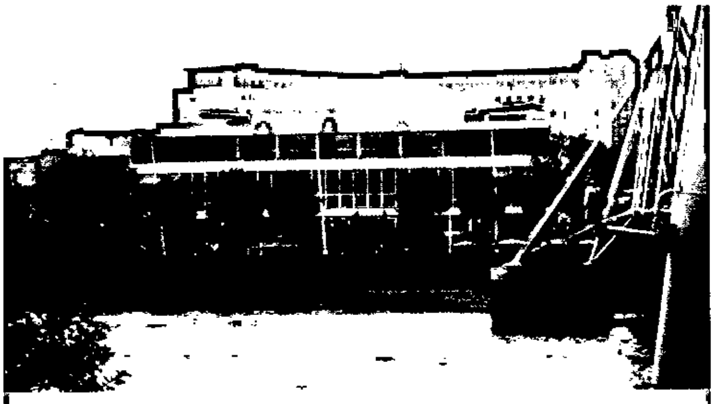
Half-day visit to the Royal Festival Hall, London.

On the afternoon of Saturday 17 May, forty IOA members met at the South Bank Centre's Royal Festival Hall for the London Branch's annual half-day visit. Taking place just one year after the venue reopened its doors, the visit provided an opportunity to learn more about the details of the extensive two-year redevelopment which included a complete overhaul of the main auditorium acoustics.

There was obvious enthusiasm as the many early arrivals conversed over coffee and biscuits before expectantly taking their seats in the third-floor Sunley Pavilion. The afternoon began with a talk from Ian Blackburn, the capital projects director at the South Bank Centre (SBC), who was responsible for the redevelopment project. He told the story of the SBC, explaining who were the key people involved in its original design, putting it into geographical and historical context particularly with reference to the 1951 Festival of Britain and also to the future development of the other buildings on the SBC site. The reopening of the venue attracted some 250,000 people to attend a weekend of special events, and Ian admitted that the major problem with the new venue (a nice problem) was that it had been too successful.

Next, we were joined by the project's acoustic consultant, Larry Kirkegaard, who kindly agreed to take time out of his brief stay in London to present and discuss his work. Larry gave us an inspiring and all-encompassing presentation which began by describing the problems of the old hall from a musician's, as well as an acoustician's, perspective. A slide of Russian conductor Vladimir Ashkenazy, emphatically struggling to control his orchestra, illustrated the problem of poor on-stage intercommunication and difficulties in achieving a good balance between instruments and sections. Results of subjective testing were presented which were attributed to very specific features of the stage environment. Through comparisons with other successful auditoria, principally the Musikvereinssaal in Vienna, Larry explained how the resulting auditorium reverberation time undershot the original targets owing to an underestimate of the effect of audience absorption and the comparatively low internal volume. He described his methodology to increase the RT, highlighting the incremental increases gained by addressing features such as the carpet, elm and Copenhagen panels, and leather linings which in combination have provided a significant improvement.

Larry's approach to enhancing the distribution of early reflections was to introduce a series of moveable fabric sails, which were originally conceived during his refurbishment of New York's Carnegie Hall. This, however, involved the controversial removal of the iconic profiled ceiling above the stage. The gamble appears to have paid off.



The Royal Festival Hall, London

Ian and Larry then took us on a tour beginning on the level 6 balcony, from where we filed up into the roof space, past the spotlights and along the centreline of the auditorium to the stage attic. They pointed out the new structural steelwork and the array of remote controlled motors used to raise and lower the sails, loudspeakers and lighting gantries. From there, we passed into the noisy plant room, located surprisingly close to the relative silence of the stage, and then out onto the roof for a unique view of Belvedere Road and the London Eye, and for a light sprinkling of rain.

Following a few words from Ian in the new sixth-floor hospitality area, a former roof garden, we concluded the formal proceedings and descended to the foyer bar for further discussion and debate.

The final feature of the afternoon was the opportunity for us to hear for ourselves the results of the refurbishment. We took our seats in the auditorium for the UK premier of Philippe Leroux's Voi (Rex), a short work for soprano, six instruments (piano, percussion, violin, cello, flute and clarinets) and electronics, beginning with a discussion with the composer. Owing to the use of a sound reinforcement system, this was arguably not the best demonstration of the hall's natural acoustics, but comments from visitors certainly highlighted its residual entertainment value.

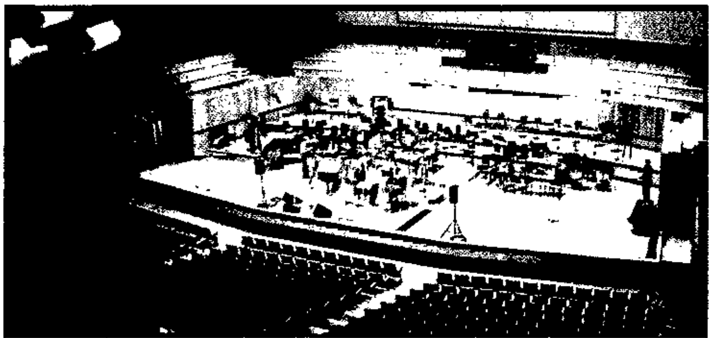
It was great to see so many people who were keen to give up some of their weekend to attend, and those who managed to secure a place appeared to enjoy the visit. The IOA London branch would like to thank Larry and Ian for giving up their time and sharing their knowledge and experiences, and Kelly Palmer at the SBC for her help in organising the event.

Balcony seating

Ian Blackburn discusses effective hearing environments

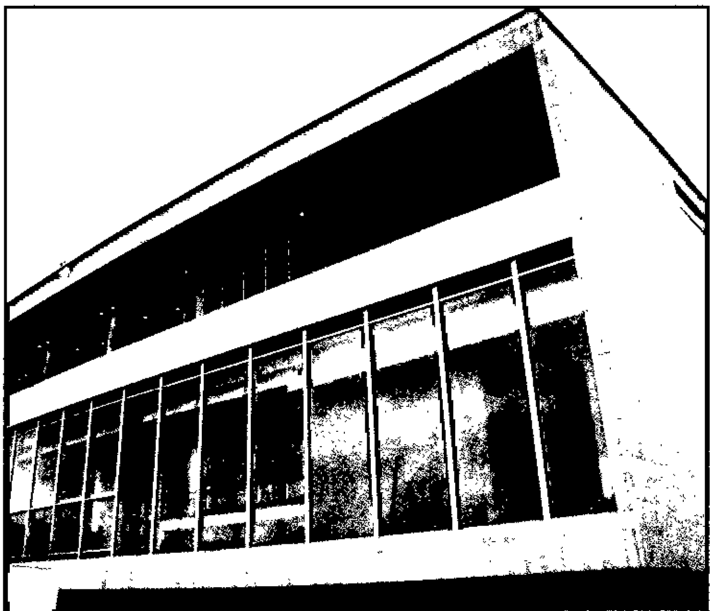
Larry Kirkegaard

Level 6 lobby



Auditorium

Ensemble



View from the Embankment

IOA certificate pass list

Certificate Name: Certificate of competence in environmental noise assessment
Exam Date: 11 April 2008

Bel Educational Noise Courses
Champion J
Gorman R J
Grant A
Hurst A
Kibaris M
Lewin A P
McClelland A M
McConnachie L
McIndoe K
Penny S J
Smith E L
Taylor D
Young P J

University of Birmingham
Brader K
Evans G
Flynn C E B
Ford R
Griffiths H M
Hall S R
Jarosz M
Limb A V
Noonan J C
Rushton N
Weston T A
Williams S R
Young S E

Colchester Institute
Bell J H
Bowen H J
Gromoff A N
Hanna C
Hart J C
Hornshaw M
Lwanga R
Warren R L

University of Derby
Ashbourne W
Staines A K

EEF Sheffield
Clarke S D
Donohoe J J
Elliot M S
Flitton J A
Huskinson B
Lenihan R
Mejer K S
Wilson N

Leeds Metropolitan University
Canavar T
Moon J
Shackley W P
Stevenson T A
Tallentire E E
Willis R

Liverpool University
Birmingham D M
Carpenter C
Doyle M B
Haynes E J
Kelly J
Lee P J D
Manniex G M
Mortley L M
Norbury B W
Phillips A
Richardson J A
Tims K
Wilkinson G J

NESCOT
Alabi O A
Bhatti H S
Chalmers N B
Duffy L M
Eastland K E M
Groom S
Javed A
Kadri Z A
Mulowoza M
Newcombe J
Nizamuddin S
Papnai A
Perella L P
Thomas D M
Wood N

University of the West of England
Bailes J M
Broad I
Douglas I W
Gardner A K
Griffin H
Hartrey C L
Hobson S E
Kinchin G
Lane W
Morgan R
Neal C J
Roberts T D
Stallard S
Williamson R

New members

The following have been elected to the membership grades shown.

Fellow

Mackenzie, R G
Robin Mackenzie Partnership

Member

Alonso Martinez, I
RBA Acoustics

Arnott, S P
Mahle Filter Systems UK

Astolfi, A
Politecnico di Torino

Block, J R
Delta Rail

Bushell, P
Parsons Brinckerhoff

Cahill, B J
Atkins Acoustics, Noise & Vibration

Disley, A C
University of Kent

Drumm, I A
University of Salford

Dursley, L
Vibrock

Frost, A E
Walker Beak Mason

Fung, W P Y
Architectural Acoustics (Hong Kong)

Gates, S D
BAE Systems Submarines

Islam, M
London Borough of Hackney

Keaney, D M
ICAN Acoustics

Koutsodimakis, C
Acousone

Le Moal, N
Buro Happold

Lewis, M J
Robin Mackenzie Partnership

Lurcock, D E J
Robin Mackenzie Partnership

Malik, M A
Peter Brett Associates

Malone, N J
Noiseair Consultants

Memoli, G
Imperial College London

Menaldino, R
BAE Systems

Morley, A J
Huntingdonshire District Council

Nichols, H C
Effective Learning Environments

Olmos, E
Peter Brett Associates

Olver, T R
Acoustic Design Consultants

Owen, R G
MWH

Riches, P G
Sharps Redmore Partnership

Rudman, E C
Wear Valley District Council

Saint Martin, P
Acoustic Design Consultants

Scott, T A
Paul Gillieron Acoustic Design

Seago, A S
London Metropolitan University

Seeto, W
M W Kellogg

Tallantyre, P L
RPS Planning & Development

Troshina, V A
Bickerdike Allen Partners

Trow, J W
Entec UK

Vine, M D
Noisecheck

Wash, P J
Bickerdike Allen Partners

Associate

Argence, T
Sandy Brown Associates

Balci, Z H

Braybrook, C L
East Cambridgeshire District Council

Cardoso, C F
Hoare Lea Acoustics

Chiba, S
TUV Rheinland

Cornu, M S
Arup Acoustics

Delorenzo, C
City Of York Council

Duggan, O
PM Group

Evans, GB
Hann Tucker Associates

Griffiths, R E
Hunter Acoustics

Keane, A M
PM Group

Laws, S R
RBA Acoustics

Mumford, P M Z
Arup Acoustics

Neale, W R

Paris, J A E
Mott MacDonald

Robertshaw, A J
Hepworth Acoustics

Robinson, P
Sharps Redmore Partnership

Swiejkowski, K M
Allaway Acoustics

Wakeling, R
WSP Acoustics

White, M R
Bickerdike Allen Partners

Wood, M J
Acoustic Associates Sussex

Youn, G Y
STATS Limited

Affiliate

Bovo, B
University of Ferrara

Gwilliam, D J
Trim Acoustics

Hanley, A
ANV Technology

Knowles, P J
Acoustic and Engineering Consultants

Murray, H A
Royal Mail Manchester APC

Shiers, N J

Unwin, A
Capita Symonds Group

Webb, C M W
Capita Symonds Group

Technician

Burgess, B
RPS Gregory

Owden, G A W
FX Rentals

Pick, R H
Applied Acoustic Solutions

Reeve, R W
Stroma

Smith, N
ORS Consulting Engineers

Student

Broadbent, R A

Kolster, E

Saba, R

Sponsoring organisation

Evans, P S
RPS Planning & Development

IOA certificate pass list

Certificate Name: Certificate of competence in hand-arm vibration **Exam Date: 25 April 2008**

EEF Sheffield

Carter J Cuttell A Dorr A

Institute of Naval Medicine

Bamford J A Ofori E K Sadza A Wright S M
Littlewood G McCrorie S Vaughan G P

Campbell Associates

Sonitus House
5b Chelmsford Road
Industrial Estate
Great Dunmow
Essex CM6 1HD

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f 01371 879106
e info@campbell-associates.co.uk
w www.acoustic-hire.com
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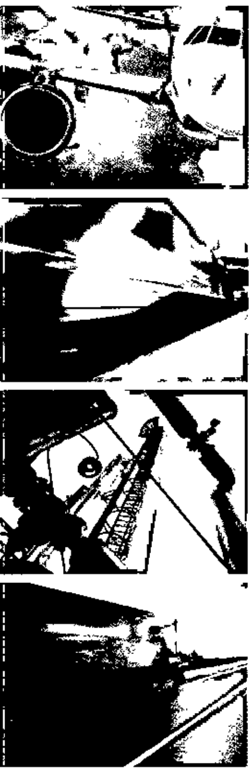

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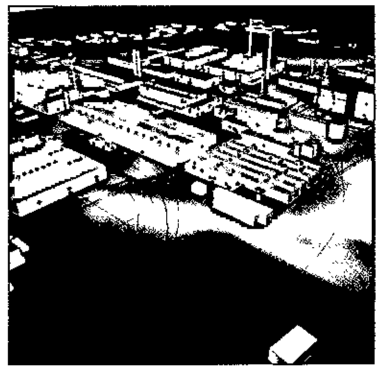
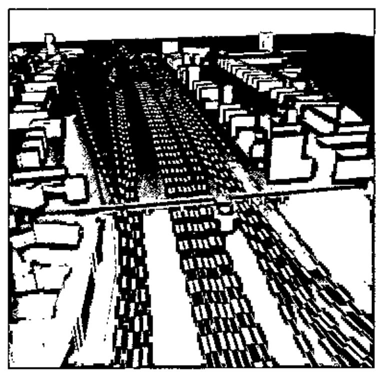
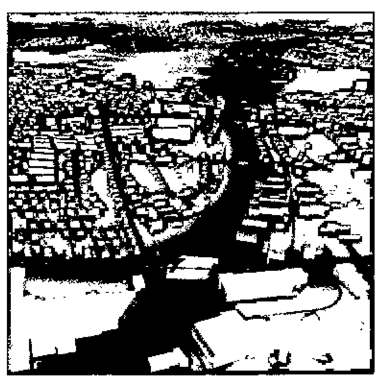


Prediction and detailed analysis of noise at industrial facilities



Optimization of building layout near roads and railway lines



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Terminal Control North (TCN) Airspace Change Proposal

Institute of Acoustics' Response to Consultation, June 2008

This document presents the response of the Institute of Acoustics (IOA) to the proposals for airspace change set out in the consultation published by the National Air Traffic Services in March 2008.

The Institute of Acoustics

The IOA is the leading professional body in the United Kingdom concerned with acoustics, noise and vibration and is active in research, education, environmental and industrial organisations. The Institute is a nominated body of the Engineering Council, a member of the International Institute of Noise Control Engineering and the 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.

Given the importance of assessing the likely noise impact of the proposed flight path changes the Institute was very disappointed not to have been asked directly for its comments. However, we have considered the contents of the consultation document and have the following observations to make. These comments have been compiled by experienced Fellows of the Institute and have been ratified by the Institute's executive prior to submission.

Technical accuracy

Acoustics is a complex subject and one of the complexities is the range of noise indicators and other measures of sound that have to be used in order to try to understand the likely impact of that sound on those affected. Over the years, the description and the abbreviations of these indicators have been standardised. It was very disappointing, therefore, to see the inaccurate presentation of the decibel unit used - it should be dB(A), not dB_A or $dB_{(A)}$, as appeared in several places in the document. To our mind, this showed a lack of care over detail, which with proper professional input could have been avoided.

In addition, in Appendix C, at Paragraph 5.1, an explanation is given for using 16 hours as the averaging period for the L_{eq} contours. The explanation given was wrong. The 16-hour averaging period came into use in the early 1990s when the Government determined a revised method for characterising the air noise impact of airports. It was not a requirement of the 'European Noise Directive' - and even that description is wrong, because Directive 2002/49/EC is commonly known as the *Environmental* Noise Directive. Given that there had been a recent major aviation-related consultation (*Adding capacity at Heathrow*) which was supported by many technical details, it is disappointing that avoidable errors of this sort appeared in the NATS TCN consultation.

Noise and related information

There was an unevenness in the nature and extent of the noise information to support the consultation. For example, where data regarding the number of movements expected along particular routes in the future is provided alongside some of the figures (*eg* Figure G3) it is unclear whether this represents an average mode value or a single (ie 100% westerly or 100% easterly) number.

Secondly, Parts E to I include maps indicating current and proposed aircraft heights. Tables are also given of the noise levels for the typical and noisiest aircraft at given heights for the various airports and routes (eg Table E2). Unfortunately, these tables give such a large range of noise levels at each range of altitude that the information that might be gleaned by the reader is very limited. For example, in Table E2, for a typical aircraft the L_{Amax} range at the 1000 to 2000 feet altitude is given as 65 to 80 dB(A), a 15dB range. This is a huge difference and really does not assist the reader in understanding the likely noise impact.

Thirdly, tables of "L_{max} equivalence" are given (*eg* Table H3). The examples of noise sources vary between road traffic vehicles and pneumatic drills at 23ft to the noise that might be experienced in busy or quiet offices. In the important middle range which is where lie the levels that will apply to many stakeholders affected by the proposals, from say 60 to 80 dB, only two examples are given, at 60 and 70 dB. In addition, it is stated that this (and the equivalent tables) should be read in conjunction with the L_{max} levels only. However, many of the examples refer to more continuous noise (eg the offices and the pneumatic drill) and only the road traffic vehicles are really relevant to the situation: where presumably the level quoted is the maximum that would be experienced should the vehicle pass by as described. It is fully recognised that *(a)* there is always a need for such contextual descriptions, and *(b)* how extremely difficult it is to provide them with any reliability. However, it is felt that the examples shown could have been improved upon. We have struggled to wonder why the vehicle pass-by distance is set at 23 feet!

Part C

Some general information is provided here. A few points are noted.

1. In Tables C2 and C3 we were not entirely clear about the definitions of the geographical area within which the stated populations fell.
2. In Tables C4 to C7, information about population exposure near the various airports is given. However, we were wondering why data on the numbers affected within the 60dB(A) and 63dB(A) contours were not shown. It is conventional when assessing air transport noise to look at the numbers within 3dB bands starting at 57dB(A). This omission seems strange.
3. On a related matter, given the extent of the potential impact of these changes, information in terms of the 54 dB(A) contour could have been provided. It is becoming increasingly common for this information to appear in impact assessment of aviation developments.
4. It is noted in Table C6 that there is an expected increase in the number of people exposed to more than 69dB $L_{Aeq,16h}$. As far as could be seen, there is no mention regarding the extent to which these people would be offered mitigation as implied in either paragraph 3.21 or paragraph 3.24 of the 2003 Air Transport White Paper. The IOA feels it is important that the public sees a consistent approach to policy regardless of the fact that there different organisations may be responsible. Out of interest, would it be the airports or NATS who fund any mitigation in these circumstances?
5. It is noted that in paragraph 4.5 in Part B, it is stated that below 4000ft the proposals attempt to minimise the overflying (and hence the noise impact) on sizeable population centres. However, paragraph 4.11 of Part C seems to explain that some routes within noise contours had to be changed 'to meet [P-RNAV] design criteria'. It seems that these are the changes that will produce the noise increases near airports, and will therefore contradict the implied desire to arrange flight paths below 4000 ft to minimise the noise impact on people. There is thus an inconsistency of approach.

Tranquillity

The Institute is acutely aware of the challenging dilemma that is increasing with regard to the effect of aircraft noise on people, and the effect on open spaces which are valued for their tranquillity or relative quiet. It is noted that the approach in this document follows the established guidance of avoiding overflying centres of population, the result being overflying generally more peaceful areas. The Institute would urge that whilst this is clearly the current policy, NATS (presumably in conjunction with CAA) should continue to explore how airspace management technologies could be used to address the problem.

General

On a related issue, we feel that the public's view regarding the balance between concentration (*ie* along NPRs) and broader distribution is changing, with a feeling that if we have to have aircraft noise, then the burden should be shared. Again, we would urge NATS to consider this point.

Meeting report: Central branch

David Watts. Consumer product testing at Intertek

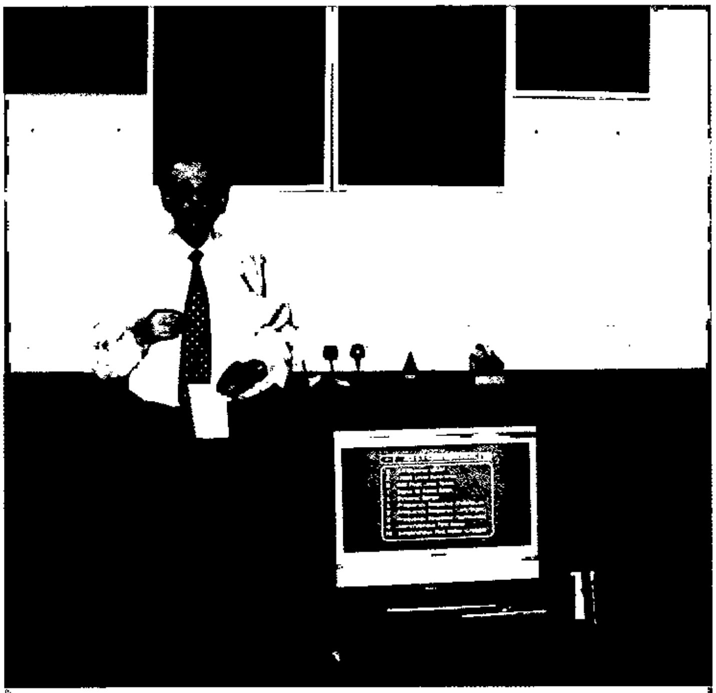
The Central Branch was treated on 1 April 2008 to an enjoyable talk and tour of the facilities at Intertek UK hosted by Roy Brooker, principal scientist and Natalie Pickering, technologist. Roy began by explaining Intertek's role providing consumer-focused product evaluations for consumer magazines, retailers, trading standards and sometimes for the manufacturer. This tends not to involve much in the way of testing against technical specifications, the emphasis being very much on evaluation rather than type testing against specific standards. Products are evaluated on the basis of the consumer perspective and the sorts of questions the consumer would ask, questions like 'Does it do what it says on the box?' and 'How does that product compare with this one?'. Roy suggested that the correct interpretation of 'How do I get a good review?' is 'How do I make my product consumer friendly?'!

All manner of products are evaluated at Intertek from corkscrews (requiring a lot of wine) to fridge freezers, from Christmas puddings to prams. The electronic products department is where Roy and Natalie are based evaluating the expected array of audio/visual paraphernalia and some less obvious offshoots such as bird-box cameras. Perhaps unsurprisingly, digital TV is the 'big thing' at the moment and Intertek is involved with providing consumer advice on the digital switchover as well as the product assessments. The subjective and objective testing encompasses sound and picture quality, ease of use, ease of understanding, features, interoperability, power consumption, safety, durability and styling. Test arrangements and patterns are developed in-house where necessary and viewing and/or listening panels are arranged according to the studies being undertaken. Extreme cases of some of the undesirable effects from which digital televisions can suffer were presented by Roy such as contouring colours, 'force fields' around people and 'mosquito' noise.

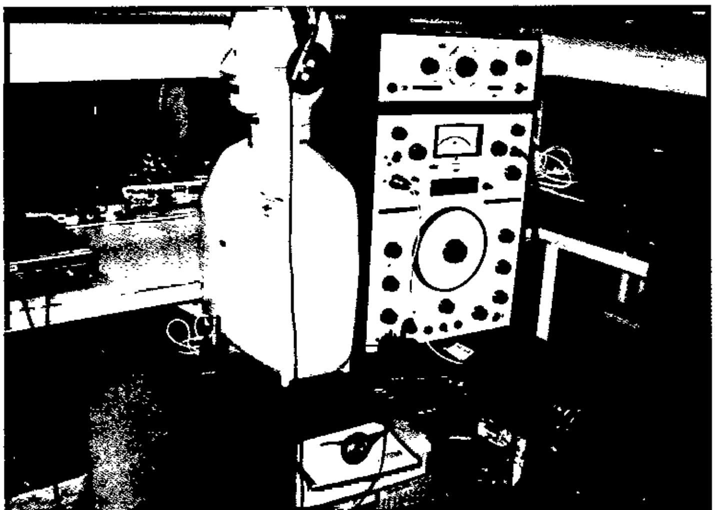
Natalie Pickering then took over to explain one area where highly prescriptive testing is undertaken, this being in relation to *The Noise Emission in the Environment by Equipment for use Outdoors Regulations*. Intertek is a Notified Body for these regulations which require a wide range of outdoor products to be measured, and around half of these must comply with specified noise level limits, the information being declared as part of the CE marking regime. Typically, the sound power level is determined according to ISO 3744 with the machine operated as specified in the regulations. The measurements are usually made outdoors over an appropriate surface with Intertek making use of the nearby Milton Keynes Bowl when necessary. Natalie explained that the ideal number of samples was five, and described the need to be innovative in developing gadgets to support machines under test.

The group was then shown round the facilities at Intertek and a flavour of what we saw can be seen from the photographs. The Central branch is very grateful to Roy and Natalie for hosting this enjoyable meeting.

David Watts FIOA



Roy in the listening room demonstrating test patterns for televisions



"Henry" and other instrumentation more readily recognisable to the group

Some of those who have burnt their breeches (or bridges?)

Don't ask!

Clean crockery

Hoarders' heaven!

Acoustics '08 conference in Paris

Gains good exposure for Euronoise 2009 in Edinburgh

A number of IOA members were among the 5,000 delegates that attended the second ASA-EAA joint conference Acoustics '08 which was held in the Palais des Congrès in Paris recently.

The meeting was organised by the Acoustical Society of America, **ASA**, the European Acoustics Association, **EAA**, and the Société Française d'Acoustique, **SFA**.

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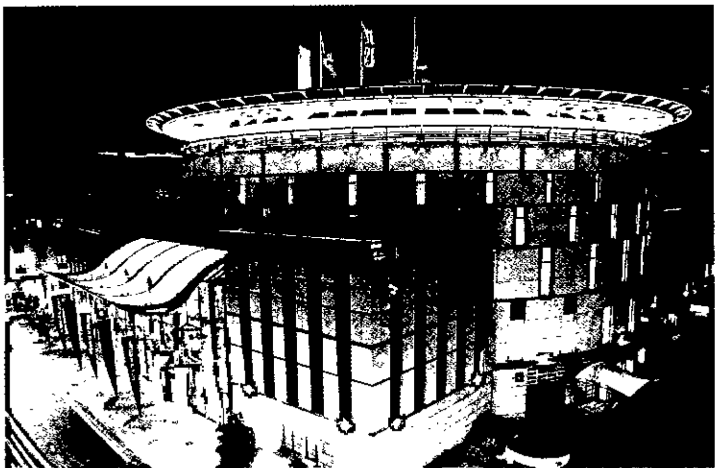
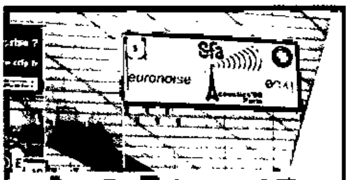
Four gold sponsors' logos



The Edinburgh venue

Antonio Perez-Lopez, Linda and Kevin Macan-Lind



Acoustics 08 signage outside Paris venue

More than 3500 presentations were delivered in 265 sessions (up to 25 sessions ran in parallel) which led to the record-breaking attendance figure. Two major European conferences were also integrated into the event: ***ecua***, the European Conference on Underwater Acoustics and ***euronoise***, the European Conference on Noise Control. Acoustics '08 also celebrated the sixtieth anniversary of the SFA.

Acoustics'08
Paris
June 29 - July 4, 2008

Acoustics 08 logo

KML on the IOA stand

The conference brought together experts from all fields of acoustics from around the world. In addition, there was a large exhibition of sixty participating organisations covering all areas of acoustics.

IOA Chief Executive Kevin Macan-Lind said that he was extremely grateful to the EAA for affording the Institute the opportunity of sharing their stand for the week at Acoustics '08 in order to promote participation at Euronoise in Edinburgh next year. It was an excellent forum to be able to encourage delegates to discover the delights of Edinburgh whilst attending this important conference. IOA President John Hinton OBE added that he was most impressed with the organisation and content of Acoustics'08 which, he understood, was the largest acoustics conference ever held attracting over 5,000 participants. In view of the size of the conference it was undoubtedly an unqualified success. Those members of the IOA's organising team for Euronoise 2009 who attended the event learnt some very useful lessons.

With a little over a year to go before Euronoise 2009, chairman of the organising committee, Bernard Berry said that significant progress was being made in the organisation of Euronoise 2009. Closer liaison had been established with the EAA and their various technical committees. This would help with the development of the technical programme. Invitations had gone out to the various session organisers, and there

continued on page 16

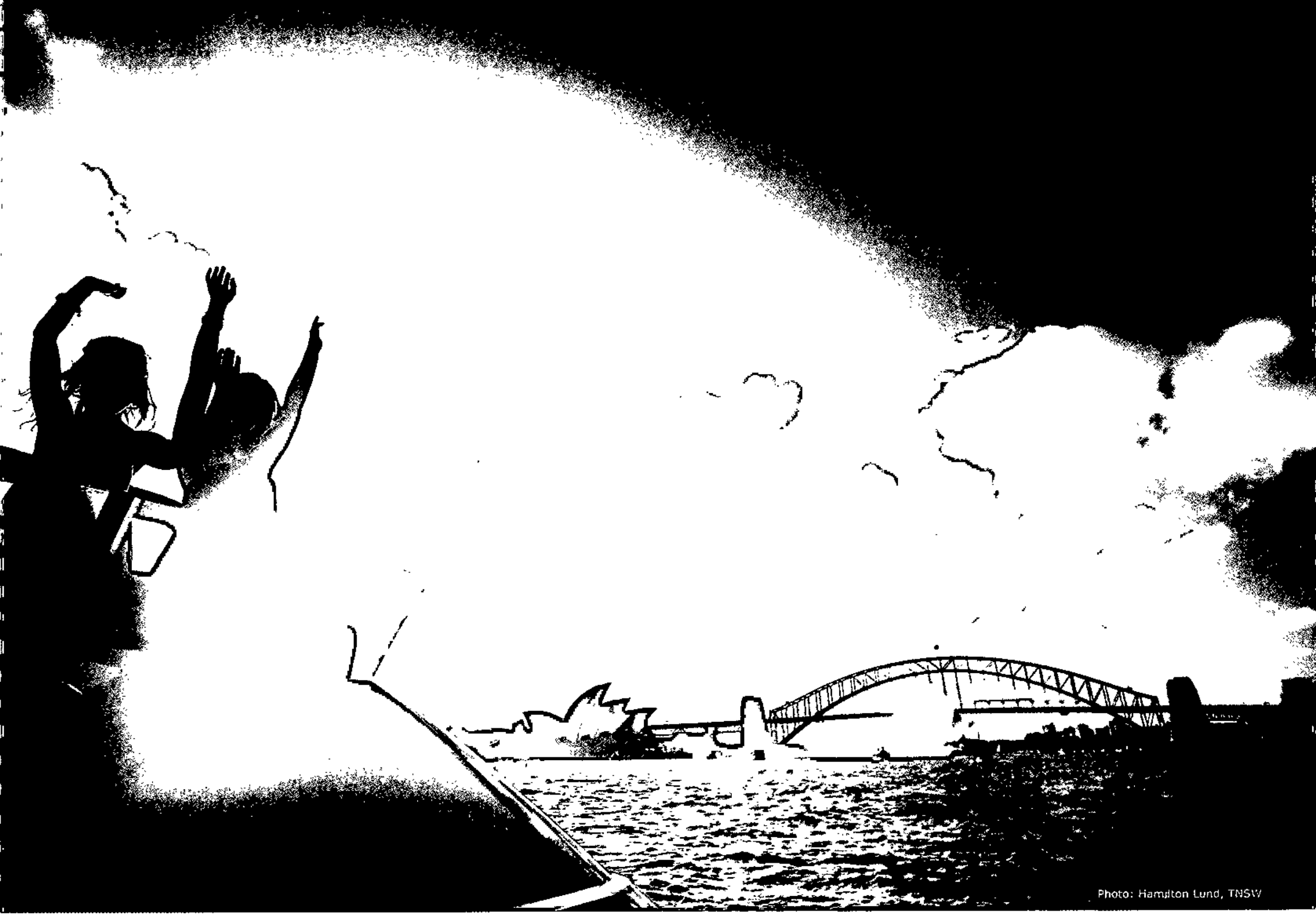


Photo: Hamilton Lund, TNSW

Next year's Euronoise conference... - *continued from page 14*

had already been a high positive response rate. A poster session was now also planned, which would, amongst more general topics, feature IOA Diploma projects, to mark the thirtieth anniversary of the Diploma. Bernard was pleased to have the chance to present a general invitation to Euronoise 2009 as part of the closing ceremony of Acoustics '08.

Luigi Maffei, John Hinton (President), KML

A number of sponsorship packages are available for organisations. Early sponsors to sign up include Brüel & Kjær, Casella CEL, Cirrus Research and Ecophon. Information about the benefits of sponsorship and the attendant exhibition are available from Kevin Macan-Lind, telephone **01727 848195** or email **kevin.macan-lind@ioa.org.uk.**

EAA logo

26-28 October 2009 • Edinburgh
EURONOISE 2009

Euronoise 2009

Meeting report: Midlands Branch

Kevin Howell. Sustainable acoustics

For its May evening meeting the Midlands branch returned to Scott Wilson's offices in Nottingham. Richard Greer of Arup Acoustics treated a large audience to a thought-provoking talk on sustainable acoustics and soundscape design.

Richard began by suggesting that the acoustics profession is still trying to determine exactly where it fits into the 'sustainability' agenda. This is not helped by the fact that there is still no real consensus on the meaning of sustainability. He described briefly the Sustainable Project Appraisal Routine (SPeAR), a tool developed and used at Arup. SPeAR focuses on the key elements of environmental protection, social equity, economic viability and efficient use of natural resources.

He went on to describe the significant challenges that the need for sustainable design presents to the process of acoustic design, particularly on inner-city brownfield sites. It is important to consider noise issues as early as possible in the design process. To reduce energy consumption there is a need to maximise the use of natural ventilation, which goes against the use of sealed glazing for sound insulation purposes. This presents a need to screen noise sensitive facades by the use of appropriate building design and layout, which can be evaluated using noise-mapping techniques, for example, the use of commercial developments to screen residential ones. However, single aspect design on noisy facades and long screening walls are generally now unpopular with planners and the police. He identified several ways of improving the effective sound insulation provided by an open window. Materials used for acoustic purposes should also satisfy sustainability criteria.

Soundscape design contributes to the sustainability agenda as it can be used to broaden the attractiveness of areas, particularly in cities. A great deal of work has been carried out on noise control issues but relatively little has been done on soundscape design, which can be considered analogous to landscape design and architectural urban design. It involves a critical evaluation of the existing or anticipated soundscape and then the application of noise control measures to unwanted sounds while preserving and protecting desirable soundscape characteristics. These may include the soundscape ecology (noise from flora and fauna) and keynote sound signatures, events and features. There may be certain 'sonic icons', for example in London the London taxi, the Routemaster bus and the sound of Big Ben. Soundmark horizons can be developed; for example, the distance over which Big Ben can be heard. Can the horizon be protected or extended? Water features can be used to mask traffic or heating and ventilation system noise. They can even be 'tuned' by choosing an appropriate surface for the water to fall onto.

Richard concluded his presentation by describing several interesting examples of soundscape design from Leeds, Rotterdam, Chicago and Sheffield, and then answered a number of probing questions. A small group then rounded off the evening with a meal at a nearby curry house.

Kevin Howell

Call for papers

ICSV16

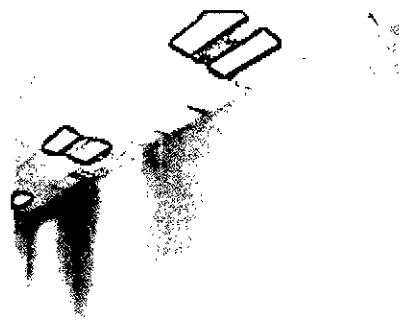
Following the successful ICSV08 event this July in Daejeon, Korea, Dr W S Gan wishes to announce that he is organising a structured session on nonlinear acoustics and vibration at the 16th International Congress on Sound and Vibration (ICSV16).

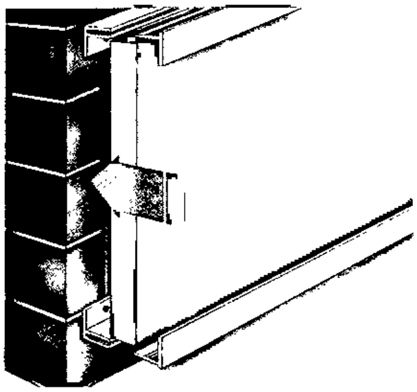
The congress will be held in Krakow, Poland, from 5 to 9 July 2009.

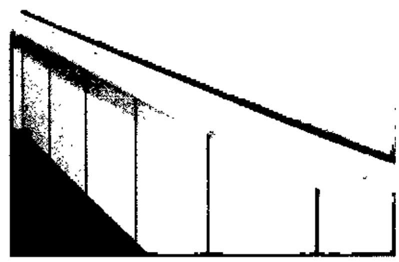
Abstracts (maximum 300 words) should be submitted by 1 December 2008 at the latest. Successful contributors will be notified on 28 February 2009, and the deadline for submission of full-length papers is 31 March 2009. The same deadline applies to early registrations for the congress.

Abstracts should be submitted by email or fax to Dr W S Gan: his email address is wsgan@acousticaltechnologies.com and his fax number is **+65 6791 3665.**

For further information and online registration please visit **www.icsv16.org**







Calling all Acoustical Engineers - Now hear this!

Peter Wheeler.

In the last five years, the Institute's Engineering Division has gone from strength to strength. Having operated under a bilateral agreement with the IMechE since the registration scheme started in 1989, the Institute was granted a licence in its own right for Chartered Engineer registration following an audit visit by the Engineering Council in 2004. We are widely recognised within the engineering community for the quality of our professional engineers and we play a part in the development of the profession with the Engineering Council (EC^{UK}) and the Engineering and Technology Board (ETB), including supporting several schools initiatives.

Our candidates come from a wide variety of professional backgrounds. Many are engaged in acoustics consultancy while some work in sectors of industry such as aerospace, automotive NVH refinement, electroacoustics, noise and vibration control, speech technology or underwater acoustics, and others are leading researchers and teachers in academia.

Engineering Council UK Register

The Engineering Council Register has three categories. These are Chartered Engineer (CEng), Incorporated Engineer (IEng), and Engineering Technician (EngTech). Applications made to the Institute for registration as CEng have grown steadily and the level of interest in IEng registration has also increased. We also expect the EngTech registration to prove popular with many of our Technician Members.

The concept of progression within these three categories of registration is being promoted by EC^{UK} so that professional engineers may transfer within the Register as their careers develop. We see a market opportunity for IEng registration among many of our younger graduate members, who can demonstrate they have acquired the relevant engineering competencies, although they have yet to gain experience in some of the leadership and innovation areas required for CEng registration.

Routes to registration

With fewer entrants to accredited engineering courses these days, and with the broad range of academic backgrounds of IOA members, many of our candidates for CEng or IEng follow what is known as the Individual Route to registration (as is also the case in several other branches of engineering). Standard Route candidates must hold a relevant accredited engineering degree such as the ISVR BEng/MEng Acoustical Engineering or the Salford BEng Electroacoustics degree course. For CEng registration, BEng level is accepted for candidates entering higher education before 1999 but MEng level is required thereafter. For IEng registration, a BEng level degree is now required but other qualifications were previously accepted (contact us for further information). Individual Route candidates, who may have a non-accredited degree or other qualification, must demonstrate that they have acquired the same level and breadth of knowledge and understanding of their field of acoustical engineering as a Standard Route candidate. They can do this by several means, such as by submission of a technical report or by gaining a further qualification

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Calling all Acoustical Engineers - *continued from page 17*

such as a Masters degree or, in part, by completing the Institute's Diploma in acoustics and noise control. We try to provide mentoring support to all candidates who require it.

What is involved?

Candidates have to prepare, and substantiate at a professional review interview with two peer Institute members, an account of their professional development and responsible experience, written in the context of a set of competencies set out by the Engineering Council in UK-SPEC and interpreted by the Institute for their particular field of acoustical engineering. Other supporting evidence of training and continuing professional development also needs to be provided.

Each year we receive around 100 expressions of interest from newly elected or promoted members and each request receives personal attention and advice throughout the application process. We can usually organise mentoring support if needed. We also promote registration within the larger consultancy practices by means of seminars. But only a relatively small proportion of these enquirers complete the registration process. Perhaps this is, in part, due to the fact that most candidates find themselves having to draw on ad hoc historical evidence rather than documented professional development records.

We will soon be able to offer candidates the option to prepare and record their professional development and competence statements online via a secure facility on the Institute's website. Candidates will be able to log on and update their evidence records as and when they wish and to ask for a preliminary review and personal advice. We hope that this new facility will make the task easier for members seeking registration. A similar process for membership applications is also under development to supplement the existing offline CPD recording option.

The success rate at professional review interview is better than 85%, although some candidates are asked to return for a second interview after gaining further professional experience over a period of around 9-12 months. Everyone who has taken up the offer of a second interview has been successful.

However, we could cope with even more demand from members seeking CEng or IEng registration and we would be keen to hear from Technician Members who might be interested in EngTech registration, which is awarded on the basis of a short written submission rather than an interview.

Are you already registered?

We also need help with our committee work, interviews and support to candidates. If you are already registered either through IOA or another institution and would like to play a part in our work please contact us at **acousticsengineering@ioa.org.uk**

Many of us belong to the IOA and one or more other institutions, through which our ECUK registration is held. If you are reviewing your professional memberships and you are currently registered through another institution, you can opt to transfer the ECUK registration to IOA, entirely at your discretion. Equally, if you are moving out of acoustics and you hold registration through IOA you can transfer your registration to CIBSE, ICE or any of the other 35 licensed institutions. To find out more, contact us at the email address above.

What comes next?

The question for you is whether, in your organisation, or in the areas that you may wish to work in the future, an internationally-recognised professional engineering qualification is of value. If you believe that it is and you wish to learn more about how to prepare an application based upon your personal qualifications and experience, may I suggest that you email **acousticsengineering@ioa.org.uk** with a short CV statement. We will then give you guidance based upon your individual circumstances.

Finally, let us blow our own trumpet! Here are our successful candidates over the past five years. You can read more about them in the next issue of Acoustics Bulletin.

Engineering Council registrations

Nicholas Antonio	Jeremy Butt
Rachel Canham	David Clarke
Stuart Colam	Stephen Elliott
Neil Ferguson	Mark Gaudet
Kelvin Griffiths	Simon Hancock
Gregory Hassell	Ian Hooper
Kirill Horoshenkov	Rodney Ip
Sebastien Jouan	Jian Kang
Andrew Lambert	Adam Lawrence
Timothy Leighton	Alistair Meachin
Samuel Miller	Carole Murray
Donald Oeters	Richard Pamley
Andrew Parkin	Adrian Passmore
Reuben Peckham	Richard Perkins
Adrian Popplewell	Bernard Postlethwaite
Sarah Radcliffe	Amanda Robinson
Craig Simpson	Michael Swanwick
Simon Stephenson	Peter Watkinson
Richard Watson	Jo Webb
Edward Weston	Caroline Williamson
Keith Woodburn	

Peter Wheeler CEng HonFIOA FIEE was President of the Institute for 1992-94 and, until 1998, was Professor of Applied Acoustics and Pro-Vice-Chancellor of Salford University. He now serves the Institute on a part-time basis as Engineering Advisor.

For further information about engineering registration or how, as a registered engineer, you can support the work of the Engineering Division please contact us at **acousticsengineering@ioa.org.uk**

Are you fit for work?

As the UK's professional body for acousticians, IOA sets standards for the education, training and competence of those seeking membership. In the increasingly litigious world in which we practice as acousticians, it is important that we keep up to date with both regulatory and metrological developments. In other words - are you using the right measurement protocol? Is your instrumentation calibrated? Are your measured data reliable?

The IOA Membership committee expects to see detailed evidence of competence and commitment to CPD in applications for membership and upgrades. Guidance is provided on our website at www.ioa.org.uk

Introduction to the acoustics of ducts, resonators and silencers

Matthew Hopley.

Introduction

Acoustic resonators and silencers are used for noise control in rooms, air conditioning systems and intake and exhaust systems on internal combustion engines. Tuning resonators is generally not well understood and is sometimes regarded a 'black art'. Formulas for resonators are difficult to find except for the Helmholtz resonator. This article describes the acoustics of basic duct elements and resonators using their acoustic impedances, and explains how these elements can be combined simply using hand calculations to predict the basic low-frequency acoustic behaviour of much more complicated acoustic systems. The models herein are one dimensional and lumped parameter models: one dimensional models require that all the dimensions of the silencers or resonators except those in the direction of propagation are much less than a wavelength. Lumped parameter models require that all the dimensions in all three axes are much less than a wavelength, and these requirements set an upper frequency limit to the accuracy of predictions using the method. If the acoustical wavelength is at least ten times the linear dimensions of a duct or expansion chamber then very accurate predictions are possible, and it is this condition which sets the upper frequency limit of these methods. If the condition is not met, wave effects will reduce the accuracy of the model because one dimensional methods do not predict the cross modes effects of wave motion, and lumped parameter methods do not predict wave effects at all.

Acoustic impedance

The acoustic impedance Z inside a duct is the ratio of acoustic pressure to volume velocity, where volume velocity is the particle velocity divided by the duct cross sectional area. The input acoustic impedance of a duct is the impedance at the start of a duct and is a very useful quantity. By combining the input impedances of several simple duct elements the behaviour of a much more complicated silencer can be predicted. The input impedance is given by $Z_0 = R + jX_0$, where R is a resistance term and X_0 is the reactive input impedance. In the following analysis the resistive part is ignored to simplify the mathematics. The resistive part only affects the magnitude of the attenuation at resonances and anti-resonances so this is not a problem. The object of tuning a resonator or silencer is usually to determine the resonant frequency.

Pipe end corrections

The effective acoustic length L_{eff} of a duct is a little longer than the physical length of the duct, because the pipe end corrections of the duct account for the radiation impedance at the ends. In the low frequency limit the end correction is 0.85r where r is the duct radius for an open-ended duct terminating in a baffle, and 0.6r for an unbaffled duct. The end correction is applied at both open ends of a duct, so the acoustic length L_{eff} of a duct which is unbaffled at both ends is $L_{eff} = L + 1.2r$ where L is the physical length of a pipe. $L_{eff} = L + 0.6r$ if the duct is closed at one end. In the following formulas the 'length' used is always the effective acoustic length, therefore the end corrections must be accounted for as appropriate.

Speed of sound

The speed of sound in a gas is proportional to the temperature of the gas and is given by

$$c = 20\sqrt{t+273} \quad ms^{-1}$$

where t is the temperature (°C). The effect of temperature on the speed of sound is to change the resonant frequencies of ducts and resonators.

Resonance and acoustic impedance of a duct open at both ends

The acoustic resonance of a duct is due to the interference of acoustic waves travelling in both the positive and negative directions axially along the duct. If a positive pressure pulse (compressive wave) travels along a duct from left to right as shown in Figure 1 (upper diagram), then when it reaches the right-hand side of the duct its momentum carries the molecules of gas slightly beyond the end of the duct. Because the impedance of the atmosphere is much lower, some of the molecules are lost to atmosphere and a suction (rarefaction) is created at the right-hand end of the duct, the rarefaction propagates in the opposite direction to the original wave and is in antiphase (180° out of phase) with the original wave. The interference of the original incoming and reflected waves create standing waves at the resonant frequencies. The standing wave mode shapes for the first three harmonics are shown in Figure 1 (lower). At these frequencies the duct vibrates naturally and the generation of sound is very efficient. This is good news if the duct forms part of a musical instrument, but not so good if the duct forms part of a silencing system of some kind.

The input reactive impedance X_0 of a duct open at both ends as shown in Figure 1 (upper) is

$$X_0 = \frac{\rho c}{S}\tan\left(\frac{2\pi f L_{eff}}{c}\right) \quad [1]$$

continued on page 20

Introduction to the acoustics of ducts... - continued from page 19

Where L_{eff} is the effective acoustic length in m, ρ is the density in kgm^{-3} and S is the duct cross-sectional area in m^2. Resonance occurs when the input reactive impedance X_0 is equal to zero. This condition determines the formula for the resonant frequencies of a duct open at both ends, that is

$$f_n = \frac{nc}{2L_{eff}} \quad \text{(Hz)} \qquad n = 1, 2, 3 \ldots,$$

The resonant frequencies occur at the natural frequency called the first harmonic, and even and odd integer multiples of the first harmonic. From the above formula the natural frequencies or first, second and third harmonics are given by $F_1=c/2L_{eff}$, $F_2=c/L_{eff}$ and $F_3=3c/2L_{eff}$. At a distance equal to the end correction past each end of the duct a pressure node exists for all harmonics, and the particle velocity is 90° out of phase with the acoustic pressure. Therefore particle velocity antinodes exist at the ends of the duct.

Low frequency lumped parameter approximation

When the length of a duct is much less than a wavelength, approximations can be used to simplify the expressions for the input impedances of duct elements. Using the long wavelength approximation for small argument that $\tan(2\pi fL/c) \approx 2\pi fL/c$ (note $f=c/\lambda$, so in the long wavelength limit L/λ is small and the approximation holds), the expression for the input reactive impedance of a pipe open both ends is

$$X_I = 2\pi f . \frac{\rho L_{eff}}{S} \qquad [1a]$$

or $X_I=2\pi f.I$ where I is the acoustic inertance and is given by $I=\rho L/S$. The acoustic inertance is analogous to an electrical inductance in an AC electrical circuit. This representation is called a lumped parameter model and is useful for understanding the low frequency interactions between several ducts as will be shown. The lumped parameter model does not predict the standing waves in ducts so this sets an upper frequency limit to the accuracy of predictions.

Resonance and acoustic impedance of a duct closed at one end

The duct shown in Figure 2 (upper), is closed at the right hand side with a stiff termination. When an incoming positive pressure pulse travelling from left to right reaches the right-hand side of the duct, it is reflected as a positive pressure pulse (in phase with the original wave) which propagates from right to left. The interference of the original incoming and reflected waves creates the standing wave patterns shown in Figure 2 (lower).

The input reactive impedance of a duct closed at one end as shown in Figure 2 (upper) is

$$X_0 = -\frac{\rho c}{S\tan\left(\frac{2\pi fL_{eff}}{c}\right)} \qquad [2]$$

Resonance occurs when the reactive impedance is equal to zero, and this determines the resonant frequencies of a pipe closed at one end. These are given by

$$f_n = \frac{(2n+1)c}{4L_{eff}} \quad \text{(Hz)} \qquad n = 0, 1, 2, 3 \ldots$$

The duct closed at one end can only sustain odd integer multiples of the natural frequency. The natural frequency or first, second and third harmonics are given by $F_1=c/4L_{eff}$, $F_2=3c/4L_{eff}$ and $F_3=5c/4L_{eff}$. At a distance equal to the end correction past the left-hand end of the duct a pressure node exists, and at the right-hand end a particle velocity node exists. The particle velocity is again 90° out of phase with the acoustic pressure, so at the closed end a pressure antinode exists.

Low frequency approximation

Using the long wavelength approximation for the tan function on the

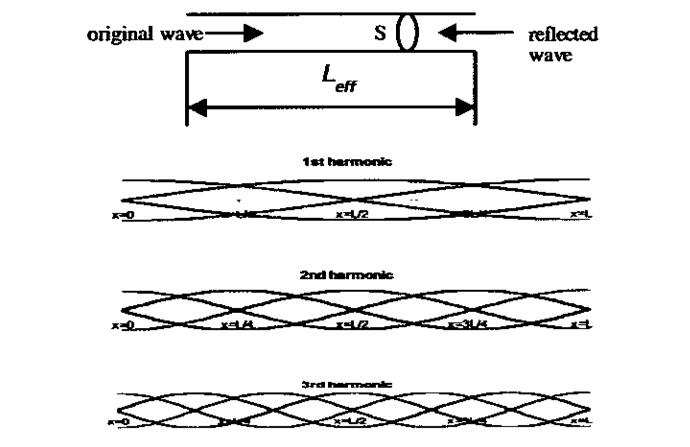

Figure 01

(upper)– duct open at both ends, (lower) – mode shapes of first three harmonics of a duct open at both ends. Black line – acoustic pressure mode, red line – acoustic particle velocity mode.

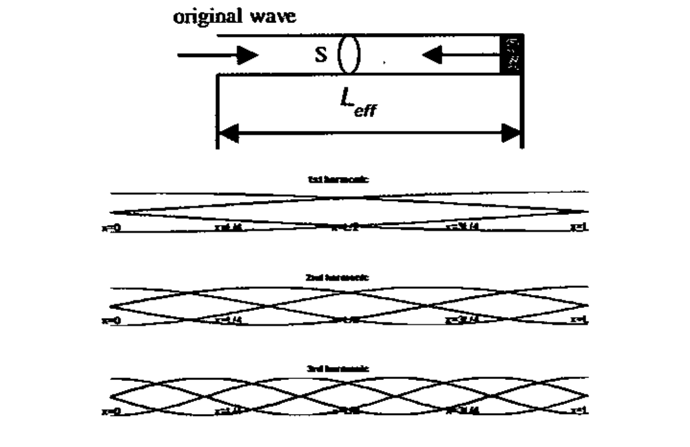

Figure 02

(upper) – duct closed at one end, (lower) - Mode shapes of first three harmonics of open-closed ended duct (duct is closed at the right hand side). Black line – acoustic pressure mode, red line – acoustic particle velocity mode.

expression for the duct closed at one end given by [2], the input impedance becomes $X_0=\rho c^2/(2\pi fSL_{eff})$. However, SL is the volume V of the duct element, so the input reactive impedance of the duct closed at one end becomes

$$X_C = -\frac{1}{2\pi f}.\frac{\rho c^2}{V} \qquad [2a]$$

or $X_c = -1/(2\pi fc)$ where C is the acoustic compliance and is given by $C=V/\rho c^2$. The acoustic compliance is analogous to the electrical capacitance in an AC circuit. The low frequency input impedance is suitable for modelling a closed chamber such as in Helmholtz resonator, and for modelling an expansion chamber in the low frequency limit when the dimensions of the chamber are much less than a wavelength.

Transmission loss of a duct or silencer

The transmission loss (TL) is a measure of the acoustic performance of a duct element or silencer, and is independent of the length of the ducts either side of the element. The larger the magnitude of the

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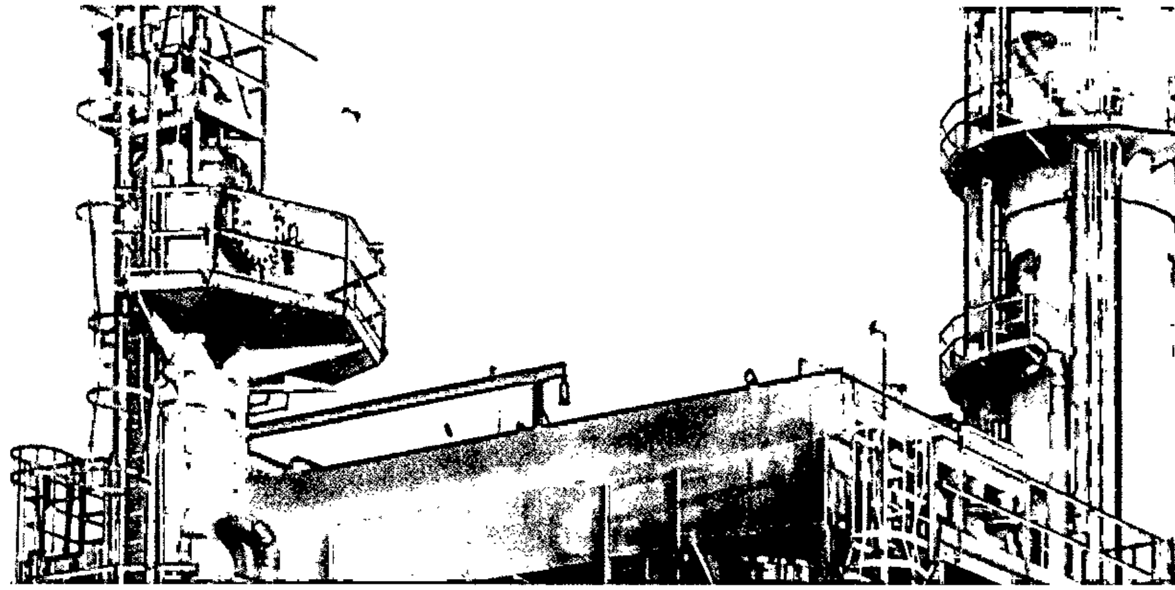

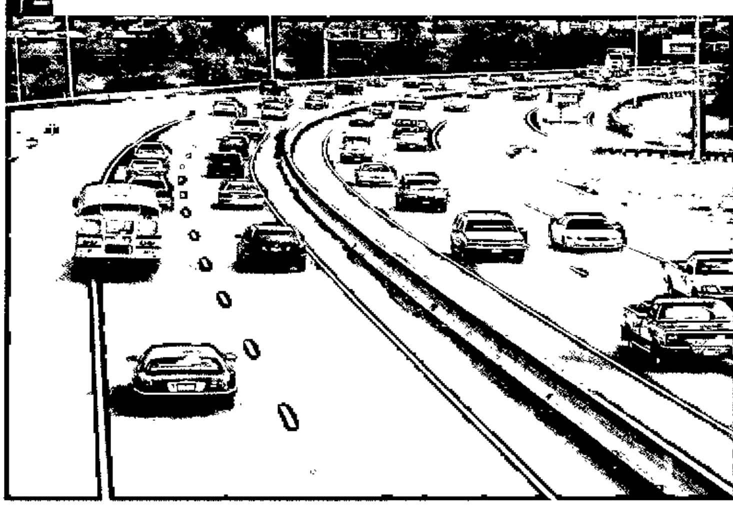

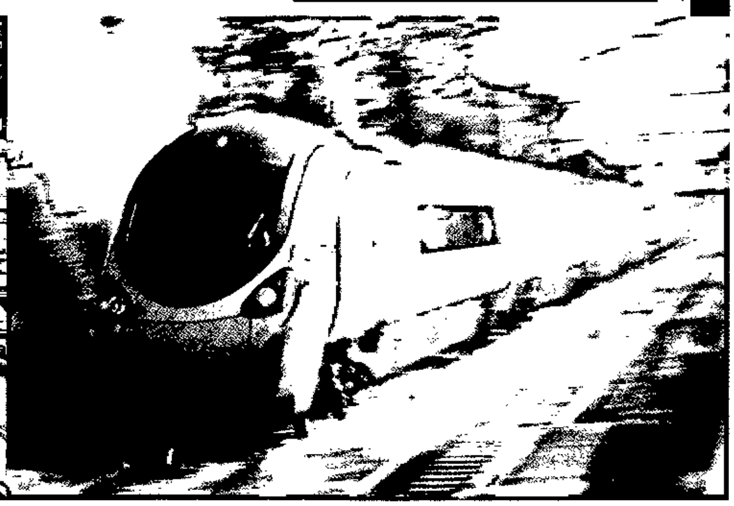

Introduction to the acoustics of ducts... - *continued from page 20*

transmission loss the more it attenuates the incident sound waves. The transmission loss of a side branch resonator (without acoustic damping term) which is attached to a duct of area A is given by

$$TL = 10\log_{10}\left[1+\left(\frac{\rho c}{2AX_{branch}}\right)^2\right] \qquad \text{(dB)} \quad [3]$$

Where X_{branch} is the reactive impedance of the side branch. A side branch resonator does not have to *look* like a side branch off the main duct as a quarter-wave or Helmholtz resonator could. The name is used because in the acoustic circuit of a side branch resonator the impedance of the resonator or duct element is shown as a side branch. In the acoustic circuit the side branch acts like a shunt impedance, and at resonance the reactive part of the shunt impedance goes to zero. The acoustic energy at that frequency goes down the side branch and is reflected back towards the noise source in antiphase, reducing the sound level at the resonant frequency by destructive interference. In the following examples an acoustic circuit is shown for each resonator or silencer, and this makes it easier to understand how the silencer works in the low frequency limit. How the constituent ducts and volumes behave as impedance elements in parallel or series will become clear in the examples.

Combining duct elements

The duct elements and their associated acoustic impedance representation in the acoustic circuits are combined either in series or parallel to obtain a total impedance X_{branch} for the side branch. The side branch impedance X_{branch} can then be used to calculate the transmission loss and resonant frequency of the resonator or silencer. The rules for combining the acoustic impedances are given by

Combination of elements in series

$$\sum X_{total} = X_1+X_2+X_3+...+X_n \quad [4]$$

Combination of elements in parallel

$$\frac{1}{\sum X_{total}} = \frac{1}{X_1}+\frac{1}{X_2}+\frac{1}{X_3}+...+\frac{1}{X_n} \quad [5]$$

The quarter-wave resonator

The quarter-wave resonator shown in Figure 3 (upper), consists of a pipe closed at its end and branching off the main duct. The main duct is of area A, and the quarter-wave resonator is of effective acoustic length L_{eff} and area S. The noise source and quarter wave resonator are represented by the acoustic circuit in Figure 3 (lower). The noise source has acoustic impedance Z_s (analogous to the source voltage in an AC circuit), the section of duct upstream of the resonator has impedance X_{up}, and the section of duct downstream combined with the orifice radiation impedance has impedance X_{down}. The quarter-wave resonator which is a side branch (analogous to a shunt impedance in an electrical circuit) has impedance X_{branch}.

The acoustic impedance of the side branch is the impedance given for a duct closed at one end given by [2]. Substituting the impedance of a duct closed at one end [2] into the expression for the transmission loss of a side branch resonator [3] gives the transmission loss of the quarter-wave resonator

$$TL = 10\log_{10}\left[1+\left(\frac{S\tan(2\pi f L_{eff}/c)}{2A}\right)^2\right]$$

The predicted transmission loss of the quarter-wave resonator is shown in Figure 4. The peak in the transmission loss is at the resonant frequency, which occurs when the acoustic impedance of the side branch goes to zero, *ie* when X_0 equals zero. Therefore the resonant frequency of the quarter-wave resonator is given by

$$f = \frac{c}{4L_{eff}} \qquad \text{(Hz)}$$

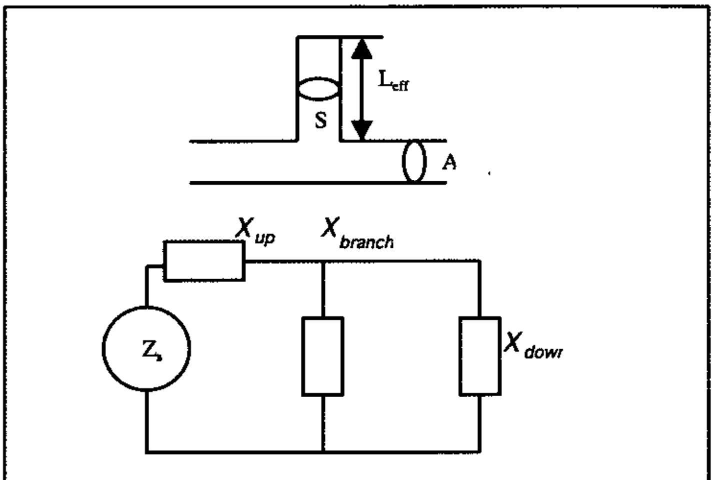

Figure 03

A quarter wave resonator and its equivalent acoustic circuit.

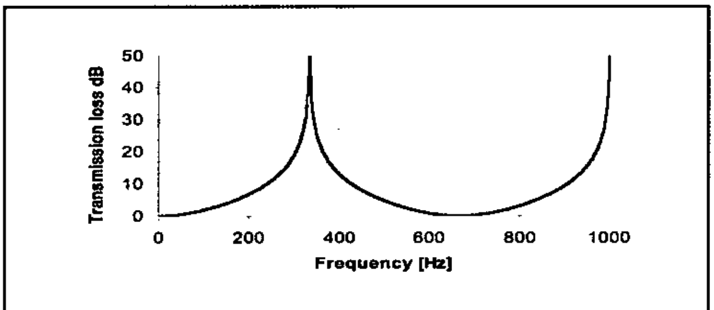

Figure 04

Predicted transmission loss of quarter-wave resonator

The Helmholtz resonator

The Helmholtz resonator is commonly used to achieve a high level of attenuation over a relatively small frequency range in the low-frequency region. The resonator consists of a neck of effective acoustic length L_{eff} and area S leading to a closed volume V as shown in Figure 5 (upper). When a sound field containing a frequency equal to the resonant frequency is incident on the resonator, large particle velocity oscillations are induced in the neck. Sound waves at the resonant frequency are then emitted from the neck which are 180° out of phase with the incoming sound field. This destructive interference reduces the amplitude of the incoming sound field at and around the resonant frequency. The resonator neck has an inertance I and the volume has a compliance C. These components are shown in series in the side branch of the acoustic circuit in Figure 5 (lower).

The input reactive impedances of the neck [1a] and the volume [2a] using the lumped parameter approximations, are combined in series [4] giving the reactive impedance of the Helmholtz resonator as follows

The transmission loss of the resonator is obtained by substituting the reactive impedance of the Helmholtz resonator X_{branch} into [3], giving

The $X_{branch} = \rho\left(\frac{2\pi f L_{eff}}{S} - \frac{c^2}{2\pi f V}\right)$

predicted transmission loss of the Helmholtz resonator is shown in

$$TL = 10\log_{10}\left[1+\left(c\Big/2A\left(\frac{2\pi f L_{eff}}{S}-\frac{c^2}{2\pi f V}\right)\right)^2\right]$$

Figure 6. The peak in transmission loss is at the resonant frequency, which occurs when the reactive impedance of the Helmholtz

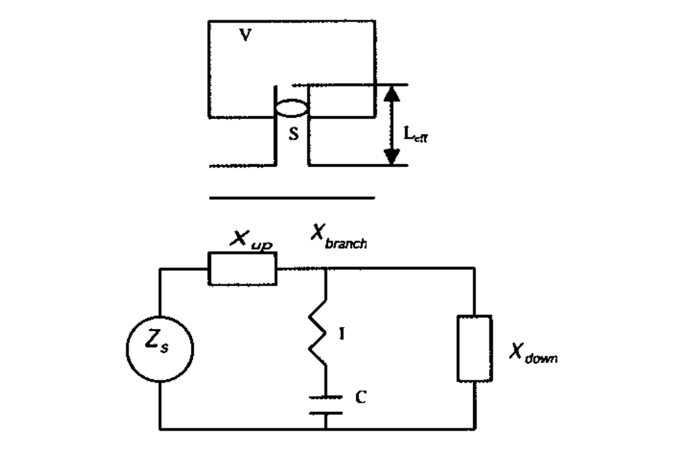

Figure 05

A Helmholtz resonator and its equivalent acoustic circuit

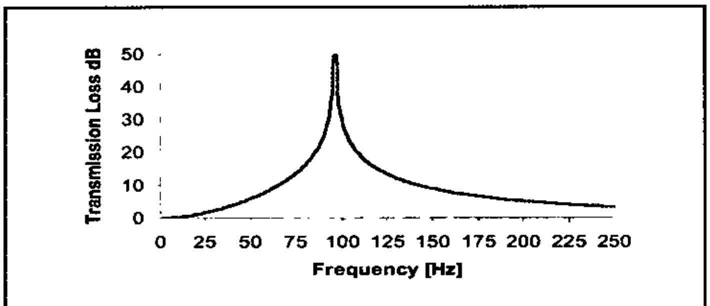

Figure 06

Predicted transmission loss of a Helmholtz resonator

resonator X_{branch} is equal to zero. This gives the formula for the Helmholtz resonator

$$f = \frac{c}{2\pi}\sqrt{\frac{S}{L_{eff}V}} \quad \text{(Hz)}$$

The double resonator

The resonator in Figure 7 (upper), is a composite resonator consisting of two necks and two volumes. When a sound field is incident on the resonator it is excited at two resonant frequencies f_1 and f_2, therefore offering more tuning than the single frequency Helmholtz resonator. The resonant frequencies are coupled so that the frequency of one affects the frequency of the other. A dip in attenuation is also introduced, which is the trough in the transmission loss curve between the two peaks in Figure 8.

The volumes V_1 and V_2 have acoustic compliances C_1 and C_2, and the necks 1 and 2 have acoustic inertances I_1 and I_2. These are combined in the acoustic circuit in Figure 7 (lower) as shown, making a single side branch composed of the individual elements in series and parallel.

The transmission loss in decibels of the double resonator (which is derived in the appendix) is given by

$$TL = 10\log_{10}\left[1+\left\{c\Bigg/\left(2A\left(\frac{2\pi f L_{eff1}}{S_1}+1\Bigg/\left(\frac{1}{\frac{2\pi f L_{eff2}}{S_2}-\frac{c^2}{2\pi f V_2}}-\frac{2\pi f V_1}{c^2}\right)\right)\right)\right\}^2\right]$$

continued on page 24

Introduction to the acoustics of ducts... - *continued from page 23*

and the two coupled tuning frequencies are given by f_1 and f_2.

$$f_1 = \frac{\sqrt{\left(\frac{S_1S_2c^2\left(\frac{L_{eff1}}{S_1}(V_1+V_2)+\frac{L_{eff2}V_2}{S_2}\right)}{L_{eff1}L_{eff2}V_1V_2}\right)+\sqrt{\left(\frac{S_1S_2c^2\left(\frac{L_{eff1}}{S_1}(V_1+V_2)\right)}{L_{eff1}L_{eff2}V_1V_2}\right)^2-\frac{4S_1S_2c^4}{L_{eff1}L_{eff2}V_1V_2}}}}{2\sqrt{2}\pi}$$

$$f_2 = \frac{\sqrt{\left(\frac{S_1S_2c^2\left(\frac{L_{eff1}}{S_1}(V_1+V_2)+\frac{L_{eff2}V_2}{S_2}\right)}{L_{eff1}L_{eff2}V_1V_2}\right)-\sqrt{\left(\frac{S_1S_2c^2\left(\frac{L_{eff1}}{S_1}(V_1+V_2)\right)}{L_{eff1}L_{eff2}V_1V_2}\right)^2-\frac{4S_1S_2c^4}{L_{eff1}L_{eff2}V_1V_2}}}}{2\sqrt{2}\pi}$$

A silencer containing an expansion chamber and a double resonator was tested on a transmission loss rig using a four-microphone technique, and the transmission loss of the silencer was also predicted using a lumped parameter model. The correlation between the measured and predicted transmission loss of the silencer containing a double resonator is shown in Figure 8. The correlation is extremely good in the low frequency limit. The graph of the transmission loss has two peaks and two dips, but the higher frequency dip is not due to the double resonator but rather to an interaction between the double resonator and an additional expansion chamber inside the silencer tested.

Triple pass silencer

The triple pass silencer in Figure 9 (upper), is commonly used to control noise from internal combustion engines on motor vehicles. The silencer consists of three internal pipes with a perforated centre section, and two baffles which divide the silencer into three chambers. If the porosity is quite high (>10%), the perforate section is acoustically transparent at low frequencies and can be ignored (for the purpose of modelling the silencer's low-frequency behaviour). The silencer acts as though it has a double necked Helmholtz resonator either end and an expansion chamber in the centre. The chambers have volumes V_1, V_2 and V_3. The necks either side have areas S and effective acoustic lengths L_{eff} with the subscripts identifying the particular necks 1 to 4. Necks 1 and 2 have acoustic inertances l_1 and l_2 which are in parallel in the acoustic circuit, as are necks 3 and 4 which have acoustic inertances l_3 and l_4. The end chamber volume V_1 with acoustic compliance C_1 is in series with the inertances l_1 and l_2 of necks 1 and 2. The end chamber volume V_3 with acoustic compliance C_3 is in series with the inertances l_3 and l_4 of necks 3 and 4. The volume of the central expansion chamber V_2 has acoustic compliance C_2. The inlet and outlet ducts of the silencer both have area A.

The transmission loss in decibels of the triple pass silencer (which is derived in the appendix) is given by

$$TL = 10\log_{10}\left[1+\left(\frac{c}{2A}\right)^2\left(\frac{1}{\left(\frac{2\pi f}{\frac{S_1}{L_{eff1}}+\frac{S_2}{L_{eff2}}}-\frac{c^2}{2\pi f V_1}\right)}+\frac{1}{\left(\frac{2\pi f}{\frac{S_3}{L_{eff3}}+\frac{S_4}{L_{eff4}}}-\frac{c^2}{2\pi f V_3}\right)}-\frac{2\pi f V_2}{c^2}\right)^2\right]$$

A triple pass silencer silencer was tested on the four microphone transmission loss rig and the measured result was compared with the predicted transmission loss given above. The results are shown in Figure 10. The transmission loss has two peaks and two dips. The peaks in attenuation are the tuned frequencies of the end chambers and are given by two independent tuned frequencies in Hertz given by f_1 and f_2. The dips are caused by the interaction between the end chambers and the centre chamber.

$$f_1 = \frac{c}{2\pi}\sqrt{\left(\frac{S_1}{L_{eff1}}+\frac{S_2}{L_{eff2}}\right)\Big/V_1} \qquad f_2 = \frac{c}{2\pi}\sqrt{\left(\frac{S_3}{L_{eff3}}+\frac{S_4}{L_{eff4}}\right)\Big/V_3}$$

If the necks going into an end chamber are identical, the tuned frequency is simplified and is given by

$$f = \frac{c}{2\pi}\sqrt{\frac{2S}{L_{eff}V}} \quad \text{(Hz)}$$

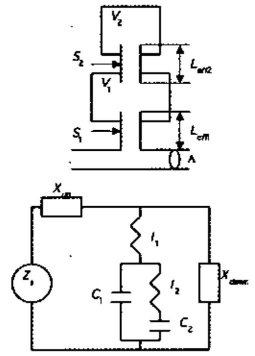

Figure 07

A double resonator and its equivalent acoustic circuit.

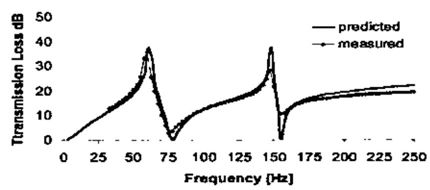

Figure 08

Predicted and measured transmission loss of a double resonator.

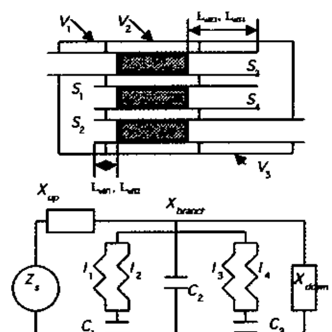

Figure 09

A triple pass silencer and its equivalent acoustic circuit.

This expression is of the same form as the tuned frequency of the standard Helmholtz resonator except that the neck area is doubled, showing how the end chambers are essentially double-necked Helmholtz resonators but with flow through the necks.

Effects of flow

The effect of flow in duct acoustics has two important effects, the more dramatic being that the flow adds significant damping. This greatly reduces the attenuation of side branch resonators with a flow through the side branch. The second effect is that the flow reduces the resonance frequency slightly. In a duct with a mean flow velocity v (ms^{-1}) the acoustic waves moving with the flow

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Introduction to the acoustics of ducts... - *continued from page 24*

have a velocity (c+v) and the waves moving against the flow have a velocity (c-v) where c is the speed of sound. A commonly used ratio in flow duct acoustics is the Mach number M, which is the ratio of the mean flow velocity in a duct to the speed of sound. The Mach number is given by M = v/c. The input reactive impedance of a duct with flow is given by

$$X_0 = \frac{\rho c}{S}\tan\left(\frac{2\pi f L_{eff}}{c\left(1-M^2\right)}\right)$$

The resonant frequency of the duct occurs when the reactive impedance goes to zero, which gives the resonant frequency of the duct

$$F_0 = \frac{c}{2L_{eff}}\left(1-M^2\right) \quad \text{(Hz)}$$

When there is no mean flow in the duct the Mach number is zero, and the resonant frequency of the duct is $F_0=c/(2L)$ which is the result given at the beginning of the article. The resonant frequency of a Helmholtz resonator with a mean flow through the neck is

$$F_0 = \frac{c}{2\pi}\sqrt{\frac{S\left(1-M^2\right)}{L_{eff}V}} \quad \text{(Hz)}$$

If there is no mean flow, the Mach number is zero and the result is that of a standard Helmholtz resonator. The predicted transmission loss of a Helmholtz resonator with flow is shown in Figure 11, as predicted using a similar analysis, but including the acoustic resistance term R in the acoustic impedance $Z_0 = R + jX_0$. This shows that even relatively small amounts of flow greatly reduce the peak attenuation.

Conclusion

The acoustic behaviour of ducts can be modelled using one dimensional and lumped parameter models, using expressions describing the acoustic impedance of duct elements. This gives a method for modelling relatively complicated resonators and silencers by deconstructing the silencers into their constituent acoustical duct elements. These elements are represented using an equivalent acoustic circuit which enables the resonant behaviour of the whole system to be predicted. The transmission loss of two predicted models correlated well with test data within the low frequency limits of 250Hz (in this case). This shows the usefulness of the method for predicting the low-frequency behaviour of acoustic ducts and silencers.

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Appendix

Derivation of transmission loss and resonant frequency equations of the double resonator

To derive the resonant frequency and transmission loss of the double resonator, the input reactive impedance of the total side branch (X_{branch} in the acoustic circuit in Figure 7) must be calculated. This is done by combining the impedances of the side branch in series and parallel as shown in the acoustic circuit using the relations given by [4] and [5] as follows.

The reactive impedances of the second neck and the volume V_2 are $X_{l2} = 2\pi f l_2$ and $X_{C2} = -1/(2\pi f C_1)$. Combining these in series using [4] gives

$$X_2 = 2\pi f l_2 - \frac{1}{2\pi f C_2}$$

The reactive impedance of the volume V_1 is given by $X_{C1} = -1/(2\pi f C_1)$. This is in parallel with the impedance of the branch X_2. Combining the impedances of the two branches X2 and XC1 in parallel using [5] gives

$$X = \frac{1}{\dfrac{1}{2\pi f l_2 - 1/(2\pi f C_2)} - 2\pi f C_1}$$

The reactive impedance of the first neck is $X_{l1} = 2\pi f l_1$. This is in series with the impedance of the branch X. Combining these in series using [4] gives the reactive impedance of the total side branch X_{branch}

$$X_{branch} = 2\pi f l_1 - \frac{1}{\left(\dfrac{1}{2\pi f l_2 - 1/(2\pi f C_2)} - 2\pi f C_1\right)}$$

Rewriting using the appropriate dimensions for the inertances of the ducts and compliances of the volumes gives

$$X_{branch} = \rho\left[2\pi f\frac{L_1}{S_1} - 1\Bigg/\left(\frac{1}{2\pi f\dfrac{L_2}{S_2} - \dfrac{c^2}{2\pi f V_2}} - \frac{2\pi f V_1}{c^2}\right)\right]$$

The reactive input impedance of the side branch X_{branch} above can now be used to predict the transmission loss and resonant frequencies of the double resonator. The transmission loss of the double resonator is obtained by substituting the impedance of the side branch X_{branch} into [3], giving the transmission loss of the double resonator in the main text. Resonance occurs when the reactive impedance of the side branch X_{branch} is equal to zero, this gives the two resonant frequencies of the double resonator f_1 and f_2 given in the text.

Derivation of transmission loss and resonant frequency equations of the triple pass silencer

Referring to Figure 9 the reactive impedances of the first and second necks are given by $X_1=2\pi f l_1$ and $X_2=2\pi f l_2$; combining these in parallel using [5] gives the combined impedance of the necks

$$X_{necks1+2} = \frac{2\pi f}{\left(\dfrac{1}{l_1}+\dfrac{1}{l_2}\right)}$$

The reactive impedance of the volume V_1 is $X_{C1} = -1/(2\pi f C_1)$. This is combined in series with the impedance of the necks using [4] which gives the reactive impedance of the left hand side flow reversal chamber. Using dimensions this is given by

$$X_{LHS} = \frac{2\pi f\rho}{\left(\dfrac{S_1}{L_{eff1}}+\dfrac{S_2}{L_{eff2}}\right)} - \frac{\left(\rho c^2\right)}{2\pi f V_1}$$

Similarly the impedance of the right hand side flow reversal chamber is given by

$$X_{RHS} = \frac{2\pi f\rho}{\left(\dfrac{S_3}{L_{eff3}}+\dfrac{S_4}{L_{eff4}}\right)} - \frac{\left(\rho c^2\right)}{2\pi f V_3}$$

The tuning frequencies of the end chambers occur when the reactive impedances of the branches X_{LHS} and X_{RHS} are zero, giving the two tuning frequencies of the triple pass silencer f_1 and f_2 in the main text. The reactive impedance of the centre chamber is given by

$$X_{Centre} = -\frac{\left(\rho c^2\right)}{2\pi f V_2}$$

The total impedance of the side branch X_{branch} is given by combining the impedances of the end chambers and the centre expansion chamber in parallel using [5], therefore

$$X_{branch} = \left(\frac{1}{X_{LHS}}+\frac{1}{X_{Centre}}+\frac{1}{X_{RHS}}\right)^{-1}$$

The transmission loss is given by inserting the total impedance X_{branch} into [3] (see text).

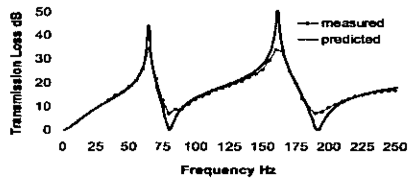


Figure 10

Predicted and measured transmission loss of a triple pass silencer.

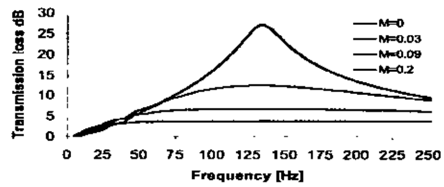
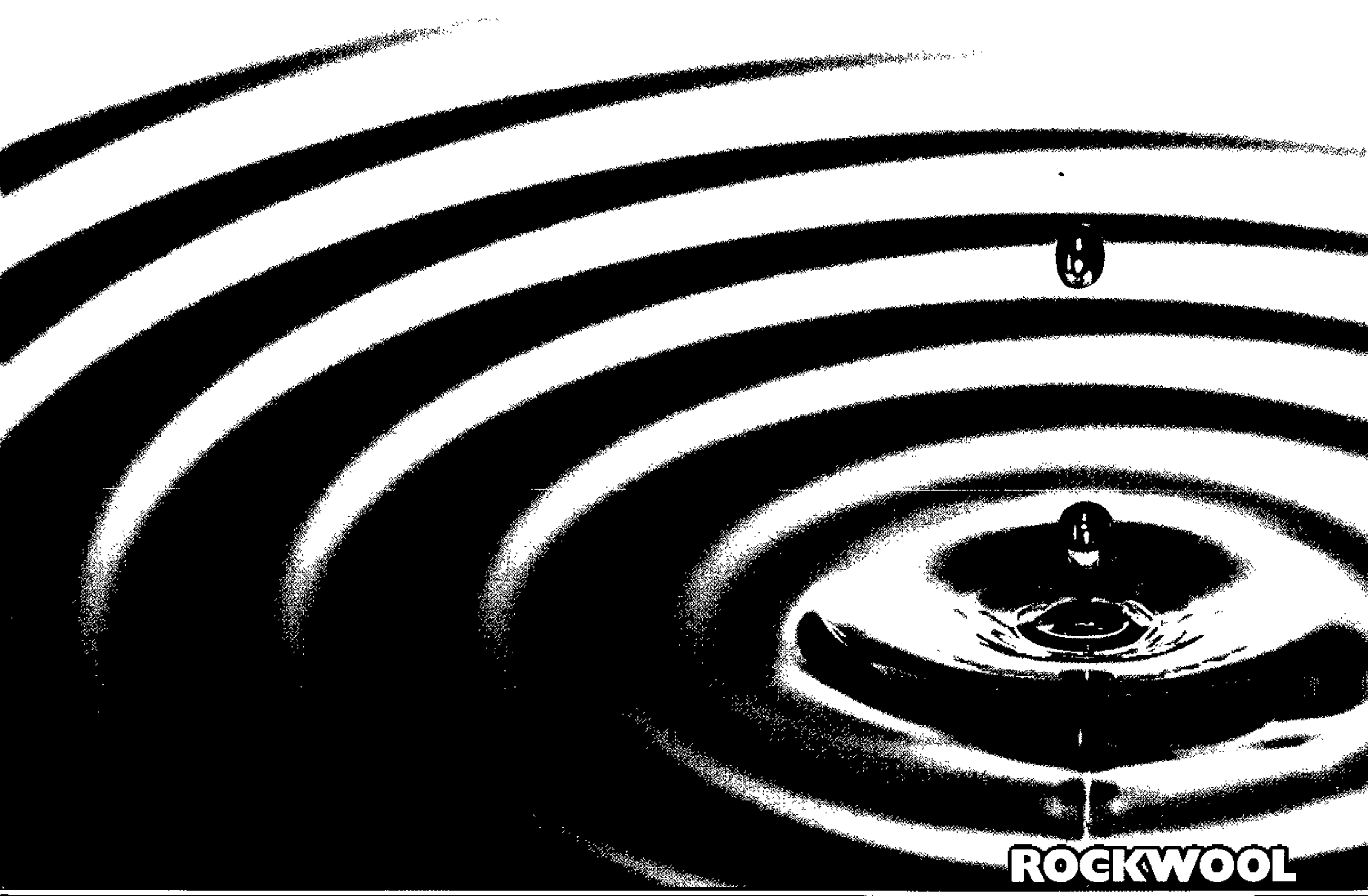


Figure 11

Predicted transmission loss of a Helmholtz resonator with a mean flow through the neck.

Superior 4 in 1 insulation

A SOUND SOLUTION FOR BUILT-UP FLAT ROOFING



ROCKWOOL

FUTUREPROOF INSULATION

RAIN NOISE TESTING ON LIGHTWEIGHT ROOFING

The combined acoustic benefits of Rockwool 4 in 1 insulation & Rockfon ceilings

By Tim Spencer

FIGURE 01 *A Rockwool roofing system being installed*

Introduction

To be (as we believe) the first organisation in the UK to complete testing in accordance with the published version of ISO Standard BSEN ISO 140–18:2006 Measurement of rain noise on building elements [1] was quite an achievement for Rockwool Ltd.

BS EN ISO 140-8 describes a laboratory method for the measurement of sound generated by rainfall on building elements, using artificial raindrops produced by a water tank.
Ideally, test specimens should be exposed to real rain for such measurements. But real rain is neither steady nor continuous with respect to time. Furthermore, raindrops can vary in diameter owing to several factors, including the geographical location, which introduces variability in measured values.

Artificial raindrop generation systems (other than the water tank used in this part of ISO 140) do exist, hydraulic spray nozzles being one example. However, nozzles corresponding to the specifications given in this part of the standard are not, so far, commercially available. Indeed, their flow rate is too high when the drop diameter is correct, and the drop diameter is too small when the flow rate is correct. Only the water tank method appears in the standard.

An alternative to real rain or artificial raindrops is the dry mechanical excitation of the test specimen. Researchers have used different methods, such as excitation by an impact hammer or other mechanical impacting simulators with the aim of simulating the noise of real rain. These methods invariably suffer from the drawback that the noise source generates sound levels and sound spectra that taken together, do not compare well with corresponding values generated by the real rain on various types of test specimens. Further research work is encouraged to develop mechanical methods of rain noise generation that can match both the sound levels and spectra of real rain.

With increasing focus on noise issues and the need for proven, sustainable, good whole life value-for-money and safe building solutions, Rockwool Ltd and sister company Rockwool Rockfon Ceilings got on with the task of roof rain noise testing.

The testing, carried out at the end of 2007 at the Building Research Establishment, is believed to have been the first to be completed in the UK, and probably internationally, in accordance with the recently published International ISO 'rain noise' standard.

The tests demonstrated that Rockwool insulated roofs with the addition of a straightforward Rockfon low-weight stone wool suspended ceiling can ensure that rain noise resistance, reverberation time and speech intelligibility criteria, together with all the other necessary performance requirements in terms of fire safety, thermal performance, light reflection and sustainability are fully satisfied for all sectors. The testing further confirmed the superior performance, enhanced practicality and peace of mind when using Rockwool insulated roofs compared with foam insulated varieties.

Test Programme

The comprehensive test programme was completed at the BRE acoustics laboratory within the extensive Building Research Establishment at Garston, Watford in November and December 2007. BRE Acoustics specifically configured one of their existing laboratories to allow for the construction of roofs and ceiling elements together with the 'rain' water tank and all of its necessary supports allowing for easy tank movement so that measurements could be made in different roof positions. The rig also included water run-off and collection systems, water collection and recycling being particularly important to minimise the amount of water being used. Because the tests took place indoors, the 'rain' water was fed from and collected in a separate supply and recycling tank on the ground floor.

Testing indoors proved to be a great benefit compared with the outdoor option, because ironically the use of a test rig built outside would be weather dependent. In other words, tests would only be possible when the weather conditions allowed, and the ambient sound level was sufficiently low. Tests would certainly be impossible when... it was really raining! Everyone is well aware how much rainfall there can be in the UK, and the past 12 months have been exceptionally wet. Programme predictability, and completion of the tests as quickly and as efficiently as possible were key factors in laboratory design and choice. In a nutshell, the testing was completed indoors in accordance with the published International Standard (as opposed to the previous drafts) in a closely controlled laboratory environment with very low background noise levels and very high flanking limits, all as required by the new ISO standard.

The results obtained on the straightforward, economical, fire-safe and easily built roof and ceiling constructions were impressive, with the samples performing well, and demonstrating their ability to achieve results well within 'best practice' target values and the guidelines for resistance to rain noise.

Designers can be confident in the use of this data and the constructions used, compared with any other previously obtained data and any subsequent predictions in accordance with previous draft or ad hoc standards and laboratory set-ups. When looking for data and making comparisons for designs to resist the negative effects of rain noise, it is prudent to ensure that the test results are current and obtained in accordance with the published standard. The solution put forward should be straightforward and easy to construct. A BRE report from January 2008 contains all the test data and results. Further details are available from Rockwool Rockfon.

FIGURE 02 *Rockwool Hardrock being laid on vapour control layer*

For more information on fire safety legislation and Rockwool's range of dual density roofing boards visit www.rockwool.co.uk or call 01443 828815

Why do the tests?

Appropriate background sound pressure levels and the need for appropriate levels of resistance to noise generated by rain are 'must haves' in modern buildings. In any built environment, an appropriate background sound level should not be exceeded no matter what the weather conditions. In design work the sound pressure level due to rainfall in the room beneath the roof element should be of considerable interest.

In some buildings the background noise levels created by rain on the roof are unacceptable - the rain is simply too loud. The noise can be disruptive to learning and concentration in the education and commercial sectors, and is not conducive to health, wellbeing and efficient healing in the healthcare sector. The problem is becoming more recognised in various best-practice codes and guidelines.

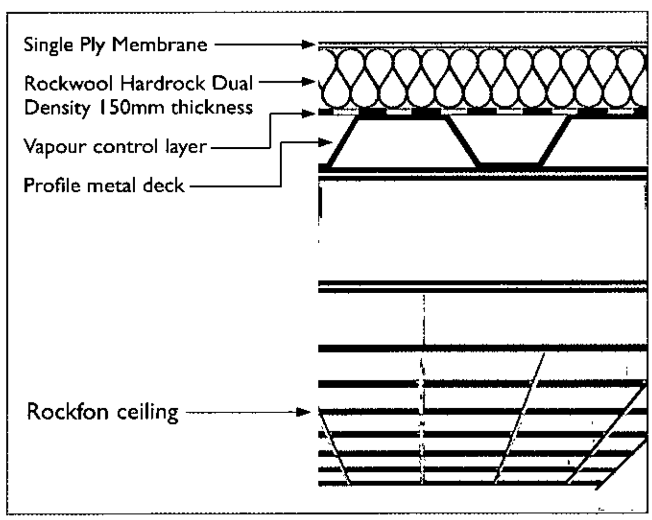
To date, some installations have used complex and costly multi-layer ceilings to provide appropriate room acoustics (speech intelligibility and reverberation times) and to combat the high level of rain noise generated by lightweight foam insulated roofs. Our goal was to prove that by using a Rockwool insulated roof and a single layer Rockfon ceiling there would be no need for complex multi-layer ceilings with overlays or other devices.

The focus was on exploiting the damping and acoustical performance of Rockwool Hardrock insulation as well as reducing reverberation times and enhancing speech intelligibility. The sound absorption and sound insulation characteristics of Rockfon ceilings were known to be excellent. Of course, the programme was also intended to add peace of mind for acousticians, particularly as they are nowadays being pressed by architects and main contractors for solutions that reduce risk to their indemnities by providing good, upto-the-minute data and reliable, safe value-for-money solutions for all.

Benchmarks for acceptable performance

Building Bulletin 93 **[2]** sets out the performance standards for the acoustics of new school buildings, and one of these performance standards is the indoor ambient noise level in unoccupied spaces. This noise level excludes contributions from rain noise, but the guidance states that it is essential that rain noise is considered in the design of lightweight roofs as it can significantly increase the indoor ambient noise level. When BB93 was published in 2004 the international standard for measuring rain noise was still being developed. The intention is that in the future, consideration will be given to including a performance standard for rain noise in BB93. Until this time, it is appropriate for design teams to provide evidence to Building Control that the roof has been designed to minimise rain noise.

In the meantime some specific benchmarking is available in the form of BREEAM for schools. The values stated in BREEAM for schools are likely to become the norm in future editions of BB93. BREEAM provides credits for roof designs that can demonstrate in the event of heavy rain that the ambient sound pressure level will not exceed normal allowable ambient sound levels by more than 20dB. Reference needs to be made to Table 1.1 of BB93 to determine the maximum levels allowable in the many different room types in educational buildings. Predictions for rain noise can then be accurately made based on test data and formulas in accordance with BS EN ISO 140-18:2006. Resistance to rain noise and its importance will also be covered in HTM 08-01 Healthcare premises - acoustics (soon to be published as a replacement for HTM 2045).



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Results

TABLE 01

Room Type	Area(m)	Height(m)	Ceiling	Upper Limit (DB)	Internal (DB)
Primary classroom	56	2.4	none	55	59
Primary classroom	56	2.4	Rockfon 20mm Scholar	55	**51**
Secondary classroom	63	2.7	none	55	60
Secondary classroom	63	2.7	Rockfon 20mm Scholar	55	**51**
Lecture room large	180	3	none	50	61
Lecture room large	180	3	Rockfon 50mm Sonar 44 dB'sandwich'	50	**45**
as above	180	3	Rockfon 20mm Scholar	50	52
'Inclusive' classroom for use by hearing impaired	56	2.4	none	50	58
as above	56	2.4	Rockfon 50mm Sonar 44 dB 'sandwich'	50	**42**
as above	56	2.4	Rockfon 50mm Sonar 44 dB 'sandwich'	50	**49**

Sample performances in schools

Note: Lower values of internal sound pressure level indicate a better performance. All ceilings consisted of Rockfon tiles in 600mmx600mm modules and a RockLink 24 exposed grid.

The roof construction without a suspended ceiling performed well, achieving 59dB $L_{Aeq,30min}$ (based on probable use in a typical classroom with a T_{mf} of around 0.6 seconds). This was certainly an impressive result, but as expected it was found to fall short of the target values when calculations were made for other types of spaces. By adding a straightforward and widely used Rockfon Scholar sound absorbing ceiling, installed using a RockLink 24 exposed T-grid to create a 600mm square module, an improved performance was achieved, meaning that in a typical classroom with dimensions 8m x 7m x 2.4m the sound pressure level from rain noise would be 51dB $L_{Aeq,30min}$ and therefore well within the target value of 35 + 20 = 55dB. Table 1 shows some examples of the performance achievable based on the data obtained from the test roof with and without Rockfon Scholar 20mm and Rockfon Sonar 44dB 50mm lightweight suspended ceiling tiles. The Rockwool insulated roof provides a high level of rain noise resistance and the addition of a Rockfon ceiling provides a significant improvement owing to its pure stone wool construction (it is made from resin bonded mineral wool). The weighted sound absorption coefficient of both the fronts and the backs of the tiles exceeds 0.9, giving them a Class A (the highest) rating. This high performance is a feature of resin bonded mineral wool ceilings, which are superior to the traditional wet felted mineral fibre ceilings. The use of the Rockfon ceiling and the Rockwool Hardrock insulated roof is enough to meet the rain noise target: there is also a performance and cost-savings benefit because the Rockfon ceiling makes a significant contribution to achieving the reverberation time and speech intelligibility requirements of many areas, specifically those covered in BB93. The tests proved there to be no need for additional intermediate dense ceilings or overlays, thereby maintaining simplicity and reducing the installation time and cost.

The tests proved there to be no need for additional intermediate dense ceilings or overlays, thereby maintaining simplicity and reducing the installation time and cost.

Test Programme

TABLE 02

Rainfall Type	*Rainfall Rate mm/h*	*Typical Drop Diameter mm*	*Fall Velocity ms*
moderate	*up to 4*	*0.5 to1*	*1 to 2*
intense	*up to 15*	*1 to 2*	*2 to 4*
heavy	*up to 40*	*2 to 5*	*5 to 7*
cloudburst	*greater than 100*	*>3*	*>6*

Classification of rain type according to IEC 60721-2-2

A tank positioned above the test roof is filled with water and constantly recharged. The flow rate is calibrated and monitored to ensure a correct rainfall. Sound pressure level measurements are taken below each roof or roof/ceiling construction in the frequency range 100Hz to 5kHz. The rain noise standard describes various types of artificial rainfall that can be used, as shown in Table 2. Real rain can be classified in terms of rainfall rate, typical drop diameters and fall velocities. The artificial rainfall parameters that affect the noise generated by roof elements are controlled in the laboratory. At present, the intention is that 'heavy' rainfall shall be mandatory for the comparison of products and solutions.

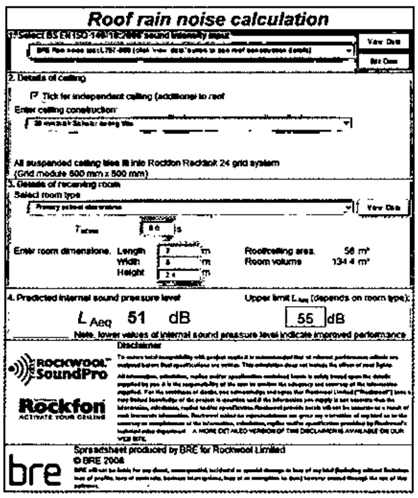

FIGURE 07
Screenshot of the BRE/Rockwool rain noise prediction programme

Using the laboratory data to calculate the sound pressure level in rooms based on the results of the test programme the BRE has produced an easy-to-use calculator to predict roof rain noise in a wide variety of spaces. This is based around the spaces and reverberation time limits set by Building Bulletin 93, but it can also be set to user-defined requirements.

The calculator can be made available to acousticians on loan: contact Rockwool Rockfon for details. An example calculation is shown in the panel (see Figure 07). Rockwool and Rockfon would like to thank Dr Robin Hall and the team at BRE Acoustics for their assistance and involvement in the completion of the tests on which this article is based.

Sustainability

Finally, a word on sustainability, understandably a subject of increasing popularity and one that is quite rightly entering into and becoming part of an ever-increasing holistic approach by acousticians. The diabase rock from which Rockwool insulation and Rockfon ceilings are manufactured possesses a rare quality among the many types of raw materials used to manufacture insulation. The natural process by which diabase is formed is taking place continuously all over the world. Volcanic activity and plate tectonics mean that mother nature creates new reserves of diabase rock every year - around 38,000 times more than is extracted by Rockwool. This unique process of natural renewal completes the rock cycle and delivers sustainability. Not only does Rockwool enhance the environment for all, but it can continue to do so for thousands of years to come. Rockwool and Rockfon ceiling tile offcuts have for many years been recycled at the large and long-established Rockwool UK manufacturing facility just west of Cardiff. Tim Spencer is with Rockwool UK Ltd, Bridgend.

References

[1] International Standards Organisation BSEN ISO 140 Acoustics – Measurement of sound insulation in buildings and of building elements – Part 18: Laboratory measurement of sound generated by rainfall on building elements.

[2] Department for Education and Skills. Acoustic design of schools. DfES Building Bulletin 93. London, The Stationery Office, 2004.

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FUTUREPROOF INSULATION

Investigating the variability of results of pre-completion testing of airborne sound insulation in accordance with Approved Document E 2003

Simon Barrett and R N Vasudevan.

A 'sound transmission workshop' intended as a benchmarking exercise took place at the 2005 IOA Spring Conference [1]. This involved ten individuals who each tested a party wall between the same pair of rooms using slightly different measurement methods and procedures. The workshop test results indicated that the variation in the measured values was typical of routine measurements of sound transmission that would be expected, and concluded that a single-figure index should properly be thought of as the midpoint of a band of uncertainty of width 3dB.

For the last four to five years, the first author and a colleague (both ANC-registered testers with Acoustic Associates Sussex Ltd) have been involved in carrying out several sound insulation tests. During the pre-completion test visits to various sites, different results were sometimes obtained. It was therefore decided to investigate the effect of changing certain variables whilst conducting the field measurements on site.

For each experiment, only one variable was changed at a time to minimise systematic errors and aim for a fair test.

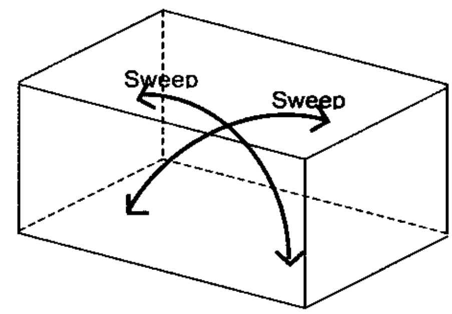

Figure 01

Sweep technique in different directions

Measurement Methodology and Instrumentation

Field testing was carried out fully in accordance with Approved Document E 2003[2] & ISO140-4[3]. In addition to third-octave band level measurements, the two single-figure indices $D_{nT,w}$ and C_{tr} were computed in accordance with ISO 717-1[4]. The following instrumentation setup was used for all experiments.

The sound source consisted of two public address system loudspeakers (DAS 108) mounted at different heights and driven by a Phonic MAX500 power amplifier. Similar but uncorrelated signals of pink noise from separate Neutrik Minirator MR1 devices were used as the noise source via a Behringer Ultracurve Pro 2496, to ensure a uniform sound level across the frequency range in the source room (meaning that at different measurement positions, the sound pressure level in adjacent third-octave bands did not change by more than 6dB). Reverberation time (RT) was measured using the 'interrupt stationary' method.

Every piece of measurement equipment was an IEC 651 Class 1 device with valid UKAS calibration. Field calibration checks were always carried on the measuring instruments before and after the test.

Testing was always carried out by two people so that when one tester moved to the receiving room, the other remained in the source room. Where more than one measurement was made in the receiving room, the sound source was not switched off between measurements. The sequence of background noise and reverberation time measurements was taken only once, and the results used for each room pair.

In all, 21 sites were visited so that there were tests on 52 room pairs in all. Most rooms were unfurnished at the date of the tests.

Variables

The following variables were considered for some of the reproducibility and repeatability measurements during the sound insulation tests.

1. Identity of tester: Each of the two testers (referred to here as Simon and Peter) carried out a complete test including background noise measurement and reverberation time determination in the receiving room, with no information about how the other conducted his measurements.
2. Direction of sweep: Sweeping the measurement microphone in the receiving room either from left to right, or from right to left, as shown in Figure 1.
3. Sweep technique or static positions: The International Standard allows use of a sweep technique (moving microphone) or six individual static microphone positions.
4. Change of equipment: two different sets of equipment were used for sound insulation measurements.

Test Results

Visits were made to 21 different sites, giving a total of 52 room pairs for test. This article is not a comprehensive record of the results, and the various room layouts are not described, but the room volumes are given along with the relevant graphs. A non-shifted standard reference curve is also displayed for reference only. The $D_{nT,w}$ and the $D_{nT,w} + C_{tr}$ values are also presented in the summary graphs.

Variable 1: Identity of tester (15 room pairs considered)

In these experiments, the author and a colleague visited many sites together and each carried out a full test in all 15 pairs of rooms. Relevant measured DnT values are shown in Figures 2 to 4. Table 1 shows the single-figure indices for the same three sites. As would be expected, there is broad agreement between the two testers' results.

The summary graph G1 (Figure 7) shows the variations in $D_{nT,w}$ and $D_{nT,w} + C_{tr}$ which occurred in approximately 60% of the room pairs tested. In some cases, no changes were observed in the single-figure indices. However, in one case (site 5), the largest difference in $D_{nT,w} + C_{tr}$ between two different sweeps was 5dB. Some variations in DnT,w

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Site 1 room pair 1	$D_{nT,w}$	$D_{nT,w} + C_{tr}$
Simon (sweep 1)	52	45
Simon (sweep 2)	53	46
Peter (sweep 1)	52	46
Peter (sweep 2)	52	45
Site 2 – room pair 1		
Simon (sweep 1)	66	57
Simon (sweep 2)	67	57
Peter (sweep 1)	66	57
Peter (sweep 2)	67	57
Site 3 – room pair 1		
Simon (sweep 1)	52	47
Simon (sweep 2)	53	48
Peter (sweep 1)	51	47
Peter (sweep 2)	51	47

Table 01

Single-figure indices for test data shown in Figures 2, 3 and 4

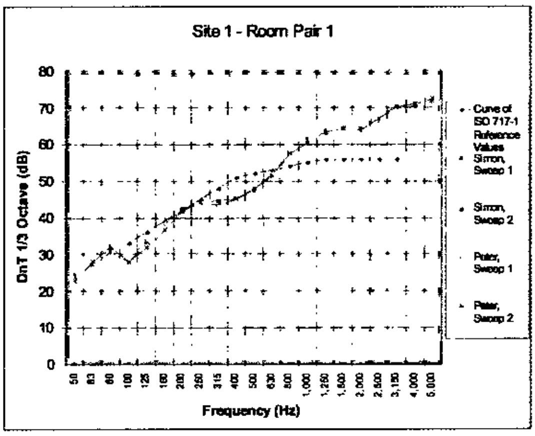

Figure 02

Little variation between measurements
source room: 68m³ receiving room: 56m³ orientation: vertical airborne

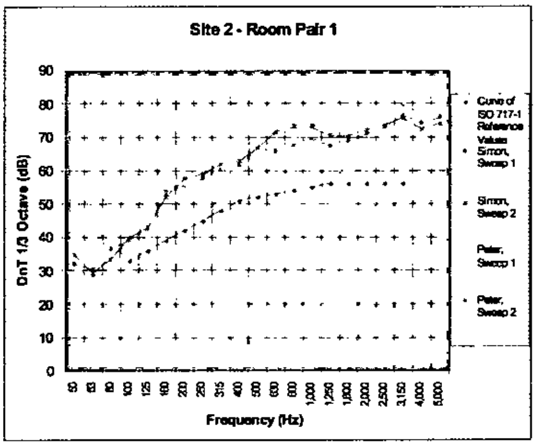

Figure 03

Variations at mid and high frequency
source room: 34m³ receiving room: 35m³ orientation: horizontal airborne

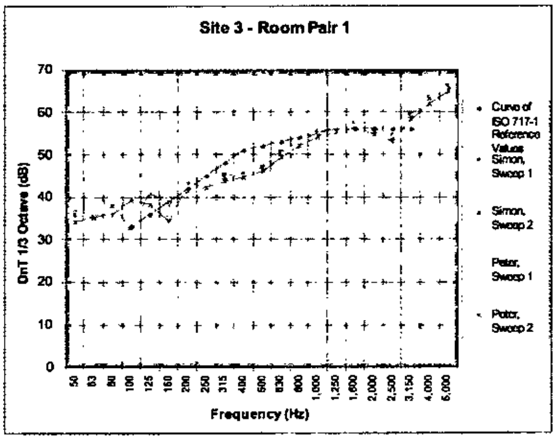

Figure 04

Variations at low frequency
source room: 35m³ receiving room: 38m³ orientation: vertical airborne

Investigating the variability of results ... - *continued from page 27*

also occurred before the inclusion of the C_{tr} correction term. Again, in site 5, a 3dB difference was observed in $D_{nT,w}$ between the two testers' results.

Variable 2: Direction of sweep (23 room pairs considered)

It is company policy to carry out a second sweep in the receiving room whenever the moving microphone spatial averaging technique is used. It is interesting to note that BS EN ISO 140-4 in section 6.3.3(b) states that using a moving microphone measurement method, with two PA loudspeakers for noise generation, only a single measurement is needed in the source room. If using only a single PA loudspeaker then two measurements are required in the source room. However, Appendix B, paragraph B2.20 of Approved Document E does not mention this, and states that if using a moving microphone measurement, regardless of which how many PA loudspeakers are used, two measurements are required. Dodecahedral loudspeaker cabinets are not affected by these provisions.

As can be seen from the summary graph G2 (Figure 8) in approximately 56% of 23 room pairs, there was significant variation in $D_{nT,w}$ and $D_{nT,w} + C_{tr}$ figures. The largest difference observed in the single figure indices between the two different sweeps was 3dB.

Table 2 shows the single figure indices for the test results shown in Figures 5 and 6. It can be seen that slight variations in the third-octave band levels between the two sweeps (Figure 6) resulted in a 3dB variation in both indices.

Variable 3: Sweep technique or static microphone positions (11 room pairs considered)

There are various methods of spatially averaging a sound field in a room. The two usual methods use either a moving microphone or multiple static positions. Multiple static positions are averaged for shorter periods of time, and the logarithmic average is then calculated.

As part of the experiment, the results from these measurements were compared with each other. They are shown in summary graph G3 (Figure 9). It is interesting that there is considerably less variation between the results for six static positions and the results for the sweep technique. The largest variation was only 2dB and this occurred in only one of the room pairs tested (at site 5). This is unexpected because the sweep technique in different parts of the receiving room (variable 2) gave much more variation than the measurements assessing variable 3. It is possible that among other factors, the variations resulted from the different dimensions of the rooms tested.

Variable 4: Different sets of equipment (3 room pairs considered)

This group of tests involved a comparison of measurements involving two different sound level meters (both IEC 651 Class 1). The meters used were (1) Acsoft 01dB with Symphonie two-channel sound card, the calculations performed using dBBati32 software, and (2) Norsonic Nor118 sound level meter, the calculations performed using Norbuild software.

In the three room pairs tested, little or no variation was observed: a maximum of 1dB was noted, in one case only. In order to validate the results properly, a far greater number of room pairs would have to be tested.

Discussion and Conclusions

The sound insulation measurements presented were carried out in 'real life' conditions rather than in laboratories or other specifically built rooms.

A change of tester (variable 1) proved to be one of the two variables that had the greatest effect on the results. Even though there was a broad agreement between the test results, in 60% of the sites visited, the single-figure indices indicated a 3dB variation.

Similar variation was observed with a reversal of microphone sweep direction during the measurement (variable 2).

However, it was interesting to note the similarity of results when comparing the sweep technique with a fixed microphone technique using six positions (variable 3). This was contrary to the initial expectation that there would be a noticeable difference between the two different spatial averaging techniques.

Generally it would be expected that changing the direction of the moving microphone in the receiving room would provide the largest degree of difference in results, owing to the random sampling of sound field, and that this difference would mostly be noticed at low frequencies because of the presence of standing waves. This could also have contributed to the greater variation in the test results observed when changing the tester (variable 1).

It was not expected that there would be a significant change in the test result by as a result of changing the test instrumentation (variable 4). Based on the few tests carried out between the three room pairs using the Nor118 and the Acsoft 01dB, the results were effectively identical.

The results presented in this article compare favourably with the outcomes of the sound transmission workshop run at the 2007 Spring Conference of the IOA.

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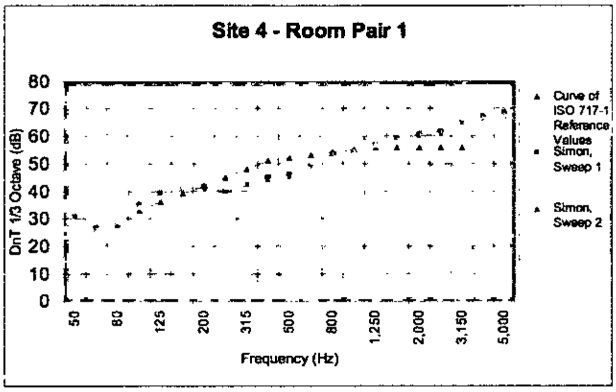

Figure 05

Little variation
source room >200m³ receiving room: 30m³ orientation: vertical airborne

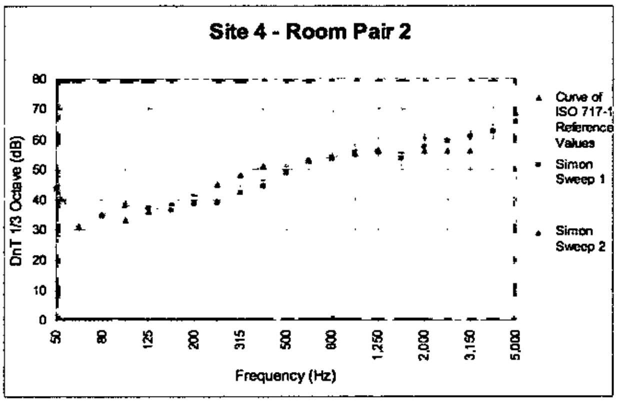

Figure 06

Variation in $D_{nT,w}$ with unchanged curve shape

Site 4 – room pair 1	$D_{nT,w}$	$D_{nT,w} + C_{tr}$
Simon (sweep 1)	52	47
Simon (sweep 2)	52	47
Site 4 – room pair 2		
Simon (sweep 1)	52	47
Simon (sweep 2)	55	50

Table 02

Single figure indices for test data shown in Figures 5 and 6

Investigating the variability of results ... - *continued from page 29*

Further research could be carried out into the effects on the single-figure ratings of

1 spatial averaging instead of static averaging;
2 different instrumentation;
3 using acoustical diffusers in the rooms;
4 various loudspeaker configurations, such as single public address loudspeakers, twin loudspeakers, and specialist dodecahedron arrays.

This article is based on the MSc dissertation submitted to Open University and NESCOT by **Simon Barrett** BSc(Hons) MSc MIOA. He is currently working for Acoustic Associates Sussex Ltd. **Dr R N Vasudevan** MIOA is a senior lecturer and course director of acoustics courses at NESCOT, Ewell, Surrey

Special thanks are due to Peter Akhurst for his valuable contributions to the pre-completion testing work during the site visits.

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2. Approved Document E *Resistance to the passage of sound* ODPM, 2003 (amended 2004 – now DCLG)
3. BS EN ISO 140-4:1998 *Measurement of sound insulation in buildings and of building elements. Part 4 Field measurements of airborne sound insulation between rooms.* British Standards Institution.
4. BS EN ISO 170-1:1997 *Rating of sound insulation in buildings and of building elements. Part 1: Airborne sound insulation.* British Standards Institution.

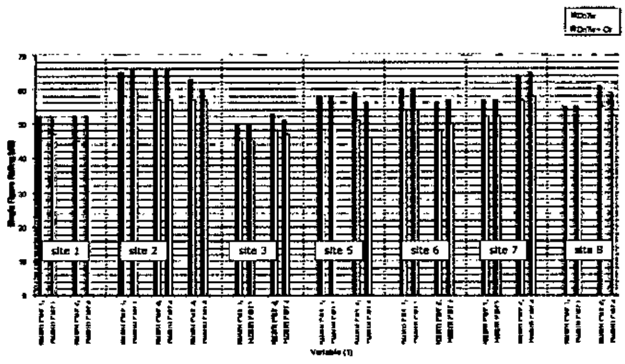

Figure 07

Summary graph G1 (effect of different tester, all room pairs considered)

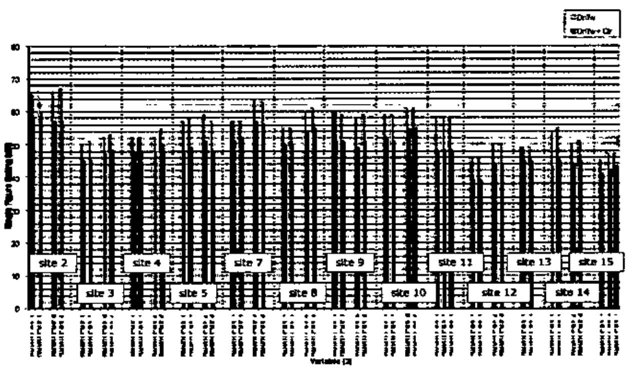

Figure 08

Summary graph G2 (changing direction of microphone sweep, all room pairs considered)

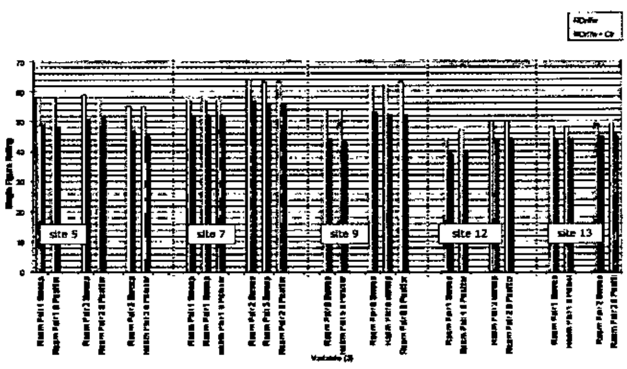

Figure 09

Summary graph G3 (moving and static microphone compared, all room pairs considered)

A guideline for the assessment of low-frequency noise

Cedric Roberts.

Introduction

Items such as boilers, pumps, transformers, cooling fans, compressors, oil and gas burners, foundries, washing machines, electrical installations, diesel engines, asynchronic motors and ventilation and air conditioning equipment are sources of high level low-frequency noise having frequency content less than 200Hz. These sources exhibit a spectrum which characteristically shows a general increase in sound pressure level with decrease in frequency.

Annoyance due to low-frequency noise can be high even though the level measured in dB(A) is relatively low. Typically, annoyance is experienced in the otherwise quiet environs of residences, offices and factories adjacent to or near low-frequency noise sources. Generally, low level and low-frequency noise becomes annoying when the masking effects of higher frequencies are absent. This loss of high frequency may occur as a result of transmission through building fabric and in propagation over long distances.

This article describes the main elements of a low-frequency noise annoyance guideline developed to deal with the high incidence of low-frequency noise complaints experienced by residents in Queensland. The elements include:

- low-frequency noise criterion adopted for initial screening inside home environments
- a measurement protocol
- an evaluation based on comparing the third-octave band low-frequency sound median hearing threshold levels, to establish auditory perception.
- establishing annoyance for non-tonal noise measured indoors as $L_{pA,LF}$

The increased annoyance impact of low-frequency 'rumbly' noise where it is possible that the loudness may change from imperceptible to loud at the modulation rate of the noise at a particular third-octave frequency is accounted for by comparing measured levels with the median hearing threshold levels corrected by 5dB.

Application

The methods and procedures described in this guideline are intended to be applicable to low-frequency noise emitted from industrial premises, commercial premises, mining and extractive operations (but not blasting using explosives) and heavy vehicle noise, and are intended for planning purposes as well as for the evaluation of existing problems.

Besides man-made sources there are some natural sources of low-frequency sound such as the wind, the sea, thunder and vibration from low level ground movements. The intention is accurately to assess annoyance and discomfort to persons at noise-sensitive places (defined in the glossary) caused by low-frequency noise with a frequency range of 10 to 200 Hz.

The frequency range of audible noise is normally taken to be from 20 to 20k Hz, and that of infrasound to be below 20Hz. However, noise at frequencies below 20Hz can be audible although tonality is lost below 16 - 18 Hz, so a key element of perception is lost.

There is a rule of thumb that for noise in the mid-frequencies generally greater than 500Hz, a 10dB increase in level represents a doubling of loudness. This rule fails for noise at low frequencies. At 20Hz a doubling of loudness occurs for a level change of about 5dB, and a still smaller change is necessary at lower frequencies.

Low frequency noise spans parts of the infrasonic and audible ranges and may be considered to range from about 10 to 200 Hz.

Infrasound

Sound in the frequency range below 20Hz is defined as infrasound. Infrasound can be heard (or felt) provided it is loud enough. Infrasound is usually not perceived as a tonal sound but rather as a pulsating sensation, pressure on the ears or chest, or other less specific phenomena.

The loudness and annoyance due to infrasound increases extremely rapidly with increasing level above the threshold of hearing. High infrasonic sound pressure levels are reported to be found in several environments such as near sites for testing large aero-engines, large wind turbines with low rotational rates of the turbine blades, boiler plant noise, in automobiles, in tube trains and high buildings in windy weather.

Natural phenomena are prodigious generators of infrasound. Examples include volcanic explosions, surf pounding the shore, thundering waterfalls, severe winds and thunder storms, tornadoes and auroral discharges

The G-weighting function is intended to determine annoyance due to infrasound. The G-weighting for the determination of weighted sound pressure levels of sound or noise, whose spectrum lies partly or wholly within the frequency range 1 to 20 Hz, has been standardised in ISO 7196 (1995). G-weighted sound pressure levels are denoted by L_{pG} and are measured or estimated in dB(G).

Acceptable criteria for infrasound

The average hearing threshold for single tones is usually about 95 to 100 dB(G), and tones with a 20dB higher level are expected to be perceived as very loud.

The recommended limit values for infrasound inside occupied spaces are shown in Table 1.

type of space	dB(G)
dwellings during day, evening and night	85
inside classrooms and offices	85
occupied rooms in commercial enterprises	90

Table 01

Recommended limits for infrasound (source: Jakobsen 2001)

continued on page 32

A guideline for the assessment of... - *continued from page 31*

The noise is measured over a ten-minute period and a 5dB penalty is added for impulsive noise eg single blows from a press or drop hammer.

An approximate determination of the G-weighted sound pressure level may be made by analysis of the signal using third-octave bands and application of the appropriate weighting values.

Low-frequency noise above 20Hz

Items such as boilers, pumps, transformers, cooling fans, compressors, oil and gas burners, foundries, washing machines, wind farms, electrical installations, diesel engines, asynchronous motors, ventilation and air-conditioning equipment, wind turbulence and large chimney resonance can be sources of high level, low-frequency noise having frequency content less than 200Hz.

These sources exhibit a spectrum that characteristically shows a general increase in sound pressure level with decrease in frequency. Annoyance due to low-frequency noise can be high even though the measured level in dB(A) is relatively low. Typically, annoyance is experienced in the otherwise quiet environs of residences, offices and factories near low-frequency noise sources.

Generally, low level/low-frequency noises become annoying when the masking effect of higher frequencies is absent. This loss of high frequency components may occur as a result of transmission through the fabric of a building, or in propagation over long distances. It may even be perceived by a resident who suffers from age–induced or noise-induced high-frequency hearing loss.

In some cases where two or more sources of low-frequency noise operate near each other (eg two adjacent gas turbines operating at a power plant, or a bank of cooling fans), sound waves propagating away from the sources can interact to cause repetitive low-frequency beats. These beats can be readily discernible (and potentially annoying) even when the overall noise level is low.

A problem also arises in determining the location of the source and the relative importance of the various transmission paths of low-frequency sound sources, as the radiation pattern is usually omni-directional. The location of low-frequency noise indoors is complicated by a number of factors such as room dimensions being normally within the wavelength range of interest (1.36 to 17 metres) which may give rise to standing waves, airborne noise causing windows and other building elements to rattle, and difficulty in distinguishing between airborne and structureborne noise.

Resonance can be set up inside a room with nodes (quiet points) and antinodes (loud points). The number and position of these nodes and antinodes will depend on the specific room dimensions and the frequency of the noise. The consequence is that the room resonances can cause elevated levels of low-frequency noise at points within a room.

The main elements of an assessment include:

- the low-frequency noise criterion adopted for initial screening inside home environments in terms of unweighted, A-weighted and third-octave sound pressure levels in the range 10 to 200 Hz;
- the comparison of third-octave low-frequency sound with the values for L_{HS} of the ISO median hearing threshold level for the best 10% of the aged population (55-60 years old).

The initial assessment is intended for use in cases where an individual complains about low-frequency noise and a decision needs to be made as to whether the particular noise is audible. This assessment does not verify whether or not the noise is annoying: a sound that is audible is not necessarily unacceptable.

Initial screening

Where a noise immission occurs exhibiting an unbalanced frequency spectra, the overall sound pressure level inside residences should not exceed 50dB (linear) to avoid complaints of low-frequency noise annoyance. If the unweighted level exceeds the A-weighted level by more than 15dB, a third-octave band measurements should be made in the frequency range 10 to 200 Hz.

Audibility assessment

The following checks are made to establish whether or not noise contains dominant low-frequency components:

- Identify disturbances by listening to the recordings associated with complaint events and analyse time histories run concurrently of the unweighted and A-weighted levels of recorded sound;
- Determine broad band L_{Aeq} and L_{LINeq} levels inside each affected room for a representative measurement interval, typically 10 minutes;
- Determine if L_{LINeq} - L_{Aeq} > 15 dB;
- If it does, measure the noise in third-octave band, in terms of L_{LINeq} for frequencies from 10 Hz to 200 Hz;
- Compare these levels with the L_{HS} values of the median hearing threshold level for the best 10% of the older population (55 to 60 years old) given in Table 2, to determine the degree of low-frequency noise audibility;
- Note that where the complainants are likely to be in the age group 18 to 25 years old, the improved hearing threshold level for this group is accounted for by subtracting a 3dB penalty from the L_{HS} values in Table 2;
- Check for the existence of an amplitude-modulating component, where the noise level changes cyclically within a particular third-octave band. The added perception of loudness caused by this attribute can be accounted for by subtracting a 5dB penalty from the L_{HS} value in Table 2.

For example, the L_{HS} level for the older group at 50Hz could be reduced from 39dB to a corrected 34dB. This could be the case for poorly designed HVAC systems that generate large turbulent fluctuations at low frequencies and which can cause fan surging with concomitant noise level surging of 10dB or more.

f_c (Hz)	8	10	12.5	16	20	25	31.5	40
L_{HS} (dB)	96	92	88	84	74	62	55	46
f_c (Hz)	50	63	80	100	125	160	200	
L_{HS} (dB)	39	33	27	22	18	14	10	

Table 02

Median hearing threshold levels (L_{HS}) exceeded by 10% of a population 55 - 60 years old (Source: ISO/CD 1996-1)

Annoyance due to tonal noise

If the sound pressure level in a particular third-octave band is 5dB or more above the levels in the two neighbouring bands, the noise is said to be tonal. There can be one or more tonal components in the spectra.

For tonal noise, the level in the frequency band with the tone is compared with the hearing threshold level (L_{HS}) in the corresponding bands (Table 2). The exceedance of the tonal value above the threshold level is then found, but the levels in other frequency bands are not taken into account.

Acceptable criteria for tonal noise

The limit values for exceedance of the threshold table values by the equivalent level of the tone/s are as follows:

frequency band	8Hz to 63Hz	[illegible]Hz and 100Hz	>100Hz and <200Hz
day	5	10	12
evening/night	0	5	7

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If these limit values are not exceeded, the noise is considered to be non-annoying.

Annoyance due to non-tonal noise

To establish annoyance for non-tonal noise in the frequency range 10 to 160 Hz, A-weighting network corrections (Table 3) are applied to the third-octave spectra measured indoors, and the resulting A-weighted values are summed to yield the A-weighted noise level in the frequency range 10 to 160 Hz. The resulting level is called $L_{pA,LF}$.

The A-weighting network corrections are shown in Table 3.

[illegible]	[illegible]	[illegible]	12.5	[illegible]	20	25	31.5	[illegible]
correction, dB	-77.8	-70.4	-63.4	-56.7	-50.5	-44.7	-39.4	-34.6
frequency, Hz	50	63	80	100	125	160	200	250
correction, dB	-30.2	-26.2	-22.5	-19.1	-16.1	-13.4	-10.9	8.6

Table 03

A-weighting network corrections (Source: AS 1259.1-1990)

Acceptable criteria for non-tonal noise

The value of $L_{pA,LF}$ is compared with recommended limits (Table 4) to assess its acceptability for the specific application. If the relevant tabled limit is not exceeded, the noise is considered to be acceptable.

type of space (note 1)	[illegible] (notes 2 and 3)
dwelling, evening and night	20
dwelling, day	25
classroom, office etc	30
rooms within commercial enterprises	35

Table 04

Recommended limits for non-tonal low-frequency noise ($L_{pA,LF}$) (Source: Jakobsen, 2001)

1. Evening and night is defined as 18:00h to 07:00h: day is defined as 07:00h to 18:00h.
2. Averaged over 10 minutes
3. If the noise has an impulsive character the limits are reduced by 5dB.

Measurement and reporting

Measurement locations

Normally, measurement of environmental noise takes place outdoors. This is not advisable with low-frequency noise because of the disturbance caused by even light winds and because an outdoor measurement will not take into account re-radiated, structure-borne noise. In addition, internal measurements are advisable because of uncertainties in the sound transmission loss of the building envelope and resonance within rooms which can occur at low frequencies. Resonances can mean large variations in measured sound levels at different points within the room. Furthermore, it is a frequent observation that low-frequency noise is considered more annoying indoors.

The noise should normally be measured at a minimum of three points in each room. One point is chosen near a corner, 0.5 to 1m from the adjoining walls and 1 to 1.5m above the floor. The other points are chosen to represent typical habitation in the room, at least 0.5m from walls and large pieces of furniture and 1 to 1.5m above the floor. Often the occupants can identify points where the noise level is highest, and it is important to measure at these locations.

Points near the centre of the room must be avoided, as the noise level is often lowest there. In small rooms (less than about $20m^2$ floor area) the noise can be measured at two points in different corners, 0.5 to 1m from the adjoining walls and 1 to 1.5m above the floor.

The operating conditions for the noise source must be representative of the situation that is the subject of the complaint, and the background noise should be as low as possible. Windows and doors should be closed: if it is claimed that the low-frequency noise is more intrusive with open windows, a supplementary measurement can be made with windows open.

If possible, the internal background noise level should be measured with the noise source inoperative. This will also assist in identifying which source is responsible for any particular part of the noise.

When trying to locate a source of low-frequency noise it is necessary to first look for the source within the building itself. All domestic electric and gas appliances (for example electric clocks, refrigerators and extractor fans) within the premises should be switched off during measurements to establish whether they might be the source of annoyance. Sometimes it may be even necessary temporarily to turn off the electrical supply to the home.

Where it has been possible to measure the internal background noise level, third-octave spectra for the noise source shall be corrected for background noise.

The measured spectra (and corrected for background noise, if appropriate) are added to the G- or A-weighting network corrections to derive the overall weighted levels.

The energy average of the G- or A-weighted noise levels from all the measurement points in the same room are calculated and compared individually with the recommended noise limits.

The added perception of loudness caused by fluctuations (throbbing, pulsing or rumbling) at particular third-octave band frequencies for low-frequency noise above 20Hz can be accounted for by subtracting a 5dB penalty from the L_{HS} value in Table 2.

Location of source

Investigation of the location of a source of low-frequency noise commences within the building itself. If this investigation does not identify the source, then consideration should be given to external sources or sources in adjacent buildings. Information on the source can often be gleaned from the spectral content of the noise. As a general rule electrical sources will generate noise at the mains frequency of 50Hz, but harmonics may also be present at 100Hz and other multiples. The fundamental frequency for transformers is double the mains frequency at 100Hz.

For rotating sources, such as fans, specific frequencies are often generated which relate to the number of blades and the speed of rotation. This is known as the blade pass frequency. In very general terms the lower the frequency of the noise the larger is the likely physical size of the source.

Possible effects

As with any noise, reported effects include annoyance, stress, irritation, unease, fatigue, headache, possible nausea and disturbed sleep.

Low frequency noise is sometimes confused with vibration. This is mainly due to the fact that certain parts of the human body can resonate at various low frequencies. For example the chest can resonate at frequencies of about 50 to 100 Hz and the head at 20 to 30 Hz.

In addition low-frequency noise can cause lightweight elements of a building structure to vibrate, causing a secondary source of noise. This vibration is generally superficial and should not be confused with vibration of the whole building.

Tinnitus

Low frequency noise presents particular problems for those who have to deal with complaints about it. It is in any case likely that the business of identifying the source of low-frequency noise will be laborious and may not always be conclusive. Complaints cannot always be confirmed by sound measurements, and in some cases the indoor low-frequency sound level is so low it is improbable that low-frequency sound can be heard at all. Complainants are convinced they hear a real (external) noise from an outdoor or (possibly) an indoor sound source. Measurements may not support this conclusion, as no audible sound measured may be related to the complaints. It may be more than likely there is an internal cause for these complaints, ie they originate within the complainants. Perception of sounds without an external stimulus usually is known as tinnitus. At frequencies in the normal frequency range it is accepted that sounds can be perceived without an obvious acoustic stimulus: millions of people hear such sounds or even suffer from them.

Potential noise reduction design measures

Some potential mitigation measures can be designed into a project and installed as a part of construction or manufacture. However, they would be difficult to incorporate after the facility has been constructed or manufactured. These measures include:

- Installation of reactive stack silencers
- Use of low-noise fans for cooling towers
- Installation of concrete block enclosures (acting as Helmholtz resonators) to large iron core transformers
- Avoidance of use of centrifugal fans for building ventilation
- Use of gas turbine exhaust silencers
- Installation of double wall enclosures and sound attenuating channels to diesel-driven compressors
- Installation of profile changers or spoilers to large chimneys
- Installation of window glazing with high low-frequency attenuation
- Design of exhaust mufflers with appropriate low-frequency insertion loss

Measures that can be included within a noise sensitive place to avoid low-frequency annoyance include:

- Repositioning a bed to a location not affected by standing waves (anti-nodes)
- Masking of the annoying low-frequency noise by using an artificially created sound within a certain frequency range around the low-frequency noise. This range is called the critical band.

The frequency components of the masking noise needs to lie within a narrow band surrounding the centre frequency of the intrusive sound in order to be effective. However, both the sound level and spectral properties should be selected so that the overall acoustic environment is neither too loud nor too 'hissy' while still masking the intrusive sound.

Information to be reported

The following information shall be reported for low-frequency noise audibility and annoyance:

Infrasound

1. Third-octave spectra (0 to 100 Hz);

2. Calculated dB(G); alternatively, the noise can be measured in dB(G);

3. Presence of impulsive character

Low frequency noise above 20Hz

1. dB(lin);

2. dB(A);

3. Difference dB(lin) – dB(A);

4. third-octave band spectra (20 to 200 Hz);

5. Comparison of measured spectra with ISO hearing thresholds;

6. Presence of tones;

continued on page 36

A guideline for the assessment of... - *continued from page 35*

7. Tonal noise evaluation;

8. Presence of impulsive character;

9. Non-tonal noise evaluation;

10. Calculated $L_{pA,LF}$

Glossary

Immission The sound energy received at a receptor point.

Impulsive sound Sound characterised by brief excursions of sound pressure (acoustic impulses) that significantly exceed the background sound pressure. The duration of a single impulsive sound is usually less than one second.

Infrasound Sound in the frequency range below 20Hz.

L_{Aeq} (or equivalent continuous A-weighted sound pressure level $L_{Aeq,T}$): the value of the A-weighted sound pressure level of a continuous steady sound that within a specified time interval, T, has the same mean-square sound pressure as a sound under consideration whose level varies with time. The time interval adopted in this guideline is 10 minutes.

L_{LINeq} (or equivalent continuous unweighted sound pressure level $L_{LINeq,T}$): the value of the unweighted sound pressure level of a continuous steady sound that within a specified time interval, T, has the same mean-square sound pressure as a sound under consideration whose level varies with time. The time interval is 10 minutes.

$L_{pA,LF}$ The A-weighted level of low-frequency noise in the third-octave band frequency range from 10 to 160 Hz. The third-octave spectrum is measured indoors using time-weighting 'F'.

L_{HS} The median values of the binaural hearing threshold levels of otologically selected subjects aged 55 to 60 years not exposed to high levels of occupational and recreational noise (minimum audible field). Given in decibels (dB) relative to 20 micropascals (μPa) in the frequency range from 8 to 200 Hz inclusive. Hearing threshold levels are determined for pure tones in free sound fields with subjects facing the sound source.

Low-frequency sound Sound in the frequency range 10 to 200 Hz.

Modulation The variation in the value of some parameter characterising a periodic oscillation. Thus, amplitude modulation of a sinusoidal oscillation is a variation in its amplitude.

Noise-sensitive place Means any of the following places:

(a) a dwelling;

(b) a library, childcare centre, kindergarten, school, college, university or other educational institution;

(c) a hospital, surgery or other medical institution;

(d) a protected area, or an area identified under a conservation plan as a critical habitat or an area of major interest, under the Nature Conservation Act 1992;

(e) a marine park under the Marine Parks Act 1982;

(f) a park or garden that is open to the public (whether or not on payment of money) for use other than for sport or organised entertainment.

Tinnitus Tinnitus in one or both ears is an otological condition in which a sound is perceived by a person without an external auditory stimulation. According to *Encyclopaedia Britannica* it is a ringing or buzzing in the ears. Tinnitus may be caused by any of a number of ear conditions, including the clogging of the external auditory canal with earwax (cerumen) or inflammation of the eardrum membrane, the middle ear, or the inner ear. Tinnitus may also result from an overdose of drugs and it may accompany hearing loss, particularly in the high frequency range. Ringing in the ears also sometimes accompanies vertigo (dizziness).

It may be intermittent or constant in character, mild or severe in intensity, vary from a low roar or throbbing to a high pitch sound so prevalent the individual may hear nothing else.

Tonal sound A sound producing in a listener a definite pitch sensation. If the sound pressure level in a particular third-octave band is 5dB or more above the levels in the two neighbouring bands, the noise is said to be tonal.

Unbalanced frequency spectra A frequency spectra unbalanced towards the low frequencies and which exhibits a spectrum which shows a general decrease of sound pressure level with increase in frequency.

Acknowledgements

The majority of the work in preparing this draft guideline was carried out while the author was employed by the Queensland Environmental Protection Agency (EPA).

The author values the contributions from Norm Broner, Sinclair Metz, Warren Renew, EPA, Chris Schulten, NSW Department of Environment and Conservation and Justin Overton from Caboolture Shire Council.

Cedric Roberts is principal engineer (noise, vibration and air quality management) with the Queensland Department of Main Roads, GPO Box 1412, Brisbane, Queensland 4001, Australia.

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The man who invented stereo

Alan Blumlein

Unique recordings by the inventor of stereo have been cleaned up so the public can hear them properly for the first time. They include Sir Thomas Beecham conducting the London Philharmonic Orchestra (LPO) at Abbey Road Studios in 1934.

The recordings were made by Alan Blumlein, an EMI research engineer, whose contribution to the invention of stereo sound is only now starting to be appreciated. His life and career were the subject of an article by John Tyler in *Acoustics Bulletin*, vol.28 no.5, September/ October 2003.

The early recordings have been re-engineered using digital technology so their true quality can be appreciated. Sound engineer Roger Beardsley, who was responsible for the digital transfers, called the recordings 'incredibly historic'. The recordings had never been properly reproduced, but at last the original information that was there had been recovered. Blumlein lodged the patent for 'binaural' sound in 1931, in a paper which patented stereo records, stereo films and surround sound. He and his colleagues then made a series of experimental recordings and films to demonstrate the technology, and to uncover any commercial interest from the fledgling film and audio industry.

The tests included Blumlein walking and talking in a room to show how sound could move, and recordings of multiple overlapping conversations to demonstrate how his techniques could open up the sound being recorded. Anyone putting headphones on today, and listening to the recordings, would think themselves right in the middle of the room, according to Beardsley. The whole ambience can be detected.

In January 1934, Blumlein took his stereo-cutting equipment to the newly-opened Abbey Studios, and recorded Sir Thomas Beecham rehearsing the LPO in Mozart's no.41 *Jupiter* Symphony. Now, Roger Beardsley has used digital techniques to remove the crackles and hiss from the original 78rpm pressings, and says that the recordings now sound as they were meant to. The result is believed to be very close to what listeners would have heard back in 1934.

Blumlein's work on stereo was soon suspended because EMI concluded that it had no immediate commercial potential. The cancellation forced him to switch to the development of television, and later or radar. He died at the age of 38 during a top secret flight over Wales in 1942, testing a prototype radar system. During his working life until then he had gained 128 patents, or around one every six weeks.

The man who invented stereo was broadcast on BBC Radio 4 on Saturday 2 August 2008.

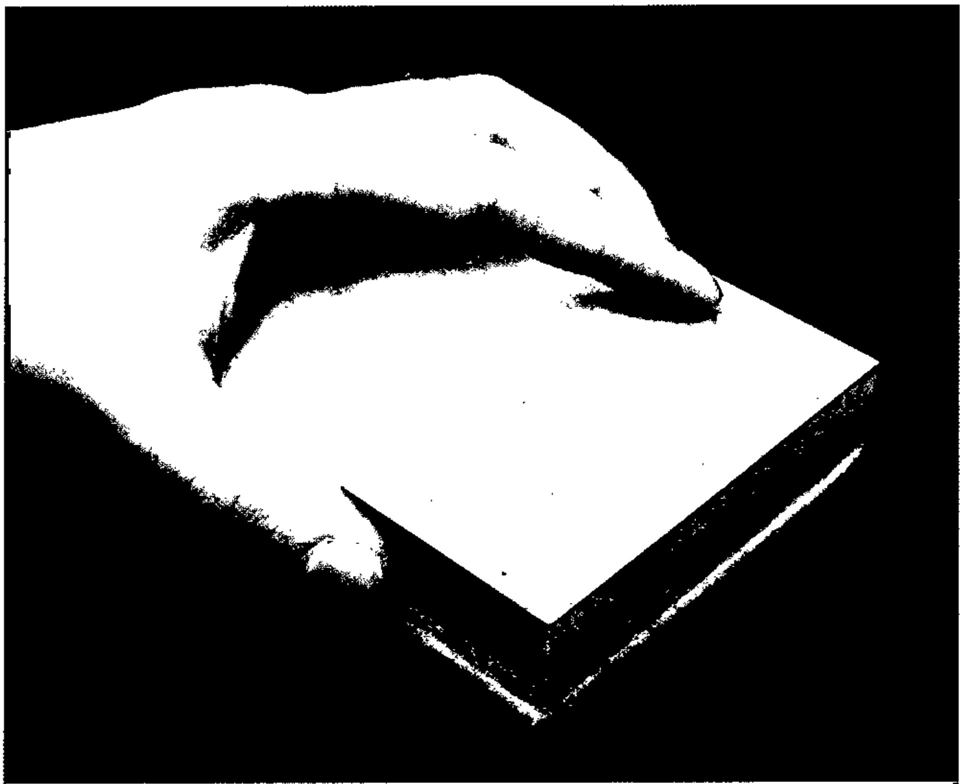
Sound Reduction Systems

MaxiDeck tested

Following its release in a recent issue of *Acoustics Bulletin*, SRS's MaxiDeck has been tested on site and has demonstrated how easily it exceeds the requirements of the Building Regulations Part E.

Baker and King Building Services had been converting the two floors above Barclays bank in Cromer into two luxury apartments, and contacted SRS for advice on meeting Building Regulations. Their starting point was a floor structure of softwood floorboards on timber joists with a lath and plaster ceiling, with the added difficulty of not having any access to the ceiling of the bank below. MaxiDeck was the obvious solution, and proved to be a straightforward and simple installation. Sound insulation tests on site gave results of up to 54dB $D_{nT,w} + C_{tr}$ (airborne) and as low as 50dB $L_{nT,w}$ (impact). The client was delighted by the results, and SRS continues to strive to offer the simplest, most robust solutions to acoustical problems on the market.

For further information on Maxideck and other SRS products and systems, phone **01204 380 074** or email **info@soundreduction.co.uk**
Web site: **www.soundreduction.co.uk**



Maxideck high-performance acoustic flooring

Association of Noise Consultants

reaches membership milestone

The Association of Noise Consultants has recently approved the application for membership of its 100th member. New Acoustics based in Clydebank, Scotland is the latest company to join the association, and takes membership numbers in to three figures.

Adrian James, chairman of the association, says that he is very pleased to welcome New Acoustics as the hundredth member. The recent growth in membership numbers demonstrated the increasing importance of acoustics in the world that we live in. The association was one of the largest organisations of noise consultants in the world, and membership demonstrated to clients that a company meets certain standards in relation to technical competence and independence from hardware interests.

Members of the association vary from small independent organisations through to some of the largest multi-disciplinary consultancies in the UK. The ANC promotes further education and knowledge in noise control, acoustics, vibration and related matters and publicises the existence of consultants concerned with noise, acoustics and vibration and the services they provide. Membership of the association also allows companies to apply to become registered sound insulation testers under the ANC registration scheme, one two government-approved schemes to provide testers for Part E of the Building Regulations 2000.

The association is regularly consulted by government organisations for comments on forthcoming acoustics legislation and guidance. More information on its activities is available at www.theanc.co.uk.

Robert Osborne

Association of Noise Consultants
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Cirrus Environmental

New business launch

Cirrus Environmental, a new business which aims to help organisations measure the noise they make and thereby manage the impact that noise has on neighbours and the surrounding environment, has been established this month. The new business is a sister company to Cirrus Research plc, the UK organisation which specialises in the design and development of noise measurement equipment for health, safety and environmental applications.

Cirrus Environmental will use acoustical equipment developed by Cirrus Research to provide tailor-made environmental noise measurement systems for a wide range of applications including: transport, mining, construction, power generation, manufacturing and entertainment. Environmental noise pollution is an extremely serious issue according to Cirrus Environmental's new Managing Director, Richard Wright. Noise can have a negative impact on people's quality of life, causing effects ranging from mild annoyance to serious health effects such as stress, sleepless nights and heart disease, he says. High levels of environmental noise had even been linked to reduced educational achievement in children. Market research had shown that though most organisations took their responsibilities with regard to noise seriously, and worried about how they might tackle the problem, they simply did not know where to start.

The new company's message was simple. To tackle the issue of environmental noise you needed to measure it. By making continuous long-term measurements, noise trends could be identified and the impact of particular noise sources on the background noise climate assessed. But equally important was the interpretation of those measurements. That was why Cirrus Environmental had been established to offer a one stop shop for the measurement, evaluation and management of environmental noise. Where other providers in the industry simply sold equipment to measure the noise, Cirrus Environmental intended to work with clients to offer advice and support, including remote data acquisition and reporting if required, leaving their customers free to concentrate on running their organisations. Target audiences were sports stadia, motor sport venues, power stations, wind farms, construction sites and small airports: all organisations which generally did not employ experts in this field. Overall the aim was to provide peace of mind and the approach was, to the best of Richard's knowledge, unique in this industry.

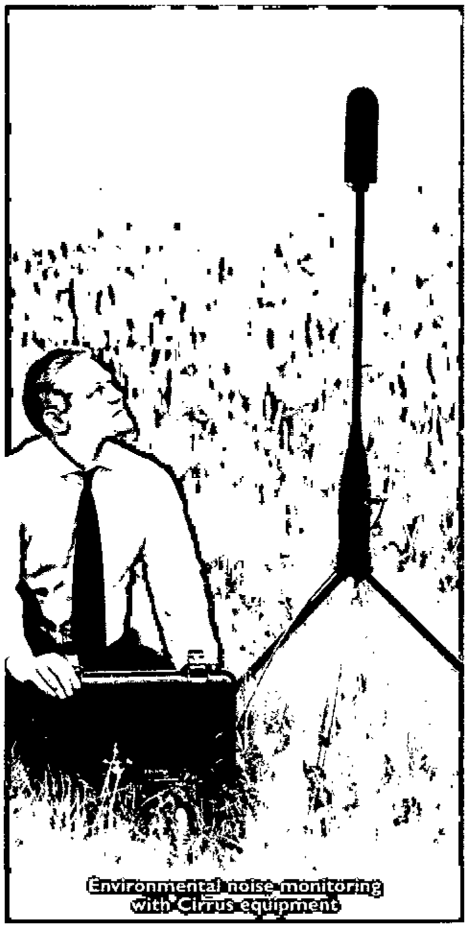
Cirrus Environmental will be integrating well-established products from sister company Cirrus Research's range of noise measurement equipment into its environmental noise solutions. These include portable, semi-fixed and permanent systems, most of which have been independently pattern approved, making them suitable for the majority of environmental noise applications.

The CR:243 series of permanent noise monitoring terminals (NMTs) from has been designed to meet the requirements for environmental noise measurement around the world. The systems are rugged and easy to use. The CR:243/4 'Noise Pole' fits discretely inside a standard lamp-post and so can be sited in public places with minimal risk of damage. NMTs can communicate with computers via a variety of serial links such as direct cable, dial-up modems, wireless radio and GSM telephones.

The software is also easy to use, and provides a full range of features from simple real-time level indication to automatic data gathering, report generation and flight tracking.

A full installation and support service is offered, with excellent technical support, training and advice to customers. Comprehensive recalibration and maintenance services are available, giving customers peace of mind in the knowledge that their noise monitoring systems will give years of trouble-free service.

For further information:
Richard Wright, Cirrus Environmental
Tel: **(44) 1262 670245**
email: **env1@cirrus-env.com**
web: **www.cirrus-env.com/env1**



Environmental noise monitoring with Cirrus equipment

IAC

Celebrates 50 years

The bunting was flying at successful Industrial Acoustics Company (IAC) of Winchester, on the Winnall Industrial Estate. Celebrating its fiftieth anniversary this year, IAC marked the occasion with family party for over 300 staff and friends at their Winnall facility on 24 June. All staff and guests enjoyed champagne and a hog roast, escorted factory tours and speeches in the specially-erected marquee.

IAC is something of a success story. Founded in 1958, the celebrations are certainly justified given the road travelled in 50 years now that IAC enjoys pole position in its markets, and the group leads the world in the design and manufacture of noise control products and systems.

As well as the 200 people employed at the European manufacturing headquarters, the company employs a further 400 people worldwide: in the USA, in five European countries and in Hong Kong.

Its key strength is the diversity of markets for its products, all of which are growing: from anechoic chambers for automotive manufacturers and research, TV and radio studios, HVAC silencers, audiological test rooms, silencers for gas turbines and diesel generators, acoustic doors and windows, aero-engine test rigs and even sound barriers for airports, road and rail.

IAC's six-year investment and European acquisitions programme have enabled the company to exploit the market growth to the full. Thanks in part to noise, health and safety legislation being on the increase throughout the world, the company is bucking the trend when it comes to the demise of much of manufacturing industry in the UK.

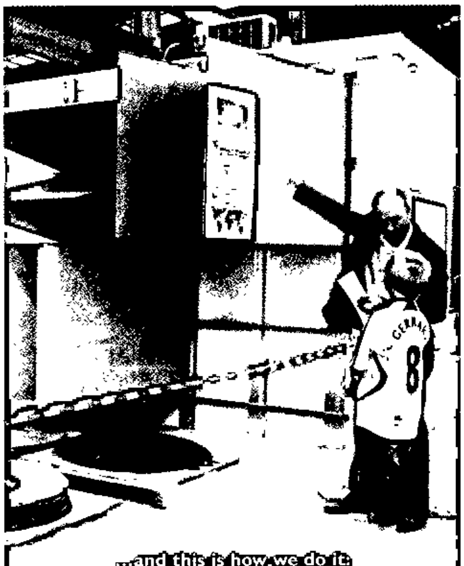
It was not always like this. Brian Quarendon, today's group president and chief executive officer took over the loss-making company in 2002, when it was regarded by its purchasers as a sleeping giant of huge potential. Brian was headhunted into the role because of his strategic skills in turning round underperforming businesses. Under his leadership turnover has grown steadily and today exceeds £120m with over 30% derived from exports.

At the fiftieth anniversary celebrations, he said that it gave him great personal pleasure and pride to celebrate where IAC had come over the past 50 years. IAC was the Rolls-Royce of their industry - his team made some great products and, as the company's slogan said, they certainly did 'make the world a quieter place'. The acoustical engineers, manufacturing managers, factory workers and office and sales teams in Winchester, Colchester and Warrington were continuing to do a phenomenal job. This was a day they could be proud of - a landmark in the history of IAC UK - and his thanks went out throughout the company for everyone's hard work.

IAC's future path looks rosy especially given its enviable reputation for its award-winning innovations. With manufacturing facilities in New York and France, and now with over a hundred agents and licensed partners throughout Eastern Europe, India and China to help reach more distant markets, the glittering client list continues to grow to include the world's greatest and most successful companies.

www.industrialacoustics.com/uk

Brian Quarendon thanks the team for 50 years of effort



...and this is how we do it: Metadyne wedges for anechoic chambers

A family party for the IAC family

View of the Winchester manufacturing headquarters

No party would be complete without a cake

Parliamentary reports

From Hansard

Lords Written Answers

11 June 2008: Energy - Renewables

Lord Taylor of Holbeach asked Her Majesty's Government: Further to the Written Answer by Baroness Andrews on 28 April, what arrangements will be put in place to monitor the outputs of renewable energy installations whose locations have not been justified during the planning process; to remove them if they do not perform; and to compensate the local population for the failure of installations which do not perform.

The Parliamentary Under-Secretary of State, Department for Communities and Local Government (Baroness Andrews): Planning authorities are expected to address the environmental, social and economic impacts that arise from the proposed location of a renewable energy project. In doing so, they can already use planning conditions to require the removal of a renewable energy installation at the end of a specified period. In such cases planning conditions can also be used to require that a site is restored to its former condition. In the case of wind farms, a guidance note prepared for the Renewables Advisory Board and published by BERR*, highlights that decommissioning conditions can be used to ensure full and satisfactory restoration of a site, either in whole or part, should one or more turbines cease to be operational for a given period of time prior to the cessation of a planning permission. There is no reason in principle why such conditions should not be applicable to other installations for renewable energy. Planning authorities can also impose planning conditions relating to other environmental matters such as noise emissions. The companion guide supporting Planning Policy Statement 22 on renewable energy** provides practice guidance on the use of planning conditions and their applicability to a range of renewable energy technologies.

* Available from the BERR and Planning and Renewable energy websites

** Available from the CLG website.

Commons Written Answers

1 July 2008: Noise - Pollution

Mrs Maria Miller: To ask the Secretary of State for Environment, Food and Rural Affairs when his Department will publish noise maps for major roads in England as required in the EU Environmental Noise Directive; and which roads in (a) Hampshire and (b) Basingstoke constituency will be mapped.

Jonathan Shaw: The interactive noise mapping website which shows major roads within agglomerations was published on 16 May 2008 and is available on the DEFRA website. Major roads mapped outside these urban areas are also available on the DEFRA website.

Mrs Maria Miller: To ask the Secretary of State for Environment, Food and Rural Affairs when the public consultation will be held on noise maps developed to meet the requirements of the Environmental Noise (England) Regulations 2006 and Directive 2002/49/EC on environmental noise; and how the consultation will be conducted.

Jonathan Shaw: The regulations, which covered the preparation of noise maps, were consulted on in 2005.

Mrs Maria Miller: To ask the Secretary of State for Environment, Food and Rural Affairs what progress has been made on a consultation to develop a national noise strategy; and if he will make a statement.

Jonathan Shaw: The Government plans to publish a combined National Noise Strategy for England, which will cover ambient and neighbourhood noise, for consultation later this year.

1 July 2008: Noise - Roads

Mrs Maria Miller: To ask the Secretary of State for Transport (1) what estimate her Department has made of the changes in traffic noise levels associated with A roads in (a) Hampshire and (b) England over the last 10 years; (2) what funding is made available to local authorities to reduce the effect of traffic noise from A roads which are near to residential areas; (3) what account she has taken of the effect on levels of road traffic noise from A-roads which results from house building targets; and what assessment has been made of the effect of such levels on existing communities.

Ms Rosie Winterton [holding answer 25 June 2008]: The management of local roads, including decisions on which road treatment to use, is a matter for each local highway authority. This Department provides funding to English local authorities (outside London) through the Local Transport Plan settlement, which they can use on road schemes such as those to reduce the effect of traffic noise. They can also use the Revenue Support Grant provided by the Department for Communities and Local Government. Neither funding is ring-fenced and authorities have discretion how to spend their allocations based upon their local priorities. Funding for highways in London is a matter for the Mayor.

The Highways Agency has not undertaken work to estimate changes in traffic noise levels on the strategic road network over the last 10 years. However, the Environmental Noise (England) Regulations 2006 (as amended) include provisions to improve the information available to the public about noise and its effect. The regulations require the preparation of strategic noise maps for urban areas, major roads, major railways and major airports. Following the completion of mapping an action plan is to be drawn up to manage noise and reduce it where possible. Mapping and action plans are to be prepared on a five year cycle. All mapping for this current cycle has been completed. The Department for Environment, Food and Rural Affairs plans to prepare guidance and consult on drafting action plans later this year.

The noise impact of proposed housing developments, including any impact on road traffic noise, is a matter to be determined at the local level. In the assessment of a planning application, noise nuisance may be a material consideration and taken into account when weighing up the merits of a case.

2 July 2008: Roads - Noise

Mrs Maria Miller: To ask the Secretary of State for Transport what guidance her Department and its agencies have issued on the level of use and the suitability of noise retardant material to resurface (a) A-roads and (b) residential roads.

Ms Rosie Winterton: The Highways Agency manages the strategic road network in England. To reduce traffic noise on their roads, all new roads and major maintenance schemes on trunk roads, including motorways, are surfaced with quieter asphalt. The Highways Agency's specification requires that any new surfacing has the capability of providing a noise reduction of least 2.5dB in the A-weighted level, or in very noise sensitive areas, a reduction of at least 3.5dB, when compared with a typical conventional surface.

The management of local roads, including decisions on which road treatment to use, is a matter for each local highway authority. However, this Department has endorsed *Well-maintained highways'* the code of practice on highways maintenance published by the UK Roads Board, which encourages highways authorities to consider noise reduction measures when maintaining roads. The code can be found at www.ukroadsliaisongroup.org.

3 July 2008: Noise - Roads

Mr Lancaster: To ask the Secretary of State for Environment, Food and Rural Affairs when his Department plans to publish noise maps for major roads in England; and which roads in Milton Keynes will be mapped.

Jonathan Shaw: The interactive noise mapping website which shows major roads within urban areas was published on 16 May 2008 on the DEFRA website. Information on major roads mapped outside urban areas is also available on the DEFRA website.

9 July 2008: Chinook Helicopters - Greater London

Dr Cable: To ask the Secretary of State for Defence on what (a) routes and (b) altitudes Royal Air Force Chinook helicopters regularly fly over the London area; and what mechanism exists for concerns about altitude and noise levels resulting from such flights to be expressed by members of the public.

Derek Twigg: Military helicopters (including RAF Chinooks) operating in the London area use the same fixed helicopter routes as civilian helicopters, and operate at such height as they are instructed to by air traffic control. Members of the public wishing to express concern may contact the Directorate of Air Staff Complaints and Enquiries Unit on 0207 218 6020, or by e-mail to lowflying@mod.uk.

14 July 2008: Local Authorities - Community Relations

Mr Pickles: To ask the Secretary of State for Communities and Local Government what requirements she plans to impose on local authorities to establish a tension monitoring committee; and whether such groups will monitor (a) complaints of noise nuisance and (b) high hedge disputes.

Mr Dhanda: Tension monitoring is not a mandatory requirement for local authorities. The *Guidance for local authorities on community cohesion contingency planning and tension monitoring*, published on 6 May 2008, sets a framework which each local authority can use to monitor local issues that may lead to tension and to put plans into operation if a problem is identified. These issues could include complaints about noise nuisance or high hedge disputes. It is up to each local authority to determine the scope of their tension monitoring and contingency planning.

21 July 2008: Microgeneration - Noise

Robert Key: To ask the Secretary of State for Environment, Food and Rural Affairs for what reason the permitted noise level from domestic microgeneration equipment has been set at a level five decibels higher than that proposed in the consultation document.

Mr Iain Wright: I have been asked to reply. My written statement of 13 March 2008 announced that secondary legislation had been laid before the House that would remove the need to apply for planning permission to install certain types of householder microgeneration. These permitted development rights now apply to solar, ground and water source heat pump, combined heat and power and biomass technologies.

The statement explained that good progress was being made in trying to resolve the issue of noise that prevented permitted development rights being extended to wind turbines and air source heat pumps at that time. It also indicated that a restriction would be imposed to ensure that habitable rooms of any neighbouring residential property are not exposed to an outside noise level exceeding 45 decibels. This figure seeks to balance the Government's desire to encourage the take-up of microgeneration with the need to consider the potential impact on others. We have not yet concluded work on this issue and therefore permitted development rights do not currently apply to these technologies.

21 July 2008: Noise - Pollution

Dr Julian Lewis: To ask the Secretary of State for Environment, Food and Rural Affairs (1) what remedies are available to people disturbed by persistent amplified noise in public places made (a) in the cause of political protest and (b) for other reasons; and if he will make a statement; (2) what his policy is on the prevention of disturbance to others by people persistently making amplified noise in public places without the permission of the relevant local authorities; and if he will make a statement.

Jonathan Shaw [holding answer 15 July 2008]: Section 79 of the Environmental Protection Act 1990, as amended by the Noise and Statutory Nuisance Act 1993, provides that noise, other than traffic noise, emitted from vehicles, machinery or equipment in a street can be a statutory nuisance, if it does, has or is likely to interfere with the quiet enjoyment of a person's land or is prejudicial to their health. Local authorities have a duty to investigate complaints about statutory nuisances, and may serve abatement notices. Failure to comply with an abatement notice can be a criminal offence. These provisions do not however apply to political demonstrations or a demonstration supporting or opposing a cause or campaign.

Section 62 of the Control of Pollution Act 1974 bans the use of a loudspeaker in a street at night (between 9pm and 8am), and restricts the use of loudspeakers for advertising at any time subject to limited exemptions.

Section 137 of the Serious Organised Crime and Police Act 2005 bans the use of loudspeakers in the area around Parliament at any time and for any purpose (subject to a number of exceptions, including where consent of local authority has been granted). The Government has however announced its intention to repeal these provisions.

There are in addition byelaws which govern the use of amplification equipment in certain areas such as Trafalgar Square and Parliament Square Garden. There may be similar local byelaws in other parts of the country.

The article on amplitude modulation of wind turbine noise by Dick Bowdler has motivated me to write. I have considerable respect for Dick as an Engineer and as an Acoustician. My guess is that he has been asked to write this article by people who should know better. Before commenting on the article I will give readers some brief background details.

Recently there was a revealing article in *Professional Engineering*, the magazine of the Institution of Mechanical Engineers, entitled *Wind farm opposition turns ugly*. Wind farm developments are being put at risk by new levels of aggressive opposition. The anchor bolts of an 85m survey mast collapsed, apparently after the holding-down bolts were unscrewed. Landowners who supported wind turbines have been subjected to a range of intimidation including their front gardens being sprayed with weed killer, a brick thrown through a window, and a car burnt out. Meetings have had to be cancelled because of threats of violence. There is a very active minority who are very deeply emotionally opposed to wind turbines in Scotland. They have some support in many critical areas including the Scottish, UK and EU Parliaments, local authorities, community councils, schools and the media. All those who realise the importance of maximising electricity generation by all forms of renewable energy should take cognisance of this powerful force which uses all means to sabotage planning applications for wind turbines.

The impellers of centrifugal fans and the blades of axial fans create gas velocity (wind) in the outlet duct. Wind turbines convert wind energy into electrical energy. There are some similar mechanisms of sound energy generation, and our decades of sound research should be useful for analysing wind turbine noise. However, wind turbines do not have vanes to create spin before the blades, hence the very high infrasonic peaks which can occur for centrifugal fans at part vane positions will not be generated. The fact that there was no apparent or reported ill health by the very high amplitudes of infrasonic peaks from large fans is very significant.

Low-frequency sound energy and amplitude modulation are often raised at public meetings and in letters to the press by agents of those who are more upset by the visual impact of large wind turbines near their home than by the desperate plight of starving children and their parents in far-off lands, who could be saved by a massive increase in operating wind turbines. Modulation is defined as *'the systematic variation of a periodic carrier signal by a lower frequency signal. There can be amplitude modulation, phase modulation and frequency modulation'*. As far as wind turbines are concerned it is, I believe, a deliberate ploy to confuse the uninformed. I may have planned and analysed more sound tests on large centrifugal fans than anyone else in the world. Peak low-frequency sound levels at stall operation and at part inlet vane angle due to the wrong angle of attack are probably orders of magnitude higher than anything generated by wind turbines. Although these high infrasonic peaks have caused severe acoustic fatigue failures in steel ducts, and caused dishes to rattle in cupboards 400m from the fan, they have not, as far as I am aware, caused any harm to the health of children or adults. None of those working close to these infrasound peaks for many years have reported any ill effects. If we had not proved by tests at B&W, Renfrew, that fan sound power is proportional to gas density and not density squared, as deduced by manipulating the fan laws, and therefore reduced the vane spin induced infrasound peaks by dorsal fin splitters before the impeller inlet, there might have been no advanced gas-cooled (AGC) nuclear power stations in the UK. The Nuclear Power Group did several months' testing on a circulator rig at Glasgow to optimise the dorsal fin splitter design. They established that a hockey stick shape gave the minimum peak amplitude.

Wind turbine generated noise is extremely complex. Most horizontal axis wind turbines have three blades, each of which generates broad-band sound energy over a wide frequency range. There is a considerable wind gradient from the twelve o'clock to the six o'clock position, and the wind is never constant for more than a few seconds. It is continually gusting, making the sound energy generation vary with time. Sound propagation in air is also extremely complicated. It is influenced by wind speed and direction, by temperature and wind gradients, *etc*. Molecular absorption depends on air temperature and humidity and distance from the sound source. Ground topography and sound absorbing properties are also critical. There is also the addition of wind generated self-noise in trees, shrubs and vegetation. Engineers would never try to calculate wind turbine noise by scientifically establishing the effect of all these complex variables and mathematically adding them.

For centrifugal fans we deduced that there are two main sources of sound energy: broad-band sound which is closely connected to the fan efficiency (this is a minimum at fan peak efficiency duty) and discrete tone interaction peaks at blade passing frequency {BPF}, and harmonics (not at all related to the fan efficiency). The amplitudes of the tones at BPF are related to the impeller speed by a much higher value than the broad-band sound energy. The interaction sound and broad-band sound were calculated separately. Most other fan manufacturers used Beranek's formulae. None, to my knowledge, tried to scientifically establish all the multitude of sound sources (edge tones, vortex shedding, cavity resonances, casing and duct thicknesses and natural frequencies). Methods of predicting fan sound power and sound pressure levels were established by statistically analysing a very large number of sound tests and using suitable factors of safety to be able to comply with guaranteed values for sound power and sound pressure specified to clients. A similar methodology should be used for wind turbines.

I have been responsible for sound measurements on 300kW and 1MW horizontal axis wind turbines. The 'swish, swish, swish' audible close by is obviously the aerodynamic sound generated by each of the three blades as they rotate through the wind gradient. At about 50m from the wind turbine the swishes blend together. I have never heard any noise from a wind turbine which I would describe as a 'thump'. It is important that all blades are upstream of the tower to avoid the possible effect of high wind speed induced turbulence affecting the aerodynamic and acoustic performance of the wind turbine.

On page 33 and 34 of the *Bulletin* article, Dick comments on the statements by the occupiers of a property near the wind farm at Deeping St Nicholas. Since they are obviously hostile to wind turbines and probably without any engineering and acoustic knowledge and experience of wind turbines, their records and comments on the controversial phenomenon of amplitude modulation are suspect and should, I suggest, not be included in any appraisal in *Acoustics Bulletin*.

There is obviously a dearth of comprehensible charts showing the measured amplitude against time or frequency for the so-called amplitude modulation in the twenty published papers in the list of references. The graph at the top of page 35 is presumably sound pressure level against time but there are no scales or units mentioned. Surely some of those who wrote the twenty papers could have actually measured *the lower frequency signal which caused a systematic variation of a periodic carrier signal*. If a graph without scales and units is the best that twenty acousticians, companies and organisations can do, they should devote their energy and resources to correcting serious flaws and mistakes in ETSU-R-97 and the Scottish Planning Advice Note PAN45. They could begin with correcting the following serious blunder.

The revised PAN45 reproduces the guidance in ETSU-R-97, which was compiled in 1996. The following serious mistake in PAN45 makes it virtually impossible to obtain planning permission for single wind turbines in Scotland unless the EHO rejects the protocol of complete compliance with the noise rules:

'For single turbines or wind farms with very large separation distances between the turbines and the nearest properties, a simplified noise condition may be suitable. If the noise is limited to an $L_{A90,10min}$ of 35dB up to wind speeds of $10ms^{-1}$ at 10m height, then this condition alone would offer sufficient protection of amenity, and background noise surveys would be unnecessary.'

The author is trying to make a concession for single wind turbines, but he has made a mistake. The 35dB(A) is **more stringent** than PAN56, which has a guideline L_{Aeq} night-time noise level maximum of 45dB. That is not a concession, it is a severe penalty. It is irrational, and against the best interests of everyone in Scotland, to have the noise condition for single wind turbines more stringent than it is for industry, road traffic, *etc*. I submit that everyone who is aware of this mistake has a moral and national duty to correct it, as it is a huge obstacle during planning applications for single wind turbines in Scotland.

Ian Watson

Frank Fahy

Receives award

Prof Frank Fahy FIOA was recently awarded the premier medal of the German Acoustical Society (DEGA), the 2008 Helmholtz Medaille for 'Lifetime achievement and outstanding contributions to research and education over the full breadth of Engineering Acoustics'. The presentation took place in March 2998 in Dresden, and Frank is the first non-German to be so honoured since the award was inaugurated 18 years ago.

The full text of the medal address is available on request to the Editor of *Acoustics Bulletin*, and an internet link to it will be shortly be established. However, the final topic of Frank's address should interest acousticians everywhere. It ran:

'At Euronoise 98 in München, I presented a paper on my view of the relationship between vibroacoustic theory and experiment. I made the point that the construction of a valid, efficient and economical theoretical model of a system requires (i) the appropriate choice of influential parameters; (ii) a proper appreciation of the relative orders of magnitude of their influences on the target responses of the modelled system; (iii) the need to tailor the complexity of the model to the precision required of its predictions. These decisions depend crucially upon a thorough understanding of the physical origins of the parametric sensitivity of the behaviours of the type of system modelled. In some cases, the relative influences of different elements of a system on the target response can be established by rather simple *ad hoc* experiments. To give a very simple example: if the noise in a car is not significantly influenced by loading the roof with a heavy rubber mat, don't trouble to include roof vibration in your radiation model.

In the recent past, it has been common practice in some industries to separate the offices of those members of staff developing theoretical, computational models of systems from those who design and perform the experimental test programmes. This schism is all the more regrettable in these days when engineering students spend more and more time in the imaginary world of computational simulation and less and less time in the real world of laboratories and test sites. This is partly due to financial pressures to reduce expense on equipment and technicians, but also, in the UK at least, due to the reluctance of students to study in the laboratory. As one student said to me a few years ago 'I don't like lab work. Labs are so messy and the results often seem to be wrong'. I didn't ask him how he defined 'wrong', but I did remind him that when he sits in front of his PC, he is in control; but when he is in the laboratory, nature is in control.

In the days before computational simulation became practicable, we used to say of the printed page that 'black and white is right'. Nowadays, I believe that some industrial managers are disproportionately impressed by multi-coloured computer outputs. Perhaps they believe that 'red, yellow, green and blue is true', and they are not the only culprits! It is therefore very important that both engineers and their managers should be fully aware of the continuing need to validate theoretical models by comparison with experimental data. Indeed the real and imaginary worlds can be combined very effectively to understand a complex world, but the need for all concerned to appreciate the strengths and weaknesses of both components is still of vital importance to a satisfactory outcome.

I would like to conclude by acknowledging the inspiration and motivation that I have received over many years from my academic colleagues and my research students, without which I would not be in a position to be able to express my gratitude to DEGA for the great honour done me, and for the pleasure of receiving such a prestigious award.'

Frank Fahy (centre) with Joachim Scheuren, the DEGA President, and Björn Petersson, Professor of Acoustics at the Technical University of Berlin, who gave the laudatio.

Hank Bass

Obituary

Dr Henry E Bass (Hank to his friends and family) died in May this year after a brief struggle with a recurring kidney cancer. Hank contributed to world-leading research in many field of acoustics including atmospheric (air) absorption, acoustic-to-seismic coupling, thermoacoustics and infrasonics. For many years Hank directed the Physical Acoustics Research Group at the University of Mississppi (PARGUM). Among many other activities, he developed a patented acoustically-based early warning system for tornados. In the 1990s through an iimpressive mixture of scientific vision, persistence, charm and political savvy, Hank was able to secure funding for the National Center for Physical Acoustics (NCPA) on the Ole Miss campus. Until his untimely death, he was Director of the Center for many years, and was responsible for assembling an outstanding collection of scientists, facilities and research funding despite the highly competitive environment in the US. Hank was responsible for intitiating the series of twelve Long 'range Sound Propagation Symposia (LRSPS) which have been attended regularly by British scientists since 1981. Recently Hank had been a leading developer of the global infrasound monitoring system for, among other things, checking adherence to test ban treaties. Hank was a member of the international panel appointed by EPSRC in 2006 to assess the status of acoustics research in the UK and researchers here owe him a debt for the excellence of the panel's report.

Hank was an officer in the National Reserve (the US equivalent of the Territorial Army) and throughout his life as a researcher was interested in the military applications of acoustics. He was a leading member of the NATO Research Study group concerned with the exploitation of mechanical waves in battlefield surveillance. Nevertheless Hank was among the first to see possibilities for developing an acoustic-seismic method for detecting buried landmines and hence for humanitarian demining.

Over the years those who had the good fortune to work with him benefited from his tremendous kindness, friendship and advice. Hank possessed a rare combination of skills encompassing theory, practical intuition, instrumentation and politics. As a result of Hank's death the world has lost an outstanding acoustician and a fine individual.

There is to be a memorial session for Hank at the ASA meeting in Miami in November.

Hank Bass and acoustician colleagues at the 11th LRSPS held in Vermont, USA in 2004

Hepworth Acoustics

New experts in regional offices

Chris Parker has joined the East Midlands office of Hepworth Acoustics Ltd as a consultant, building on the team headed up by principal consultant, Richard Housley. A graduate of the University of Derby, Chris joined the Hepworth office after three years with a similar consultancy. Since joining he has been involved in the assessment of noise in educational, entertainment and commercial sectors in addition to the design and testing of sound insulation for Part E of the Building Regulations. As part of the East Midlands office his role will also involve environmental acoustics, industrial noise assessment and planning application work.

Chris says he joined the company as he was impressed with their professionalism, and the fact that it seemed to be such a well-structured organisation. The close proximity of the Donington office to his home was also a bonus! It was exciting to be able to build on his existing knowledge by learning from the wealth of experience that is evident throughout the company.

In London an international flavour is introduced with the recruitment of Antonio Meireles. Portuguese by birth, Antonio, after spending several years working in his homeland, has returned to London having completed his second degree in Environmental and Architectural Acoustics there. He brings a cosmopolitan, international understanding and approach to building acoustics that complements that of principal consultant, Duncan Newhall's environmental expertise.

Chris Parker Antonio Meireles

Antonio is enjoying city life - the mix of cultures socially and in the office. He says he joined Hepworths rather than a larger consultancy because of the people, the central location of the London office and the clear organisational structure that he found.

Blip, Ping and Buzz: Making sense of radar and sonar

by Mark Denny

Is it possible to describe radar and sonar without using mathematics? Mark Denny sets himself the challenge. 'I do not intend to write a textbook' he says, instead, the book is an introduction for those with a technical background but no mathematical specialisation.

The six main chapters are set out as a narrative of past, present and possible future developments. The author's own background is in radar and he uses this subject as his starting point by describing early experiments in the 1920s. There follows a fascinating and well-researched historical account of radar developments during the Second World War. A combination of technical challenge, espionage, deception, and sheer bravery reads like a page-turning thriller that could be a book in its own right.

Having captured the reader's imagination it is time to 'get technical'. Radar engineers describe their transmissions as 'blips' which are reflected from distant objects according to a few basic rules. At this point the related subject of sonar is introduced, as radar cannot penetrate water, the sonar 'ping' being familiar from war films and obeying many of the same rules. Both radar and sonar are 'remote sensing' techniques and their final products are pictures. Hence the author adopts a pictorial approach to describe the physics at the heart of their signal processing. To avoid interrupting the narrative style there are detailed technical notes for all chapters at the end of the book. These retain the same pictorial representation and are aimed at those readers wishing to delve deeper, hence providing a link to more theoretical textbooks.

Building on the theme of deception, and again using a partly historical perspective, the author then turns to the secretive world of electronic counter-measures, jammers and anti-submarine warfare. Throughout the book, and especially in this section, there are footnotes which include historical details, anecdotes and amusing examples from real life and which, to use the author's words, 'please be sure to read'.

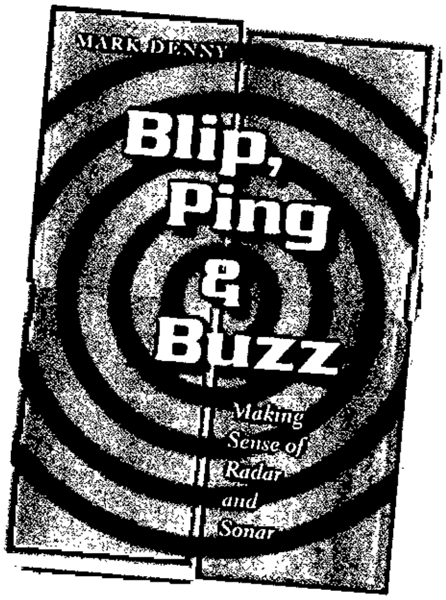
Not only humans have developed sonar. Whales, dolphins and porpoises have beaten us by several million years, and bats by even longer, as revealed by fossil evidence. Here the focus is on the microchiropteran bats which use echolocation to catch insects. Their signals sound like a 'buzz', giving the third element of the book's title. So sophisticated is their signal processing that we are only just beginning to understand them, and this is why their treatment is delayed until a late stage of the book, allowing the reader to accumulate the necessary ideas.

The field then expands to a wider look at commercial applications of remote sensing. It covers such topics as air traffic control, weather forecasting, fish-finding and medical imaging. It then continues with some speculation as to where we may be going in future, in particular with respect to military requirements which, as always, are likely to be at the forefront of technical research.

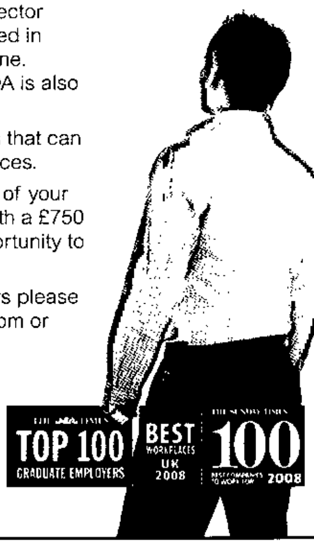
Finally the author allows himself a few pages of personal reflection. In a career spanning more than two decades he has experienced the highs and lows of technical challenge and gives an insight into the motivation that drives professional engineers. He uses the term *managerial entropy* to describe to the social dynamics of large organisations, and stresses the remarkable effect that even a single individual can have in the right or wrong place. Many who read this section will know his frustration at the layers of bureaucracy that seem inevitable in complex projects, and I wonder how many will agree with his suggestion that there is a sociological, rather than a technological, limit to the complexity of an engineering system that humans are capable of building.

I very much enjoyed this book. The light-hearted commentary feels untechnical yet penetrates the subject to a surprising depth. I would recommend it to anyone with an interest in physics, engineering or biology, and especially to anyone who wants to step across the boundaries between them, either for pure interest, or for their career.

Geoff Steel MIOA



Blip, Ping and Buzz by Mark Denny is published by The Johns Hopkins University Press, 2007. ISBN 9780801886652.



Ventilation and the Building Regulations Part E

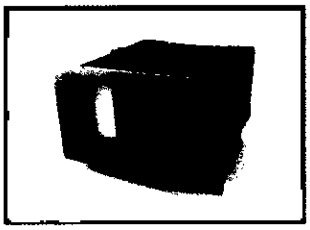
How to give clients a quiet life but still maintain aesthetic appearance in all types of buildings

The number of official noise-related complaints has increased more than 300% over the last few years, and they now make up the majority of complaints to local authorities. Approximately 4 million people in Britain feel they suffer from noisy neighbours and almost a quarter of occupants of dwellings rate their privacy as 'poor' or 'very poor' as a result of inadequate sound insulation. The number of 'brown field' sites is also growing, putting residential developments very close to railway lines, motorways, airports and industrial estates.

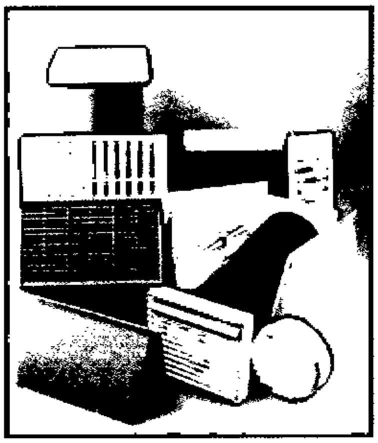
How can a building be adequately ventilated with minimum noise transmission?

There are now ventilation products available to help meet the requirements of the Building Regulations Approved Document E *Resistance to the passage of sound*. However, one manufacturer, Rytons Building Products Ltd, believes it should not be necessary to sacrifice the appearance of the building, or the provision of effective and vital ventilation under Part F of the Building Regulations *Means of ventilation*, in order to meet these requirements. The company has designed and manufactured acoustical versions of their popular 125mm and 150mm diameter AirCore Ventilators, '9×3' AirLiners, '9×6' AirLiners and '9×9 AirLiners that appear exactly as normal from the outside, and to the occupier of the building, but in fact hide an intricate and efficient system of acoustic panels and foam which claim to reduce the amount of sound transferred by up to 42dB.

Not only is there a variety of styles and sizes, but also a wide range of standard colours and a choice of suitable fitments for the inside, eg adjustable hit-and-miss vents for background ventilation, or fixed open louvre vents for appliance and general venting, ensuring the safety of the building's occupants whilst still improving levels of sound insulation between one building and another, and within buildings. One type can even be retrofitted entirely from the inside of the building, which is ideal for existing high-rise dwellings.



Rytons '9×6' Acoustic AirLiner: internal view



Rytons Acoustic Vents have the appearance of standard through-wall ventilators from the outside

However, Rytons do not just expect specifiers to take their word for it. A large proportion of their acoustical range is British Board of Agrément-approved (only new products pending approval), and **all** acoustic products have been fully tested by the Building Research Establishment with comprehensive test data freely available. The original telescopic acoustic AirLiner received an Innovation Award from the BBA when it was launched in 2002. Those acoustic ventilators within Rytons range that can be used to ventilate heat-producing appliances have also undergone testing by Advantica and the BRE to BS5440-2:2000 and have been accredited with a calculated equivalent free area.

Many major housebuilders including Charles Church Developments, Countryside Properties, Bryant Homes Social Housing, Bellway Homes, Barratt Homes and Redrow Homes have used Rytons acoustic ventilators. They have also been successfully installed in many non-domestic situations including City Airport Travelodge, London E16 and Tesco, Islington Green, London N1. They have even travelled abroad, including a private project for a resident of New York who was so impressed with one he encountered in his Dublin hotel on a visit that he ordered one over the internet on his return home!

These products are just some of the latest in an ever-expanding range from Rytons, all of which are manufactured in the UK. Most forms of domestic construction ventilation are available including Slim Vents for effective and essential timber frame cavity ventilation, Rytweeps and Weep Hole ducts for drainage of interstitial condensation, and Periscope underfloor vents for the ventilation of sub floor voids. Rytons' wide range of louvre and hit-and-miss vents is now available in VO-rated flame retardant material to help prevent the spread of

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CMS Acoustics

launches Regupol SoundFoam

One of the UK's largest providers of acoustical systems, CMS Acoustic Solutions, has expanded its market leading screed isolation range for Part E compliance with the launch of Regupol SoundFoam, a reliable and cost effective screed isolation solution. Developed to address impact sound, Regupol SoundFoam is ideal for new-build projects where .ound control is essential but budget must be kept to a minimum.

The unique manufacturing process of Regupol SoundFoam injects EVA rubber cells into a cross-linked, closed cell polyolefin foam, providing the material with higher elasticity compared with traditional foam under-screed products. This delivers superior acoustic insulation and increased resistance to compression and creep over a longer lifespan.

Available in 5mm, 10mm and 13mm thicknesses, the product provides impact sound insulation of up to 20dB. Moreover, the closed cell composition has low water absorption, eliminating the need for a separate waterproof membrane and reducing the cost of using the under-screed system even further.

Designed for use with cast in-situ and pre-cast plank subfloors, the material is simply laid on top of the subfloor. Complete isolation is achieved with the installation of SoundFoam edge sections around the perimeter of the floor. Quick and easy to install, these self-adhesive edge sections reduce the risk of on-site workmanship error and secure the isolation performance.

Paul Absolon, technical director, CMS Acoustics, commented that Regupol SoundFoam offered greater flexibility than most foam-based products currently on the market. Complementing their existing range of under-screed products, the material would allow the company to continue to provide impact sound solutions for all construction

Regupol SoundFoam provides a cost-effective screed isolation solution for social housing

types and budgets.

Providing effective impact sound control for new build projects, it is suitable for use on developments such as social housing, apartments, educational buildings and hotels. Being a foam-based product, it is recommended only for use with a sand and cement screed.

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www.cmsacoustics.co.uk

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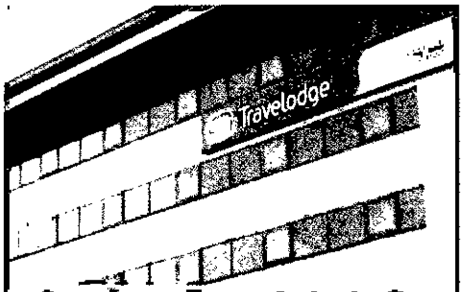
fire. Most of Rytons' products for external use are UV-stabilised to ensure that sunlight and weather exposure do not affect the appearance or durability of the ventilators for decades to come.

Rytons' web site **www.vents.co.uk** contains the 2008 editions of the Product Guides for free download plus over 100 technical data sheets that include full product specification, dimensional drawings, accredited test data, and colour photographs, as well as frequently asked questions and the answers to them. Alternatively, product information can be sent by email, fax or post. Technical specifications for Rytons' products are now also listed on NBS Plus, part of the NBS industry-standard specification software used by architects, building surveyors and other construction industry professionals.



Rytons Acoustic Vents used in London City Airport Travelodge

Shhh - Listen to the Vocis!

Quiet as a mouse!

Did you know that the 'vocis' is the Latin word for 'voice'? The newly-updated Vocis sound meter from Castle Group seems to have a lot to say for itself. It incorporates an in-built hearing protection database, which means that after making a measurement through the instant template system, it can show how much protection can be expected with any particular hearing protection device, straight to the screen. This can then be directly compared with the Exposure Limit Value from the Noise at Work Regulations 2005.

This removes all the time-consuming and possibly erroneous calculations by the safety officer, and provides fast, accurate analysis of attenuation data. The hearing protection comparison can then be downloaded onto a PC via Castle's dBdataPRO dedicated software, or directly onto a portable printer, giving information that could be vital in future litigation.

With real-time octave band analysis, twin measurement channels and data-logging into 32Mb of memory, the Castle Pro-DX Vocis sound meter can capture all the data required for a noise at work risk assessment in one measurement, making it ideal for the busy safety professional.

Chris Frear of Coors Brewery, Tadcaster says that in the brewing industry, a rugged instrument was needed that was simple to use in a potentially tough environment. The Castle Vocis seemed to fit the mark and had certainly proven itself since his organisation purchased one. Some of the team had also attended a Castle training course, which they found to be geared to exactly what was needed - the right amount of practical and theory to help get the job done.

The Vocis is proving to be a huge success for Castle, with sales on every continent. The meter has been designed for tough environments and is weatherproof and dustproof, protecting the advanced technology held within.

For further information: Michelle Uprichard
telephone: **01723 858063**
fax: **01723 857164**
email: **mu@bulluk.co.uk**
web site: **www.castlegroup.co.uk**

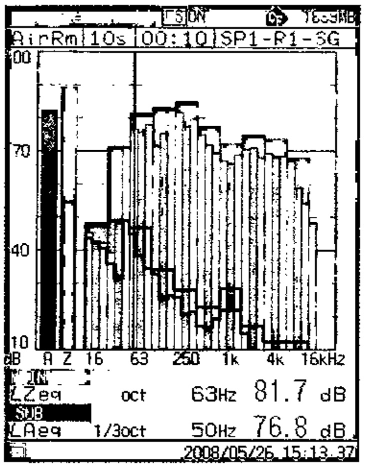
Building Acoustics Package from Rion

NX-28BA Building Acoustics Option for the Rion NA-28

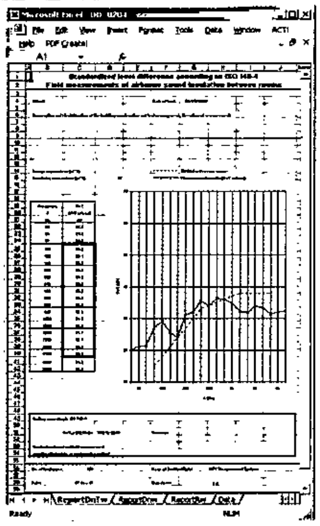
The NX-28BA Building Acoustics Option for the Rion NA-28 is now being used by consultants throughout the industry, including organisations with accreditation under the UKAS and ANC schemes. The system is also available for hire from ANV Measurement Systems. Designed in consultation with leading UK consultants, the NA-28BA is quick and flexible. Reverberation times are calculated in an instant, and the system makes full use of the Rion NA-28's superb colour display showing the receiver room levels and background noise levels on the same display.

All the main single-figure ratings for both airborne and impact sound insulation testing are calculated in the meter. The meter can calculate the results according to the ISO 140 method or in the manner set out in Approved Document E (either method can be used on the same data in the meter).

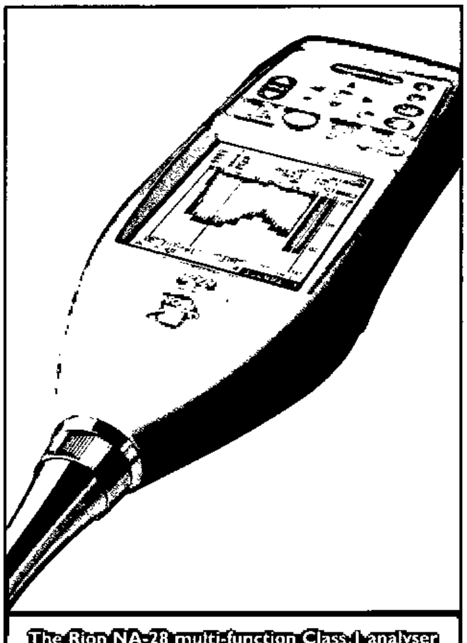
Exporting the data into reports is simplicity itself. The data files are stored as text onto a compact flash card, so they can be read directly with Microsoft Excel. By storing the data as text files on compact flash cards, it is always possible to get access to data without the need for bespoke software or download cables. The NX-28BA is, however, supplied with macros for Excel which formats the data and enables the results to be printed in accordance with ISO 717 in seconds.



The superb colour display is backlit and can be seen clearly under all lighting conditions ranging from complete darkness to bright sunshine



The Excel macros supplied format the data in accordance with ISO 717, and facilitate access to the results for reporting



The Rion NA-28 multi-function Class 1 analyser

Call ANV Measurement Systems (**01908 642846**) or visit **www.noise-and-vibration.co.uk** for more information, or ask to try the system that is claimed to be the quickest and easiest means of carrying out sound insulation testing.

PDA-based analysis

Brüel & Kjær SoNoScout

Binaural recording and analysis is now much simpler and quicker to perform with the launch of Brüel & Kjær's super-slim PDA-based tool, SoNoScout NVH. Created to record and analyse binaural sound for noise, vibration and harshness development applications, the SoNoScout system is ideal for conformation of prototype or design performance changes, benchmarking of competitor vehicles and evaluating vehicle behaviour during on-road tests.

Recording is carried out via two high-quality microphones, which for convenience and comfort are mounted on a pair of folding headphones. Immediately after recording, the stored data is available for replay and analysis. The saved data can be analysed on the PDA itself, transferred to the PC software supplied, or even exported to other analysis systems, such as Brüel & Kjær's PULSE data analyser.

The PDA's display has large, simple icons making it easy and safe to control the start and stop of recordings, even whilst the operator is driving. Keith Vickers, B&K's technical specialist, explained that SoNoScout had been designed to provide engineers with complete flexibility. It contains analogue and digital sound cards for recording with the microphones supplied, or with a head and torso simulator. It simultaneously stores audio and positional data through an included global positioning system (GPS) device. As well as route mapping, this also allows the user to plot vehicle speed during the recording. The audio and vehicle performance data recorded by SoNoScout can also be used for analysis with Brüel & Kjær's PULSE NVH Vehicle Simulator, as both systems are fully compatible.

The entire SoNoScout NVH system is contained in one rugged transport case and the main components are compact enough to fit inside a jacket pocket.

Brüel & Kjær SoNoScout

Brüel & Kjær UK is also running a free, interactive training course called *Ultra portable sound quality*, which covers sound quality metrics (L_{Aeq}, loudness, roughness *etc*), measurement procedure and post-processing, and will act as an introduction for the new SoNoScout system.

For more information or to register for this course, visit: **http://www.bksv.co.uk/default.asp?ID=3550**

For more information about SoNoScout, see **www.bksv.co.uk** or phone **01438 739 000.**

Colouring sound level readings

Casella CEL-600

One of the UK's leading manufacturers of environmental monitoring equipment has developed a colour-coded display system for sound level meters which simplifies their use and reduces the risk of misinterpreting data. Casella CEL has now launched the all-new 620 series of pocket-sized meters which incorporate the high resolution colour display into the smallest and easiest-to-use sound level meter on the market.

The Casella CEL-620 series is now the smallest octave band analyser in the world, and probably the strongest too. The colour readout assists the user by displaying results in a simple colour-coded format that is impossible to misinterpret. Ease of use has been a key design goal in the development of this instrument, so from simple point-and-shoot measurements to full industrial hygiene assessments, all measurements can be performed quickly and easily.

This is industrial equipment and was designed with an overmoulded case to give it the strength and durability needed for tough industrial environments. The CEL-620 uses all-digital technology that can measure in a range up to 140dB, eliminating the need for range adjustment and the reading errors which may result. Another unique feature is that it measures all occupational noise parameters simultaneously: rather than changing the instrument setup you simply change the noise parameters you wish to view, knowing that all parameters can be viewed afterwards even if they were not selected at the time.

The CEL-620 really presents the next generation of workplace sound level meters, according to Tim Turney, product manager for Casella CEL. A real-time octave band analyser had never been so compact and yet filled with technology designed to make life easier for the health and safety professional.

The CEL-620 is supplied as a kit in a rugged briefcase, which also includes an acoustic calibrator, windshield, software and USB download cable. Both the instrument and calibrator come with calibration certificates as standard, documenting compliance with the latest IEC 61672 sound level meter standard.

For further information contact Casella CEL on **01234 844100,** by email: **info@casellameasurement.com**
Web site: **www.casellameasurement.com**

CEL-600

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Committee meetings 2008

DAY	DATE	TIME	MEETING
DAY	DATE	TIME	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

11 September 2008
Building Acoustics Group
Building acoustic materials: towards sustainability
London

3-5 October 2008
Building Acoustics Group
Auditorium acoustics 2008
Oslo, Norway

14-15 October 2008
Underwater Acoustics Group
Underwater noise measurement, impact and mitigation
Southampton

21-22 October 2008
Measurement & Instrumentation Group
Autumn Conference 2008 - Demonstrating current and emerging techniques for sound measurement
Oxford

20 21 November 2008
Electroacoustics Group
Reproduced Sound 24 - Immersive audio
Brighton

16 January 2009
Wind farm noise
Bristol

5 March 2009
Measurement & Instrumentation Group
Audible - Inaudible
London

31 Mar – 1 April 2009
Underwater Acoustics Group
Bioacoustics 2009
Loughborough

28-29 April 2009
Environmental Noise Group
Spring Conference 2009 - Environmental noise management in a sustainable society
Oxford

26-28 October
EURONOISE 2009
Edinburgh

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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