

ACOUSTICS

BULLETIN



in this issue...

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plus... Changes and challenges in
environmental noise measurement

New measurement methods in room acoustics

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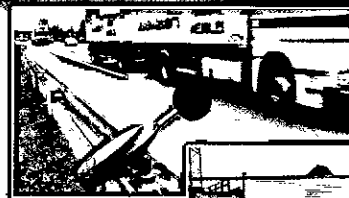
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ACOUSTICS

BULLETIN

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The Institute of Acoustics was formed in 1974 through the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society and is the premier organisation in the United Kingdom concerned with acoustics. The present membership is in excess of two thousand and since 1977 it has been a fully professional institute. The Institute has representation in many major research, educational, planning and industrial establishments covering all aspects of acoustics including aerodynamic noise, environmental, industrial and architectural acoustics, audiology, building acoustics, hearing, electroacoustics, infrasonics, ultrasonics, noise, physical acoustics, speech, transportation noise, underwater acoustics, and vibration. The Institute is a Registered Charity no.267026.



Institute of
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Dear Members

The Institute may appear dormant during the winter months, but much has been happening behind the scenes. Considerable effort was put into our bid to host EuroNoise 2009 and I am delighted that the European Acoustics Association has selected us to stage this major event. We will hold the conference in Edinburgh and this will give our members an excellent opportunity to participate in a major international conference. I am particularly grateful to Bernard Berry and also Linda and Kevin at St Albans for the efforts they made in securing this event for us.



In the meantime our own conferences are rapidly taking shape and it was good to see the Building Acoustics Group grappling with the high quality problem of having more papers submitted than times slots available - a problem solved by the introduction of a poster session to accommodate all of the authors.

I recently attended the Institute of Physics' Awards Dinner and heard their President outlining the steps that they are taking to reverse the dramatic fall in numbers of students entering physics courses and then moving into their profession. These sentiments resonated with many discussions in Council over the years I have been a member of our own Institute. One of the steps we are taking in order to encourage students to follow acoustics is our 'Acoustic Ambassadors' initiative. This is a scheme being piloted in schools near St Albans, and we plan to roll it out throughout the country. This is part of a broader science and technology promotion project coordinated by Setpoint, a charity funded by the DTI. Members who wish to participate can use the material that has been developed to present a talk and experimental project in schools.

Another initiative we are introducing is for the Institute to act as a clearing house for student work placements. We have already been approached by a number of students seeking work experience and would like any employers wishing to provide work opportunities for students to let Judy have details of their requirements. This will cover summer and year-out placements for undergraduates, and also shorter work experience opportunities for sixth form students.

Finally, still on the theme of youth, we are currently seeking nominations for this year's Young Persons' Award for Innovation in Acoustical Engineering. I know that there are many young people making enormous contributions to our profession and if you work with one of these people, please take a few moments to send in a nomination and get them recognised. Again IAC is generously supporting this year's award and the prize includes a weekend in Barcelona. The judges are looking forward to receiving your nominations.

Colin English

PRESIDENT

2007 Young Persons' Award

Bob Bonnington MIOA, Trevor Baylis to preside at acoustical engineering innovation award

Acousticians with no more than five years' experience in the industry are invited to enter the Institute of Acoustics (IOA) 2007 Young Persons' Award for Innovation in Acoustical Engineering. The award is sponsored by Industrial Acoustics Company Limited (IAC), with a top prize of a luxury week-end break for two in Barcelona, a cash prize of £500 and a solid silver trophy designed by British silversmith Alfred Pain. In addition two other entries will qualify for prizes.

The Institute and IAC wish to reward those engineers who are in the early stages of their career and who have developed innovative and practical acoustical engineering solutions to problems they have faced. The award will be presented at the IOA Autumn Conference in October 2007 by acclaimed British inventor Trevor Baylis, OBE.

Trevor Baylis OBE, inventor, entrepreneur, and philanthropist, was awarded the Presidential Gold Medal of the Institution of Mechanical Engineers for services to engineering in 1998. Trevor is perhaps best known for the invention of the 'wind-up radio' in 1994 and for ongoing support of the disabled and disadvantaged. He is chairman of Trevor Baylis Brands plc, a company dedicated to helping inventors with interesting ideas find a route to market.

Colin English, president of the IOA, says: 'A career in acoustics gives engineers a great opportunity to make a positive difference to people's lives in a noisy world. The award is a way to celebrate and acknowledge the enthusiasm and inventiveness of young acoustical engineers and the enormous contribution they make to society. We are delighted that Trevor Baylis, as the champion of British innovation, will be presenting the award'.

Entries for the Young Persons' Award will be judged against a wide range of criteria that reflect the diverse challenges that acoustical engineers face in their professional lives.

The judges seek entries that are not only practical and cost-effective to implement but that are also novel and inventive. Other criteria that may be taken into account include 'greenness', and the difference the solution has made to people's lives or to society in general. However,

entries are not restricted just to products. Improvements to existing processes may also be submitted for consideration.

Brian Quarendon, chief executive officer and president of IAC said: 'The company is delighted again to help the Institute of Acoustics promote the achievements of young acoustical engineers'. He continued: 'IAC knows the value and cost of innovation and the Young Persons' Award for Innovation in Acoustical Engineering provides an opportunity to reward the good ideas and the hard work of young acoustical engineers'.

Entries will be judged by a distinguished panel consisting of: Dr Bernadette McKell BSc MSc PhD CEng MIOA, partner, Hamilton & McGregor Acoustics Division and chairman, Engineering Division, Institute of Acoustics; Dr Ian Flindell BSc MSc PGCertEd PhD MIOA, part-time lecturer, Institute of Sound and Vibration Research at the University of Southampton and independent acoustical consultant; Dr Frederick Brechley MDes (RCA) MIOA, technical and development manager and acoustic specialist, Armstrong Building Specialists; and Geoff Crowhurst MIOA MIOD, director, IAC UK Acoustics Division.

Entering the IOA-IAC Young Persons' Award is straightforward. Acousticians may either nominate themselves or be nominated by a third party. They are considered 'young' if they have worked in the industry for no longer than five years at the closing date for entries of 30 March 2007. Entries need to be supported by two referees who have agreed to act as such. As part of their submission, candidates must provide a description of the project in not less than 500 words and explain how it meets the aims of award. In addition the candidate should include a separate statement of no more than 150 words that explains why he or she should receive the award. Candidates do not need to be members of the Institute of Acoustics. Full details of the terms of the award are detailed on the entry form.

Entry forms can be downloaded either from Industrial Acoustics Company website at www.industrialacoustics.com/uk from the Institute of Acoustics at www.ioa.org.uk. Forms may also be requested from the institute by telephone: 01727 848195; by fax 01727 850553; or by e-mail ioa@ioa.org.uk.

Meeting Report: London Branch

Edward Weston.

On Wednesday 18 October 2006, Jim Griffiths of Vanguardia Consulting presented the findings of his research project: *Amplified music from licensed premises - developing the new night noise offence*. Around forty members were present at Capita Symonds, who kindly hosted the event.

The aim of the work was to bring licensed premises into the Noise Act 1996. The reasons for carrying out the work were to fill gaps in relevant legislation, to address the potential increase in noise disturbance due to the liberalisation of the licensing regime, and to guide a strategy of rapid response to noise problems when they occur. Following the work, proposed amendments to the legislation went out to consultation in June 2006, and the deadline for responses was in the following September.

An initial desk study was undertaken to review relevant literature, and to develop a list of methodologies and criteria for assessment of noise from pubs and clubs. Assistance was provided by the University of Salford and Hepworth Acoustics.

Jim's work followed, which was to scrutinise methods of assessing this type of noise and to develop an appropriate rating method to complement the application of the provisions of the Noise Act. This was achieved firstly by means of a series of laboratory tests conducted at the Building Research Establishment (BRE). Sixty test subjects representing a broad mix of the population were asked to rate the disturbing effect of four different types

of music played in one of the rooms through a typical PA system, and transmitted through the structures of two adjacent buildings. The subjects, who were located in other rooms in the same and adjacent buildings, were asked to respond by completing a questionnaire. Noise levels were measured in the rooms occupied by the test subjects.

The correlation between those noise metrics measured and the subjective acceptability was analysed. The noise metric that provided the best overall prediction of subjective ratings was the absolute L_{Aeq} , and a level of 34 dB $L_{Aeq,5min}$ was found to be 'just acceptable'. The test subjects were able to tolerate a modest degree of audibly intrusive entertainment noise and the threshold of audibility did not equate to a measure of acceptability.

In addition, field trials were conducted at test zones chosen for their good geographical and urban/rural spread. Apart from facing numerous practical and logistical challenges, the findings of these trials were in line with those of the laboratory tests. The highest performing metrics exhibited some shortcomings when used to assess field measurements. Jim listed the metrics most suited to the assessment of different types of one-off noise events occurring after 23:00h.

For more information on the DEFRA consultation, see: <http://www.defra.gov.uk/corporate/consult/noiseact-guidance>.

Meeting Notice - It's practically a quality measurement!

Are your acoustic measurements fit for purpose?

It's practically a quality measurement is the title of an IOA Measurement and Instrumentation group one-day meeting which will be held at the National Physical Laboratory in Teddington on Wednesday 11 July 2007. The day is of interest to anyone who makes acoustical measurements or interprets them, such as acoustical consultants, environmental health practitioners, planners, health and safety officers, the legal profession and instrument manufacturers.

When making any acoustical measurement one of the main questions often faced is 'How good a measurement should I make to ensure it is fit for purpose?'. To answer this key question there are many items to consider - what is the appropriate instrumentation and accuracy, what method should be employed, and what will be the eventual use of the

instrumentation or results of the measurements? This meeting has a varied programme providing illustrations and practical guidance on this key question for different applications. It includes papers on sound level meter accuracy, measurement systems, a case study relating to traceability for telecommunications equipment, noise dosimetry, industrial application of machinery noise standards, unattended environmental noise measurements and post-measurement analysis of results of environmental noise surveys. There will also be an opportunity to observe some practical demonstrations in NPL's suite of specialist measurement facilities.

For more information, please contact Susan Dowson, the meeting organiser, at susan.dowson@npl.co.uk

IOA certificate pass list

Certificate Name: Workplace Noise Assessment

Exam Date: November 2006 - Pass Candidates

**Colchester
Institute**
Smith R P

**University
of Derby**

Buchanan A J
Cannon M
Foley M M
Gleeson M
Hanratty B
Mason T
McWeeney J
Ryan M
Pick R H

**EEF East
Midlands and
Mid-Anglia**

Berridge D
Heslop J M
Langmead N M
Lee M J
Riddett S L
Robinson S
Taylor S C

EEF Northern

Galbraith M S
Johnson L A
O'Rourke B
Roberts D
Thorpe P J

EEF Sheffield

Bolland M E
Dawes R
Dickson M
Elliot M S
Robinson S
Smith T T

**Institute of
Occupational
Medicine**

Clark D
Green C
Hodgson M J G
Khalid O
Shackley W P
Wilson A
Wilson L

**Leeds
Metropolitan
University**

Brown S W
Donaldson J
Hewson-Smith R
MacMillan S E
Peacock I
Simcox K
Skidmore S
Smaczlyo O
Starbuck S

**Rapid Results
College**

Bagshaw R
Caddy J N
Chapman P
Devonport P G
Evans M
Greenall D
May M J
McNeill J I
Nicholls P A J
Owen D J
Simpson J R
Stigter K L

Errata

Some transcription errors were introduced during the production process into the article 'An acoustical hypothesis for the spiral bubble nets of humpback whales, and the implications for whale feeding' which appeared in Acoustics Bulletin, vol.32 no.1 January/February 2007. A version with these errors corrected can be found at http://www.isvr.soton.ac.uk/fdag/spiral_nets.htm. Figure 11 was inadvertently cropped by the publisher so that it no longer clearly showed the features in question. The caption should have included the following credit: 'Photograph by Tim Voorheis www.gulfofmaineproductions.com. Photographs were taken in compliance with United States Federal regulations for aerial marine mammal observation.'

We are grateful to Tim Leighton for pointing out the errors, and offer our apologies for any inconvenience or embarrassment.

IOA certificate pass list

Certificate Name: Hand Arm Vibration

Exam Date: 17 November 2006 - Pass Candidates

EEF Sheffield
Bristow C
Hall J
Marsden W

**Institute of Naval
Medicine**
Harmer A
Pryce M P
Taylor N P

Mulholland N P
Mullings D
Reynolds J M
Smith N

Examination Dates

Members intending to sit Institute examination this year (2007) are requested to take note of the following examination dates. Previous listings are no longer valid and should be disregarded.

Date Examination

18 May Certificate of Competence in
Environmental Noise Measurement

23 March Certificate of Competence in
Workplace Noise Assessment

27 April Certificate in the Management of
Occupational Exposure to Hand-arm Vibration

Date

21 June ASBA Examination

14/15 June Diploma Examination

5 October Certificate of Competence in
Environmental Noise Measurement

3 November ASBA Examination

9 November Certificate of Competence in
Workplace Noise Assessment

19 October Certificate in the Management of
Occupational Exposure to Hand-arm Vibration

Meeting Report

Vibration & structure-borne noise from trains in buildings

Organised by the Building Acoustics & Noise and Vibration Engineering Group
Wednesday 24th January 2007 - The Royal Society, London

Many domestic and commercial buildings are built near to or above railways. There are many ways of predicting the vibration and re-radiated noise in buildings but with a lot of confusion over the accuracy of predictions.

This one-day meeting assembled many of the world's experts in this field, looking at this hot issue from the perspective of the academic, the consultant, the local authority and the users of the building.

The meeting was extremely popular, selling out 2 weeks before the event, and was very well received. Following is a summary of each of the talks:

Striking a cost-effective balance between vibration control and the need for safe railway operation

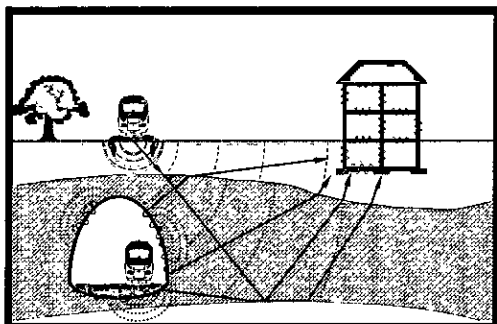
Dr Rick Jones, Head of Acoustics, DeltaRail

Rick Jones, from his experience in the railway industry, looked at the mechanisms that generate vibration from the trains themselves. These included un-sprung mass, wheel roundness, track roughness and rail deflection. Engineering devices that reduce the level of vibration transmitted into the ground were then discussed along with their respective performance improvements: rail pads, base-plate pads, under-sleeper mats, ballast mats, floating slab-track, floating ballasted trough etc..

He concluded with the following points:

- The main safety concerns arising when designing and installing vibration mitigation are rail deflection and maintenance of gauge
- There is always a compromise between guaranteeing safety while achieving the required vibration reduction cost-effectively
- To ensure track structural integrity and to maintain gauge, vibration mitigation can require elaborate, massive and costly structures
- Conversely, routine measures to maintain railway safety (eg track tamping, grinding and wheel machining) can reduce vibration generation

Rick Jones – the path of vibration from trains to buildings



Using the new PiP model to assess prediction accuracy for vibration from trains

Dr Hugh Hunt, Cambridge University Engineering Department

Hugh Hunt and his team at Cambridge University have developed a new free-ware computer programme that calculates the vibration from trains running in underground tunnels.

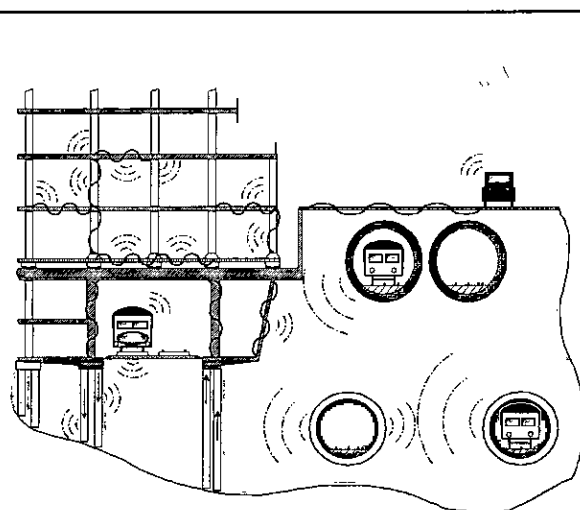


Back row (L to R): David Trevor Jones, Dr Rick Jones, Rupert Thornley-Taylor, Prof Geert Degrande, Michel Villot, Roger Kelly
Front row (L to R): John Miller, Jo Webb, Dr Hugh Hunt, Paul Shields

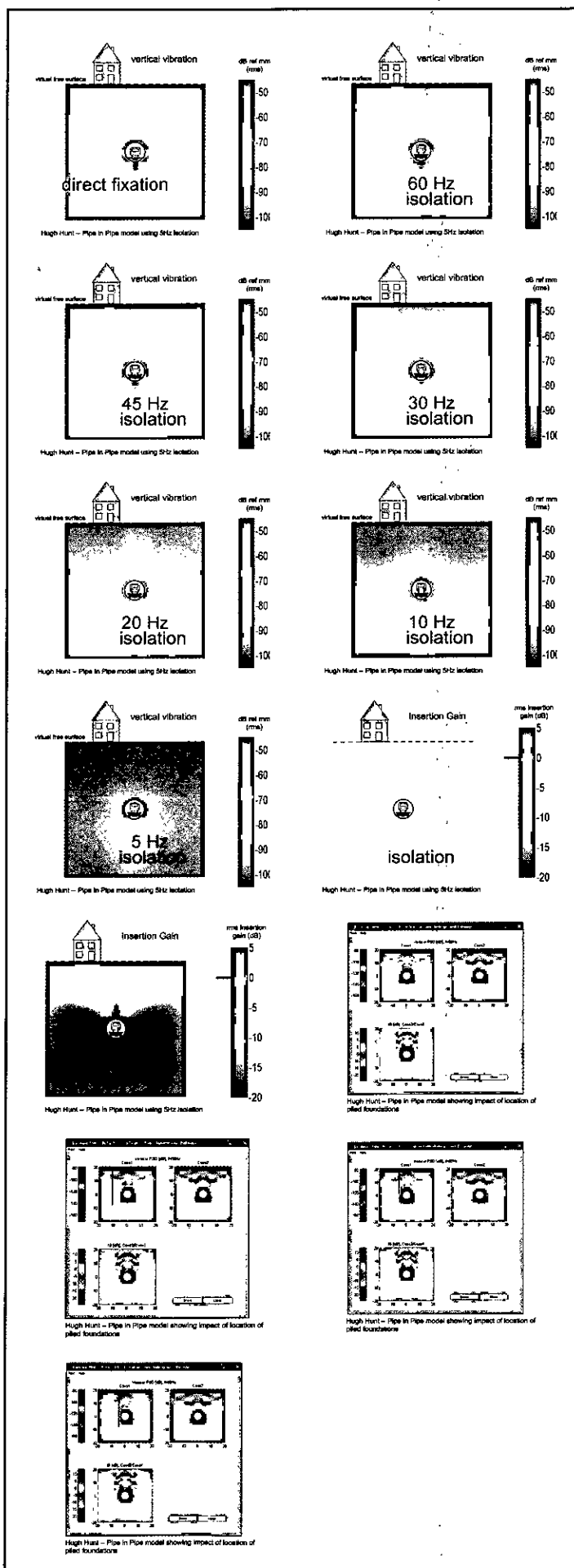
He began by giving a well needed refresher on basic vibration theory and stressed the importance of using the term 'Insertion Gain' instead of 'Insertion Loss' so that when we see a positive figure we know there is amplification and when there is a negative figure we know there is attenuation.

The Pipe-in-Pipe model was shown to be particularly useful in assessing what vibration attenuation devices should be used to minimise vibration at the building location. Some interesting conclusions were found showing that floating slab-tracks delivered high attenuations directly beneath the tunnel but sometimes not at the location of the building. The model could be particularly useful when determining the foundation structure of a new building directly above a tunnel.

By running the model during the talk he demonstrated that small changes in receptor locations and other model inputs (such as soil parameters) could make quite large differences in the results, and he questioned the ability of any model to predict the vibration input into a building to an accuracy of better than $\pm 10\text{dB}$.



Hugh Hunt – vibration paths



Re-radiated noise from trains – research carried out for CONVURT and beyond

Professor Geert Degrande, Leuven University, Belgium

Geert Degrande worked with Hugh Hunt on the CONVURT project (Control Of Noise and Vibration from Underground Rail Traffic). His work focussed on the prediction of structure-borne vibration and noise in buildings from underground trains.

The computer models developed looked at the whole vibration path, all the way from vibration generated by rail/wheel roughness, interaction of the tunnel with the soil, the propagation of the vibration through the soil and into the foundations of the building, the dynamic response of the building using finite element analysis, and finally the conversion of the vibration into re-radiated noise.

The control site that was used to verify the model was in Regents Park directly over the Bakerloo Line in the buildings on York Terrace West. One of the interesting conclusions was that room shape, the location of the noise measurement within the room and internal room finishes could have large implications on the measured noise levels.

Prediction and Assessment of vibration and re-radiated noise from trains

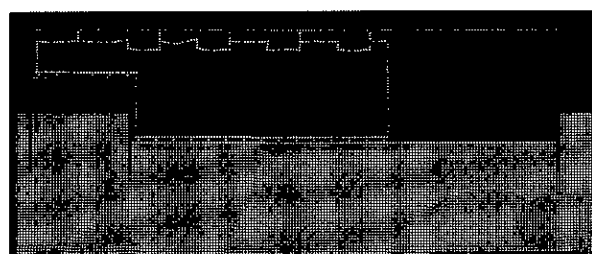
Rupert Thornley-Taylor, Rupert Taylor Ltd, Railway Noise & Vibration Consultants

The presentation started with a summary of the different standards and technical guidance documents available for the prediction and assessment of vibration and re-radiated noise from trains.

This was followed up by explaining the complex route that vibration takes all the way from the rail/wheel interaction to the radiation of noise from a structure within a building. There are many factors that need to be taken into account to carry out accurate predictions: train characteristics, track support, tunnel shape, soil conditions, wave propagation (eg. compression, shear and Biot), secondary waves (eg. surface, bending), loss factors (eg. 0.1 for clay, 0.02 for rock), soil/foundation coupling, dynamic response of the building, room acoustics etc...

For scoping studies he suggested using $SPL = L_v + 27dB$ with a +15dB constant if the building has piled foundations. For detailed design he recommended that numerical modelling was required using computer programs such as FindWave® and accurate prediction was possible.

For underground trains it was his experience that vibration was never a real issue but structure-borne noise could cause complaints. The criteria for structure-borne noise used by CTRL/LUL/CLRL was $<40dB_{L_{Amax}(slow)}$.



Rupert Thornley-Taylor - FINDWAVE® model output

Vibration & Re-radiated noise – R&D at CSTB during the last 10 years

Michel Villot, CSTB, France

Similar to the research carried out by Leuven University, CSTB (Centre for Building Science & Technology in France) has developed models for the flow of vibration from the train all the way to structure-borne noise in rooms.

continued on page 10

Meeting Report - Vibration & structure-borne... - continued from page 9

Conclusions that were interesting were:

- Increased mass significantly helps the insertion loss of vibration isolation elements inserted in the track design
- Soil layers can dramatically change vibration levels (eg. layer of soil on clay)
- Different train types will significantly change the spectrum shape of the input vibration
- The radiation efficiency of structures was important in the prediction of re-radiated noise in rooms
- Small differences in room shape could make large differences to the levels of re-radiated noise.

BBC Broadcasting House – case study of vibration & re-radiated noise from trains in the new radio studios

John Miller, Bickerdike Allen Partners

Bickerdike Allen Partners were the acoustic consultants for BBC Broadcasting House in the centre of London's West End. The existing building was to house the main radio studios for the BBC and suffered from significant structure-borne noise from trains on the Bakerloo underground line and also from the Victoria line.

To assess what solution was required to ensure noise levels were less than BBC Curve 1 a mock-up studio was built in the basement of the existing building. The mock-up allowed 3.5Hz springs, 6Hz elastomers and 10Hz elastomers to be tested with different air voids beneath the floating concrete slab. Not surprisingly the 3.5Hz springs were 4dB better than the elastomers when the void depth was 150mm but this difference reduced with smaller air voids. In the end 10Hz elastomers were chosen in jack-up 90mm thick concrete floating floors on 45mm air voids (this thin floating floor was a necessity due to the limited floor to ceiling height in the existing building).

In the completed studios, which were built off suspended slabs, the vibration insertion loss was less than in the mock-up. This was put down to the resonant behaviour of the suspended slab. Measured re-radiated noise levels were lower than predicted and this was explained by the low radiation efficiencies of the box-in-box constructions.

A review of Vibration and ground-borne noise criteria used by Local Authorities and Developers

Jo Webb, Arup Acoustics

As part of preparation for this one-day meeting a questionnaire was sent to all local authorities with a simple tick list of what their current criteria were. Out of the 458 Local Authorities only 45 replied but even this small sample allowed some interesting conclusions to be made. Vibration: 34 out of the 45 had no criteria; 9 implemented the BS6472 criteria; 2 had other criteria. Ground-borne noise: 36 had no criteria; 4 used a $L_{Amax(slow)}$ of 35dB; 1 used a $L_{Amax(slow)}$ of 40dB; 4 had other criteria. The conclusions were that most Local Authorities did not have criteria (this was also the case for some London Boroughs) and that there was confusion as to what were the appropriate criteria to use, especially when it comes to ground-borne noise.

Jo then went through her understanding of BS6472 and BS6471, and summarised criteria used in other parts of the world. She then went on to explain future research planned by DEFRA and the proposed revisions to BS6472.

Testing Real World Outcomes

David Trevor-Jones, David Trevor-Jones Associates

David talked about the statistical modelling of CTRL Phase I and

compared it with the actual outcome now it is in use. Learning from this experience he discussed how we might approach the same problem again – for instance the CTRL London Tunnel.

A critical review of the methodology used to assess ground-borne railway noise complaints

Paul Shields, Scott Wilson

The summary of his research into what causes complaints from vibration and ground-borne noise was the topic of this paper. An interesting opening observation was that vibration complaints often occurred in residential buildings where the level of vibration was below the threshold of perception. This was put down to the ground-borne noise being a problem. $L_{Amax(slow)}$ is commonly used as the index to determine ground-borne noise issues but there is no thought given to duration of events or the spectral content of the intrusive noise.

He then summarised the results of the questionnaire given to consultants and Local Authorities. One of the conclusions was that complaints as a result of ground-borne noise were far more common than complaints from excessive vibration. He found that most consultants used $L_{Amax(slow)}$ of 40dB as the maximum level allowed before mitigation was required.

As part of his research he carried out on site measurements. He found that $L_{Amax(slow)}$ was 1-2dB less than $L_{Amax(fast)}$ and there was a 2dB variance depending on where the measurement was taken in the room.

He concluded by highlighting the need for more research and also a 'Best Practice Measurement and Assessment Guide' was badly needed.

Discussion

During the meeting people had been writing their questions on a sheet and these questions came into 2 main categories:

- What criteria should be used for residential buildings near to railways?
- How do we go about assessing the problem and how accurate are those assessments?

I have picked some of the conclusions reached from the discussions:

Criteria
Vibration Criteria

- The majority thought the following was appropriate: Maximum Vibration dose values ($ms^{-1.75}$) for 16h day = 0.4
- A few thought the following should be used: Maximum Vibration dose values ($ms^{-1.75}$) for 16h day = 0.2
- All thought the following should be used: Maximum Vibration dose values ($ms^{-1.75}$) for 8h night = 0.13

Ground-borne Noise Criteria

- Pretty much all of the consultant body thought $L_{Amax(slow)}$ of 40dB should be used
- Most of the Local Authority representatives thought $L_{Amax(slow)}$ of 35dB should be used

Assessment
How accurate could predictions be?

Many people thought the best that a prediction model could achieve was ± 10 dB. Some thought significantly more accurate predictions were possible but this relied on having accurate information on all elements of the vibration path from the source to the receiver.

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The Institute Diploma Examination 2006

Keith Attenborough FIOA.

The numbers of candidates gaining merits (M), passes (P) or fails (F) in each module are shown for each centre in the table of results. This includes the results of appeals. Note that the 'fail' grade numbers include those who were absent from the written examinations. This year 216 candidates entered for the General Principles of Acoustics (GPA) written paper (135 entered in 2005, 140 entered in 2004, 121 entered in 2003, 154 entered in 2002, 129 entered in 2001, 150 entered in 2000 and 183 entered in 1999), and 14 candidates were absent or withdrew. There were 77 candidates for Law and Administration (L&A), 120 for Noise Control Engineering (NCE), 94 for Architectural and Building Acoustics (ABA), 43 for Transportation Noise (TN), 15 for

Vibration Control (VC), 8 for Sound Reproduction (SR) and 8 for Measurement (M). In 40 cases, candidates deferred their projects until November and 26 have still not completed their projects. Candidates who have not submitted their project reports are included in the table in the 'fail' count.

The mean marks for the GPA this year are comparable with previous years. DL (Edinburgh) candidates again did relatively well overall. These candidates also did very well in the ABA module. For the third

continued on page 14

Grades awarded to Diploma candidates in 2006

Centre	Grade	GPA	Project	ABA	L&A	NCE	TN	VC	Meas	SR
NESCOT	M	2	3	2	2	4	1	0	0	0
	P	21	16	4	8	10	10	0	0	0
	F	1	3	1	1	5	1	0	0	0
Leeds Metropolitan University (LMU)	M	0	1	0	0	2	0	0	0	1
	P	8	6	7	3	2	0	0	0	1
	F	7	8	6	3	4	1	0	0	1
University of Derby	M	3	3	0	0	0	2	0	0	0
	P	15	14	4	13	7	7	0	0	0
	F	7	8	5	2	3	3	0	0	0
Colchester Institute	M	2	1	0	0	2	0	0	0	0
	P	8	11	0	5	9	0	3	0	0
	F	1	0	0	3	3	0	3	0	0
University of the West of England (Bristol)	M	1	0	0	0	1	0	0	0	0
	P	11	2	0	0	0	0	0	0	0
	F	12	3	0	0	1	0	0	0	0
Salford University	M	3	3	3	0	5	1	0	0	0
	P	18	15	12	6	11	2	1	0	0
	F	1	1	0	0	2	0	0	0	0
University of Ulster	M	2	1	0	2	0	0	0	0	0
	P	9	12	4	5	9	0	0	0	0
	F	3	2	3	0	6	0	0	0	0
Distance Learning (St Albans)	M	3	3	1	0	2	1	0	1	0
	P	11	10	8	2	5	2	5	1	1
	F	3	4	2	0	4	0	0	1	1
Distance Learning (Edinburgh)	M	6	2	0	1	2	1	0	0	0
	P	5	9	6	0	5	3	2	1	0
	F	0	1	1	0	0	0	0	1	0
Distance Learning (Bristol)	M	1	1	1	1	1	1	0	0	0
	P	4	4	2	1	2	1	0	0	0
	F	1	1	1	1	0	1	0	0	0
Distance Learning (Cornwall)	M	0	0	0	0	1	0	0	0	0
	P	3	3	0	3	2	0	0	0	0
	F	0	0	0	0	0	0	0	0	0
New Zealand Acoustics Research Centre	M	0	0	0	0	0	0	0	0	0
	P	0	0	0	0	0	0	0	1	0
	F	0	0	0	0	0	0	0	0	0
Totals	M	23	18	7	6	20	7	0	1	1
	P	113	102	47	46	62	25	11	3	2
	F	36	31	19	10	28	6	3	2	2

Defra calls for input to noise study on Performance Indicators

Rupert Taylor FIOA commissioned to carry out new research project

IOA members in local authorities and other bodies that have adopted, or are considering the use of, performance indicators are being invited to participate in a Defra study covering neighbourhood and environmental noise.

The government department, which is in the process of developing a national noise strategy for England, is investigating the feasibility of national performance indicators that could provide a method for assessing the effectiveness of strategies and management of noise issues in general.

Performance indicators are already used by a wide range of bodies. In local authorities they form part of local public service agreements and local area agreements to assess whether stretch targets for improving performance have been met. Whilst meeting these targets is the main way for local authorities to receive extra funding for public services, there is currently no national guidance on measuring noise service performance.

To provide this guidance Defra, and through it the devolved administrations in Scotland, Wales and Northern Ireland, has commissioned Rupert Taylor's consultancy to carry out a study which will initially determine the extent of the use of performance indicators in the management of environmental and neighbourhood noise, by local authorities and other bodies, in the UK and other European countries.

The study will also examine how performance indicators are used and identify any variation in application based on locality as well as provide details of any common themes, threads or key issues that may help or hinder the implementation of performance indicators - nationally at strategic level, or locally - in relation to noise management.

Performance indicators are typically used to determine whether a task or process task has been carried out in accordance with set targets. A question of particular interest to the researchers is whether the introduction and implementation of a set of national performance indicators for noise management by local authorities would be practicable. If not, could a set of performance indicators be adapted to reflect their local circumstances?

Any members who are using or developing performance indicators in this field are invited to contact Stuart Dryden on

01993 852347

or e-mail: smd@ruperttaylor.com



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The Institute Diploma Examination 2006 - continued from page 12

successive year, the numbers of failures in GPA were particularly high at Leeds. However the mean marks at Leeds for GPA, L&A, NCE and ABA are significantly less than those gained elsewhere and this might be the result of a poor cohort.

In the GPA written examination, Question 6 about a noise barrier was most popular and was answered fairly well except at Leeds. Questions 1, 2, 5 and 8 on sound absorption, outdoor sound, hearing loss and sound transmission loss respectively were also popular. The mean marks gained on Q5 were high. Questions 3, 4 and 7 on fan noise, vibration white finger and the physics of sound waves respectively were much less popular but good mean marks were obtained on Q4. Q7 was answered relatively poorly, particularly at Colchester, DL (St Albans) and NESCOL.

As in the previous two years, a merit threshold of 70% was applied to the written paper and the conflated GPA mark. The examination scripts of candidates satisfying the conflated mark threshold but gaining between 67% and 69% on the written paper were examined at moderation, re-marked where appropriate, and judged individually as 'pass' or 'merit'. However, even if these criteria were satisfied, a merit was not awarded if the assignment mark was carried over from a previous year.

As a result of the coursework (CW) moderation process introduced in 2003, three examples of assignments corresponding to 'fail', 'moderate' and 'merit' marks were provided by each centre for the moderation meeting. This year there were significant differences between the mean GPA CW marks between centres. It is not clear that this can be attributed to differences in cohort abilities, so the CW marking is to be monitored carefully in subsequent years. Given (a) that this was the first year for a new specialist module examiner; (b) that the mean marks on ABA were significantly lower than in previous years resulting in relatively few merits; and (c) that tutors (see Appendix) have remarked on exam difficulty (in particular, the excessive length of the questions), it was agreed to raise the ABA exam marks by 10 at the moderation meeting.

Although the L&A exam was not considered unusually difficult by tutors, the mean L&A mark was lower than in previous years. At moderation it was considered that the L&A papers had been marked relatively harshly, so it was agreed to raise the examination marks by 5. At the moderation meeting it was clear that without moderation, a relatively large number of NCE students (16/120) would fail CW despite having passed the exam (indeed there are some exceedingly large discrepancies between exam and CW scores). After considering previous years and inter-module comparability, the CW marks were raised by 4. Although the mean examination score on SR was low compared with previous years, after consideration of scripts, it was decided not to moderate these marks. Several complaints about the VC questions have been received from DL students but, given that the mean scores are comparable with previous years and with other modules, it was decided at the moderation meeting to take no action.

Grades awarded to Diploma candidates in 2006

(see table on previous page)

For the first time since the introduction of specialist module CW, no specialist module mean CW marks were lower than the corresponding mean written examination marks. This conforms to the expected relationship between CW and examination marks. For a 'merit' grade, candidates were required **either** to have a conflated mark of at least 75 plus a mark of at least 70 in the examination **or** a mark of at least 70 in examination and a mark in the upper quartile in the relevant assignment. No merit was awarded if it depended on a deferred score.

This year there have been an unprecedented number of appeals (22). Most of these seem to have been made on the basis that the candidates were unhappy with their results! The allowable grounds for appeals are set out clearly in the Diploma handbook which is issued to all those who register. The rules will be applied strictly in 2007 and onwards, and will result in automatic disqualification of appeals based solely on dissatisfaction with outcomes.

The IOA Diploma prize for best overall performance (four merits including project) has been awarded to Wayne Seeto (NESCOL). Special commendations for achieving three merits have been given to Gary Haines (Colchester), Lisa Worrell (Derby), Russell MacDonald, Moira Cartwright and Michael Reid (DL Edinburgh), Daniel Kelly (DL St Albans) and Martin McVay (DL Bristol). The ANC Prize for the best Diploma project has been awarded to Claire Churchill (Salford).

List of Diploma projects

(includes deferred projects submitted in November 2006)

Leeds Metropolitan University

Whole body vibration in helicopters

A comparison of road/tyre noise on two road surfaces

The measurement of reverberation time within a church hall

Assessment of hand-arm vibration exposure when using domestic DIY equipment

An assessment of tranquillity in the East Riding of Yorkshire

Hearing protection for musical use

Use of the mini-laser as a sound level meter

The acoustic characteristics of engineering workshops and their contribution to noise exposure

Acoustic emissions from a domestic central heating system

Orchestras and the Control of Noise at Work Regulations 2005

The effect of enclosure on a noise source

Noise and vibration from a wind turbine

Investigation of noise levels at a motorcycle track

University of Ulster

Noise control measures in restaurant ventilation and extraction systems

Assessment of noise problems resulting from an engineering firm moving to late-night working

Investigation of noise sources and potential for nuisance to nearby residents

Comparative insulation performance of floors and walls and the effect of surface finishes

Room noise assessment

Noise attenuating properties of constrained layer damping

Suitability of conference room as a permanent training facility

Nightclub noise control

Investigation of suitability of site for residential development

Assessment of acoustics in an unusually-shaped hall

Noise exposure of staff at indoor swimming pool

Noise levels in proposed dwellings beside an hotel

Noise source identification

Effect of grain dryer noise on nearby housing

Control of noise from a grain mill

Control of noise from a grain dryer

Colchester Institute

Goods vehicle delivery noise study

Optimising acoustic performance of jet fan silencer

Roof rain noise test rig and testing

Meteorological conditions of road noise

Community air handling unit noise complaint

PPG24 rail and road noise

Room reverberation times using a single sound source
 Appraisal of Building Regulations 2000 Approved Document 'E' and Robust Details
 Sound insulation testing and effects of people in RM
 Noise from glass mini recycling banks
 School noise break-in, measured versus predicted
 Predicting reverberation times
 Correlation between radiated sound pressure level and vibration (airborne versus structure-borne)

University of the West of England

An investigation into the radiation efficiency of panels of different materials using sound energy generated by a key-wind musical box
 Comparison of CADNA, a noise mapping method, versus measurement for road traffic noise
 An investigation into the effect of applied load on the noise produced by a rotary percussion hammer drill

University of Derby

Noise exposure of music teachers
 Workplace noise assessment: karting
 Noise induced hearing loss from car radios
 Soft/hard ground attenuation correction factors in BS.5228
 Noise exposure from fairground rides
 Repeatability and variability of sound insulation testing
 Investigation into low frequency noise from an electricity substation
 Noise exposure within clubs and bars
 Impact of railway noise
 Noise exposure from D-I-Y tools
 Comparison of actual noise levels from landfill gas generators
 Speech interference from fans within a public meeting room
 Sound absorption coefficients of variety of materials
 Comparison of CRTN methods
 Noise exposure of helicopter crew
 Noise from kerbside glass collection
 Noise signature of a wind farm
 Verification of CRTN for low traffic flows
 Speech interference in a public meeting room
 Measured and predicted reverberation time in an open plan office
 Occupational exposure in a knitwear factory

University of Salford

Multi-purpose recording studio screen
 Floor transmission noise
 Anti-vibration mounts in a transmission suite
 Air conditioning noise
 A sound insulation system
 Speech intelligibility in an auditorium
 Acoustics of an audio projects studio
 Impact noise insulation
 Drilling rig noise
 Night time noise levels, urban and suburban
 Noise from a wheeled-play facility
 Wind farm noise impact
 Bass guitar noise transmission in a dwelling

Noise from vacuum cleaners
 Adaptation term C and C_{tr}
 Skate park noise
 Investigation into the number of measurement positions for L_w
 Reverberation time module of a sound level meter
 Noise impact of wind farms
 Acoustics in primary school
 Identification of a source of wind noise at a multi-storey car park

NESCOT

Impact testing for pre completion testing on carpets in comparison to finished floor surfaces
 Alternative source mechanisms to generate a new field within different room
 The attenuation of sound by partially open windows
 Noise impact from a bus garage station
 Effectiveness of computational modelling of open-plan offices
 Comparison of noise reduction from lobby doors of a nightclub
 Noise at Work assessment at licensed premises
 A critical analysis of PPG24 for two case studies
 The variation of sound level from shotgun cartridges
 Establishment of a new site for a noise monitoring terminal in Hounslow
 Validation and measurement of the acoustic isolation of a TV suite
 PPG24 and its implementation to a proposed residential development
 A critical review of noise control measures for Reading rock festival
 A study of residential noise due to glass recycling
 Effectiveness of guidance available for high performance vehicles
 Comparison of prediction to measurements of ground floor noise levels due to road traffic noise
 Noise at Work assessment of people involved in kerbside collection
 A survey of environmental impact on travellers in the London area
 Investigating the feasibility of possible noise mitigation measures at a pavement research laboratory according to the Noise at Work Regulations
 Vibration isolation at acoustic frequencies
 Noise study in the Runnymede BC area
 Noise in an open-plan office within a gymnasium
 PPG24 assessment of the Swan development in London
 Investigation of noise nuisance from the PA system at a London Underground station
 Noise exposure at waste transfer stations
 Effectiveness of a teenage deterrent noise source

Distance Learning St Albans

The environmental noise assessment of multi-function radar, including the design and design proving of partial barriers
 A study of some acoustic properties of vestry hall Ranelagh Road, Ealing
 Acoustic treatment of an open-plan office
 Investigation into CADNA/mapping software
 Investigation and rectification of acoustics in a college performing arts department in accordance with BB93
 Assessment of road traffic noise propagating from road surfaces under wet and dry conditions

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The Institute Diploma Examination 2006 - continued from page 15

An investigation into field measurements of reverberation time for airborne sound insulation, and the effect of increasing the number of reverberation time measurements on the weighted standardised difference

Airborne sound insulation tests using a new under-screed product for concrete floors

Can acoustic measurements determine the configuration of an internal combustion engine?

Comparison of traffic noise levels inside and outside dwellings

Design and building of an enclosure around a washing machine to reduce noise disturbance

Optimum placement of inscriptive materials

The effect of the number of reverberation time measurements on $D_{nT,w}$

An investigation into the shortened measurement procedure in CRTN

Sandwich panel partitions

Noise breakout from a building

Distance Learning Edinburgh

The regulation of noise from motor vehicles

Optimising speech intelligibility within a lecture theatre using geometric modelling techniques

The environmental assessment of noise from wind farms

An investigation of a tonal noise problem at Castle Cement, Ketton works

Evaluation of human exposure to vibration in bed (1Hz to 80Hz)

Directivity index of four normally omni-directional sound sources

The acoustic performance of box beam joist systems

Development of a subjective rating system for airborne sound insulation levels

Noise from Newcastle International Airport

Measurement of the underlying noise level

Effect of presence of the operator on sound insulation measurements

Distance Learning Bristol

Investigation into noise levels experienced by motorcyclists at different speeds

Regulation of industrial noise in England and Wales

Investigation into temperature effects on environmental sound propagation

Investigation of the accuracy of field measurements of sound pressure levels in a room

Assessing noise at work exposure to nightclub workers

Investigation and comparison of mitigation measures applied to plasterboard-on-dabs wall construction in order to satisfy the Building Regulations

Noise at Work Regulations in recording studios

Investigation into the noise levels at East Holme Rifle Range, Wareham, Dorset when using moderated firearms

Motorcycling noise level measurements

Distance Learning Cornwall

An investigation into a suitable set of guidelines to assist in determining planning applications for skateboard parks in noise-sensitive areas

An investigation into the failure of sound attenuation in the floor system of timber frame building

Sound quality of a clock tower bell

Successful Diploma Candidates November 2006
Colchester Institute

Barrett M J	Mynott B P
Barritt R M J	Pridmore A A N J
Haines G	Way P A
Kirsopp N	Wright D J
Marshall A E J	

Distance Learning (Bristol)

Carter R S	Matthews O J S
Cerutti C E	McVay M J
Hafezi P	

Distance Learning (Edinburgh)

Anstee B J	Kennedy R P
Bremner J D	Lurcock D E J
Broadway J	MacDonald R R
Cartwright M E M	Parnell N
Cramond D	Reid M
Hill L	

Distance Learning Cornwall

George M A	Mycock H
Grattan S J	

Distance Learning St Albans

Bailess T D	Kim S
Belsey P	Kirk S D
Burns N	Laws G J
Duncan J A	Majeed B A
Gregory J	Nash A M
Griffiths N D	O'Kelly D K
Kerry P G	Stanbury C

Leeds Metropolitan University

Grove R	Neale J R
Johnson P S	Rose P
Marsden H W	

NESCOT

Anstice J N	Hill S J
Bangura P	Lemagnen L M Y
Brightwell M A	Mills J P
Choongh S	Nelson O
Glass A D	Parr S M
Goldsmith B K	Pitter D
Goodwin J G	Saunders D T

NESCOT cont.

Saunders D T
Scott D M B
Seeto W
Sheard P
Smith J T

Walker S M
Wooltorton L
Wyatt T J
Yaqub S

Salford University

Barrett S L
Cain J
Churchill C E
Coppock M R
Davidson S E
Greenwood K E
Hickman D
Jones D F
Jones H R
Kearney C P J
Lee S A
Lee S J W
Maclagan M

McNulty R
Monk-Steel R H
Moore M P
Noon M P
Ormerod J O
Phillips G
Stigwood D M
Walton S P

University of Derby

Bird S M
Chaddock L J
Clothier S N
Craddy M A
Eaves D M J
Edge P P
Follows EL
Hands A M
Kierek-Bell A

Lewis R J
Mann A H L
McNally I H
Palmer S
Pickup P D
Pritchard D J
Reece L A
Wells J T
Worrell L M

University of Ulster

Campbell S
Christie M J
Connolly R T
Keaney D M
McAlister K

McGinley H J
McKnight C M
Shaw L A E
Whelan M A

University of the West of England

Elliott L M
Harris A J

Landeg C

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Airborne sound insulation in buildings

David Fleming MIOA.

Setting D_w targets: a numerical model based on the twin concepts of noise disturbance and speech privacy

Scope

DfES Building Bulletin BB93 *Acoustic design for schools* is a useful model for the process of classification and assignment of acoustic design targets to rooms in buildings. The steps in this process are:

- (1) Make a classification of room types (done by the authors of BB93);
- (2) Assign acoustic design targets to each room type, for background noise, airborne and impact sound insulation, room acoustics (done by the authors of BB93);
- (3) Identify each room with a 'room type' from the classification in (1);
- (4) Assign acoustic design criteria and parameter values from (2) to each room in the project: for airborne sound insulation these include activity and noise tolerance levels used as indices to assign D_w targets from a D_w matrix supplied in BB93;
- (5) For airborne sound insulation, identify adjacent pairs of rooms (horizontally and vertically) and calculate in-situ R'_w targets using the D_w matrix, together with room geometry and a room acoustics target (reverberation time);
- (6) Select suitable construction specifications to meet the R'_w targets established in (5), bearing in mind the control of flanking transmission and other factors affecting performance on site.

The purpose of this article is:

- to clarify the process used in steps (2) and (5) to set airborne sound insulation targets;
- to suggest the basis of a generalised approach that could be applied to various building types including schools, higher education institutions, hospitals and GP surgeries, law courts, performing arts centres and others;
- to illustrate ways in which the generalised approach could be used as a yardstick to explore the reasons for the assignment of specific numerical acoustic targets and to reduce apparent arbitrariness.

Concepts

In general, the derivation of airborne sound insulation targets for adjacent rooms in buildings is based on the twin concepts of controlling noise disturbance and providing speech privacy or confidentiality where necessary. It is a premise of this article that both 'noise disturbance' and 'speech privacy' are assessed subjectively relative to the prevailing background noise level, as illustrated in BS.4142 and in BS.8233. For instance, BS.4142:1997 is a method for assessing the extent to which a potentially intrusive noise is likely to be noticeable, by considering by how much its level exceeds the background noise level at the recipient (strictly, in BS.4142, outside the recipient's dwelling). In BS.8233:1999, clause 7.6.3.1, speech privacy is conceived as inversely related to the audibility of incoming speech, again assessed by its level relative to the background noise level at the recipient.

In BS.4142 it is clear that the datum for assessment is the existing background noise level, but in BS.8223 the distinction between actual and notional background noise levels is not clear. This may be why it is difficult to reconcile numerical speech privacy with the sound insulation recommendations for offices in the latter Standard.

The perception of noise disturbance is associated with the recipient's room, whereas the requirement for speech privacy is a property associated with a speech source room.

Using these concepts, the simplest form of equation for the required airborne sound insulation, D_w dB, to control noise disturbance and provide speech privacy between rooms might be as follows.

$$D_w = K - (b \times L_{pb2}) + (a \times L_{p1}) + P \text{ dB} \quad [1]$$

where

indices 1 and 2 refer to the source and receiving rooms respectively

L_{p1} is the nominal source room sound level, dB

L_{pb2} is the receiving room background noise level, dB

P is zero or a positive value indicating the required degree of speech privacy, dB

K dB, a and b are positive constants.

From equation [1] the required D_w increases with rising source room sound levels and privacy requirements, but decreases with increasing recipient background noise levels - both as intended.

Development

In the language of BB93, numerical values of the source room sound level L_{p1} dB need to be linked with the 'activity level', and numerical values of the receiving room sound level L_{pb2} dB with the 'tolerance level'. In the latter case, the authors of BB93 achieved this correspondence consistently with only a few exceptions associated with extreme values (see Table A).

For BB93 activity levels there is no obvious correspondence with source room sound levels L_{p1} dB but a correspondence can be established for some of the entries in the D_w matrix of BB93 Table 1.2. Compare Table B with BB93 Table 1.2: the D_w values of Table B are generated by equation [2] for the tabulated values of L_{pb2} and L_{p1} .

$$D_w = 80 - L_{pb2} + 0.5(L_{p1} - 60) \text{ dB} \quad [2]$$

The agreement between nine values in Table A and the corresponding entries in BB93 Table 1.2 suggests that equation [2] is on the right lines, but in five cells of the sixteen (grey), the authors of BB93 saw fit to increase the minimum values of D_w by 5dB or (in one case) by 10dB. Why was this?

Formulation

Encouraged by a measure of success, equation [2] has been recast, increasing the range of values to which it applies and including the concept of privacy, as shown in Table C.

Numerical values in the pink cells are generated by either of the disturbance equations, depending on whether the receiving room background noise level is stated as an A-weighted level or a Noise Rating (NR). Where these levels differ by 5dB (ie where $NR_2 = L_{A_{b2}} - 5$ dB), the two expressions for D_{w0} are equivalent, that is, they give the same numerical values. Typical values for privacy, P , are likely to be in the range 0 to 9 dB, the highest value representing the greatest privacy, ie confidential.

Comparison with Draft HTM 08-01, Table 6

A draft replacement for Health Technical Memorandum 2045 is

Table A:

BB93 Tables 1.1 & 1.2, receiving rooms

tolerance level	ambient noise limit, L_{Aeq} dB
high	45
medium	40
low	35
very low	30

BB93 Table 1.2		activity level			
tolerance level	minimum D_w dB	low	average	high	very high
	high	30	35	45	55
	medium	35	40	50	55
	low	40	45	55	55
	very low	45	50	55	60

Table C: General formulation									
		ACTIVITY [source 1]						D _{w0} dB	
TOLERANCE [Receiver 2]	index	low	avg	high	very high	ultra high	max	L _{Ahp2} dB	
		1	2	3	4	5	6		
	very high	1	25	30	35	40	45	50	50
	high	2	30	35	40	45	50	55	45
	medium	3	35	40	45	50	55	60	40
	low	4	40	45	50	55	60	65	35
	very low	5	45	50	55	60	65	70	30
	zero	6	50	55	60	65	70	75	25
L _{Ap1} dB		50	60	70	80	90	100		
CRITERIA:									
disturbance		D _{w0} = 80 - L _{Ahp2} + 0.5(L _{Ap1} - 60)							
		D _{w0} = 75 - NR ₂ + 0.5(L _{Ap1} - 60), NR ₂ = L _{Ahp2} - 5 dB							
disturbance + privacy		D _w = D _{w0} + P							

available for consultation as Health Technical Memorandum (HTM) 08-01, November 2006. HTM 08-01 Table 6, reproduced here in its essentials, shows a matrix of recommended minimum D_w values.

Also shown is an equivalent Table D which uses the same formulation as Table C and identical numerical values for D_{w0}, but is adapted to the different terminology of HTM 08-01 and thus includes specific numerical values for privacy.

The formal differences between the draft HTM 08-01 Table 6 and Table D are:

- In Table D the categories of receiver sensitivity are increased from three to four and each is associated with a specific background noise level in the receiver room;
- In Table D each source level category is associated with a numerical sound level;

HTM 08-01 Table 6

in-situ targets, D_w dB

SOURCE ROOM		RECEIVER SENSITIVITY		
privacy	noise	not	med	sen
		1	2	3
confidential	very high	48	53	*
	high	48	48	53
	average	48	48	48
	low	43	43	48
private	very high	48	53	*
	high	43	48	53
	average	43	43	48
	low	38	43	43
moderate	very high	48	53	*
	high	38	43	48
	average	38	38	43
	low	35	35	38
not private	very high	48	53	*
	high	30	43	48
	average	30	35	43
	low	30	30	38

* avoid adjacency

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Airborne sound insulation in buildings - continued from page 19

In Table D specific numerical values are assigned to privacy, P dB.

The D_w targets generated by the formulation of Table D in many cases differ from those in draft HTM 08-01 Table 6. Where these differences occur the values in Table D are always lower than in HTM 08-01 Table 6. Compare HTM 08-01 Table 6 with Table E, in which the occupied cells show D_w values from Table D that are more than 3dB lower than values in corresponding cells in HTM 08-01 Table 6.

Three trends are evident:

- (1) With some notable exceptions, there is a large measure of agreement between the tables in intermediate and higher source level categories: in more than 50% of cells, the discrepancy between assigned D_w values is less than 4dB.
- (2) In privacy categories 'not private' and 'moderate', the Table 6 D_w values consistently exceed those in Table D. In fact, Table 6 values in the highest source level category are the same for all privacy categories: presumably the authors of Table 6 either did not trust the privacy model at very high source sound levels or considered it inapplicable at those levels.
- (3) In all but the lowest privacy category (with one exception), the discrepancies increase towards lower source levels ('typical' and 'low'), suggesting perhaps that the authors of Table 6 were reluctant to rely on the noise disturbance model at low source sound levels, or, if they trusted the model, they did not expect the actual background noise level in the receiving room to be as high as the design value.

The purpose of this comparison is not simply to propose alternative numerical values to those in HTM 08-01 Table 6, but to illustrate the advantages of a more numerically rigorous approach. These advantages are:

- A plausible numerical model based on the twin concepts of noise disturbance and speech privacy provides a rational framework for setting airborne sound insulation targets in terms of D_w dB.
- A model that embodies specific numerical values for source sound levels, receiver background noise levels and privacy exposes the effect of changes in these parameter values.
- The seemingly arbitrary assignment of D_w targets, for perhaps legitimate but unstated reasons, is avoided.
- Judgments of the appropriate design levels for a given room are made in the assignment of activity, tolerance and privacy levels to room types, where they can easily be changed. Judgments are not applied to insertions made directly in the D_w matrix itself. As a result, the model is robust and transparent: with cooperation, it could be used for a wide range of building types including schools, higher education institutions, law courts, health and hospital buildings, offices and buildings for the performing arts.
- Where consultants expect that receiving room background noise levels from building services will fall short of design NRs, predicted mechanical services noise levels can be inserted in the model and revised D_w targets obtained, in a rational manner. Alternatively, for a given D_w target the required performance specification of sound masking system to augment the background noise level can be numerically justified.
- The apparent rigidity of the model is in fact a virtue, because it exposes the effect of changes in parameter values. Arbitrary insertion of D_w values directly in the matrix is, in essence, obfuscation.
- Finally, the model is in a suitable form for easy computation.

David Fleming MIOA is with Fleming and Barron, London.

References

BB93 Building Bulletin 93, Acoustic design of schools, Department for Education and Skills, 2003.

BS.4142:1997 Method for rating industrial noise affecting mixed residential and industrial areas.

Table D: Alternative to HTM 08-01 Table 6

In-situ airborne sound insulation targets, D_w dB

privacy target, source room	P dB	SOURCE LEVEL		RECEIVER SENSITIVITY				L_{Apt} dB
			index	low	medium	high	very high	
confidential	8	very high	4	48	53	58	63	80
	8	high	3	43	48	53	58	70
	8	average	2	38	43	48	53	60
	8	low	1	33	38	43	48	50
private	5	very high	4	45	50	55	60	80
	5	high	3	40	45	50	55	70
	5	average	2	35	40	45	50	60
	5	low	1	30	35	40	45	50
moderate	3	very high	4	43	48	53	58	80
	3	high	3	38	43	48	53	70
	3	average	2	33	38	43	48	60
	3	low	1	28	33	38	43	50
not private	0	very high	4	40	45	50	55	80
	0	high	3	35	40	45	50	70
	0	average	2	30	35	40	45	60
	0	low	1	25	30	35	40	50
		NR ₂		45	40	35	30	

avoid adjacency

$$D_w = 75 - NR_2 + 0.5(L_{Apt} - 60) + P \text{ dB}$$

where P = {0, 3, 5, 8} dB

Table E: Differences exceeding 3dB

in-situ targets, D_w dB

privacy	SOURCE ROOM noise	RECEIVER SENSITIVITY		
		not	med	sen
		1	2	3
confidential	very high			58
	high	43		
	average	38	43	
	low	33	38	43
private	very high			55
	high			
	average	35		
	low	30	35	
moderate	very high	43	48	53
	high			
	average	33		
	low	28		
not private	very high	40	45	50
	high			
	average			
	low	25		

avoid adjacency

BS.8233:1999 Sound insulation and noise reduction for buildings. Code of practice.

HTM 08-01 SRL Healthcare, Acoustics, Health Technical Memorandum 08-01, Draft for consultation, November 2006.

Application of new measurement methods in building and room acoustics

Ian Campbell FIOA.

The classical methods of determining the sound transmission between rooms have been with us for some time and their limitations are well known, to such an extent that practitioners have a good understanding of when it is simply not possible to make a measurement. These traditional methods are based on the use of random noise, ie covering all frequencies and amplitudes, and the test signal has a high crest factor which in turn restricts the sound level which the noise generation system can produce. Moreover the level in the receiving room must be well above the background noise throughout the measurements, so once the maximum output power of the speaker system has been reached, measurements are limited to those locations or times when the background noise is sufficiently low. With the improving performance of separating elements used in modern constructions and increasing background noise levels in the environment, problems with field testing are becoming more common.

These difficulties are now recognised by the standards authorities and in response they have published BS EN ISO 18233:2006 *Acoustics - Application of new measurement methods in building and room acoustics*. This standardises measurement procedures based on deterministic signals that can be used to obtain the impulse response of the test space which in turn may be post-processed to give both the level difference and reverberation time. For those who are new to impulse response it must not be confused with what has been traditionally called 'impulse excitation' of the test space to obtain the reverberation time, eg the use of a shot from a starting pistol, or a bursting balloon, to excite the room as an alternative to interrupted random noise. The results of impulse excitation are sometimes processed in the same way as interrupted noise methods but in more advanced instruments they are processed as a true impulse response (by using the Schröder method of reversed time integration, giving the true impulse response). The impulse response used by these new room acoustic standards is therefore the response of the room when it is excited by a

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Traditional test methods are based on the use of random noise

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Application of ... in building and room acoustics - continued from page 21

single ideal impulse that will result in the characteristic 'ring' of the room as the sound energy decays. An example of the response of a room is shown in Figure 1: it can be seen that the acoustic conditions in the room add colouration to the signal. Thus, the single square pulse that was introduced to the room now contains artefacts that represent the dominant frequency and time decay characteristics due to the acoustic conditions found in the room. Analysis of this single impulse in the time domain can give the reverberation time and the impulse can also be analysed in the frequency domain to get the spectral data, but of course it has to be a big 'bang' to make sure that background noise is covered.

An advantage of the impulse response is that a sequence of lower level impulses may be averaged, thereby improving the signal-to-noise ratio, and hence the effects of background noise in a measurement may be minimised. A series of complex mathematical computations known as the Maximum Length Sequence (MLS) has been developed. This presents a rapid series of synchronous pulses that can be used to build up a picture of the impulse response of the room. A result can be obtained even when the background noise is higher than the excitation signal, as the synchronous averaging process removes the random element from the result.

To understand the method, consider the case of a single impulse used to excite a room. The ideal would be a square wave that excites the room at all frequencies and this is shown in Figure 3a: time is the x axis, y is frequency and z amplitude. The resultant impulse response at each frequency is shown in Figure 3b. In this example the result has been squared, x^2 , so that all of the energy is positive and a level is seen, rather than the actual waveform as shown in the first two figures. To obtain a usable response it would necessary to excite the room with very high levels but this is not very practical, but if a sequence of pulses is used as shown in Figure 4a, with the results shown in Figure 4b, the pulses can then be averaged with the effect that levels can be much lower: the averaging process minimises the effects of the unwanted noise. The averaging process is achieved by use of the Hadamard transform which basically involves shifting the start of each squared impulse response back in time so that it is placed at the origin: all responses then appear at the same time, allowing an average of all pulses to be obtained. To do this it is necessary for there to be 'synchronisation' between the MLS noise generator and the sound level meter that has to perform the Hadamard Transform, in order that the meter 'knows' when each pulse should appear and hence can move it back in time to be added to the average result. The engineering compromise is between the disadvantage that the measurement time is increased, and the advantage of allowing work in adverse signal-to-noise conditions. Having obtained the impulse response it is post-processed to obtain the time and frequency domain characteristics of the room in the normal manner.

It can be seen that the Hadamard Transform requires there to be stable conditions throughout the acquisition of the sequence of pulses: if, for example, there were air movements or temperature changes there would be a corresponding change in the speed of sound and this would produce a distortion when the average result is produced. An example of this is shown in Figure 5, where the tail of the impulse response is altered by changes in the speed of sound, with the result that the impulse obtained at the lower speed will be stretched in time as it takes more time to gather the energy. The reflections arrive later because they are travelling more slowly.

The example assumes that the change in the speed of sound occurs between the two time instances t_1 and t_2 and shows the response for a fixed frequency f_1 . The upper curve shows the effect of an increase in the speed of sound in that the response appearing at t_2 is shorter than the one at t_1 . Synchronous averaging shifts the responses to time 0 and averages them, with the result that the correct one at t_1 is summed with the compressed one at t_2 . The resulting decay is distorted and the noise floor will be higher as it will not be averaged out.

The need for time in-variance restricts the MLS method to those situations where the acoustic conditions are very stable, such as in an acoustic test laboratory, and certainly rules out the use of rotating microphone booms. The method can only be used in field testing where air turbulence and temperature changes can be controlled. The new standard sets out the conditions in which the method may be used and also has in its annexe a full description of the way in which the MLS method may be applied to building acoustics measurements.

A development of the MLS method designed to overcome the time

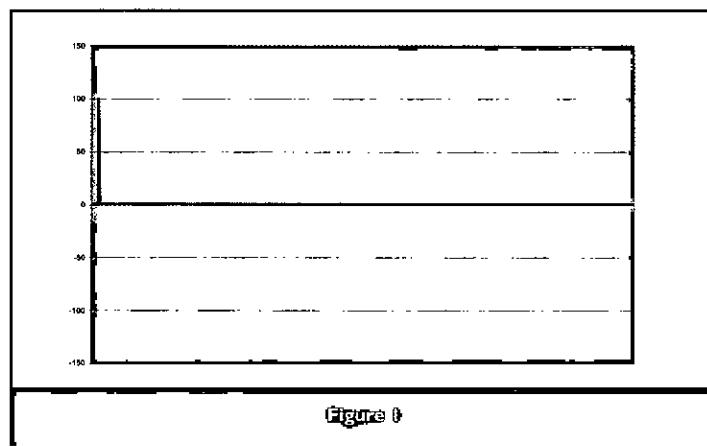


Figure 1

Input impulse

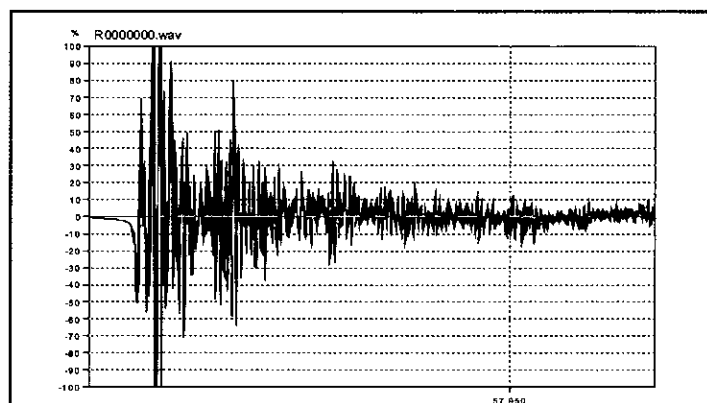


Figure 2

Response of a room to a single impulse

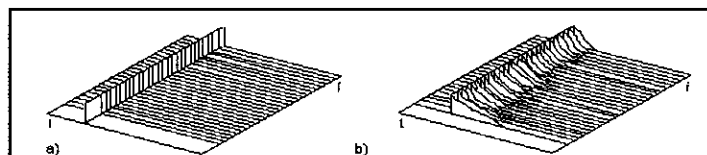


Figure 3

Excitation by a single impulse shown in the time and frequency domain

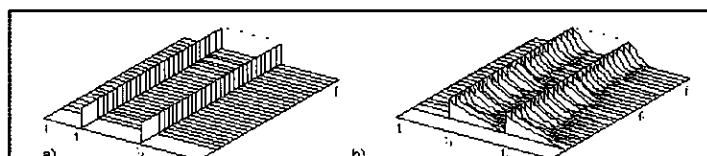


Figure 4

Presentation of a sequence of synchronous pulses

variance problem is now available, and this is also covered by the new standard. It is known as the 'swept sine' method and will be found in annexe B. In this method the excitation signal is changed from a sequence of pulses (which in many ways has the same characteristics as white noise) to a sine wave that sweeps over the frequency range of interest. In this method the excitation can be viewed as a single pulse that is stretched in time; so if a 50Hz sine wave was taken, and its frequency slowly increased

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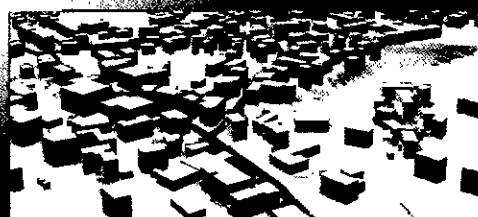
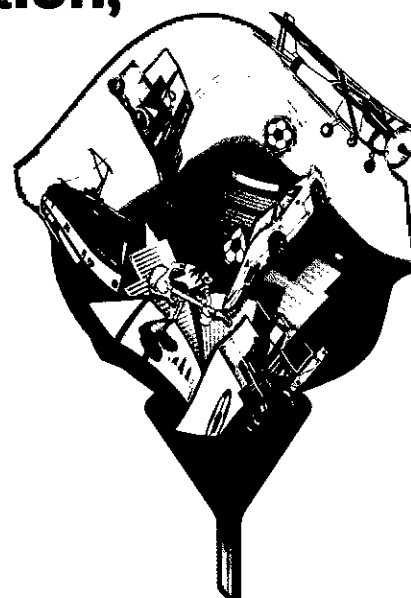
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Application of ... in building and room acoustics - continued from page 22

in increments up to 5kHz, the overall frequency response would still be flat when viewed in the frequency domain. When viewed in the time domain it would be at one frequency at one instant in time and would produce the same effect as a pulse when considered over a period of time. Because the frequency of the signal changed the system would be at any one given frequency at exactly one instance of time, as can be seen diagrammatically in Figure 6. This shows the sweep excitation at (a) and the resulting impulse responses at (b) with each band staying 'open' for 10 seconds to capture the squared impulse response. The response recorded by the instrument would also be a sine wave but one modified by the acoustic conditions in the room. To transform this response into an impulse response a mathematical operation known as deconvolution has to be performed: the effect of this operation is to transfer responses at individual times and frequencies so that they appear at the same time.

The reason why swept sine technique is less sensitive to time variance is that the response to each frequency appears at exactly one instance of time. This means that deconvolution only shifts and aligns responses at different frequencies, ie there is no summation of several responses at the same frequency that may be time scaled differently. Having obtained the impulse response of the room then the data may be post processed in the normal manner in order to obtain the reverberation time and level difference required.

Additional advantages also follow from the use of sine sweep methods in that the excitation signal is now a sine wave and not a high crest factor pulse train. It follows therefore that the full dynamic range of the power amplifier may be used resulting in higher sound pressure levels in the source room, again helping with the signal-to-noise ratio, or allowing smaller speakers and amplifiers to be used. Swept sine also has the advantage that any distortion introduced by the speakers or amplifier (or both) appears in the result. With MLS this appears as spurious peaks which limit the signal-to-noise ratio, so that the impulse response deteriorates to such an extent that the method cannot be used. With swept sine the effects of harmonic distortion can be completely removed as the use of linear deconvolution makes the distortion components appear at 'negative' times in the measured impulse response: these components can be completely removed by time windowing the impulse response.

A practical implementation of the sine sweep method, which will provide results over the frequency range required for building acoustic measurements in octave or third-octave bands, is shown in Figure 7. This is achieved by one continuous sweep through all 21 third-octave bands with the energy in each being separated from the others by filtering. For sine sweep applications this is done by a combination of time and frequency domain windowing with the final result meeting the requirements of type 1 filters as described in BS EN IEC 61260. The duration of the sweep, or dwell time in each band, is directly related to the amount of energy used for the excitation, giving greater resistance to the effects of background noise at the measurement site.

For the measurement of reverberation time, background noise is not often a problem as the speaker and measurement microphones are in the same

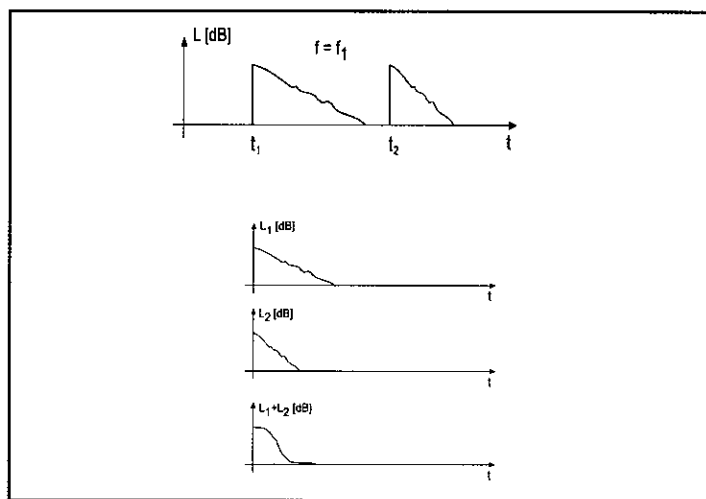


Figure 6

Distortion due to time variance with MLS method

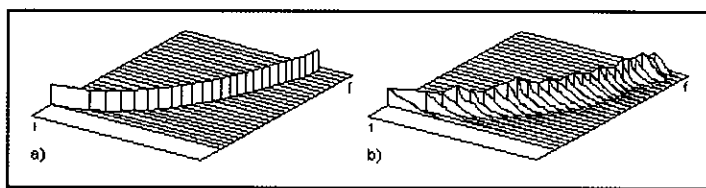


Figure 7

Measurement of impulse response with sine sweep excitation

room. A sweep of 60 seconds is usual, as this gives a signal-to-noise ratio of up to 100dB which is far more than the standard requires. When it comes to measurement of levels in the receiving room, the necessary signal-to-noise ratio may be more difficult to achieve, so it is usual to have a selection of sweep durations in the range of 1 to 12 minutes. These slow sweep speeds allow measurements to be made when the signal-to-noise ratio is negative, but care is needed as with ratios of 80dB or more there is always the possibility of crosstalk in the instrument. This occurs between the noise generator output and the microphone input, but the simple precaution of adjusting gain in the power amplifier or microphone preamplifier (or both) can soon overcome crosstalk problems. The operator must be aware that the high performance possible with sine sweep can bring artefacts to light that have always been there, but were hidden in the background noise.

Ian Campbell FIOA is a director of Campbell Associates

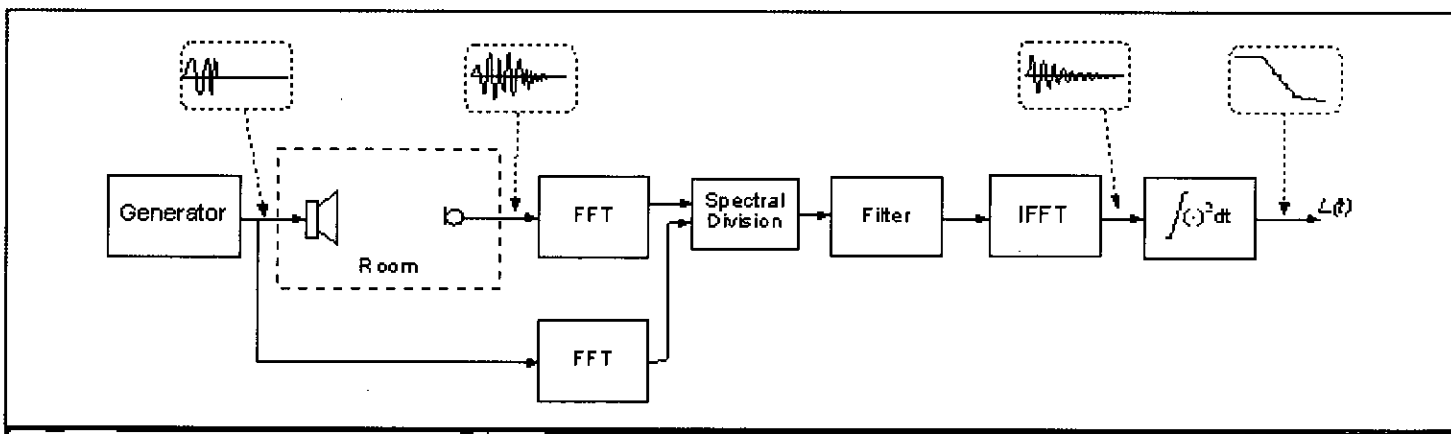


Figure 7

Implementation of sine sweep in the Nor-121 Building Acoustics Analyser

A proposal for identifying quiet areas in accordance with the environmental noise directive

G R Watts, P A Morgan and P G Abbott.

Introduction

The European Directive on the Assessment and Management of Environmental Noise (END) [1] has identified the importance of so-called 'Quiet Areas'. The END requires Member States to produce Action Plans in order to protect these areas against any increase in noise in the future.

In broad terms, in a rural environment a Quiet Area is most likely to be considered by the general population as being a location where noise levels are low enough to result in a feeling of relaxation and calm. However in a city, it may be a location which offers individuals the freedom to converse easily or to read a newspaper in relative peace. This perception may however also be dependant upon other factors, such as the type of location or the visual aspect of the immediate and surrounding landscape.

Quiet Areas are important in that they provide people with a place to relax, unwind and escape from the rigours, stresses and strains of day-to-day life. This factor is recognised by the London Health Commission assessment on the draft Ambient Noise Strategy which states that 'green environments and quiet places are needed to provide respite from stressful urban living and allow for recreation'. [2]

To date, considerable research has been undertaken which has led to a wide range of possible definitions for Quiet Areas. Some of these definitions are based on recommended noise levels or general acoustic conditions, whilst others are based on spatial location relative to important noise sources. Indeed, many studies and consultations have recommended the need for further work to refine these definitions.

Where Quiet Areas are referred to in existing policy and legislation, there

is again no common definition that is widely used. The END refers to two distinct types of Quiet Areas, ie those in agglomerations and those in open country; the definitions provided for these two types of area are quite different, highlighting the complexities and difficulties in providing a uniform definition.

Existing definitions which must be taken into account in this study are those which are given in the END, which state that

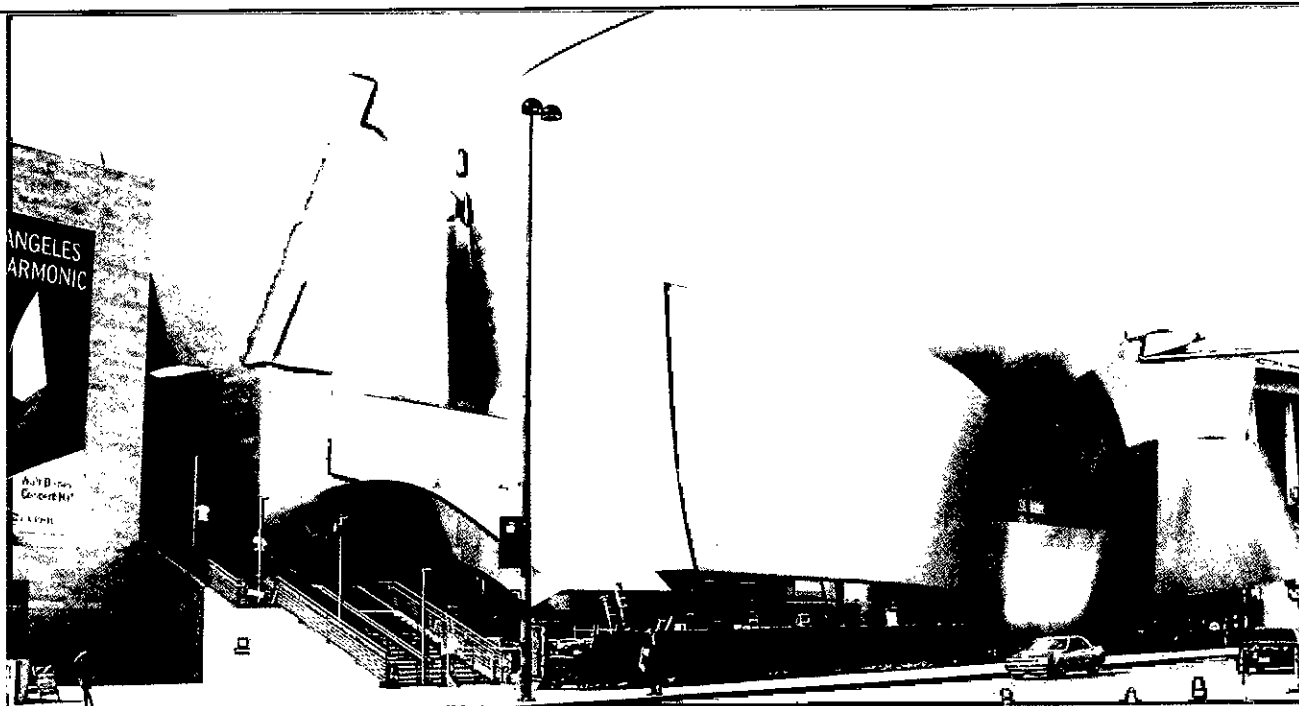
- A 'Quiet Area in an agglomeration' is defined as an area 'which is not exposed to a value of L_{den} or of another appropriate noise indicator greater than a certain value set by the Member State from any noise source'.
- A 'Quiet Area in open country' is defined as an area which is 'undisturbed by noise from traffic, industry or recreational activities'.

This immediately provides two different class of definition, one defined by the specification of an absolute maximum noise level (albeit the numerical value is the responsibility of individual Member States) and the other based on a far more subjective assessment of the soundscape of the area. It is noted that Annex 1 of the END states that the use of supplementary indicators in addition to L_{den} , L_{day} , $L_{evening}$ and L_{night} may be advantageous for the specific case of Quiet Areas in open country.

It is also the responsibility of individual Member States to clarify the precise definitions that will be used.

In the consultation paper on proposals to transpose and implement the END in the UK [3], it is stated that 'the UK Government is of the opinion that

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A proposal for identifying ... noise directive - continued from page 25

the strategic noise mapping will not be able to identify definitively Quiet Areas and will in practice only identify potentially Quiet Areas'.

The Department for Environment, Food and Rural Affairs (Defra) therefore wishes to develop its understanding of how to define Quiet Areas in the many noise environments that are found in the UK, in accordance with the requirements of the END and other policy objectives.

In particular Defra requires the development of appropriate criteria for the identification of Quiet Areas in agglomerations and in open country in the UK, and has commissioned TRL to carry out a review of existing knowledge and to develop the appropriate methodologies.

The proposals presented in this paper are the recommendations of TRL. These proposals are currently being reviewed by Defra and, it must be noted, are not Defra policy.

Within the literature, legislation and policy, the terminology 'tranquil area' is perhaps used more widely than 'Quiet Area'. It is therefore important to draw the distinction between the two terms. As part of a study by Northumbria University and the Landscape Research Group [4], a participatory survey asked 'What is tranquillity?'. The responses can be summarised as follows:

- A perceived link with 'nature' and 'natural features';
- The importance of wildlife;
- Peace, quiet and calm.

Low noise levels and 'quiet' are therefore only one aspect of what defines a tranquil area. Tranquillity is based more on subjectivity, involving both aural and visual cues and the complex interaction is currently being studied at the University of Bradford [5]. It is clear that tranquillity is linked more to Quiet Areas in open country than in agglomerations. Quiet Areas may therefore be far easier to demarcate than tranquil areas, as a more clearly defined indicator is involved.

Review of previous research and legislation

Based on a review of over 60 relevant papers, there is too little research information available to allow the identification of Quiet Areas purely on the basis of acoustical criteria. In urban areas, noise levels below 55dB(A) can be identified from noise maps. However, there are further considerations relating to landscape quality and public access that need to be considered in defining a Quiet Area. Table 1 summarises some of the acoustic criteria, in terms of maximum levels, proposed by different research studies.

Although distance-based criteria have been used in a number of studies, as shown in Table 2, there is a very wide range in minimum distances from the various noise sources. The reasoning behind the selected criteria has not been explicitly explained and further research would be needed to determine the selection criteria for the distances used. Therefore, the robustness of these methodologies is uncertain.

Some EU Member States are beginning to clarify their own interpretations of the definitions for Quiet Areas used in the END. However, there is not a common definition in use, as shown in Table 3. The criteria for noise limit values fall in the range 40 to 55 dB(A) for Quiet Areas in agglomerations and 40 to 45 dB(A) for open country, and are based on different noise indicators including L_{den} and $L_{Aeq,T}$.

There are a number of limitations of the research that has sought to set limit values for Quiet Areas:

- A dose-response relationship for people exposed to noise in Quiet Areas is not well established. Much previous research has concentrated on doorstep interviews where people have been at home usually in the suburbs and not in rural or open country. In such situations exposure levels have been generally high eg above 50dB(A) so that there is little information relating perceptions at low exposure levels. It is therefore difficult to set limits below which a high percentage of people (mainly visitors) are likely to be undisturbed outdoors in rural areas.
- Background levels in rural areas in the UK are not well established so it is difficult to impose meaningful limit values if the current situation is unknown.
- Accurate methods of predicting noise in Quiet Areas are not established. For example, the UK method for traffic noise prediction, Calculation of Road Traffic Noise (CRTN), has only been validated out

Quiet Area location	Symonds Group Ltd [6]	Waugh <i>et al</i> [7]	Karvinen & Savola [8]
agglomeration	50dB L_{den}	-	45dB $L_{Aeq,1h}$
open country	40dB $L_{Aeq,24h}$	30dB $L_{A90,1h}$	30-35dB $L_{Aeq,18h}$ (natural quiet areas) 35 - 40 dB $L_{Aeq,18h}$ (rural quiet areas)

Table 1

Comparison of acoustic criteria (maximum levels)
for Quiet Areas recommended by research activities in Europe

noise source	Quiet Areas			tranquil areas
	Waugh <i>et al</i> [7]	Karvinen & Savola [8]	CPRE [9]	
motorway / dual carriageway	7.5km	4km	4km / 2 km	
national primary route	5km	4km	1km	
regional roads	-	3km	1km	
local roads	-	2km	-	
railway lines	-	3km	1km	
air and water transport	-	3km	-	
motor sport	-	3km	-	
large towns / urban areas (pop. > 10000)	15km	-	4km	
smaller towns / urban areas (pop. > 5000)	10km	-	2km	
urban areas (population > 1000)	3km	-	-	
major industry site	10km	-	-	
local industry	3km	-	-	
largest power stations	-	-	3km	

Table 2

Comparison of distance-based criteria for quiet and tranquil areas

Quiet Area location	END [1]	Norway [10]	Denmark [11]	Netherlands [12]	Finland [13]	Italy [14]
agglomeration	55dB L_{den}	50dB L_{den}	45dB L_{Aeq}	-	55dB $L_{Aeq,1h}$	50dB $L_{Aeq,40-22h}$ and 40dB $L_{Aeq,22h-40h}$
open country	-	40dB L_{den}	-	40dB $L_{Aeq,24h}$	45dB $L_{Aeq,1h}$	-

Table 3

Comparison of acoustic criteria (maximum levels)
for Quiet Areas used in policy/legislation within Europe

to 300m [15]. At this distance from a busy rural single carriageway road the L_{Aeq} would probably lie close to 50dB(A) which for many is probably not considered 'quiet' in a rural area. It would therefore be inaccurate to determine levels, say, out to distances of 1 or 2 km from such a road where levels might be considered quiet.

- The audibility of man-made noise sources is often mentioned as an issue detracting from tranquillity. However audibility depends as much on the background noise level as the level of the source. In fact it is the signal-to-noise ratio that is crucial. Where the signal is above background in a given frequency band it is likely to be audible and therefore potentially annoying. Hence it can be argued that the use of a limit based on the A-weighted broadband level is inappropriate because it fails to take into account the background level of noise.
- To impose a 55dB(A) limit on London parks may mean some squares are excluded when they clearly are valued for relative quiet. This may be because city workers and visitors are exposed and, therefore, are adapted to high levels of noise; hence such a small city square may be perceived as relatively quiet and therefore much valued for relaxation.
- Noise maps are currently being prepared with areas above 55dB L_{den} mapped in 5dB bands, but areas <55dB are not differentiated. If data are available it may be possible to define areas below 55dB. In urban areas a Quiet Area could be considered as an area below 55dB in daytime (eg L_{day}) if this was thought appropriate, but in open country the indications are that this is likely to be unacceptably high.
- A limit in terms of the energy average level L_{Aeq} alone may not protect areas from many annoying noise events. Examples would be noise from wind farms where the modulation noise caused by blade passage frequency can be clearly audible at several hundred metres. In average dB(A) terms levels may well be <40dB(A). Other annoying sounds might include noise from motor sports circuits or from quarries. Such noises may only occur on certain days and may change over time so cannot be easily predicted and as a consequence may not be included in a predicted average level.

It is therefore concluded that there is too little research information available to allow the identification of Quiet Areas purely on the basis of acoustical criteria. There is unlikely to be a noise limit below which noise disturbance can be prevented due to the signal-to-background noise problem mentioned above. In urban areas, levels below 55dB(A) can be identified from noise maps and so this could be the default value pending more refined prediction methods. However there are further considerations relating to landscape quality, perceived quietness and public access that need to be considered. These issues are taken up in the following sections.

It is likely that each Quiet Area is unique with different amounts of natural and man-made noises. Table 3 gives the range of levels that have been adopted for Quiet Areas in some European countries and elsewhere and this can be used for guidance. However, for the reasons given above, this should not imply that the authors agree that these limit values are appropriate, desirable or should be adopted.

Selecting a suitable approach

The literature review therefore clearly highlighted the difficulties in developing a precise, widely applicable definition for a Quiet Area in an agglomeration or open country. Consequently, the way forward was to develop procedures which will, ultimately, identify a priority list of designated Quiet Areas. It was considered that these procedures should offer some flexibility in terms of the definition of a Quiet Area, so that 'local' requirements, perceptions, availability and public access can be taken into account while recognising the long-term aim to protect such valued areas.

Two types of procedure are proposed:

- A (short-term) approach which is suitable for providing an immediate list of candidate areas to comply with the first round of noise mapping in 2007 and action plans in 2008;
- An alternative, preferred approach which is more suited for the wide-scale identification of Quiet Areas over the longer term, particularly with respect to the second round of EU noise mapping due in 2012.

The 'short-term' approach

It is noted that Defra is required under the terms set out in the Statutory Instrument to transpose the Directive into English law to identify all designated Quiet Areas for agglomerations in England by September 2007, in order that the action plans required by the END can include the protection of such Quiet Areas [16].

There are over 27,000 parks and open spaces in the UK and there was a need to reduce the number to a manageable number which can be listed by Defra. The following procedure is suggested for consideration and is shown schematically in Figure 1.

The procedure applies a series of 'filters' to an initial dataset which is assumed to consist of all relevant open spaces; details of the types of area that could be considered as being relevant can be found in Urban Parks Forum [17] and Bell *et al* [18].

- The application of each subsequent filter reduces the potential number of candidate areas until a suitable dataset or list containing a manageable number of areas is obtained.
- It is recommended that this final list should be distributed to the relevant Local Authorities for comment; this will, if necessary, allow the list to be supplemented with additional areas that may be considered particularly relevant for designation as Quiet Areas by the authorities but which have been overlooked by the proposed procedure, or alternatively allow for areas to be removed from the list for planning, economic, usage reasons etc. However, the number of additional areas would ideally be required to be small.
- The procedure will identify Quiet Areas in agglomeration in a manner that satisfies the broad definition set out in Article 3 of the END.

Details of the individual filters

It is suggested that the following filters are applied to the dataset in the sequence listed, as shown in Figure 1, until the dataset is of a

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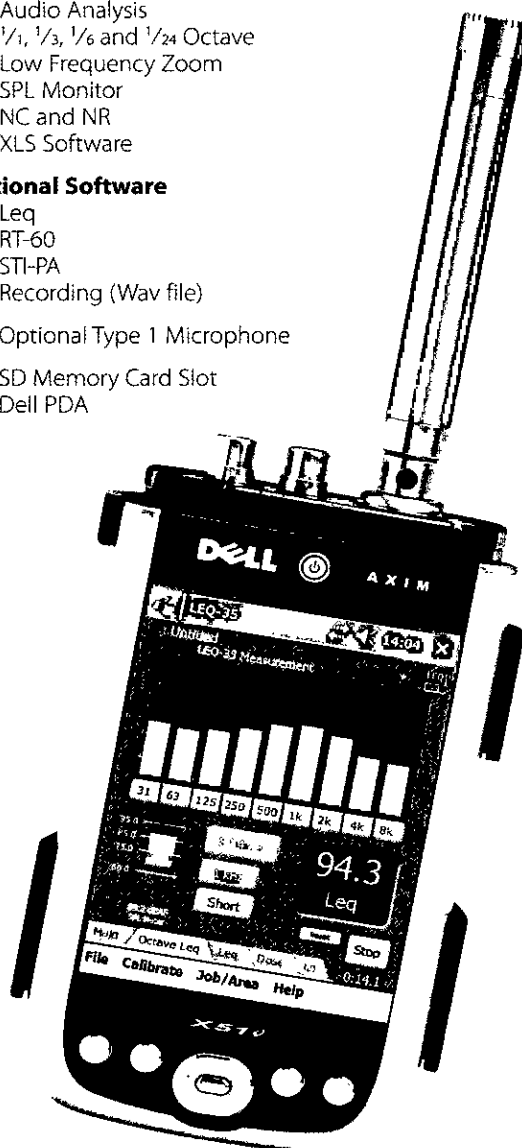
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manageable/satisfactory size. It may not be necessary to apply all seven filters, however the first three filters should be applied.

- **Filter #1 - Geographical:** The open space should fall within the geographical boundaries used to define agglomerations with a population of greater than 250,000 persons in accordance with the END. These agglomerations are those which are to be included in the first round of noise mapping.
- **Filter #2 - Land type:** This defines a limited number of area categories which could, for example, be selected from the types listed by the Urban Parks Forum [17] or Bell et al [18], for example, allowing only designated public parks that are readily accessible to the general public to pass the filter.
- **Filter #3 - Noise level:** Some part of the areas remaining after the application of Filter #2 should lie within a designated noise band as determined during the first round of noise mapping. The recommendation is for this to be the noise band $<55\text{dB } L_{\text{day}}$, however other limit values and/or indices may be appropriate depending upon the categories used in the 'land type' filter (see below). At this stage a suitable list may be generated but filtering will be necessary if the list is unmanageable.
- **Filter #4 - Detailed land type:** This defines more specific types of those areas identified within Filter #2, for example, allowing only public parks which have historical interest to pass the filter.
- **Filter #5 - Minimum area:** This defines a minimum area for each candidate Quiet Area. An example would be greater than 10 hectares, ie 100,000m² or 25 acres.
- **Filter #6 - Minimum area 'of quiet':** This defines the minimum area within the selected noise band that must be $<55\text{dB } L_{\text{day}}$. As an example a minimum area of 5ha could be applied. This filter ensures that the remaining candidate areas have a substantial area within their boundaries that meet the noise limit.
- **Filter #7 - Enlarge minimum area:** If, after application of the previous six filters, the number of identified areas is still not manageable, a final filter which increases the minimum area of a park beyond 10ha (the area from Filter #5) can be applied.

Justification for choice of noise indicator, contour and area selection

Using the L_{day} indicator rather than L_{den} will ensure that noise assessments will be related to the period when most people enjoy the benefits of Quiet Areas in agglomerations, ie 07:00h to 19:00h. Excluding the night time period from protection may provide benefits in protecting residential areas close to Quiet Areas from sleep disturbance caused by lorries, by allowing night time lorry deliveries to be routed along roads which bound Quiet Areas without compromising the daytime protection. However, it is acknowledged that there may be circumstances when other indicators, eg L_{evening} , may be included in the assessment. Any limit value should be based on total combined noise level for all environmental noise sources in the Directive that prevailed during the specified time period.

The recommendation to designate Quiet Areas based on the $<55\text{dB } L_{\text{day}}$ band is based on a consideration of the accuracy of the prediction method, the lowest contour noise level required to be mapped in accordance with the END and the range of noise levels that have been considered for the definition of Quiet Areas in agglomerations within Europe.

Approximately one third of parks listed in the Urban Parks Forum [17] database that are within agglomerations have an area of 10 hectares or greater. Even if a busy road ran alongside one side of such a park it can be shown that there is likely to be a significant area below 55 dB(A) (about 50% if the park is assumed to be approximately square). Clearly the minimum area can be adjusted to take account of the size of a manageable list using a relationship such as the one shown in Figure 2.

The 'long-term' approach

The approach is shown schematically in Figure 3.

- Candidate Quiet Areas should initially be identified on the basis of the

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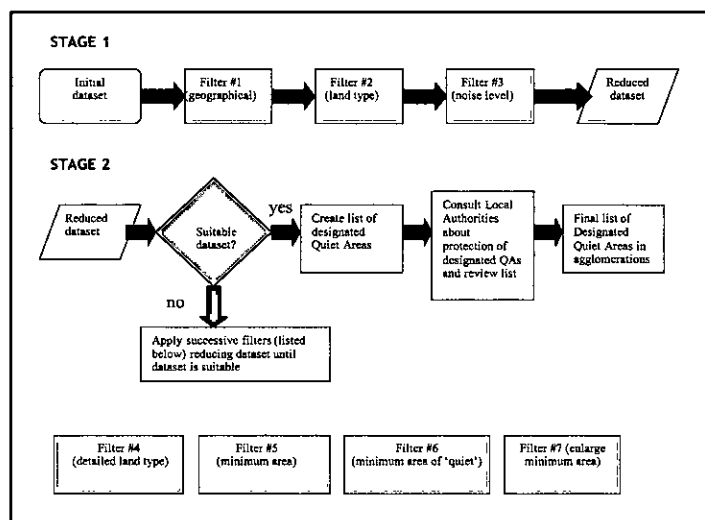


Figure 1

Proposed procedure for identifying Quiet Areas suitable for use in the short-term (agglomerations only) including example filter definitions

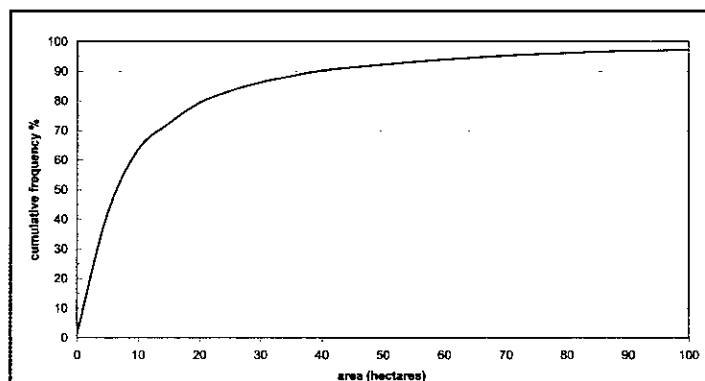


Figure 2

Cumulative distribution of the areas of public parks within agglomerations based on Urban Parks Forum dataset [15]

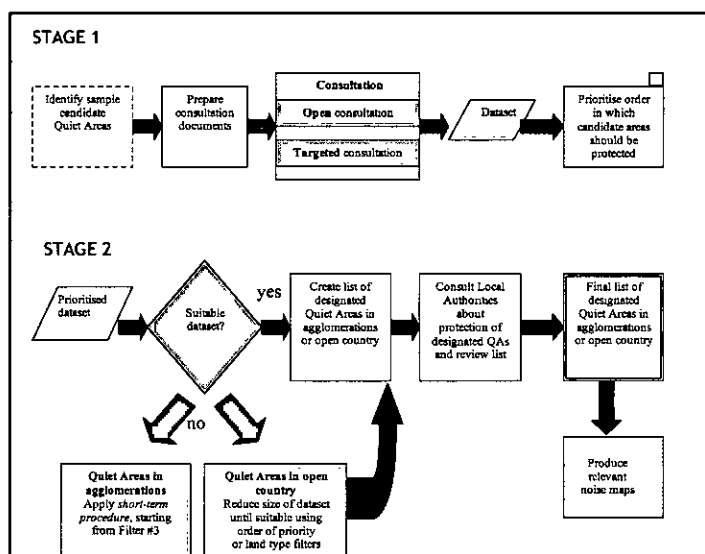
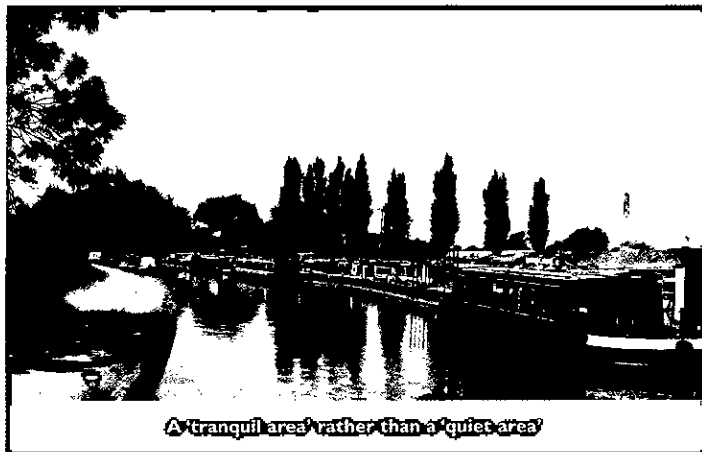


Figure 3

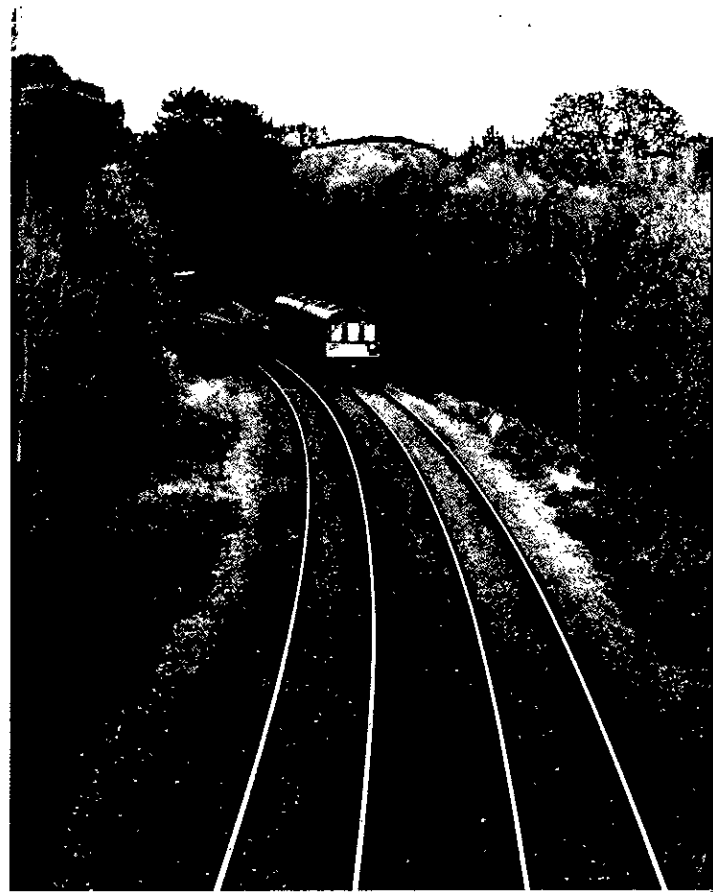
Procedure for identifying Quiet Areas suitable for use in the long-term (agglomerations and open country)



A 'tranquil area' rather than a 'quiet area'



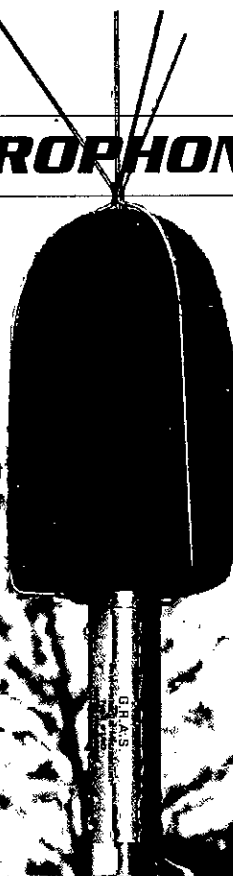
Sea fronts and promenades could be included as candidate quiet areas



Candidate quiet areas should take into account the landscape quality, perceived quietness, and the use made of the area

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views of users and stakeholders. This would involve the appropriate authorities consulting local residents, visitors and stakeholders, either via open consultation or targeted consultation. This should take into account the landscape quality, perceived quietness, degree of public access and enjoyment, and the use made of the area. Examples of the types of candidate area that could be considered are as follows:

Candidate areas in agglomerations: Town and city parks, squares, cemeteries, areas around historic buildings and places of worship, city farms and zoos. Possibly playing fields and playgrounds should also be considered for designation. At the seaside sea fronts and promenades could be included;

Candidate areas in open country: National Parks, Areas of Outstanding Natural Beauty (AONB), moorland, country parks, picnic areas and natural areas with public access close to the sea, lakes, ponds, rivers, streams, canals, disused railways and sites of special scientific interest (SSSI) would be obvious candidates.

- It is assumed that that for agglomerations the existing noise climate in the candidate areas which is considered worthy of preservation would be shown on noise maps of the areas produced using information from the first round of mapping. However, there will be a lack of appropriate noise maps for candidate Quiet Areas in open country.
- The procedure will identify Quiet Areas in both agglomerations and open country in a manner that satisfies the broad definition set out in Article 3 of the END.
- The relevant Local Authorities would then be responsible for prioritising the order in which candidate Quiet Areas within their boundaries should be protected. The costs of protecting designated Quiet Areas over time should be considered. This information is intended for potential use if the list of candidate areas is too large.
- The list should then be reviewed to assess if there are too many potential candidate areas requiring protection.
- If the overall list is acceptable noise maps should then be prepared based on the indices selected above to determine the noise contours to be used for the preservation of the areas.
- If the list is deemed unacceptable, the size of the list can be reduced either based on the prioritisation lists produced by the Local Authorities, or by applying some type of land type filter.
- Any further reduction of the candidate list for Quiet Areas in agglomerations could be undertaken using the short-term procedure starting from the application of an appropriate noise level filter, to

derive the final list. For Quiet Areas in open country, any further reduction should be taken again based on prioritisation or land use type. The final list should be reviewed as above.

Protection of quiet areas

Once identified, Quiet Areas need protection otherwise the identification process is worthless. The long term aim would ideally be to reduce all man-made noise. The following steps are suggested:

- Predict and regularly monitor the noise bands for combined sources from transport and industry;
- Ensure over time that the noise band boundaries (contours) covering the designated Quiet Area shrink toward the sources or at the very least do not expand into the protected area. Remedial action in the associated Action Plan would be in place if the contours were predicted to encroach on designated Quiet Areas;
- Noise maps would be published at regular intervals so that appropriate agencies and the public could monitor the performance and apply pressure if noise levels were observed to rise. This would most likely coincide with the 5 year review of noise maps;
- Monitor noise sources that cannot easily be predicted eg wind farms, leisure and sporting activities and ensure as far as is possible that noise from these sources does not increase (eg in terms of duration, maximum levels and the number of events).

Consideration will have to be given as to how the protection of designated Quiet Areas can be or will be integrated into UK legislation and policy at both a national and local level. The potential impact of this may influence the number and types of Quiet Areas that are designated in the first instance. Practical and economic factors will all need to be taken into account.

Where road and rail traffic or aircraft movements are predicted to grow which might impact on the Quiet Areas, measures should be taken to mitigate the increased noise. In the case of road traffic noise this may include the use of lower noise road surfaces, lorry restrictions, earth mounds and noise barriers, traffic management including speed reduction etc. It may be possible to redistribute heavy traffic across 24 hours such that the L_{day} levels (and possibly $L_{evening}$ levels) are unaffected, but levels may as a consequence rise at night. Innovative approaches could be attempted, for example the use of shuttle buses to transport visitors to and from car parks set up on the fringes of Quiet Areas. Where a new road is proposed, serious consideration should be given to preventing any additional noise. In this respect the example of Twyford Down in Hampshire is relevant. If

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the designation had been applied to this area and vigorously defended then the M3 extension may well have been placed in a tunnel rather than a cutting. The economic implications of designation could therefore be very important and this issue will need to be addressed at an early stage by all agencies likely to be involved.

There may also be a need to identify potential Quiet Areas where the landscape quality is very good and access is easy, but because of the position and strength of current noise sources the area could be described as blighted. In such cases the aim would be to improve the noise climate and targets would need to be established.

It is recommended that a performance indicator is developed for Quiet Areas which would encourage local authorities to maintain this valuable asset as part of the Government's policy on liveability which is concerned with creating high quality and attractive places particularly in urban areas.

The authors are with TRL Ltd. A version of this article was presented at the 2006 IOA Autumn Conference.

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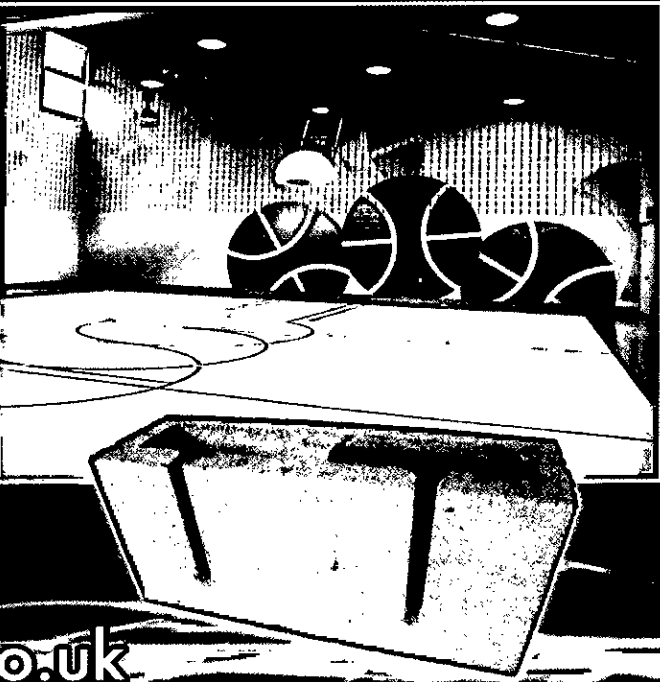
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Changes and challenges in environmental noise measurement

Philip J Dickinson

Introduction

Many changes have occurred in the last seventy years, not least of which are the changes in our environment and interdependently our intellectual and technological development. Sound measurement had its origins in the 1920s at a time when people were still travelling by horse and cart or on steam trains, and few people used electricity. The technology of electronics was in its infancy and our predecessors had limited tools at their disposal. Nevertheless, they provided the basis on which we rely for our present day sound measurements. Since then we have come far, but we still await a solution for the abysmal lack of accuracy we have come to accept.

The beginnings

In the early part of last century, the study of sound was given a large boost by the American Telephone and Telegraph (AT&T) Company's research headed by Harvey Fletcher at Western Electric to improve reception in the telephone. The Western Electric Laboratory as the name suggests was engaged primarily in electrical research and development. Acoustics was only a small facet of its work and the development of acoustical measurements occurred on the back of electrical developments. The Laboratory had been engaged for many years in the development of a means to measure an AC voltage. This was not easy and the Laboratory had to use a root mean square in order always to achieve a positive value for the moving coil meters then in use. In those days the unit for resistance was 1 mile of standard cable, which varied with frequency and temperature, and for measurement of AC power to make it independent of frequency and temperature, it was convenient to use a power (or logarithmic) series for its description based on the power developed by a one volt sinusoid across a mile of standard cable. This measure was called the 'Transmission Unit' TU [1].

Harvey Fletcher (whom this author is very privileged to be able to have called a friend) studied the reactions of (it is believed) 23 of his colleagues to sound in a telephone earpiece generated by an AC voltage. He came up with the idea of a 'sensation unit' SU, based on a power series compared with the voltage that produced the minimum sound audible. Harvey initially called this the 'loudness unit' [2] but later changed his mind following his work on loudness with Steinberg [3]. As a ratio it was not really a unit, but nevertheless was called one, following the use of the 'transmission unit'. With the AT&T development of the Wente microphone [4], an instrument to measure sound in sensitivity units could be developed based on an arbitrary sound pressure close to that simulated by Harvey Fletcher's voltage that produced the minimum audible sound for his research subjects. The idea of an 'intensity level' meter was born - as was the idea of an acoustical society: The Acoustical Society of America was founded in 1928 and held

its first meeting in May 1929 [5].

In the mid 1920s there were suggestions of renaming the Laboratory after Alexander Graham Bell who had recently died, and on 8 February 1924 AT&T and Western Electric created the Bell Telephone Laboratories, or Bell Labs as it was called from then on. In 1927 there was a further suggestion to call the Transmission Unit the 'Bell', but after some consultation with telephone engineers in France, who objected to the word because it was too close to the French word 'Belle' [6], Bell Labs decided to call the Transmission Unit the 'Bel' with a tenth of it called the 'Decibel' [7]. Later, of course, by international convention 'deci' and 'bel' are always lower case, with the bel abbreviation as 'B', hence our use of dB in electrical work. The Director of Research at AT&T, H D Arnold, had led the development of the vacuum tube, and electronic amplification was becoming available to measure small values of power, which is of course proportional to the square of the voltage. In such work, a logarithmic measure was also quite useful in that when amplifiers and attenuators were connected in series, power levels could be added or subtracted arithmetically.

During the 1920s, quite independently there were similar studies being carried out in Europe with similar results, except that the Europeans (with the exception of the British) used a napierian logarithm series that resulted in development of the 'neper' - the natural logarithm of a power ratio. It is understood this pre-dated the decibel [8], but this author has been unable to find any reference to the development of a valve-voltmeter or wattmeter using nepers and it is interesting to note that Georg von Békésy in his experiments in hearing [9] used the decibel for his research at the Royal Hungarian Institute for Research in Telegraphy. Professor Erwin Meyer of the University of Göttingen preferred the decibel for all his work in the 1930s, and his colleague Arnold Schock wrote a small book on acoustics in which only the decibel was used [10]. Békésy later worked in the Department of Telegraphy and Telephony at the Royal Institute of Technology in Stockholm and this may account for the use of the decibel in Scandinavia after World War II.

The first sound level meters were large, consisting of a condenser microphone, an amplifier with thermionic valves and a valve-voltmeter with a logarithmic scale covering the voltage range of one sensation unit split into 10 segments. Almost immediately it was found that something had to be done to the meter to make the movement of the needle readable, and some damping was inserted so that the needle would move over the whole scale in 1 second. The (logarithmic) scale had a range of one bel divided into decibels with a reference level of 10^{-16} watts/cm² [11]. At the same time, the first audiometers started to appear with voltage settings linked to sensation units [12]. Speech clarity and hearing studies were the main acoustics focus, and sound level meters and audiometers were research instruments only for comparison studies. There were no standards to give the reference power or voltage - indeed some researchers used 10^{-13} watts/m² and some used 10^{-12} watts/m² [13] - and accuracy was questionable. So the next step was to try to get some order, and a standard by which everyone could work. Such a standard was not to appear until around 1936 when the Acoustical Society of America published the first embryo standard for sound level meters [14].



Figure 1
Harvey Fletcher,
first President of the
Acoustical Society of America.
Courtesy Emilio Ségre
Archives

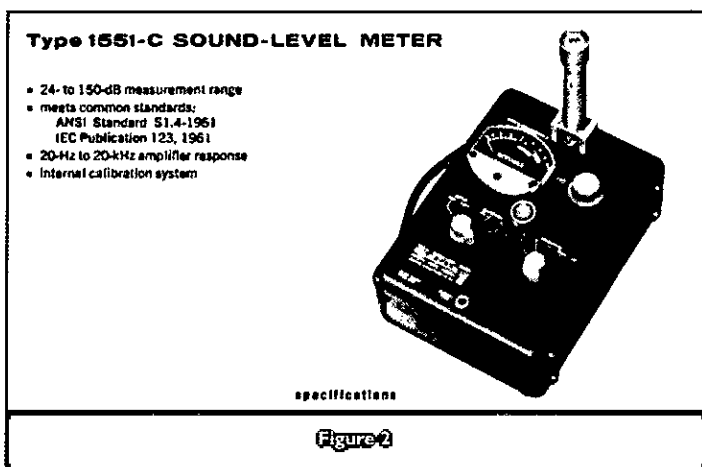
In conjunction with CBS and NBC, Bell Labs explored the way to describe audio power levels in recording and broadcast studios and developed the 'volume unit' VU based on a reference power level of 1 milliwatt into an impedance of 600 ohms. The metric was labelled dBm and a standard appeared in the late 1930s [15].

At a time when electronics was in its infancy and the choice of materials very limited, a good structural base had been set for the development of acoustics research in an era of a relatively quiet environment for most people. There were very few cars on the road and even fewer aircraft to upset the noise environment. The main transportation was by steam train supplemented by horse and cart in country areas and by the omnibus and bicycle in towns. Certain industrial processes such as stamp mills were abominably loud and the noise in textile factories and mills much more than is experienced today. In general, the home and school were quiet places, but children were still employed in factories and Harvey Fletcher even in those days noted the large number of children with hearing loss [16].

The Developmental Years: 1935 to 1959

The early work of Fletcher, Wegel and Munson [17], [18] into auditory thresholds and sensitivity clearly showed that the reading on a sound level meter did not represent a measure of how loud or intense the subject sound might be. Something was needed in the meter's circuitry to give a measure of loudness. Initial work produced the A, B and C frequency weightings [19]. At some time in this period - this author has been unable to find out exactly when - the decibel became the official measure for sound pressure level. It is popularly attributed to Harry Olsen, the Chief Engineer of RCA who, when talking about electrical sound recording, said he could see no difference between acoustical watts and electrical ones [20]. Whatever the source, by the end of World War II, the decibel was in general use for the description of sound.

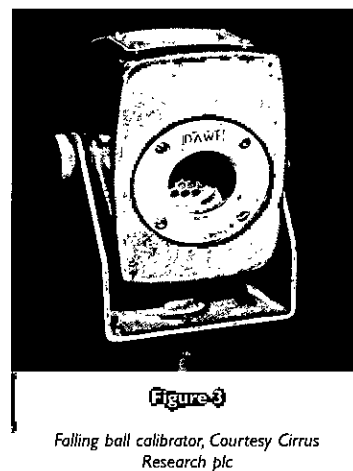
Rapid developments in electro-technology, as a result of the war effort, spawned a number of companies producing sound level meters in the late 1940s, and the formation of the International Electrotechnical Commission which in 1953 formed Technical Committee 29 to develop and establish performance standards for acoustical instrumentation [21]. ISO Technical Committee TC43 was also formed around this time and the decibel was also adopted by them [21]. It became possible to buy sound level meters off-the-shelf, enabling researchers to study environmental noise and develop ways of describing it.



An early sound level meter used by the author

Quite surprisingly, little thought was initially given to maintaining accuracy of measurement, and acoustic calibrators were not part of

the measurement regime until the 1960s. Indeed, from personal experience, in some countries the use of acoustic calibrators was not introduced until the 1990s. Early calibrators were simply a box with a diaphragm onto which tiny ball-bearings were dropped from a fixed height, by inverting the box. By use of a spacer bar, the sound level meter was set up with the microphone 4 inches away. It was not very accurate, but it was better than nothing.



The Age of Surveying: 1950 to 1975

Following World War II and the introduction of jet aircraft into commercial travel, environmental noise levels rose to such an extent that people started to complain. Military air bases in particular came under attack by local residents for making too much and quite unnecessary noise. Some air bases responded by placing large notices at their boundary saying 'Listen to the sound of peace and security' or 'Hear the sound of safety' etc. Whereas the military might well get away with the noise, commercial airports were much more vulnerable and moves were made to restrict the noise emissions to reasonable levels.

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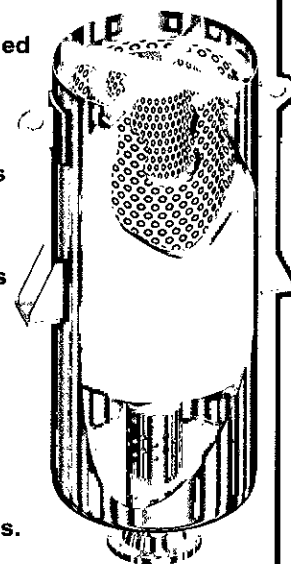
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Changes and challenges ... noise measurement - continued from page 33

In order to find out what was a reasonable level of noise (in government's eyes of course) surveys were made around some of the major airports of the day, for example the Wilson Report [22].

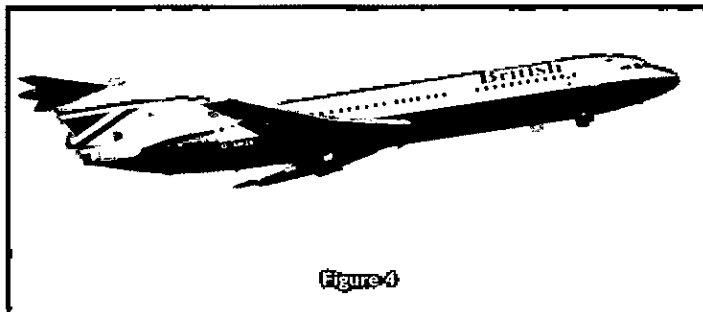


Figure 4

One of the noisiest aircraft at London (Heathrow) Airport: a de Havilland Trident

In each case, the occupiers of certain picked residences were interviewed about their reactions to the aircraft noise, which was measured very simply with a short series of instantaneous measurements of A-frequency weighted sound pressure level (although it is believed no survey ever admitted it). Relating the respondents' survey answers to the given noise level outside seemed often to have political overtones, for in general the study came up with a relationship between the residents' reaction and the environmental noise involving some obscure metric that no one could measure and hence prove the researchers or the government wrong. For example: The surveys around London (Heathrow) Airport [22] produced a relationship called the noise and number index NNI where:

$NNI = \text{average perceived noise level (PNdB)} + 15 \log_{10} (\text{Number of flights}) - 80.$

And with the obscure metric, compatible land use policies were developed [23] with which the local territorial authorities were expected to comply, whereas no control was placed on the airports or airfields to reduce the noise emission.

This was readily accepted by the British Government and regulations involving maximum permitted levels from aircraft were introduced into law in the late 1960s. Noise insulation grants were given to residences receiving (or at least predicted to be receiving) more than 35 NNI. Everyone was led to believe the government had accurate figures for the noise exposure, but not only could the local people not measure the noise in PNdB, neither could the government officers. They (we) simply made an A-frequency weighted measurement in decibels and added 13. A system of noise monitoring stations was set up around the airport, with noise limits in PNdB that the aircraft were obliged not to exceed. The monitoring stations were set up very carefully in prominent positions and this author recollects the pilots were very worried about being prosecuted for making more noise than the limit. They all kept very carefully to the allocated flight tracks, little realising that this was all the monitoring system was set up to accomplish. It too only took A-frequency weighted readings in dB and added 13. The outdoor microphone systems were prone to corrosion and several (somewhat questionable) methods were used to keep out the wind and the rain, all of which must have rendered the system way out of calibration. At one major airport (not in England) hydrophones were used to overcome these problems. Several other countries came up with their own aircraft noise measures and monitoring systems, and it is believed they all used metrics in which nobody outside government could measure - nor could the government officers, but this was never publicised!

Not all noise surveys targeted major airports: the reaction to noise in a number of major cities was also surveyed. The Greater London Survey was one of the first noise surveys, predating the airport noise surveys, and differed from almost all the rest by the introduction of a metric that the general public themselves could measure - the 'percentile level' - but then it did not include a (government) sensitive facility such as a major airport. From the author's own recollections, the metric stemmed from a conversation over morning tea between four British representatives at an ISO meeting in Paris (circa) 1955 including Peter Parkin, George Vulkan and Hugh Humphries. Who raised the question cannot be remembered, nor who answered, but on being asked 'What do you think would be the best way to describe the background noise level?' someone answered 'The level that is there for 90% of the time.' The others thought this a very good idea, and one of them suggested that the noise that is there for 10% of the time was the nuisance noise. Unfortunately they were not mathematicians and termed the measure the 'percentile level'. This stuck for some years until someone dared to suggest that the L_{90} was mathematically the tenth percentile level and the L_{10} the 90th percentile level. At the time, few people listened, but eventually the measure became known as the 'centile level'. Although a very poor measure of community reaction [24], it was all that was really possible with an instantaneous reading sound level meter, and the methodology was simple. Although obsolete in modern day technology, the measure still lingers on in a very few places that favour industry being able to make whatever noise it likes as long as it is for not longer than just under 10% of the time.

A very important step with far-reaching effects was made by the US Federal Aviation Administration (FAA) and the International Civil Aviation Organization (ICAO) in introducing noise certification for all new aircraft entering service in Europe and the United States after 1972. Again, politics were involved in that the first step (to Stage 2 or Chapter 2 aircraft noise certification) would be achievable by 75% of the civil aircraft then extant. A next step (to Stage 3 or Chapter 3) was to be achieved by 1976 and gradually introduced throughout the world. Although some airlines still flew Chapter 2 aircraft well into the 1990s the overall result is that aircraft individually are much quieter than they were and public reaction is noticeably reduced. For example, at Wellington International Airport, New Zealand, in the 1980s there were hundreds of complaints every month about aircraft noise. Today, with adherence to good airport noise management, and a workable national standard, NZS 6805:1992 [25] aircraft noise exposure is only a tenth of what it was, and complaints are very few. Some of the monthly records each year register no complaints at all.

University research benefited too in having government research money readily available for studies into people's reactions to noise, and a multitude of frequency weightings appeared to describe the sound produced by different sources. Indeed, until a stop was called internationally in 1973, more than a hundred different frequency weightings had been produced for sounds ranging from those of different types of jet aircraft to that of noise in pipes or the barking of different types of dog. None was significantly better than the original A-weighting, and so by international agreement all were dropped by ISO and IEC except for the 'A' frequency weighting. One other - C-frequency weighting - was temporarily retained to provide a lower and upper cut-off frequency when measuring peak levels, so as to avoid recording any high levels of sound outside the audio-frequency range. Modern sound level meters now employ a Z-frequency weighting to provide such cut-off frequencies [26].

Yet perhaps the greatest advances during this age were in the sound recording industry. The new plastics allowed the development of the

reel-to-reel tape recorder to quite sophisticated levels with Ampex, Grundig, and above all Nagra producing some exceptional recording machines that could be used in conjunction with the instantaneous reading sound level meters to store sounds for future analysis. However it was a little known company called 'Soundstream' led by Dr Thomas Stockham that arguably produced the most important advance in acoustics since the work of Harvey Fletcher in the early 1920s - that of the flash card and digital recording and analysis. Sadly Tom died trying to protect his invention from piracy by big business, but the advantage he gave to the acoustics industry was a quantum leap forward at a time when computers were in their infancy and RAM almost an unknown quantity.

The world at last had a reliable way of measuring environmental sound, and well researched guidelines for planning the home environment to protect residents from the adverse effects of too much noise.

Perhaps the most useful (measurement) development of this time was that of a true time-average-level based on short L_{eq} measurements [27]. The computer, of course, had made this possible and from then on high grade sound level meters used computer chips to capture sound exposure in pascal-squared-seconds and then converted it to whatever unit or decibel measure was desired. It became possible to log sound level measurements at one-second intervals over several hours and obtain a time history of the sound. We now benefit greatly from this, but at a cost: a number of major companies could not keep up with the pace and went into liquidation.

As the development of the computer advanced, so did that of the sound level meter. Electronically the sound level meter advanced to be capable of doing almost anything the user wanted, but then other

concerns came to the fore.

The Age of Uncertainty: 1995 TO 2005

Two things caused much concern in this particular decade. The international Institute of Metrology pointed out that to conform with Standard International convention the SI unit should be the neper and not the decibel. This resulted in much heated discussion and no conclusion could be drawn at the ISO/TC43 meeting in 2003, although the decision was taken that some existing draft standards should continue to employ decibels [28].

The meeting did, however, conclude that for field quantities F , the quantity should be written as

$$L_F = 10 \lg [F^2/F_0^2] \text{ dB} \quad \text{and not as } L_F = 20 \lg [F/F_0].$$

Not until the 31st meeting in Toronto was the problem resolved. Almost unanimous agreement was reached that the decibel would remain the descriptor for sound [29].

The other concern was a directive by ISO and IEC that in reporting all measurements there must be a statement of percentage uncertainty. It is difficult enough for a testing laboratory using carefully controlled environmental conditions to put such a value on its measurements, but for measurements outside it is almost impossible. The problem is always the microphone, how it receives the signal and how it sends on the response to the central processing unit of the meter. When we have a fixed signal in a controlled environment we can expect accuracy to $\pm 0.7\text{dB}$. For the calibrator we can expect accuracy to $\pm 0.3\text{dB}$. So in practice the best we can measure in carefully controlled environment is to $\pm 1\text{dB}$ and the testing laboratory has to achieve better than, say, one

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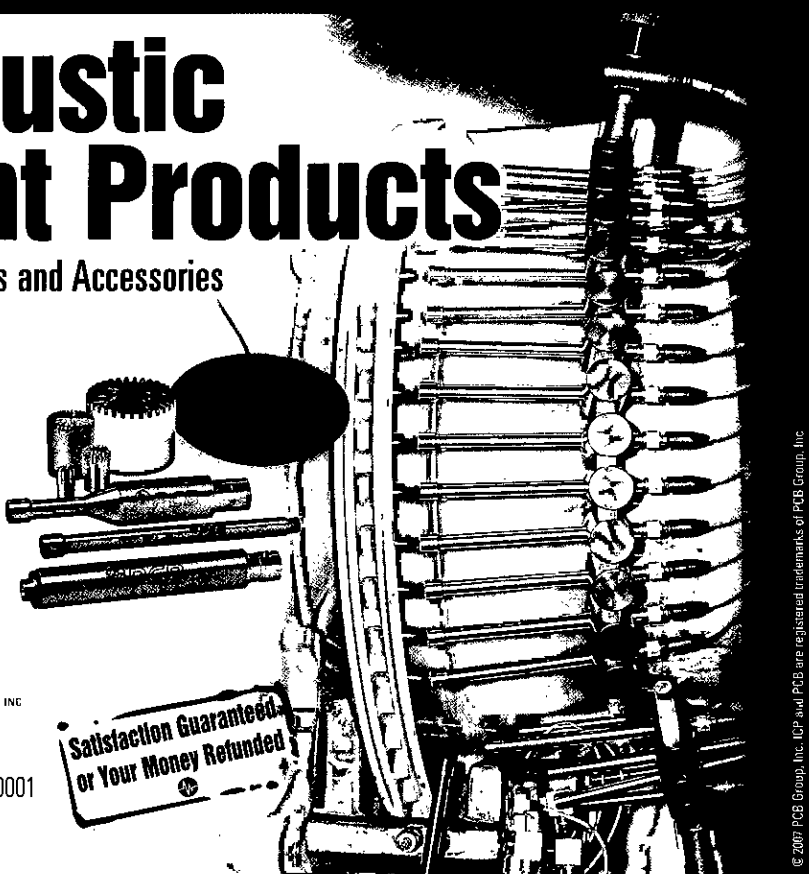
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Changes and challenges ... noise measurement - continued from page 35

third of this uncertainty. How they can achieve this including the microphone in the system must be questionable: purely electrically, there would not be a problem.

For field measurements it is a totally different matter. Even the best of us can only manage to measure within $\pm 5\text{dB}$ or $\pm 300\%$ [30]. No doubt, this is the main reason for the retention of the decibel as the metric rather than the pascal-squared-second. It is not that we have to measure in decibels with all its inherent complications, but stating the uncertainty of a sound measuring system as $\pm 1\text{dB}$ clearly sounds much better than $\pm 26\%$.

The Challenging Years Ahead

Now in the 21st century, technology has progressed almost beyond our wildest dreams. We have sound measurement instrumentation we would never have thought possible a decade or two ago. We can log sound in third-octave bands at intervals of a few milliseconds and immediately read off reverberation times across the entire spectrum, or we can log sound levels at one second intervals over long periods of time and analyse any period at will. We can also store raw data to give measurement results in any metric we like, all with instant graphs in wonderful colours, and have an audio playback as well, if we wish. We can operate a sound level meter by remote control from a thousand miles away while watching the activity through a telelink, and synchronise the recordings of a multitude of noise monitors. We can also record in several channels at once incorporating sound pressure, particle velocity and phase in three dimensions. Yet our one drawback remains: the microphone has not undergone the advances we have made in the other parts of the sound level recording systems, and we have not found a better way of capturing a sound wave. The new 'Microflow' system [31] shows promise, but for now acoustics must still be considered the least accurate of the sciences. We can measure the light from a star millions of kilometres away, we can measure the time for light to travel a distance less than a tenth of a millimetre, we can measure the heat output of a candle more than a kilometre away - all to an accuracy of 3% or better - but we cannot measure a sound, even under strict laboratory control conditions, to better than $\pm 26\%$, or in the open air (it would seem) to much better than $\pm 300\%$. Clearly we need to do better than this over the next few years.

Philip J Dickinson is with Massey University, Wellington, New Zealand. This article, based on an invited paper presented by the author at the Australian Acoustical Society Conference 2005, is reproduced with permission from *Acoustics Australia*. The assistance of the editorial board is gratefully acknowledged.

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INTERNATIONAL CONFERENCE: Detection and Classification of Underwater Targets

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The accurate detection and identification of underwater targets continues as a major issue, despite, or as a result of, the promise of higher resolution underwater imaging systems. With the additional threat of terrorist activities as well as traditional warfare based application the problem has now expanded.

With the increasing deployment of Autonomous Underwater Vehicles for mine countermeasures applications, the automated processing of the large volumes of data gathered by these vehicles to detect and classify targets has become a critical task. Numerous techniques have been proposed for Computer Aided Detection (CAD) to detect all possible mine-like objects, and Computer Aided Classification (CAC) models to classify whether the detected object is a target or not. The question remains as to whether the perfect technique can be found for all applications, or whether the answer lies in collaboration and data fusion.

The detection of objects is hampered in environments such as shallow water or in regions of complex cluttered seabeds with rock outcrops or seaweed. The design of targets is also becoming more sophisticated to hamper detection with cladding to disguise the shape of the target or attenuate the reflection. One of the most complex to detect are buried targets and the problems of detecting these using conventional systems suggests that a novel approach is required using new sensors, signals or multi-static deployment techniques.

The conference will address the entire process of detection and identification, encompassing the design of sensors (both acoustic and others) to aid detection, deployment strategies, signal design, target scattering as well as CAD/CAC processing algorithms. It will also encompass diver detection, harbour surveillance and underwater archaeology as well as detection of mine like targets.

Particular themes of the conference include, but are not limited to:

- Computer aided detection/computer aided classification (CAD/CAC) algorithms for sonar and video data
- Design of sensors to improve detection/identification
- Buried object detection
- Diver detection
- Harbour surveillance
- Target tracking
- Shallow water impacts
- Target scattering
- Seabed classification
- Deployment strategies including AUVs
- Signal design: bio-inspired signals
- Synthetic Aperture Sonar

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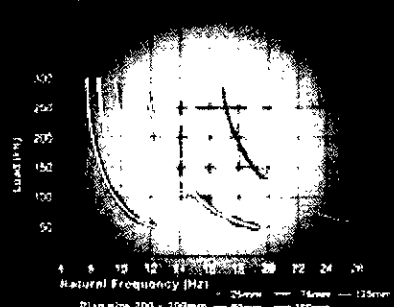
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Parliamentary reports

From Hansard

Extracts from Commons debates

15 January 2007: Helicopter Flights (London)

Susan Kramer (Richmond Park) (LD): I sought this debate because I received many complaints from local residents in my constituency about the noise of helicopters overhead. To provide a flavour of those complaints, I quote some of them:

'I really do find it intolerable that very few helicopters, if any, keep to their designated route.'

'This year the noise from helicopters going to and fro from Battersea has become intolerable. To make matters worse the helicopters frequently seem to be in holding patterns over Barnes resulting in continuous and unbearable noise.'

'This morning, I felt I was in 'Apocalypse Now' under attack.'

In reply to our letters urging the Government to try to find a way of tackling the problem of helicopter noise, the Under-Secretary of State for Transport, the hon. Member for Lincoln (Gillian Merron) told us in October 2006 that where standards were concerned, further progress was dependent upon international negotiation and agreement. No significant technology advances were in prospect, and considerate flying was the key to legitimate operations not causing unacceptable disturbance.

We were provided with contact details for the British Helicopter Advisory Board, but it appears that existing bodies do not take responsibility for the environmental impact of helicopters that fly across our communities, and certainly not for the noise that they create.

I very much welcome the investigation into these issues that was published by the Greater London authority last October, entitled "London in a spin - a review of helicopter noise". I would love to tell the House the number of helicopter movements across London, but there is no comprehensive database that keeps count of such movements.

The pattern of flights is particularly annoying. We suspect that corporate entertainment is a major cause of aircraft movements, as there are clusters of flights during events such as Ascot and the Farnborough air show, causing disruption for several days.

There is an attitude in government that anything that business wants in aviation it gets, regardless of the impact on the community. My constituency suffers significantly from noise from Heathrow, and my residents believe that the Government's approach to aviation is one of predict and provide. There is no incentive to reduce helicopter noise, and many fleets are 30 years old and continue to disturb people.

Residents are disturbed by helicopter noise, but it is hard to determine that objectively, because there are not any standards by which to measure it. It is important that we do not repeat a key mistake in the measurement of fixed-wing aircraft

noise, which determines average noise. No one ever hears average noise - people are disturbed by individual events.

What practical steps can residents take in order to avoid living in a zone disturbed by helicopters? There is no way to find a noise map to see where the problem is.

I hope that the Minister will give a commitment tonight that the issue will be taken seriously. Noise pollution, especially from the air, is an increasing blight over one of the finest capital cities in the world - the finest, I would argue. Residents should not have to suffer from such disturbance. Other than police, military and ambulance movements, we are dealing with a luxury service which serves a small number of people while disturbing a very significant number.

The Parliamentary Under-Secretary of State for Transport (Gillian Merron): A gentleman by the name of Igor Sikorsky who built the first helicopter said that the helicopter approaches closer than any other vehicle to the fulfilment of mankind's ancient dreams of the flying horse and the magic carpet. The helicopter is a key tool in emergency and military situations. We know how many lives have been saved, perhaps in our own areas, by air ambulances.

Susan Kramer: Surely the Minister recognises that the overwhelming cause of noise in London is the commercial helicopter, rather than police or ambulance helicopters. I would be very interested if there were more than 12,000 movements to and fro. That would account for the commercial movements out of Battersea alone. That number has never been acknowledged before as involving police and ambulance helicopters.

Gillian Merron: The difficulty is that much of the discussion is anecdotal, important though that is. Just as helicopters are important to the emergency health services, they are critical to the police, and no one would challenge the need for them to be used in key police operations. Helicopters are a feature of life today and we cannot wish them away.

Clearly, helicopters have a particular local environmental impact through the noise that they make. It was therefore timely and welcome for the Greater London assembly environment committee to look into the issue of helicopter noise, and its report gives valuable food for thought.

The hon. Lady suggested, erroneously, that the Government's policy on aviation was to predict and provide. The fact is that the issue is not all about predict and provide; it is about balance, economic development, the environment and the interests of local communities. The progress report on the air transport White Paper has been well received by stakeholders across the country rather than only those involved in the aviation industry.

I reassure the hon. Lady and her constituents that we take the measurement of aircraft noise seriously. We take account of the operational noise made by aircraft in setting noise objectives, and we are very conscious of its impact on local

communities. My Department has a broad role on overall helicopter noise policy, but it is not involved in overseeing or approving helicopter operations. There are, of course, regulations under civil aviation legislation governing flight by helicopters over London, which are the Rules of the Air Regulations 1996 and the Air Navigation (Restriction of Flying) (Specified Area) Regulations 2005.

Police helicopter activity is governed by the provisions of the police operators certificate, which exempts the police from certain parts of the rules of the air regulations. No legal action can be taken against pilots for noise disturbance, providing that they observe the rules of the air and fly in accordance with normal aviation practice.

Improved technology means that helicopters are less noisy than they were, and we seek reductions in noise at source by encouraging industry developments in aircraft and engine technology. The noise signature of helicopters does indeed differ from fixed-wing aircraft in that the noise derives not only from the engines but from the main and tail rotors, particularly from their tips. Therefore, silencing an engine alone will do little to improve the level of disturbance.

Since 1 August 1986, all new and modified versions of existing designs of helicopters to be flown in this country have been required to meet noise certification standards. The current requirements for helicopters are laid out in the Air Navigation (Noise Certification) Order 1990 and are based on the International Civil Aviation Organisation's annex 16. We in this country helped to establish, and have adopted, that international standard. However, where standards are concerned, further progress is dependent on international negotiation and agreement, which can then be implemented by the European Union and in national regulation. I assure the House that we will continue to seek reductions in source noise where possible, as we do for all aircraft.

At present, it is true to say that there is little co-ordinated information collection, meaning that concerns about increased noise tend to be somewhat anecdotal. I assure the House that the Department will work with the CAA and National Air Traffic Services to collect more comprehensive data, liaising as appropriate with the environment committee's officers. It is right to proceed in that way. Instead of launching a flurry of activity to try to address a problem the detail of which is not clear enough, we should first establish an understanding of the actual position and the trends. That will enable us to inform decisions on next steps. It will not be straightforward to collect the further information, but we shall pursue it. I hope that the hon. Lady will agree that this represents a considered and sensible response to the points that she and the London assembly's environment committee have raised.

Commons Written Answers

10 January 2007: Car exhaust noise

Mr Drew: To ask the Secretary of State for Transport what measures he has put in place to ensure that car owners do not alter exhaust or silencer systems after an MOT test to ensure that those systems do not break noise regulations.

Dr Ladyman: Enforcement of the Road Traffic Regulations is primarily a matter for the police, although the Vehicle Operator and Standards Agency support this process through a programme of roadside inspections.

An objective assessment of the noise levels of individual vehicles during a roadside inspection is problematic due to interference from other noise sources, and static testing does not necessarily give a good representation of the level of noise with the vehicle in motion. However the Department is considering letting further research into the feasibility of a simple and robust test that might be used in these circumstances.

Mr Drew: To ask the Secretary of State for Transport if he will further tighten regulations 54 and 97 of the Road Vehicles (Construction and Use) Regulations 1986 to ensure that exhaust and silencer systems remain in good working order and do not make excessive noise.

Dr Ladyman: The Department currently has no plans to tighten the regulations referred to, although this position is kept under review. Regulation 54 already requires exhaust systems to be maintained in good and efficient working order and prohibits modification to increase the level of noise emissions. The regulations as they stand are therefore adequate for dealing with noisy vehicles.

15 January 2007: M3 motorway

Mrs Maria Miller: To ask the Secretary of State for Transport what resurfacing and noise reduction works are planned to be undertaken between junctions 5 and 7 of the M3 motorway, and

whether the Highways Agency plans to undertake noise reduction works of each lane of the M3 between junctions 5 and 7; and if he will make a statement.

Dr Ladyman: The Highways Agency resurfaced lane 1 Northbound of the M3 between junctions 5 and 6 with quieter surfacing in September 2001. It has a scheme within its current four year maintenance programme to resurface the remaining lanes of both carriageways in two phases between 2008 and 2010. A quieter surface will be used for this as a matter of course.

The road between junctions 6 and 7 is in a safe and serviceable condition and therefore there are no current plans for its resurfacing.

Noise reduction works, consisting of the construction of a 300 m acoustic barrier, are planned for the financial year 2007-08 for the northbound carriageway of the M3 between junctions 5 and 6 at Hatch.

16 January 2007: Exhaust noise

Mr Drew: To ask the Secretary of State for the Home Department how many vehicles were prosecuted for (a) exhaust and (b) silencer systems that make excessive noise in the latest year for which figures are available.

Mr Coaker: Available information taken from the Court Proceedings Database held by the Office for Criminal Justice Reform shows that in 2004 (latest available) there were 2,048 prosecutions for noise offences under the Road Vehicles (Construction and Use) Regulations 1986. Data for 2005 will be available later in 2007.

18 January 2007: Helicopter noise

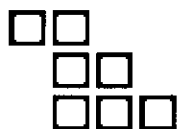
Mr Burstow: To ask the Secretary of State for Transport pursuant to the answer of 5 December 2006 on helicopter noise, what the conclusions were of the meeting held with representatives of the London Assembly's Environmental Committee to discuss the recommendations in the committee's report, 'London in a spin - A review of helicopter noise'; and if he will make a statement.

Gillian Merron: I held a very constructive and productive meeting with representatives of the London Assembly's Environment Committee. We agreed on two key priorities which were the improvement of data collection with a central database and a clear complaints procedure for the public. The Department will be taking these issues forward in dialogue with the Civil Aviation Authority, National Air Traffic Services and the Committee.

25 January 2007: Nightclub noise levels

Mr Leech: To ask the Secretary of State for Health if she will commission research into the potential for damage to be caused to people's hearing by the level of noise in nightclubs.

Andy Burnham: The Department has no plans to do so. My right hon. Friend the Secretary of State for Work and Pensions has responsibility for health and safety. This includes responsibility for legislation that requires employers to prevent or reduce risks to health from exposure to noise at work.




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Highways ■ Property ■ Rail ■ Water



EC^{UK}

Coordinates master plan to develop new route to professional registration

Deterred by the prospect of incurring further debt, many BEng (Hons) graduates opt not to continue their studies to Master's level. Consequently, their academic qualifications fall short of what is normally required for registration as a Chartered Engineer (CEng)*. Indeed, it is estimated that thousands more such graduates might have achieved chartered status had gaining an MSc or other form of Master's been more affordable. Student concern over costs has had a similar effect on the numbers qualifying for Incorporated Engineer (IEng) status.

Affordability is at the heart of an innovative collaborative venture between EC^{UK}, professional engineering institutions, industry and higher education. Being coordinated by EC^{UK}, in partnership with Kingston University and the University of Northumbria, the government-backed project will develop and pilot routes to registration that integrate education and supervised work-based professional development. It will take as its starting point Kingston's existing work-based MSc and its Foundation Degree with Honours top-up, which is relevant to IEng candidates. The programmes developed from these could potentially satisfy all the requirements for registration. The DfES has provided funding of £561,000 towards the cost of the project

(under its *Gateways to the Professions initiative*).

The project's overall aim is to create a flexible, work-based learning 'escalator' that enables pre-technician entrants to progress to IEng or CEng registration, maximising their employment and earnings prospects but without their having to incur large debts. This should prove a particular incentive to those groups who are currently under-represented in engineering, including women and ethnic minorities, as well as those wishing to return to the sector. The initiative's ultimate objective is to tackle shortages of professional engineers and technicians by encouraging more people both to enter and stay in the profession.

During an initial 18-month phase Kingston and Northumbria Universities will work with EC^{UK} and three of its licensed institutions - IET (Institution of Engineering & Technology), IMechE (Institution of Mechanical Engineers) and RAeS (Royal Aeronautical Society) - to develop, validate and launch the IEng/CEng work-based programmes. These will be rolled out nationwide during a second, three-year phase, during which it is intended that the majority of licensed engineering institutions and at least ten HEIs will adopt them. The project will benefit from the Knowledge

Transfer Partnerships and other links that already exist between universities and industry; Kingston for instance has links with BA, KLM, Eurostar and Laing O'Rourke.

It is envisaged that in five years' time over 20,000 engineers may be following the work-based route to IEng or CEng status, which would make it one of the main pathways to professional registration.

* Those wishing to register as Chartered Engineers are normally expected to have gained the following academic qualifications:

- An accredited Bachelor's degree with honours in engineering or technology together with an accredited or approved Master's degree or appropriate further learning to Master's level, or
- An accredited integrated MEng degree.

The normal academic requirements to become an Incorporated Engineer are:

- An accredited Bachelor's degree in engineering or technology, or
- A Higher National Certificate or Diploma or a Foundation Degree, plus further learning to Bachelor's degree level.

Queen's lecture to 'rock' young scientists

Unique lecture for 300 schoolchildren

Rock-and-roll music struck the right chord for around 300 secondary schoolchildren at a unique science lecture at Queen's University, Belfast, on 31 January.

Dr Mark Lewney, winner of the 2005 Channel 4 FameLab competition to discover the next generation of gifted science communicators, used rock guitar music to explain the mysteries of physics to an audience of 15-18 year olds from throughout Northern Ireland.

Entitled 'Rock guitar in eleven dimensions: Strats, Strads and Superstrings', Dr Lewney's talk was the 2007 Tyndall Lecture organised by the Institute of Physics in Ireland. As well as Belfast, Dr Lewney is delivering his lecture in Waterford, Carlow, Dublin, Galway, Cork and Limerick.

Dr Lewney studied Physics at Edinburgh University before gaining a PhD in acoustics from Cardiff University. He works at the UK

Patent Office, dealing with new inventions in telecommunications, and pursues anthropological research in his spare time by playing rock guitar in Welsh pubs. He has appeared on CBBC's 'Xchange' and Radio 4's 'Material World'.

During his lecture, Dr Lewney explained the physics of rock using riffs from Vivaldi to Queen, and the theme music from 'Bullseye', revealed the secret of the Stradivarius and showed how string vibrations might lie at the heart of the answers to questions about the Big Bang and the dimensions of the universe.

Local organiser Prof Bob McCullough of Queen's, said that the event was very entertaining and informative. Physics was the study of the deepest mysteries of the cosmos, ranging from subatomic particles to outer space, and had tremendous practical applications in everyday life. Demonstration

lectures like Dr Lewney's had a vital role to play in enthusing and exciting young people about the wonders of physics, and encouraging them to think about a career in science.

The lecture series commemorates the 19th century Irish scientist John Tyndall, from County Carlow, a fellow of the Royal Society, whose research led to the discovery that light only becomes visible after bouncing off air particles, and also predicted the use of fibre optics for communications. His work in acoustics is also commemorated by the Institute of Acoustics, which awards a Tyndall Medal biannually to a citizen of the UK, preferably under the age of 40, for achievement and services in the field of acoustics. It was first awarded in 1975 with the aim of recognising early career attainments in acoustics.

Selectaglaze scales monumental heights

Birmingham Town Hall

At the noisy heart of bustling Birmingham is the city's Town Hall, an impressive example of Roman revival civic architecture. Designed by Joseph Hansom (of Hansom cab fame), this Grade I listed landmark building is based on the Roman temple of Castor and Pollux.

With a refurbishment budget of £34m, the 1830's iconic masterpiece will once more become the performance centre of the city. However, the journey from faded glory to world class concert venue was hardly straightforward and took the combined expertise and ingenuity of main contractor, Wates Construction and Selectaglaze, the country's leading secondary glazing specialist.

The challenge was to prevent the sounds of the city from interfering with the most sensitive of arias while maintaining clean sight lines for the building's original windows and listed facade. The solution was a monumental story in the real sense of the word.

Working with their tried and tested Series 50 side hung casement, Selectaglaze produced a unit which, at 4.5m high, was substantially taller than any previous construction. At 1.8m wide, the complete casement weighed over 200kg. Having met this first challenge, the next was how to fit the largest casement ever made, with its sill 8m above floor level.

Working closely with Wates Construction, an ingenious combination of rollers, vacuum lifting gear and purpose-designed scaffolding looked to be the most practical way of positioning the windows so that they could be presented to the specially reinforced openings. Of course, the acoustic performance of the glazing combination and the fitting procedure had to be tested on the initial prototype before the main task of manufacture and installation could be undertaken.

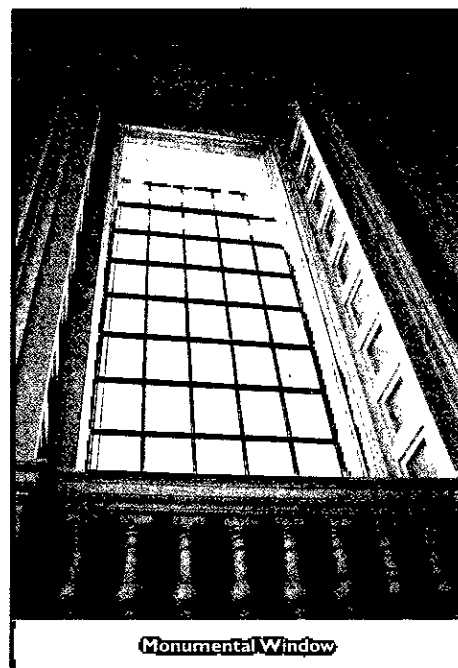
Other necessary changes to the original Series

50 unit included modifications to the locking mechanism so that the unit could be closed by a single handle located near the base of the window.

Contemporary standards

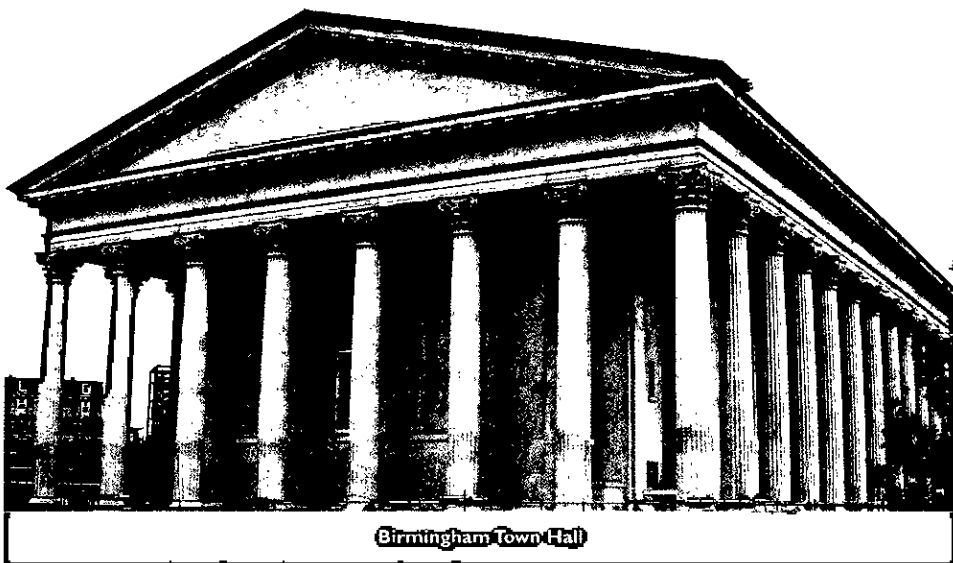
The benefits of secondary glazing systems are not only in sound insulation. The range also offers high levels of thermal insulation and can be specified to incorporate Part L compliant sealed units. The company also offers security windows providing certified protection against blast, physical and ballistic attack and with a fire rating.

Secondary glazing systems are purpose-made and arrive fully assembled to allow rapid installation with minimal disruption. They need very little maintenance and will continuously contribute to energy savings.



Monumental Window

For more information:
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Birmingham Town Hall

Parsons Brinckerhoff

Providing sound advice to Defra

Parsons Brinckerhoff Ltd employs over 1,700 staff and is part of the Parsons Brinckerhoff (PB) group, an international engineering, design and programme management firm offering a multi-disciplinary consultancy service in transportation, environment, buildings, power and telecommunications. Having gained national and international recognition for its research work with Defra over the last three years, the company has been re-appointed to work with the government agency on environment and neighbourhood noise issues. The team has provided in-house support to the Local Environment Quality Policy Unit of Defra, based in London, since 2002. Under the contract PB will

continue to provide technical advice and research management support for a further six years.

PB will fulfil a wide range of roles and responsibilities. As well as providing the technical input to parliamentary questions as required, the team will also have involvement on government committees, managing research projects, and will provide 'first-call' technical advice to the policy unit and the general public.

According to the project manager, Richard Perkins, this was an exciting time to be involved with noise policy development. Defra was in the final stages of completing maps of roads, rail, industry and aircraft noise under the EU Environmental Noise

Directive, developing a Noise Strategy, revising the planning guidance note (PPG24) for noise, and delivering guidance on new legislation such as the Noise Act and the Clean Neighbourhoods Act. The robust technical evidence provided by PB would help to steer the outcomes.

Having project managed several dozen research contracts for Defra over the last three years, the company's results are starting to gain national and international recognition: the reappointment allows another six years of contribution to noise policy development in the UK.

For further information please contact:

Liz Morgan, Marketing Communications Officer

Parsons Brinckerhoff Ltd

Tel: 0117 933 9125

E-mail: morganliz@pbworld.com

Sickening

worst sound in the world announced

The sound of vomiting is officially the most horrible ever, according to over a million votes cast worldwide in a mass online science experiment.

International visitors to the BadVibes website (www.sound101.org) - a research project from the University of Salford - listened to sounds such as a dentist's drill, fingernails scraping down a blackboard and aircraft flying past, before rating them in terms of their unpleasantness.

Although fingernails scraping down a blackboard is said to be the worst sound by many people, the actual recording of this sound only came sixteenth out of 34 sounds auditioned. Microphone feedback came a close second in the 'horribleness ranking', with many babies crying coming third.

Over 1.1 million votes were statistically analysed by Prof Trevor Cox of the University's Acoustic Research Centre, who conducted the experiment in order to explore the public's perceptions of unpleasant sounds and help inform the acoustics industry.

He admitted to be driven by a scientific

curiosity about why people shudder at certain sounds and not others. Humans seem to be pre-programmed to be repulsed by horrible things such as vomiting, as it is fundamental to staying alive to avoid nasty stuff, but interestingly, the voting patterns from the sound did not match expectation for a pure 'disgust' reaction.

Similarly, the sound of fingernails down a blackboard has been compared with the warning cries of monkeys - again, something that humans might instinctively respond to because of their ancestry. The study examined whether the voting patterns for the scraping sounds were consistent with an evolved response, but only for the worst scraping sound were the results consistent with the hypothesis of an evolved response.

One of Trevor's discoveries was that females rated 25 out of the 34 sounds more horrible than males. However, baby cries were one of the few sounds males found worse than females. This may be because women played a role in protecting both themselves and their offspring from attack. It could be that females have

become habituated to the sound of babies crying.

Trevor, who is now planning a similar experiment to rate the most pleasant sound in the world, is hoping to use the results of the BadVibes project to help inform industry about how to engineer sounds which are more pleasant.

He said that the research had been fascinating in gaining an insight into why people were repulsed by certain sounds, and how this differed by sex, age and nationality. This was very important because noise significantly affected quality of life for so many people.

The project was funded by the Engineering and Physical Sciences Research Council (EPSRC).

As a footnote, Trevor has just started as resident scientist on BBC Radio Manchester.



Trevor Cox undertakes his selfless research in the cause of science

Human response to noise and vibration

training in India

Loughborough University's Neil Mansfield and Andrew Rimell have just returned from India, where they gave a one-week short course 'Human Response to Noise and

Vibration'. The intensive course was designed to train Indian engineers to understand and tackle problems of noise and vibration including health effects, environmental impact, measurement, risk management and principals of product design.

The 25 delegates from industry, railways, academia and healthcare were able to practise noise and vibration measurements including measurement of seating dynamics, power tool vibration and noise mapping. The course was held at the Indian Institute of Technology, Roorkee, and was the first of a series which form part of a European Commission funded project 'CIRCIS' with partners from India (IIT-Roorkee, IIT-Delhi, Indian Railways) and Europe (Loughborough University, KTH Sweden, Sarin Aeroacoustical Services).

The CIRCIS project includes collaborative multi-centre research, development of courses for Indian Universities, training for those working in industry, and exchange of students between Europe and India.



Measurement of power tool vibration



Delegates practise noise measurements

For more information please contact
Dr Neil J Mansfield
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Candidates must be capable of managing and executing noise and vibration-related consultancy projects, and be prepared to apply their expertise to a range of engineering platforms including military and commercial vehicles, railway systems, gas turbines, and luxury yachts. The level of services we offer ranges from basic acoustic design and troubleshooting consultancy based on hand calculations and experimental measurements, through to provision of enterprise level advice on noise and vibration issues including legislative compliance. The successful applicant will have a solid understanding of the principles underlying current noise and vibration regulations.

Frazer-Nash operates a range of modern modelling software and experimental measurement equipment, and therefore familiarity with noise modelling and analysis, noise survey techniques and data manipulation are a pre-requisite. Particular skills and experience desired may include:

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- Noise control engineering
- Noise and vibration measurement
- Noise and vibration modelling
- Provision of consultancy advice

Interested? Please send your CV to Suzanne Archer - Frazer-Nash Consultancy Limited, Stonebridge House, Dorking Business Park, Dorking, Surrey, RH4 1HJ email s.archer@fnc.co.uk

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PLASA backs National Skills Academy

Plans boosted with the addition of more influential supporters

Plans for a National Skills Academy for the creative and cultural industries have been boosted with the addition of more influential supporters. PLASA - the Professional Lighting and Sound Association - is the latest organisation to join the unprecedented alliance of employers and industry bodies backing the project. PLASA is a pro-active trade association serving the entertainment, leisure, communication and architectural industries. It looks after the interests of a large commercial membership, influences the business practices adopted by the industry and is dedicated to improving standards. With over 500 members worldwide, it is one of the largest trade communities in the industry, contributing to a market worth £10.5 billion. In recent years, the membership has broadened to include designers and consultants, as well as students. The Association runs the PLASA Show, the main international exhibition for this sector, and publishes *Lighting & Sound International* and *Lighting & Sound America*, together with a daily online news service.

The National Skills Academy is designed to address shortages in offstage and technical skills for live music and the performing arts. Detailed plans being prepared by Creative and Cultural Skills, the employer-led Sector Skills Council, will be submitted to the government

in April 2007.

The support of PLASA is hugely significant, according to Tom Bewick, chief executive of Creative and Cultural Skills. Its wide membership of leading specialists in professional audio, lighting, staging, rigging, communications and related disciplines fully understood the skills needed in the real world. That input was going to be crucial in making sure the National Skills Academy delivered industry-specified training to the very highest international standards.

PLASA will also lead a drive to raise capital and in-kind support from its members for development of the National Skills Academy. £3 million of the estimated £10 million start-up costs have to be raised by industry, with the balance provided by the government on final approval of the project plans.

Matthew Griffiths, chief executive of PLASA, commented that the appeal of the National Skills Academy was that it gave employers control of the training - what skills were taught, how they were taught, and where. This aligned to one of PLASA's core objectives, namely to provide assessment and vocational qualifications through industry consensus. The shortage of skilled, experienced and qualified technical staff was holding back the growth and development of the industry and

this was an unparalleled opportunity to ensure that the right people were available in years to come.

Since the launch of the project in October 2006, the list of prestigious supporters for the Academy has also been joined by Denis Desmond's MCD Promotions, the International Live Music Forum and the Production Services Association. Others behind the project include the Royal Opera House, EMI Group, Academy Music Group, the Arts Council of England, the National Theatre, the Royal Shakespeare Company, the Live Music Forum, Live Nation and English National Opera.

For further information on PLASA please contact Ruth Rossington
e-mail ruth@plasa.org

On 1 February 2007 PLASA relocated and can now be reached at
PLASA Ltd.

Redoubt House,
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BN23 8AS, UK.

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PEOPLE NEWS

Graham Turgoose

named managing director, PCB Piezotronics Ltd

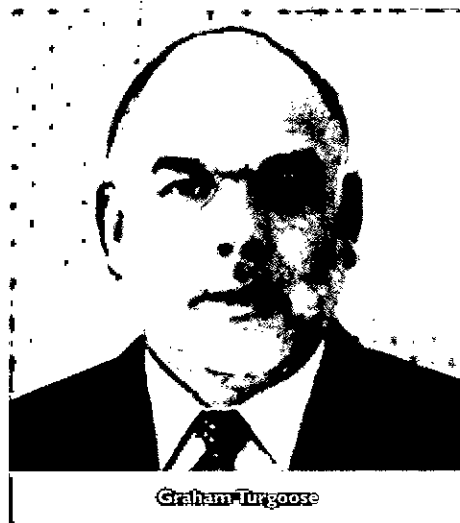
PCB Group has announced the appointment of Graham Turgoose as managing director of PCB Piezotronics Ltd at its newly established sales office in the United Kingdom.

As managing director he will oversee all aspects of sales, marketing and customer service for PCB and IMI Sensors within the United Kingdom and Ireland, as well as having overall responsibility for focused speciality product and programme support in aerospace, automotive, defence, machinery monitoring, process control, and test and measurement applications.

Graham has served as European Sales Manager for PCB for the past six years. He

has more than 25 years of sensor and instrumentation experience, and has worked in the areas of process control, electrodynamic shaker systems, acoustic testing, and government research.

Founded in 1967, PCB Piezotronics is a global leader in the design and manufacture of force, torque, load, strain, pressure, acoustic and vibration sensors, as well as the pioneer of ICP technology. Core competencies include ICP and charge output piezoelectric, piezoresistive, strain gauge, MEMS and capacitive sensors and instrumentation. With 24-hour customer support; direct sales offices throughout Europe and Asia; and an established global distribution



Graham Turgoose

network, PCB attributes its continued growth to an unwavering commitment to total customer satisfaction.

How quiet is a quiet area:

a reply from Greg Watts

In reply to the letter from Oliver Hetherington questioning our proposals for identifying quiet areas I would like to make the following points.

Firstly, our paper sets out two procedures

- A (short-term) approach which is suitable for providing an immediate list of candidate areas (in agglomerations) to comply with the first round of noise mapping in 2007 and action plans in 2008.
- An alternative, preferred approach which is more suited for the wide-scale identification of Quiet Areas over the longer term, particularly with respect to the second round of EU noise mapping due in 2012.

It should be noted that Defra is required under the terms set out in the Statutory Instrument to transpose the Directive into English law to identify all designated Quiet Areas for agglomerations in England by September 2007, in order that the action plans required by the Environmental Noise Directive (END) can include the protection of such Quiet Areas.

Another constraint is the requirement of the END, which states that

A 'Quiet Area in an agglomeration' is defined as being an area 'which is not exposed to a value of L_{den} or of another appropriate noise indicator greater than a certain value set by the Member State from any noise source.'

The noise limit value approach must therefore be an important part of any identification process. There is clearly no single figure or index that can address all requirements but based on a review of the literature world-wide it was considered that a figure of 55dB(A) for L_{day} was defensible in this particular context.

Note that the term 'relative quiet' would be a more appropriate term for agglomerations. For example, pavement levels in the city centre may average 72dB(A) while peak levels may easily be 10dB(A) higher. From personal experience wandering around Bradford city centre with a sound level meter I found a city centre square or small park giving 55dB(A) or less was a relief. You can hold a conversation and can hear the birds singing. This was 'relative quiet' and it was appreciated.

But things are much more complex. Consider the noise exposure of people sitting outside a café near a busy road. We have a remarkable ability to in a social context to direct attention such that the noise from passing traffic hardly matters. So much more is going on in our auditory perception system than the biological equivalent of a SLM.

It was therefore recognised at the outset that a dB level however defined is not sufficient. There are further very



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Career Progression: If you have the experience, ambition and capability to reach the highest level in your profession, we have a career opportunity for you. We offer excellent career prospects with no restrictions on how far you can progress.

How to Apply: Applicants should forward a fully completed Vacancy Application Form available on our website together with a full CV, detailing current remuneration package and the name and address of two professional/employer referees.

Please quote job reference number: STAFFS/SES/14/01/07

Closing date for applications is: Monday 16 April 2007

Applications to: Patricia Goodchild, Human Resources Manager
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E-mail: tgoodchild@wardell-armstrong.com Web: www.wardell-armstrong.com
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important aspects relating to landscape quality and perceived quietness that need to be fully considered. Our aspiration was to provide a framework which would allow all spaces that are valued as quiet places to be considered. This is referred to as the 'long term approach' in our paper. It is a more subjective approach that would involve widespread consultation with users and stakeholders and an assessment of the accessibility and use made of these spaces.

Our research at Bradford University is beginning to quantify the role of visual aspects in the perception of tranquillity and underpins the long term approach we set out for identifying quiet areas.

A version of the IOA Autumn conference paper that prompted Oliver Hetherington's remarks is reproduced in this issue of Acoustics Bulletin, and I hope our two approaches can thereby more easily be understood.

Greg Watts

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Sound System Engineering (Third Edition)

David & Patronis

This book is an excellent text for anyone interested in this field of acoustics. Whether you have little to no knowledge of audio systems, or 20 years' experience, this publication provides the reader with an in depth understanding of loudspeakers and arrays, large room acoustics, signal processing and microphones, to name but a few.

Drawing on a huge range of work on the subject of sound engineering systems, the book combines all the available useful data in a concise, accurate and understandable form.

The first chapter starts with setting out the relevant mathematics involved in audio engineering, providing a great basis for understanding before you delve into this

subject in detail. It finishes with a very useful chapter on 'putting it all together', highlighting the areas to be considered when designing your complete sound system.

This is an excellent resource, clearly laid out, and well structured with something for everyone to learn.

Michael Morrow

Noise control from concept to application

Colin Hansen

This text is a presentation of the basic principles of noise control and how they are applied in practice to real problems. It is intended as a learning tool for those who wish to address noise control principles and apply them to solve problems in industry, whether at an undergraduate or postgraduate level. The seven chapters, each of which is largely self-contained, cover the fundamentals of noise control and acoustics; noise criteria and noise measuring instruments; sound sources and sound power management; sound propagation, outdoors and indoors; sound absorbing materials; the control of noise using partitions, enclosures and barriers; and muffling devices. The author acknowledges the similarity of his work to Engineering Noise Control by Bies and Hansen, but says in his preface that he has tried to present an entirely different approach to relevant material.

The Fundamentals chapter introduces the reader to basic terminology, noise control strategies for new and existing facilities, then provides a summary of the wave equation, decibels and sound levels, frequency analysis and decibel arithmetic. Chapter Two covers the measurement parameters used in occupational and environmental noise, hearing damage criteria, speech interference, NR, NC and similar curves, environmental noise criteria and measuring instruments.

Sound sources and sound power measurement looks at simple, dipole and quadruple sources, line sources, the concept of directivity, and the relation between sound power and sound pressure. It goes on to consider ways in which sound power levels may be determined. I was slightly disconcerted to see the phrase 'sound power measurement' in the sense of 'determination' as the techniques discussed are limited to reverberation rooms and field methods of deriving the sound power from sound pressure level measurements, but this is perhaps bordering on the pedantic. Sound propagation (Chapter Four) includes ground reflection and atmospheric effects, as well as

prediction methods, and room acoustics is covered to the extent of Sabine reverberation and sound absorption.

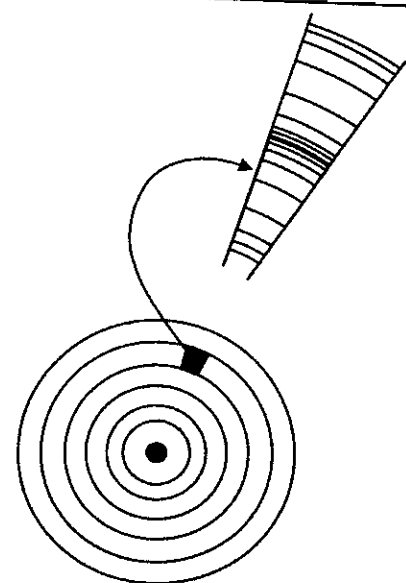
These latter topics lead naturally into the chapter on sound absorbing materials, which explains the concept of absorption and how it is measured, and the application of absorptive materials to reverberation control. Next, Partitions, enclosures and barriers introduces sound transmission loss, the design of acoustic enclosures, and the effects of barriers to sound propagation.

The use of worked examples throughout the book, especially in Chapter Six, whilst keeping the mathematical derivation of equations to the minimum, permits a ready understanding of the calculation methods without discouraging those who are less mathematically gifted, and besides their illustrative purpose are used to transmit ideas in the first place, rather than being revision exercises. This reviewer found this technique made the book particularly approachable.

The final chapter deals with Muffling devices, mainly but not exclusively in air-moving systems as found in industrial applications. There is a single appendix on the properties of materials, but I found myself wondering why that information, to the exclusion of all else, had been included. There is a wealth of general data of more direct utility to the

NOISE CONTROL FROM CONCEPT TO APPLICATION

Colin Hansen



noise control engineer in the main text, but this I would expect to be more time consuming to 'look up'. Nevertheless, the author is to be commended on treading the fine line between the academic and practical, and the £42.00 price asked for the paperback edition is not unreasonable.

Ian Bennett

Acoustics and Psychoacoustics

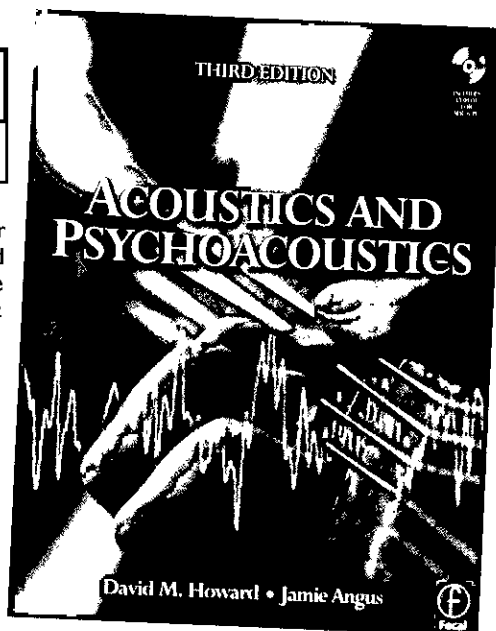
David M Howard and Jamie Angus

This is the third edition of a popular book, which has been extensively updated and improved. The book is aimed primarily at acoustics and music technology students, but will be of benefit to a wider audience including engineering professionals from other disciplines, besides interested 'intelligent laymen'. The last group need not fear the mathematical content, which is kept straightforward. The book would form a useful introduction to the subject areas covered, even for those who specialise in some of those areas. It includes an audio CD, compatible with both Mac and PC drives, of anechoically recorded samples of the human voice, several musical instruments, and audio demonstrations. There are one or two surprises, however: for example, what purports to be an F major chord definitely seems to have an added second!

A wide range of topics is covered in

considerable depth in the text. The chapter subjects include sound, hearing, harmony and temperament, musical instruments and the voice, timbre, room acoustics, and electronic signal processing. There are many illustrations, all of a high standard of clarity. The 'Introduction to Sound' concepts, particularly well explained in Chapter 1, are a good example: I enjoyed the neatly drawn 'golf ball and spring' diagrams illustrating the well-known analogy for sound propagation through air, even though balls from two different manufacturers had apparently been drawn.

Researchers and authorities on the various subjects are quoted liberally throughout the text, which adds interest. There is more in this book than might be expected from its title: the authors have taken the opportunity of including a good deal of material which might be of practical use to the reader, such as the acoustical performance of partitions and glazing



systems, and the ways in which room acoustics can be modified by engineering means such as absorption and diffusers.

Ian Bennett

Self on Audio

Douglas Self

'Self on audio' is a collection of articles written by Douglas Self for Wireless World, (now Electronics World) spanning three decades which have seen major technological advances in analogue electronics. The book is in two parts; Part One deals with audio signal processing and Part Two with audio power amplifiers.

The book is more than just a collection of articles. Taken as a whole, it constitutes a comprehensive and detailed guide to analogue audio electronics and will be an invaluable resource for the professional designer or the seriously interested audio enthusiast with a good grounding in electronic principles.

Douglas Self is well known in the audio electronics world for his straightforward no-nonsense views on audio electronics and circuits, and the book takes a dedicated engineering approach throughout. Each chapter is fully referenced and gives a full and detailed understanding of the particular circuit operation and the methods by which the circuit performance may be accurately measured. Spice simulations are also used throughout for comparison with measured results and to demonstrate theoretical circuit performance. Self presents a refreshingly straightforward approach to audio circuit design and the book is entertaining to read with much wry humour and some very pointed observations on the world of audio electronics in general. To give one example: 'In an era where directly heated triodes designed just after the First World War are prized, it is a bit difficult to come up with a working definition of obsolete'.

Section One begins with an account of the evolution of Self's discrete transistor pre-amplifier designs beginning in 1976 and spanning twenty years, interestingly with considerable attention to detail regarding (what might now be regarded as obsolete) phono RIAA stages, since much high-quality recorded material on vinyl is still in use. The preamplifier chapters are followed by chapters on balanced systems in audio electronics which clarify the various methods of balanced operation, the technologies available to implement them, and the pros and cons thereof. This is followed by Self's design for an FET based high quality compressor/limiter and chapters on the technical details of mixer design, in particular the minimum residual noise and distortion requirements, and the need for silent switching. It is worth mentioning here that Douglas Self has developed mixers for a leading manufacturer that are considered to be amongst the quietest and best performing available.

Section Two covers the work for which Douglas Self is probably best known, on distortion in power amplifiers, published in Wireless World during 1993 and 1994. Self has considered power amplifier architecture in detail, breaking the power amplifier down into its constituent parts and carrying out a full analysis on each section to expose the possible distortion mechanisms inherent within each circuit stage. Conventional wisdom ('more convention than wise') states that most of the distortion occurs in the output stage. However Self has identified shortcomings in the preceding stages which

can introduce significant distortion and which, with careful design, may be minimised to realise the 'blameless amplifier'. The last few chapters cover associated aspects of power amplifier design and distortion measurements.

The book gives detailed circuit diagrams throughout, and component lists for many of the circuits so that the reader can realise the circuits for their particular requirements. My only minor criticism of the book is that a chapter on component layout, construction, wiring practice, grounding and EMC issues in audio electronics (particularly mixed analogue/digital systems) would be useful, although these could be found elsewhere.

'Self on Audio' is an indispensable comprehensive reference guide for design engineers working in analogue audio electronics. With the exception of distortion effects and artificial reverberation, I cannot think of anything one might want to do to an analogue audio signal that is not covered here.

In this digital age, it is easy to forget that the complete audio signal chain always involves analogue circuits, and the quality of the audio delivery is critically dependent upon them. In order to realise the quality that digital recording and storage technology can deliver, the analogue circuits at each end of the chain must be of the best design available/possible and in this respect, the book offers a complete set of design solutions to most, if not all, modern analogue audio electronic circuit requirements.

Philip Duncan

Regupol Keraflex

Acoustic treatment for balconies

One of the UK's leading independent providers of acoustic systems, CMS Acoustic Solutions, has launched Regupol Keraflex, a frost-resistant exterior acoustic tiling system. Designed to attenuate impact sound from general footfall, the product is available as two systems, Keraflex XT and Keraflex FB.

The panels are constructed from a rubber crumb base foundation, and can enhance the impact sound insulation by up to 23dB. When installing them there is no need to repair the existing surface as the base panels are simply laid on top of the sealed exterior to create an elastic foundation.

To form the XT system, marble granules are mixed with binder and worked into the webs of the rubber base panels. In the FB product, stoneware tiles are adhered between the rubber base panel recesses. These two aesthetically pleasing solutions are final floor finishes.

Paul Absolon, technical director of CMS Acoustics, commented that by offering a wide range of innovative acoustic products, the company could always specify the most appropriate materials for any type of development. The addition of Regupol Keraflex to the portfolio meant that CMS could continue to provide solutions which delivered sound insulation in all areas, even those not covered by Part E.

With a low structural height of only 25mm and 31mm respectively, Keraflex XT and FB can be installed in a variety of settings. Either system is suitable for refurbishment or new build construction projects, and either can be used in any area where an exterior tiling system is required, such as balconies, patios and roof gardens.

Keraflex retains its high durability over a long life span. The system is easy to maintain as its three-dimensional structure is porous and provides complete water drainage to prevent puddles, mould and frost forming. This also



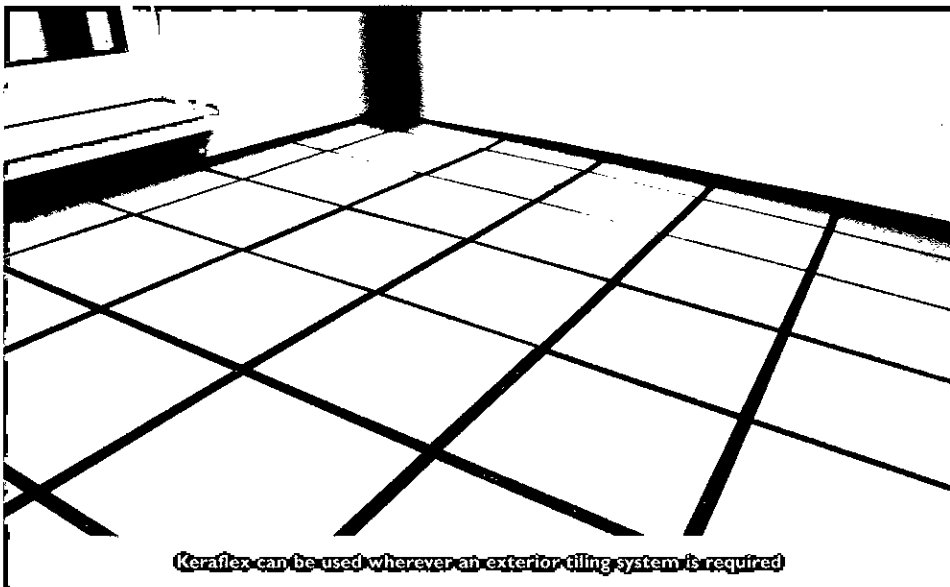
Stoneware tiles are adhered between the rubber base panel recesses

simplifies the cleaning process as no special treatment agents are required.

The product is available in 16 different marble granules or corresponding mixtures. FB offers a choice of six different coloured ceramic

tiles. Which system is selected depends on whether a marble granulate or ceramic appearance is preferred.

Contact CMS Acoustics on 01925 577 711, web site www.cmsacoustics.co.uk



Keraflex can be used wherever an exterior tiling system is required

Bay Systems Ltd

Hand-arm and whole-body vibration

It is now possible to calculate hand-arm vibration levels from time histories and spectral data using nVision. This NVH PC software accepts data from most sampling and analysis systems including wave cards and USB systems. The new module enables the summed hand arm vibration level ($x + y + z$ directions) to be calculated. It uses standard drag-and-drop to load the module with data. The user simply selects the channels and

presses 'process': the result appears immediately as a document in html format, and as an appended weight in the original data object.

A major advantage of the nVision based system is that any hand-arm or whole-body set of response curves can be loaded, making the system future-proof. Data can be acquired using an ultra-portable full-function PC and the DT9837 USB powered four-channel

acquisition card with IEPE accelerometer.

What is so special about this offer, says Bay Systems, is that the customer gets a full-function PC and versatile software for about the same price as a 'dumb' instrument.

For more information:

Alan Bennetts, Bay Systems

Tel: +44(0)1 458 860 393

e-mail: sales@baysystems.ltd.uk

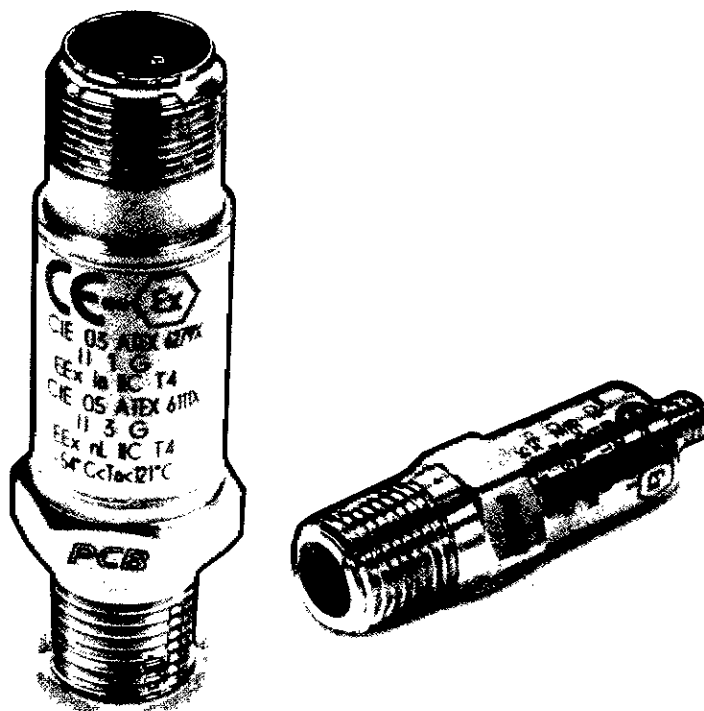
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Series 102 and 121 pressure sensors are ideal for monitoring performance of compressors, pumps, and gas turbines, because they measure dynamic pressure events such as surges, pulsations, and spikes. The sensors also detect wellhead acoustics to determine properties of mud and water. Sensors may be used with ICP signal conditioning and permit the use of a variety of inexpensive two-wire cable systems. The low-impedance signal may be transmitted over long cable distances, and the sensors may be used in dirty environments with no signal degradation. Various mounting configurations are available, with pressure ranges from 350 to 350,000 kPa, and sensitivities from 0.15 to 1.5 mV/kPa.

For detailed product specifications, drawings or additional information, see www.pcb.com



ICP pressure sensors

Senior/principal acoustic engineer

Southampton

Mott MacDonald, a global engineering, management and development consultancy, is looking for a senior/principal acoustic engineer to join the team of acoustic specialists working from our Southampton office.

The acoustic team currently comprises five people and the post has arisen due to expanding workload. The team is part of an environmental group, which operates within a broader technical advisory services team providing a range of specialist advice on civil engineering and development schemes. Progression prospects are potentially very good for the right candidate. By working in close association with other engineering and environmental disciplines the post offers a unique opportunity to enhance an existing career.

The focus of the work is on transportation projects, although currently the majority of these are related to various aspects

of highway design, construction and maintenance. A broader range of projects relating to civil engineering and the environment are often encountered and encouraged.

Essential academic, professional qualifications and experience:

- Degree or similar in acoustics/vibration related field
- Member of Institute of Acoustics
- Proven technical ability in terms of problem solving and analytical thinking
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Committee meetings 2007

DAY	DATE	TIME	MEETING
Thursday	29 March	11.30	Council
Thursday	5 April	10.00	Meetings
Thursday	19 April	11.00	Research Co-ordination
Tuesday	24 April	10.30	CCVPPNA Examiners
Tuesday	24 April	1.30	CCWPPNA Committee
Thursday	10 May	10.30	Membership
Thursday	24 May	11.00	Publications
	TBA	TBA	Annual General Meeting **
Tuesday	5 June	10.30	CMOHAV Examiners
Tuesday	5 June	1.30	CMOHAV Committee
Thursday	7 June	11.00	Executive
Tuesday	19 June	10.30	CCENM Examiners
Tuesday	19 June	1.30	CCENM Committee
Thursday	21 June	11.30	Council
Thursday	28 June	10.30	Distance Learning Tutors WG
Thursday	28 June	1.30	Education
Thursday	5 July	10.30	Engineering Division
Tuesday	10 July	10.30	ASBA Examiners
Tuesday	10 July	1.30	ASBA Committee
Thursday	12 July	10.00	Meetings
Tuesday	7 August	10.30	Diploma Moderators Meeting
Thursday	6 September	10.30	Membership
Thursday	13 September	11.00	Medals & Awards
Thursday	13 September	1.30	Executive
Thursday	20 September	11.00	Publications
Thursday	27 September	11.30	Council
Thursday	4 October	10.30	Diploma Tutors and Examiners
Thursday	4 October	1.30	Education
Thursday	11 October	10.30	Engineering Division
Thursday	18 October	11.00	Publications
Thursday	1 November	11.00	Research Co-ordination
Tuesday	6 November	10.30	CCENM Examiners
Tuesday	6 November	1.30	CCENM Committee
Thursday	8 November	10.30	Membership
Tuesday	13 November	10.30	ASBA Examiners
Tuesday	13 November	1.30	ASBA Committee
Thursday	15 November	10.00	Meetings
Tuesday	20 November	10.30	CMOHAV Examiners
Tuesday	20 November	1.30	CMOHAV Committee
Thursday	22 November	11.00	Executive
Thursday	29 November	11.00	Publications
Tuesday	4 December	10.30	CCVPPNA Examiners
Tuesday	4 December	1.30	CCWPPNA Committee
Thursday	6 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.

Examination dates 2007

DATE	EXAMINATION
23 March	Certificate of Competence in Workplace Noise Assessment
27 April	Certificate in the Management of Occupational Exposure to Hand-arm Vibration
18 May	Certificate of Competence in Environmental Noise Measurement
14/15 June	Diploma Examination
21 June	ASBA Examination
5 October	Certificate of Competence in Environmental Noise Measurement
19 October	Certificate in the Management of Occupational Exposure to Hand-arm Vibration
3 November	ASBA Examination
9 November	Certificate of Competence in Workplace Noise Assessment

Conferences & meetings

Diary 2007

20 March 2007
Environmental Noise Group
Wind Farm Noise - Swaffham, Norfolk

10-12 April 2007
Underwater Acoustics Group
4th International Conference on Bio Acoustics - Loughborough

24-25 April 2007
Spring Conference 2007
The Sound of Sustainability - Going for Gold Cambridge

23 May 2007
Underwater Acoustics Group
Workshop on Measurement of Underwater Radiated Noise NPL, Teddington

5 June 2007
Environmental Noise Group
The Art of being a Consultant Manchester

11 July 2007
Measurement and Instrumentation Group
It's practically a quality measurement - are your measurements fit for purpose? NPL, Teddington

18-19 September 2007
Underwater Acoustics Group
Detection and Classification of Underwater Targets Edinburgh

26 September 2007
Measurement & Instrumentation Group
Perception, Consideration and Closure... a better way of dealing with noise from aircraft Birmingham

17-18 October 2007
Autumn Conference 2007
Advances in Noise and Vibration Engineering Oxford

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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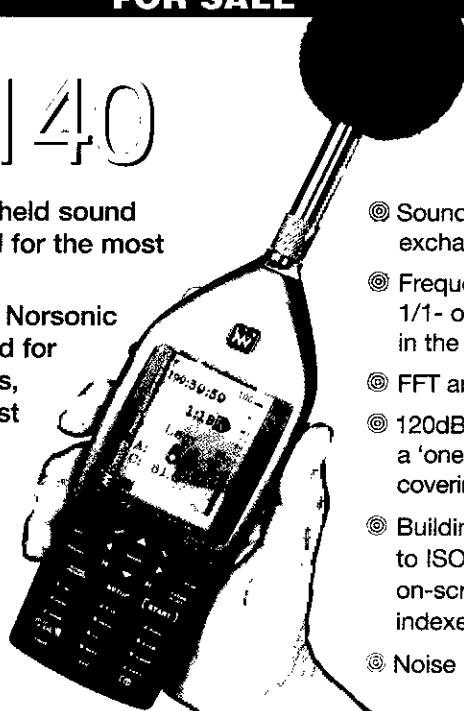
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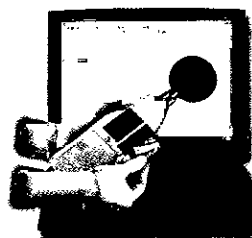
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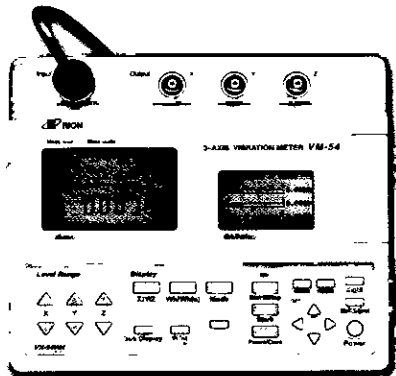
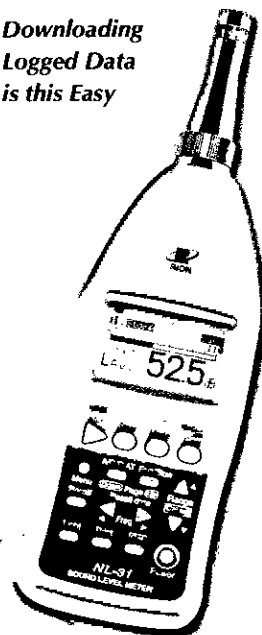


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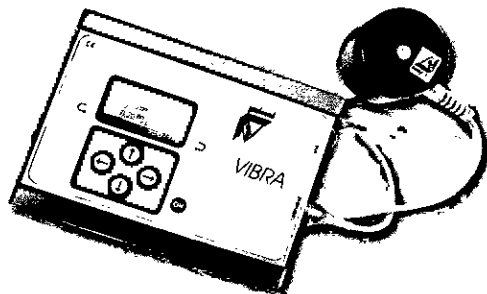
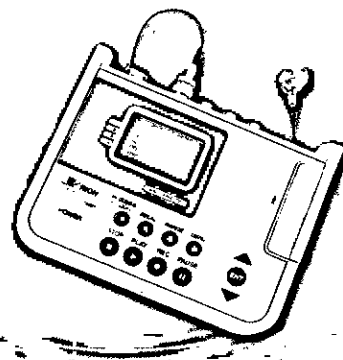
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