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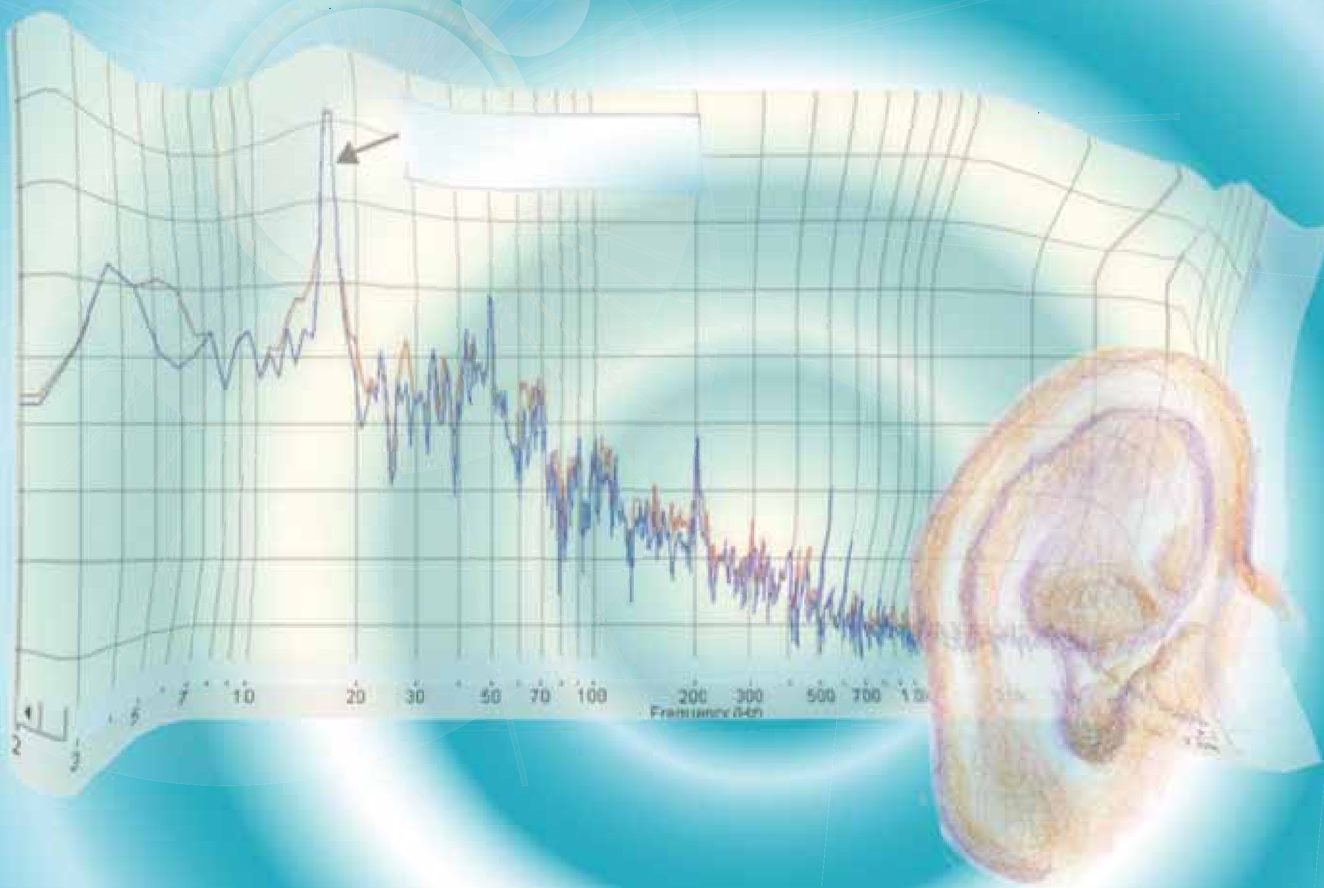

Low frequency noise emission

Dynamics of reactor fuel plates

Noise from licensed premises

Road traffic noise in Denmark

Australian Acoustical Society Vol. 39 No. 1 April 2011

Acoustics Australia

Acoustics Australia General Business
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Acoustics Australia is published by the Australian Acoustical Society
(A.B.N. 28 000 712 658)
ISSN 0814-6039

Printed by
Cliff Lewis Printing
91-93 Parraweena Rd,
CARINGBAH NSW 2229
Tel (02) 9525 6588
Fax (02) 9524 8712
email: matt@clp.com.au
ISSN 0814-6039

Vol 39 No. 1 April 2011

PAPERS

TECHNICAL NOTES

Cover design: Heidi Hereth

Message from the President

Dear Members

It was an honour to be elected as President of the Society and I take this opportuniity to introduce myself and the Federal Committee in this first issue of Acoustics Australia for 2011.

I would start with thanking the outgoing president Dr Norm Broner and fellow councillors and the incoming councillors for the time and input that they have and will provide on behalf of the Society. Norm is especially noted for his dual roles as past President and very successful exhibition organiser for AAS conferences and ICA 2010, in a role we hope that he will continue with in the future. Of course Norm is still on the Federal Council in his role as Vice President.

It has been an unfortunate and sombre commencement to 2011 with the recent catastrophic event in Queensland, Christchurch (NZ) and Japan. Our heartfelt sorrow and wishes go out to the many people affected. The adversity of the human spirit and compassion in such events is noteworthy. I note a number of fellow and compatriot (NZ) members were up and operational in make shift offices at homes and 'garages' within a day or two the Society was in immediate contact with our fellow councillors in the Queensland division to express our concern, sympathy and to ascertain what if any assistance could be provided. At this stage we can only implore that you the members, apart form personal assistance such as donations, consider attending the 2011 AAS annual conference which is being organised by the Queensland division - please refer to the ACOUSTICS 2011 advertisement on page 24 in this issue.

Marion Burgess, on the behalf of the AAS and in her role as Asia Pacific Vice President of INCE, has expressed our sincere condolences and sympathy to the Japanese Acoustical Society with an offer of assistance during their recovery.

On a common theme, an item was raised and presented by Geoff Barnes (our Federal Treasurer) at the 2010 AGM in Melbourne, for the Society to consider entering into philanthropic activities, such as coordinating and providing second hand hearing aides or acoustic equipment for third world/developing countries. As this is outside the AAS current charter a small team has been established from the Federal Councillors to further review and discuss this proposal to determine what opportunities there are, and issues that this may present. A report with recommendations is proposed for later this year. Please contact Geoff if you would like to review a copy of his presented proposal or provide him with any suggestions and feedback.

Nicole Kessissoglou and her team at Acoustics Australia, Tracy Gowen, Marion Burgess and Leigh Wallbank, are doing a tremendous and excellent job as seen by the impressive and technical quality of the journals that we have seen throughout 2010. As always Acoustics Australia relies on its members for support by submitting fully referenced papers, technical notes and opinion pieces. Suggestions are always very welcome.

There are a couple of members of the Federal Council team that I would like to especially thank on behalf of the society: Terry McMinn for his devoted and continued efforts as the Society's webmaster. There have been a number of changes to the website that you may have noticed. Richard Booker, the Society's General Secretary. Richard has been extremely busy over the past several months tidying up and updating the Society's two databases, correlating them and streamlining to provide a more efficient and streamlined society in terms of membership details and subscriptions. Richard's efforts have raised several items including how we treat members who undertake several years overseas experience, retired members and resignations. These items and others will be reviewed by the Council and recommendations made to assist in its operational efficiency.

April is also annual subscription time and you should have received these by now. Although our rates are reasonable, when compared with other society's it is apparent from recent articles that this year is going to become financially tough and we appreciate your continued membership.

Whilst reading this issue of the journal, please consider the above items and I look forward to catching up with you in the next issue and at the Queensland ACOUSTICS 2011 conference. You are always welcome to contact any of the Federal Councillors.

Looking forward to an improved 2011.

Peter Heinze

Message from the Editor

Welcome to the first issue of Acoustics Australia for 2011. Also welcome to the new president of the Society, Peter Heinze. I'd like to take this opportunity to thank the past president (and current vice president), Norm Broner, not only for his leadership but also for his on-going excellent effort as exhibition and sponsorship manager of the annual Australian Acoustical Society conferences.

The articles and technical notes in this issue are sure to generate discussion. The cover story focuses on low frequency noise emission, including sources of low frequency noise, its annoyance to humans and its assessment, while another article discusses the assessment of noise emission from licensed premises. There is also a very interesting technical note on the tools used in Denmark to mitigate road traffic noise, including noise guidelines, prediction of noise, the socio-economic evaluation of noise, and noise in relation to planning a new highway.

There are a number of prizes and awards available to members and students being offered by both the Australian Acoustical Society at a federal level and by several divisions of the society. For more information please see the section on Prizes and Awards on page 27 of this issue.

I welcome your contributions to the journal – both articles and technical notes, and I look forward to seeing you at ACOUSTICS 2011 on the Gold Coast in November!

Nicole Kessissoglou

A SIMPLE OUTDOOR CRITERION FOR ASSESSMENT OF LOW FREQUENCY NOISE EMISSION

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INTRODUCTION

Complaints about the effect of higher level Low Frequency Noise (LFN) in the form of rumble, a "feeling of pressure" and resultant headaches and nausea have been known for decades [1,2]. Human hearing becomes gradually less sensitive as frequency decreases, so for humans to perceive LFN, that is, to perceive frequencies below 100 Hz, the sound pressure level must be relatively high when compared to that for mid frequency noise, e.g. 500–3000 Hz. As the frequency decreases toward the infrasonic range (frequencies less than 20 Hz and a subset of LFN), the sensation of hearing changes to one of a feeling of ear pressure and envelopment for those noises which exceed the hearing threshold.

It can be said that the effects of LFN are broadly similar to those of high frequency noise in the sense that any unwanted sound is potentially annoying. However, LFN exhibits itself in the form of "rumble" and "pressure" and while not at all loud in the normal sense of the word, LFN can exacerbate the annoyance reaction when compared to higher frequency noise, especially when the noise is perceived to be "fluctuating" or "throbbing".

An example of a possible LFN problem case is shown in Figure 1 below which presents the linear narrow band Sound Pressure Level (SPL) spectrum in the bedroom of a house adjacent to a gold mine with two vibrating screens operating. The wife of the house owner complained about a "rumble" noise causing her sleep disturbance and she was the only person in the house to hear the "noise'. Figure 2 below shows the A-weighted one-third octave band spectrum in the bedroom of the house while the screens were operating. The tone at the 16 Hz third octave can be readily seen.

Figure 3 presents the overall sound pressure level versus time trace in the bedroom with both of the screens operating. The modulation effect is clearly observable and can be seen to begin once the screens start operating. The modulation period is approximately 60 seconds. A waterfall plot showing sound pressure level versus frequency versus time in the third dimension is shown in Figure 4. The variation in level in the 16 Hz third octave band (due to the tone at 16.48 Hz) can be seen by the change in colour representing level. The periodic level variation at this frequency is from 58 dB down to 29 dB. It could be understood from these plots that such a LFN might cause some form of annoyance to anyone that might hear or perceive it.

For this case, the overall A-weighted SPL was 19 dBA, the overall dBC fluctuated from 49 dBC to 36 dBC while the overall linear SPL varied from 57 dBZ to 43 dBZ. The (C-A) level difference indoors varied from 30 dB down to 17 dB.

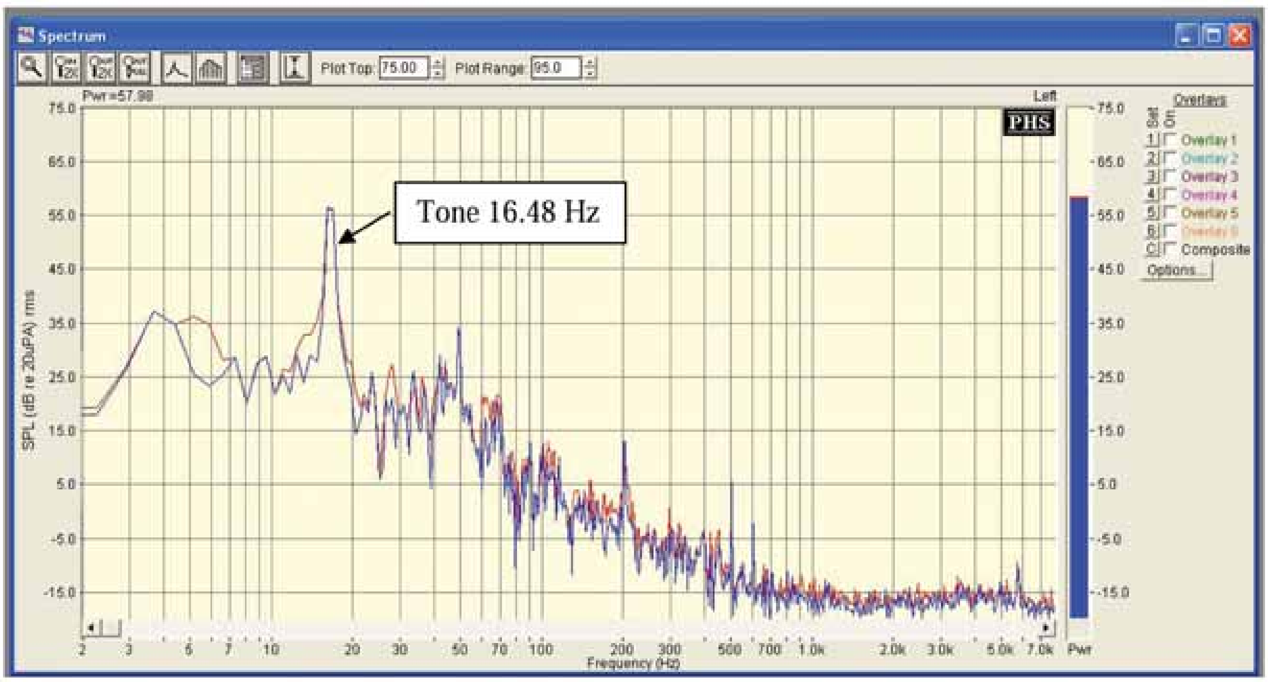

Figure 1. Narrow band spectrum in bedroom of house near a gold mine when the screens are in operation

Figure 2. A-weighted third octave band spectrum in bedroom of house near a gold mine when the screens are in operation

However, as can be seen in Figure 5, the maximum spectrum is well below the ISO median hearing threshold level [3]. Even if it is considered that at 125 Hz, 10% of 60 year old males have a better hearing sensitivity than the median 18 year old by 4 dB and that 2% are more than 12 dB more sensitive (see [3]), it can be seen that it is very unlikely that, in this instance, the complainant can actually perceive the sound as claimed.

Indeed, the complainant claimed to be able to hear the "rumble" even when the screens were not operational, so that this further raises doubt as to what the complainant was actually "hearing" or "perceiving". The extremely low level of background noise in the bedroom was noted and it was wondered whether in this instance, a lack of masking noise is responsible for the apparent claim. The observed screen level fluctuations would appear to possibly be just co-incidental in this case.

TYPICAL LOW FREQUENCY NOISE SOURCES

There are many sources of LFN in the environment [4]. These range from boilers, pumps, fans, cooling towers, ventilation plant and gas turbines to wind farm turbines [5,6]. At larger distances from many industrial plants, the noise character will be that of LFN due to the relatively large attenuation of high frequency energy as compared to LFN (note that the LFN level also decreases due to geometrical spreading). Transportation noise sources such as aircraft and diesel trains also are sources of LFN. Helicopters generate LFN and blade slap in particular. Furthermore, LFN can be generated at pubs/band venues and concerts where the bass sound is considered as wanted sound by patrons but can be very annoying to neighbours.

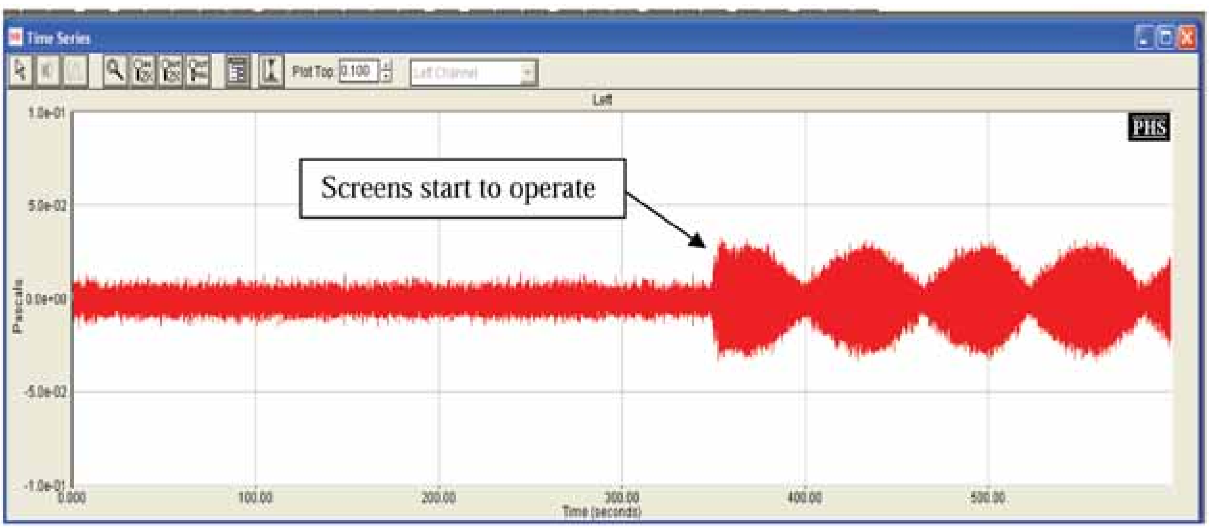

Figure 3. Sound pressure level versus time plot in bedroom of house near a gold mine when the screens are in operation

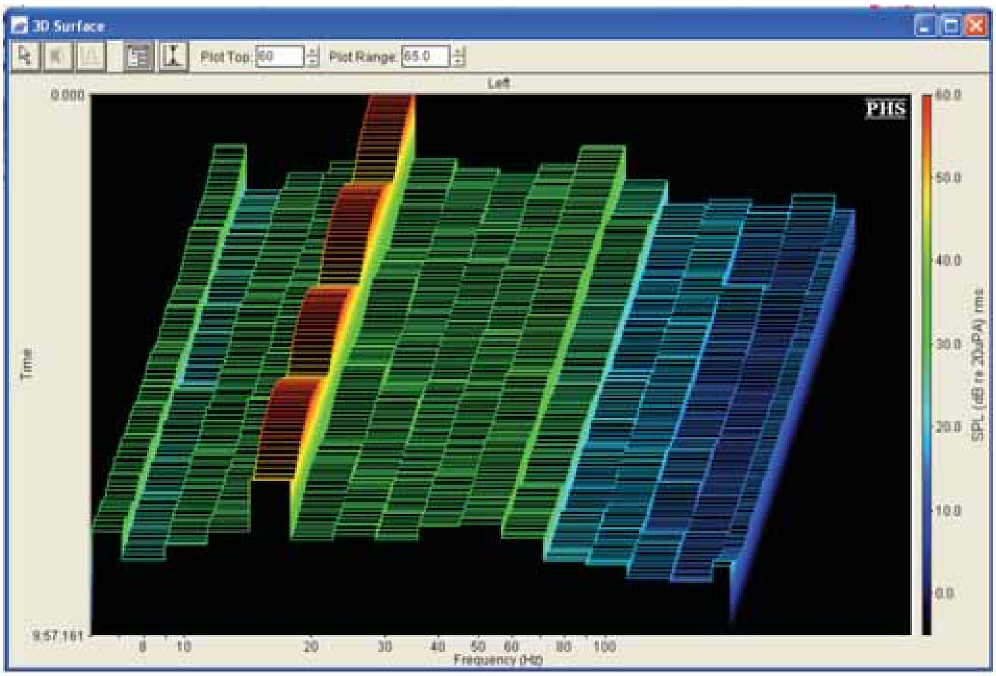

Figure 4. Third octave sound pressure level versus frequency vs time plot in bedroom of house near a gold mine when the screens are in operation

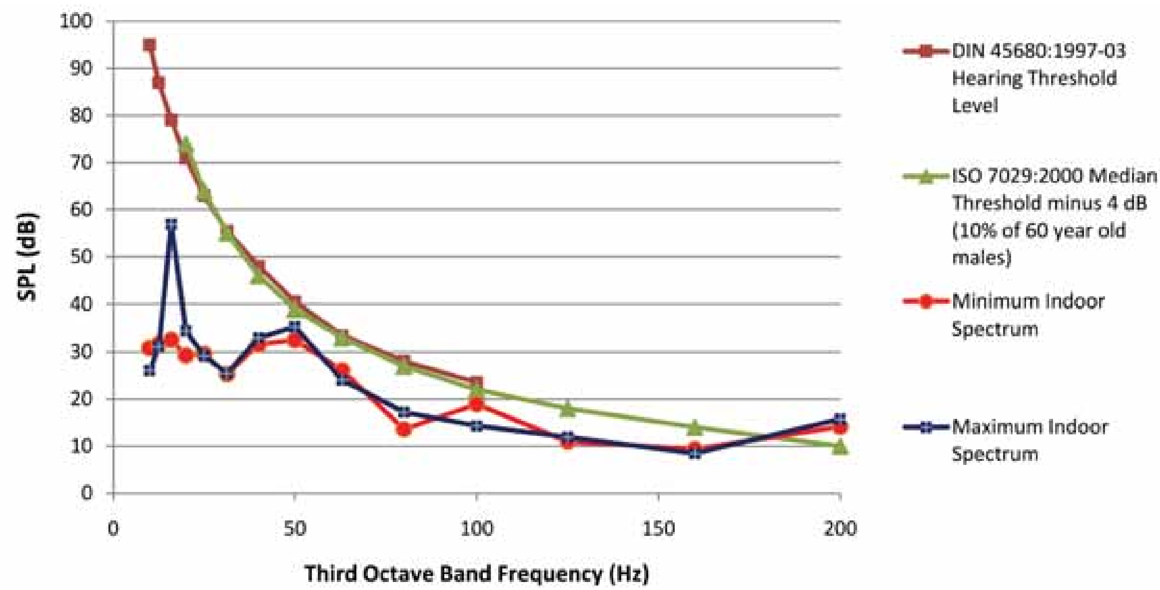

Figure 5. Maximum and minimum third octave sound pressure level in bedroom of house near a gold mine when the screens are in operation versus the threshold of hearing

Typical low frequency noise sources include:

- Open cycle gas turbines
- Boilers
- Forced draft and induced draft fans
- Shakers on hoppers
- Vibratory screens
- Compressors
- Wind farms

The noise sources listed above generate low frequency noise due to the operation of various items of plant or equipment in the following sites:

- **Power Station** - Open Cycle Gas Turbines / Forced Draft Fans generate low frequency due to combustion and turbulent air flow.
- **Industrial Sites** - Boilers generate low frequency noise through combustion noise / Forced Draft Fans generate turbulent airflow
- **Mine Sites / Quarries** - Shakers on hoppers / vibratory screens generate low frequency noise due to excitation of the structure, large FD/ID fans associated with exhaust stacks may generate LFN.
- **Wind Farms** – Wind Turbine Generators with the rotors downwind of the tower were noted for LFN due to the

passage of the blades through the tower's wind shadow (resulting in pulses at about one per second which were analysed as infrasound). However, current generation wind turbines have the rotors "upwind" of the turbine tower thus avoiding this problem. Turbine blade rotation may result in a "swishing" sound which is at higher frequencies with a low frequency modulation. This should not be confused with LFN though some LFN may result from a wind farm of many wind turbines under some meteorological conditions [7].

It should be realised that just because these sources exist at a site, it does not necessarily mean that a LFN problem will occur. There are many plants/facilities with LFN sources in them and where LFN is not a problem in the surrounding community. Whether or not LFN becomes a problem will depend on the level of the LFN, whether it is fluctuating and on other individual circumstances.

LFN PERCEPTION AND ASSESSMENT

Perception and Annoyance

Based on empirical and laboratory studies, it can be shown that the primary effect due to LFN appears to be annoyance and that this affect is greater than would be expected based on the A-weighted level alone [5, 6, 8-10]. It would seem that for sound with "tonal" low frequency content below 50 Hz and for infrasound (< 20 Hz), particularly where the sound level is perceptibly fluctuating or throbbing, annoyance and loudness are perceptually treated differently and that this difference may increase with time [11]. As the loudness adapts more rapidly with time than the annoyance (i.e. the perceived loudness decreases more rapidly with time than the perceived annoyance), the effect is to effectively increase the annoyance with time. Hence it seems that we can adapt to the loudness element more readily than to the annoyance. This effect would be more pronounced for lower frequency infrasound where, at levels above the hearing threshold, the sound is not so much heard but is rather perceived as a feeling and sensation of pressure. The perception of annoyance is particularly dependent on the degree of amplitude modulation and spectral balance [12-14]. As a result, it is considered that there is a significant limitation in the long term averaging of LFN noise levels, as this approach results in the loss of information on fluctuations [2, 10, 15].

Applicable Noise Measures

Assessment and prediction of annoyance due to LFN is not simple. Based on empirical evidence and many documented cases [2, 10, 16], it is very clear is that the A-weighted SPL alone is not successful in assessing the response to LFN (and to infrasound). One obvious reason for this is that the A-weighting network significantly decreases the contribution of low frequency energy in a sound due to the reduced loudness sensitivity of a person's hearing at low frequencies. The relative response for the A-weighting is shown (in blue) in Figure 6. It can be seen that the A weighting network significantly reduces the contribution to the sound of the low frequencies. At 250 Hz, the reduction is -9 dB and at 63 Hz, the reduction is -26 dB.

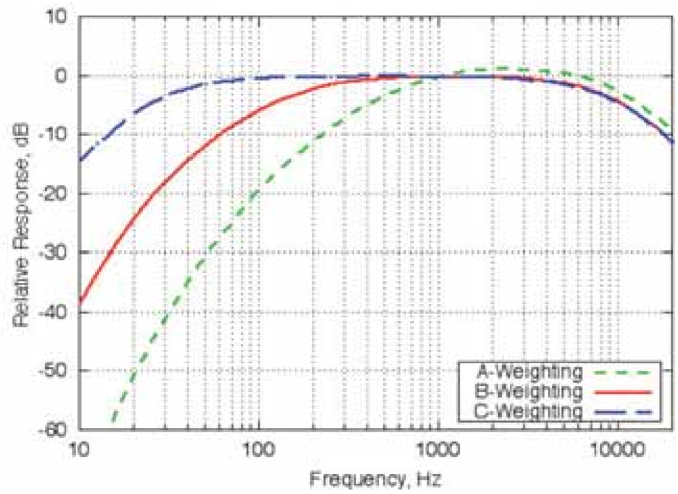

Figure 6. The A, B and C weighting networks [17]

Although the A-weighting network is commonly used for most applications, the 'C' weighting is more appropriately used for assessment of higher noise level generating noise sources and for some entertainment noise level measurements (see the blue line in Figure 6). This is because at higher sound pressure levels (SPLs), that is at approximately 100 dB, the ear's response is flatter than at lower SPLs and this response is represented by the 'C'-weighting. The C-weighting includes nearly all of the low frequency energy in a signal and so would be more appropriate for situations where the transmission of bass noise or significantly high levels of LFN from plants or equipment can be a problem in the community. As a comparison, at 250 Hz, the C-weighting is zero and at 63 Hz, the weighting is only -0.8 dB. In addition, because until recently there was no accepted Standard for the Linear network, if one wanted to use a noise measure that didn't significantly affect the low frequency content of a signal when they were measuring it, the C-weighting network would have to have been chosen.

It can be deduced from the above discussion that a simple method of indicating how much LFN there is in a sound would be to subtract the A-weighted SPL from the C-weighted SPL. Both the A and C weighted SPLs are readily available on current sound level meters so it easy to determine this difference quite readily. It could be expected that the (C-A) difference might be a reasonably good indicator of the presence of LFN which could cause annoyance. But there are two questions viz. what (C-A) difference is necessary, and, is this difference the same at all sound levels? Note that all of the A, C and Z weighting networks are currently defined [18].

Assessment based on (C-A)

As indicated above, the (C-A) difference can provide an indication of how much LFN is present in a sound. Empirical evidence shows that where the imbalance is such that the difference between the Linear and A-weighted Sound Pressure Levels is at least 25 dB, the sound is likely to cause annoyance. Broner and Leventhall [10] and DIN 45680-1997 [19] suggested that a difference of 20 dB can result in an unbalanced spectrum which could lead to LFN annoyance. Similarly, the Alberta EUB [20] requires the (C-A) difference to exceed 20 dB to determine the presence of a LFN problem. Others have suggested that a difference of only 15 dB was a good rule of thumb to identify a potential infrasound LFN problem situation [21]. In New South Wales (Australia), the current Industrial Noise Policy (INP) [22] allows the determination of either an intrusiveness or amenity criterion when considering land use planning. It recommends that a 5 dB modifying factor be added to the outdoor A-weighted measured/predicted sound pressure level when the 'C' weighted sound pressure level minus the 'A' weighted sound pressure level difference is 15 dB or greater.

Based on the above, it is recommended that a minimum (C-A) difference of at least 20 dB is necessary to indicate the possible presence of a LFN problem. However, a greater difference may be permissible at low A-weighted levels, as the (C-A) difference for low levels of background noise may exceed 20-25 dB without causing complaints

In general, the (C–A) level difference is only an appropriate starting metric for indicating when a potential LFN problem may become a significant source of annoyance to the public. As indicated previously, averaging the SPL to obtain the difference can lead to loss of information in terms of fluctuations and spectral balance and modulation also needs to be considered. The predictive ability of the (C-A) difference is therefore of limited value (see also [2]) and indeed, as can be seen from the above, higher (C-A) differences are suggested as being necessary to indicate a LFN problem. What would be most suitable is a simple overall criterion below which annoyance due to LFN is not expected to occur regardless of the (C-A) difference (or above which annoyance could be anticipated). In addition, if it is necessary to utilise a (C-A) SPL difference at all, it is recommended that a (C-A) difference of at least 20 dB be used to indicate the presence of a potential LFN noise problem. A review of overall noise level criteria for LFN is presented in the following section which will assist in determining if a complaint due to LFN should be considered.

OUTDOOR LOW FREQUENCY NOISE LEVEL ASSESSMENT

It has been known for many decades that gas turbines, boilers, forced draft fans and other sources can produce low frequency noise which can cause feelings of annoyance due to nausea, headache and uneasiness and vibration induced rattle. In terms of simplicity of application, the determination of an overall noise level that could be used for assessment of LFN would be the optimum approach rather than requiring any detailed spectrum analysis and calculations (as are required in some European countries – see above). Much of the data concerning an acceptable external overall criterion for LFN comes from research associated with power station noise. However, any criteria so developed would certainly apply to any LFN problem regardless of the source due to the spectral and fluctuating characteristic of the consequent LFN.

Concern about the impact of LFN on residential communities was already raised by Hoover in 1973 [23] who recognised that, if homes were located within 1000 feet of an open cycle gas turbine (OCGT) installation, then the SPL in the 31.5 Hz octave band needed to be no more than 65–75 dB at 400 feet. Hoover suggested a guideline that the SPL in the 31.5 Hz octave band should never exceed 70 dB (L_{eq} 67 dBC) or even 65 dB (L_{eq} 62 dBC) outside a house when ambient levels were in the range 48–53 dB.

ANSI B133.8 -1977 [24] recognised that for installations where frame structures are occupied by people near to gas turbine installations, the A-weighted sound level alone does not adequately define permissible low frequency sound emissions. Indeed, ANSI B133.8 Appendix B recommends the selection of a maximum C-weighted level outside the nearest occupied framed structure and suggests the upper limit should be selected not to exceed 75–80 dBC. The range of values was given due to uncertainty as to the sound level required to induce a structural vibration in a frame structure.

Challis and Challis [25] also recognised that even though a level of 40 dBA might seem to be moderate, gas turbine emissions could have SPLs as high as 96 dB at 16 Hz and 110 dB at 10 Hz which are both audible, causing strong negative community response. Challis and Challis [25] also identified a number of English and Australian Utilities that had specified criteria, basically NR curves, but with significantly reduced noise levels below 63 Hz, specifically for 8Hz, 16 Hz and 31.5 Hz Octave Bands. These utilities had experienced LFN problems and came up with their criteria for neighbouring residences based on the experience of others. As an example, Figure 7 shows the specification for two utilities for stack emission at 100 metres [25]. These two criteria are quite different and vary from L_{eq} 72 dBC to L_{eq} 60 dBC.

In discussing low frequency gas turbine noise, Newman and McEwan [26] quoted a British Gas Corporation criterion for specifying noise control for gas turbines viz. 60 dB in the 31.5 Hz octave band at the nearest dwelling. This would be equivalent to L_{eq} 57 dBC. This value was said to have been determined by review of the noise levels which complainants found satisfactory.

In 2001, Hessler [27] noted that low frequency noise was only a problem for OCGT plants and he recommended that "a level of 70 dBC at the closest residence is normally low enough to prevent perceptible vibration but that a slightly lower level of 65 dBC is needed in quiet, rural environments where the residual ambient noise level is low". In 2005, Hessler [28, 29] described the low frequency noise problems that have occurred in the USA due to incorrect siting of gas turbine power plants close to residential areas. Typically, neighbours expressed complaints of low frequency rumble noise, vibration rattle, nausea and headaches in some people. At low frequencies, apart from the spectral imbalance issue, a major factor in causing annoyance is the significant temporal level fluctuations that may occur. Hessler considered that his experience since 1971 had shown that the recommendation of ANSI B133.8 was "woefully inadequate" for protecting residential areas against low frequency noise problems and that the problem continued to occur for combustion turbine open cycle plants. He therefore proposed C-weighted SPLs supplementary to the A-weighted site criteria which are listed in Table 1. These levels contained no factor of safety or

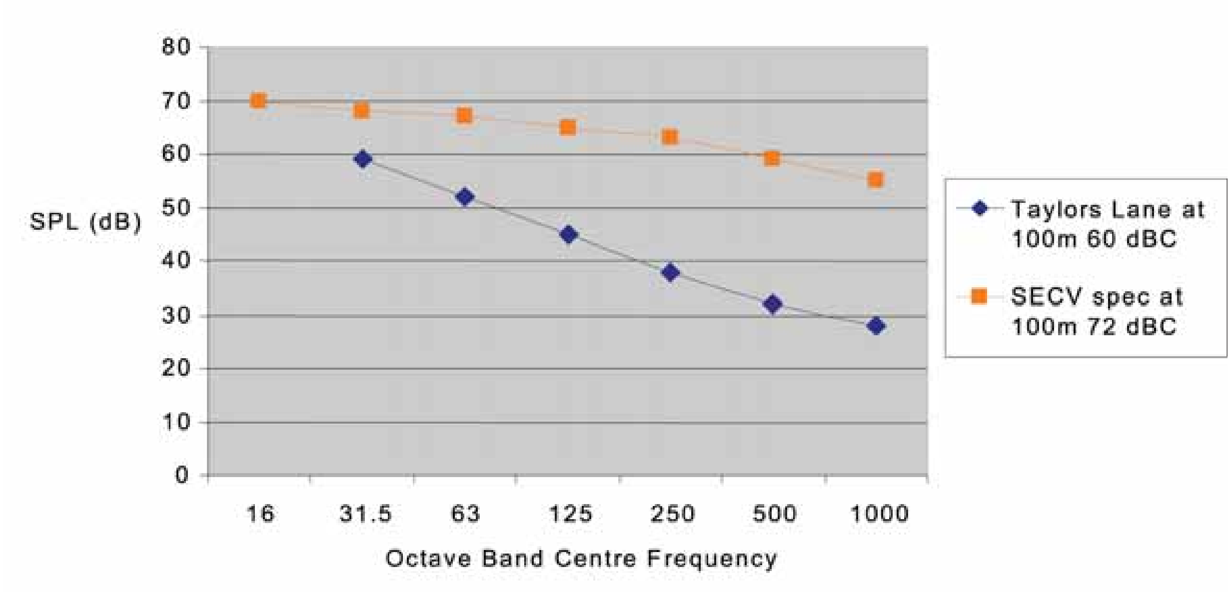

Figure 7. LFN specifications by utilities quoted by Challis and Challis [25]

margin of error and Hessler cautioned that these levels should be considered the maximum allowable. Hessler [30] has since clarified that his criteria are all in terms of the C-weighted L_{eq}.

Table 1. Maximum allowable dBC levels at residential areas to minimise infrasound noise and vibration problems

	For normal suburban/ urban residential areas, daytime residual level, L_{90}>40dBA	For very quiet suburban or rural residential areas, daytime residual level, L_{90}<40dBA
For intermittent daytime only or seasonal source operation	70	65
Extensive or 24/7 source operation	65	60

Similarly, Annex D of ANSI S12.9 – 2005/Part 4 [31] deals with sounds with strong low frequency content and for essentially continuous sound where the C-weighted sound level exceeds the A-weighted sound level by at least 10 dB. Annex D provides a means for calculating an adjustment to the sound exposure level based on the summation of the time–mean–square sound pressures in the 16, 31.5 and 63 Hz octave bands. ANSI recognises that generally, annoyance is minimal when octave band sound pressure levels are less than 65 dB at these octave bands (equivalent to L_{eq} 67 dBC) and that to prevent the likelihood of noise-induced rattles, the low frequency sound pressure level should be less than 70 dB (ANSI does not make clear which octave bands this applies to but it is presumably at the 16, 31.5 and 63 Hz octave bands – this would be equivalent to L_{eq} 72 dBC).

The Oregon State Noise Control Regulations [32] for industrial and commercial noise sources also quote low frequency allowable octave band sound pressure levels for the 31.5 Hz and 63 Hz octave bands as 65 dB and 62 dB respectively for the night time period 10pm – 7am [this would be equivalent to L_{eq} 65 dBC] (the limits are 68 dB and 65 dB for the daytime period 7am – 10pm respectively [equivalent to L_{eq} 68 dBC]).

Table 2. Summary of outdoor criteria for LFN

Developed by	Citeria
Hoover	67 dBC (70 dB at 31.5 Hz) should never be exceeded
Challis	72 dBC overall with 70 dB @ 16 Hz 60 dBC overall with 60 dB @ 31.5 Hz
ANSI B133.8 1977	75-80 dBC
Hessler	Max 70 dBC when L_{90} >40dBA daytime intermittent, normal suburban, Max 65 dBC when L_{90} >40dBA 24/7, normal suburban Max 65 dBC when L_{90} <40dBA daytime intermittent, quiet suburban, Max 60 dBC when L_{90} <40dBA 24/7, quiet suburban
Newman	57 dBC - 6 dB @ 31.5 Hz
ANSI S12.9	67 dBC to minimise annoyance 72 dBC to prevent noise induced rattles
Oregon USA	65 dBC between 10pm-7am 68 dBC between 7am-10pm
Hale	65 dBC
Hessler	65 dBC with a maximum regulatory limit of 70 dBC (wind turbines)

In a recent paper, Hale [33] described a power plant that was to be located in an area where the proposed project location was in an unincorporated jurisdiction that had enacted C-weighted daytime and night time noise limits of 50 dBC and 45 dBC respectively. In response to objections by both commissioners and the local community, the original power plant location was abandoned and a new site selected. The project sought and obtained a noise variance for a 65 dBC noise limit at the plant boundary. The local consultant indicated that the C-weighted SPLs due to the plant did not comply because of 16 Hz tones. However, the local community indicated the operating plant could not be heard in the community and Hale concluded that the plant design was adequate for compliance with the noise variance limit and that no noise impacts to sensitive locations would occur.

In a very recent paper dealing with wind turbines, Hessler and Hessler [34] recommended a limit of 65 dBC with a maximum regulatory limit if 70 dBC but also cautioned that a C-weighted SPL limit does not mix well with wind turbine applications because it is extremely difficult to accurately measure C - weighted sound levels in the presence of any kind of wind. Table 2 summarizes the outdoor noise level criteria for LFN.

RESIDENTIAL CRITERIA VS COMMERCIAL CRITERIA

It is clear from the above that:

- High levels of LFN are necessary for perception.
- Most cases of LFN annoyance occur when an unbalanced spectrum occurs with a decreasing level as frequency increases.
- LFN needs to be above threshold for a nuisance to occur but there is a very small percentage of the population that may be more sensitive to LFN than most ie they have relatively low LFN thresholds and tolerance.
- Continuous audible LFN can be a noise nuisance in the same way as can be any other noise.

Ideally, LFN criteria should be set for indoors where the LFN complaints normally occur. However, in planning terms, it is much easier to set criteria for the outside of residences where artefacts of the measurement do not play such a big role and where there is no need to enter a person's premises after start-up to confirm compliance with an outdoors noise level specification. Similarly, an overall noise level criterion is much preferred to one relying on an octave band or third-octave band analysis and calculation. We would therefore propose that to prevent low frequency noise complaints, the simplest approach is to limit the overall noise level outside the residential locations to the following:

For the daytime or when the LFN source operates only intermittently (for 1 - 2 hours):
Desirable: L_{eq} 65 dBC
Maximum: L_{eq} 70 dBC.

For the night time or for where the LFN operates continuously (24/7), it is proposed that the criteria for residential locations should be:
Desirable: L_{eq} 60 dBC
Maximum: L_{eq} 65 dBC.

The impact of LFN level fluctuations also needs to be considered as when they occur, the annoyance is exacerbated due to the significant change in perceived loudness with change in SPL at LFN. Thus, if the dBC level is fluctuating at least +/- 5 dBC (ie 10 dBC overall fluctuation), the above criteria should be reduced by 5 dBC.

Should there be a different set of criteria for commercial office/industrial locations? For commercial office/industrial situations, there would appear to be an expectation that acceptable LFN noise levels could be higher than for residential areas. In most circumstances, office/commercial structures are much more solid than a framed residential house. In addition, it could be expected that there would be greater tolerance to low frequency noise from LFN sources such as OCGT peaking plants, if these plants are operated for only short time periods during the normal working day or after normal working hours when employees are not normally present. On the other hand, LFN due to incorrectly balanced HVAC systems may be continuous, but not necessarily at as high a SPL. Thus, for day operations or where the LFN source only operates intermittently (say 1-2 hours), it is proposed that the criteria for offices/commercial structures should be:
Desirable: L_{eq} 75 dBC
Maximum: L_{eq} 80 dBC

For night time operation or for where the LFN operates continuously (24/7), it is proposed that the criteria for offices/commercial structures should be:
Desirable: L_{eq} 70 dBC
Maximum: L_{eq} 75 dBC

Again, a "penalty' of 5 dBC to the proposed criteria is recommended where the measured LFN SPL is fluctuating at least +/- 5 dBC. The above criteria are expected to protect 90-95% of the population. There will always be someone who might be more sensitive than the majority of the population. In such a circumstance, a detailed investigation by an acoustic consultant who is familiar with LFN problems might be warranted. On the other hand, an exceedance of the recommended criteria by 2-3 dBC should not necessarily result in LFN complaints if the noise source is not continuous.

RECOMMENDATION

Ideally, LFN criteria should be set for indoors where the LFN complaints normally occur. However, for the purpose of planning, it is much easier to set criteria for outside residences. Based on a review of many case histories and the literature, the author recommends the criteria listed in Table 3.

Table 3. Criteria for assessment of LFN

Sensitive Receiver		Range	CriteriaL_{eq} (dBC)
Residential	Night time or plant operation 24/7	Desirable	60
		Maximum	65
	Daytime or Intermittent (1-2 hours)	Desirable	65
		Maximum	70
Commercial/ Office/ Industrial	Night time or plant operation 24/7	Desirable	70
		Maximum	75
	Daytime or Intermittent (1-2 hours)	Desirable	75
		Maximum	80

If the measured LFN SPL is fluctuating at least +/- 5 dBC, then a "penalty' of 5 dBC to the proposed criterion (ie a reduction in the proposed limit) is recommended. When measuring the noise, all energy down to 10 Hz should be considered (the weightings are not defined for frequencies less than the 10 Hz one-third-octave-band and, in addition, do not generally contribute significantly to the overall SPL). Further, a minimum sampling duration of 3-5 minutes should be used so as not to average out the LFN fluctuations which are characteristic of many LFN problems. This is further to ensure that the low frequency sound level is sampled accurately.

The noise levels to be recorded are the maximum and minimum C-weighted SPLs using the Fast time weighting, the L_{C10} and L_{C90} levels (the C weighted SPL's exceeded for 10% and 90% of the recording time) for the purpose of providing an indication of the level fluctuation of the LFN. The same metrics are to be recorded using the A-weighting instead of the C-weighting.

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RELATIONSHIP BETWEEN NATURAL FREQUENCIES AND PULL OUT FORCE FOR PLATES WITH TWO CLAMPED EDGES

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Plate type nuclear fuel assemblies consist of a box like structure containing several thin rectangular fuel plates clamped to the side plates by a swage connection. In cooling these fuel assemblies during reactor operation, the coolant flow causes a longitudinal drag force that may shift the plates if they are not properly clamped. The aim of this work is to find a relationship between the natural frequencies of a plate with clamped edges and the pull out force needed to shift a plate from its designed position for various different clamped conditions. The results can be used in the future to assess the quality of the swages in plate-type nuclear fuel assemblies. An experimental rig consisting of a plate clamped along two opposite edges using bolted beams tightened to various torque settings to emulate the swage quality was built. Modal analysis was performed to relate the natural frequencies to the torque used to fasten the bolts.

INTRODUCTION

Many research nuclear reactors utilise plate-type fuel assemblies constructed as a box-type assembly. In a typical fuel assembly the plates are inserted into slots machined into the side walls of the fuel box. The clamping of the plates to the box is generally assured by a swage between adjacent plates. Fuel assembly plates are likely to be affected by structural instabilities due to the interaction with the coolant flow [1-3]. Many researchers investigated both the static and dynamic behaviour of such fuel assemblies using wide beam theory [4] or using the thin plate theory with simply-supported boundary conditions [5] or fully-clamped edges [6]. In previous work [7], the authors showed that the boundary condition of a plate with an edge fixed by a swage can be modelled assuming a perfect clamp of all the degrees of freedom (dof) except for the rotation around the axis parallel to the swage which is elastically restrained with a torsional spring, giving a theoretical and experimental justification of the model used by Kim and Davis [8]. It is evident that a poor swage will not restrain the plate from shifting axially due to the force of the coolant flow. The purpose of this work is to relate the force needed to slide a poorly clamped plate to the natural frequencies of the plate itself. In the first step, a relationship is found between the natural frequencies and the torque applied to fasten the bolts that clamp the plate. The second step is to relate the fastening torque to the pull force to shift the plate. The results from the previous experiments are then combined to find the relationship between natural frequencies and pull out force. The results can be transferred to a real fuel assembly to estimate the resistance of the swaged fuel plates to the drag force of the coolant flow.

FEM OF THE CLAMPED PLATE

A finite element model was built to predict the natural frequencies of the clamped plate. The edges are restrained fixing all degrees of freedom except for the rotation around the axis parallel to the swage which is elastically restrained with a torsional spring [7]. The plate is modelled using 4 node plate elements (QUADR element). The boundary conditions are modelled using 6 dof spring elements (BUSH element). Five dofs are fixed using a large value of stiffness while the different values for the 6th dof are used to simulate the conditions between a perfect clamp ($K_s \rightarrow \infty$) and a simple support ($K_s = 0$). Results are presented introducing a frequency parameter λ_n given by $\lambda_n = \omega_n a^2 \sqrt{\rho h/D}$, where ω_n is the natural frequency of the plate and ρ is the volume density of the material. D is the flexural rigidity given by $D = Eh^3 / 12(1-\upsilon^2)$ where E and υ are, respectively, Young's modulus and Poisson's ratio. a is the width of the plate of thickness h. Only modes with increasing wave number along the length are considered since they can be found at low frequencies and result in a large displacement. The first 4 modes for the case of a perfect clamp are shown in Fig. 1. Changing the boundary conditions from a perfect clamp towards a simply supported condition, the mode shapes appear very similar except showing a larger rotation close to the edges. The plate has a very high aspect ratio (b/a) and for this reason the lower natural frequencies are very close to each other. In the real plate, the damping increases the modal coupling making it difficult to observe the lower order natural frequencies.

The 1st, 4th, 7th and 9th frequency parameters were normalised with respect to the perfectly clamped case and are plotted against the spring stiffness in Fig. 2. They have been chosen since they are more widely spaced. Observing the slope of the curves it can be seen that the sensitivity to spring stiffness decreases with increasing modal order.

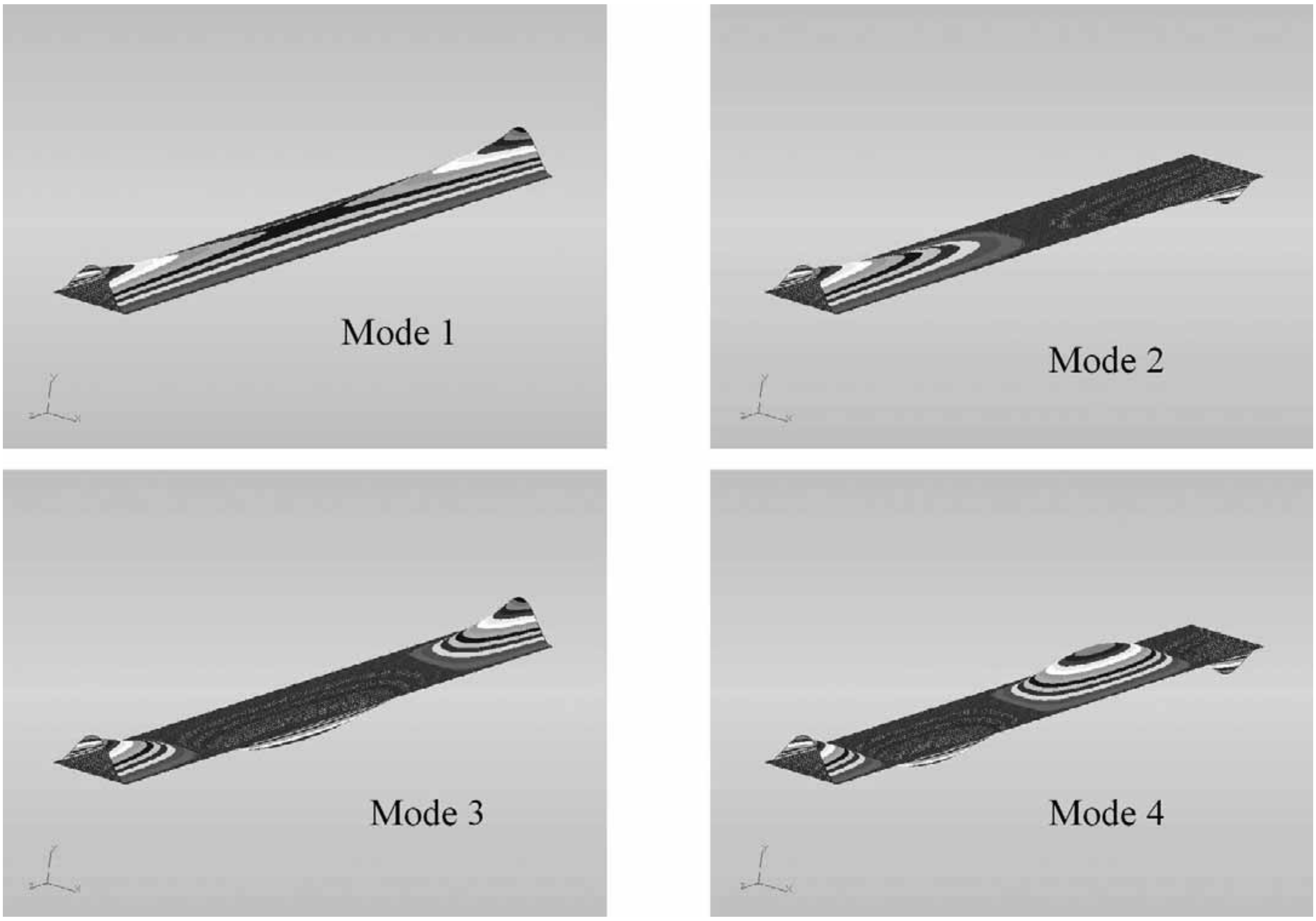

Figure 1. Modeshapes for a perfectly clamped plate (finite element results).

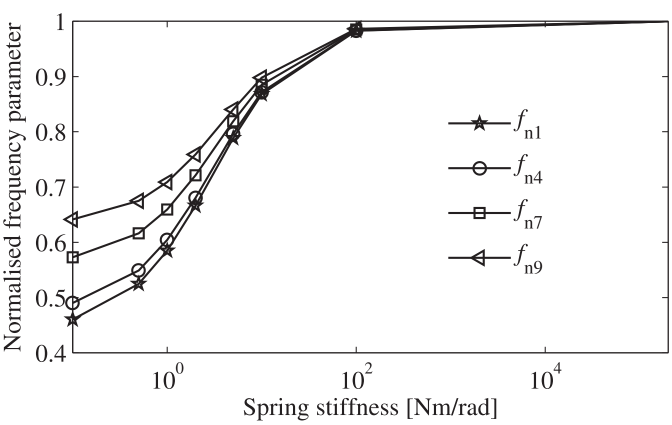

Figure 2. Variation of the natural frequencies with the spring stiffness (finite element results).

EXPERIMENTAL MODEL OF THE CLAMPED PLATE

A scale model of a fuel plate as found in a fuel assembly for the ANSTO research reactor 'OPAL' was manufactured keeping the same length for the edges but using a different thickness corresponding to commercially available sizes. Similar theory [9] allows us to easily transfer the results using materials of different thickness. The aluminium plate is restrained in the jig on the long edges by means of bolts as shown in the sketch of Fig. 3.

a and *b* are the width and length of the plate of thickness *h*. The plate is held between two thick beams detailed to recreate a situation similar to the one found in the fuel assemblies. The top beam has a fixed swage detail and the bottom beam has a small rebate where the plate is located (Fig. 4). The pressure and the clamping strength is adjusted by the fastening torque of the bolts. A wire is also used as a pivot to allow a certain contact of the top beam swage detail to the plate when the bolts are fastened.

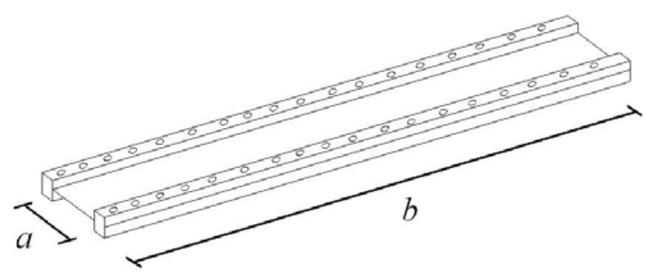

Figure 3. Model of the clamped plate

Modal analysis was performed by exciting the plate with an impact hammer and measuring the response on 21 equally spaced points on the plate using a laser vibrometer. Frequency response functions were calculated using a Brüel & Kjær Pulse signal analyser and imported into MEScope to calculate the mode shapes and determine the natural frequencies of the plate. It was difficult, when viewing the FRF, to distinguish the lower natural frequencies due to the high modal coupling mentioned before. A loose connection results in a higher damped structure since part of the vibration energy sinks at the boundaries. Focus was then shifted to the 8^{th} and higher modes. Table 1 reports the experimental and finite element method (FEM) frequency parameter, showing good agreements between the results. Figure 5 shows the 9^{th} mode shape obtained experimentally compared to the 9^{th} mode shape obtained using finite element modelling.

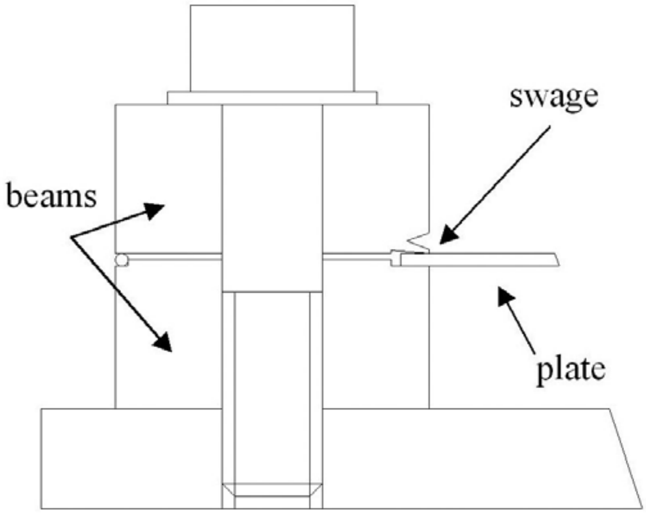

Figure 4. Particulars of the clamped edge.

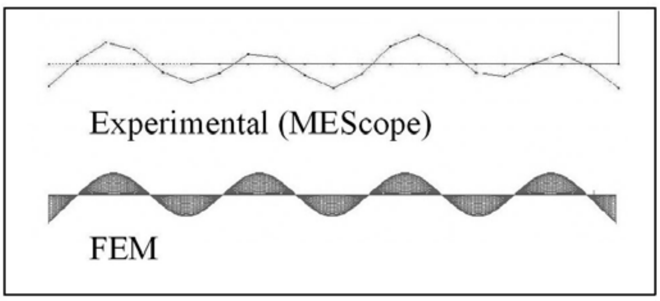

Figure 5. Mode shape of the 9^{th} natural frequency.

Table 1. Experimental and FEM results for the frequency parameter λ_n

Modal order	Experimental	FEM	% diff
8	28.2117	28.2345	-0.1
9	29.5605	29.5377	0.1
10	31.3209	31.0923	0.7
11	33.1499	32.8526	0.9

VARIATION OF FREQUENCY PARAMETER WITH FASTENING TORQUE

Modal analysis was performed using different values of the fastening torque on the bolts. A perfect clamp condition was achieved with around 8 Nm of torque applied onto the bolts. Figure 6 shows the variation of the 9^{th} frequency parameter with the fastening torque. The maximum sensitivity is found for low values of the torque where the frequency parameter increases following a steep curve. For each side there are 23 identical bolts that are fastened one after the other, the resulting preload can be assumed to be reasonably constant from bolt to bolt.

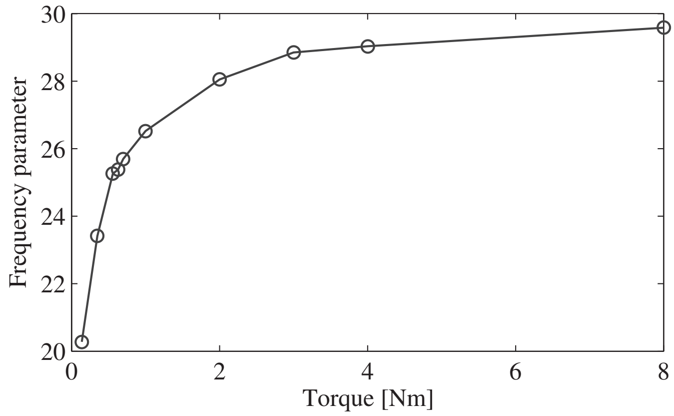

Figure 6. Experimental variation of the frequency parameter with the fastening torque.

PULL OUT EXPERIMENT

The plate clamp was mounted vertically on a solid structure and weights were applied to the bottom edge of the plate by means of a special clamp as shown in Fig. 7. Weights were slowly applied until the plate started to shift. A maximum load of up to 90 kg was able to be applied to the plate.

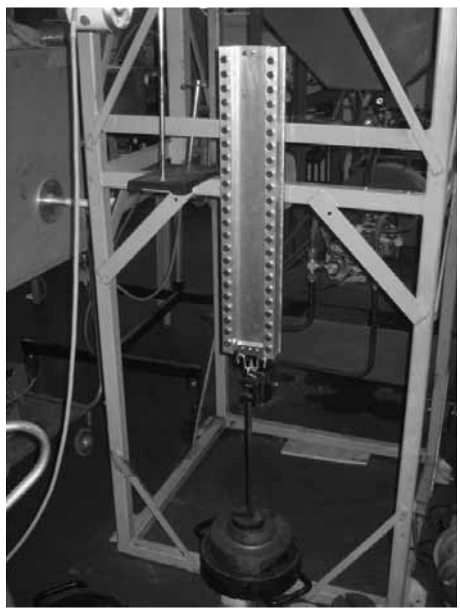

Figure 7. Photograph of the pull out experiment.

The relationship between the torque T and the pull force P needed to shift the plate is shown in Fig. 8, with a linear interpolation of the data which seems appropriate. A small torque was enough to hold a significant weight. The linear interpolation is found to be $P = c_1 T + c_2$ with $c_1 = 2300\ m^{-1}$ and $c_2 = 7.9$ N. Finally, using the linear approximation calculated by the previous figure, the relationship between the frequency parameter and the pull out force needed to shift the plate is shown in Figure 9. Fig. 9 can be used to estimate the resistance of a fuel assembly plate to a pull out force once the natural frequency of the plate is known.

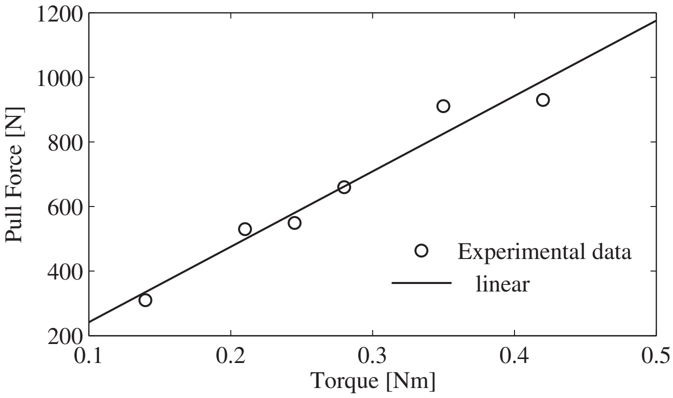

Figure 8. Experimental variation of the pull out force with the fastening torque.

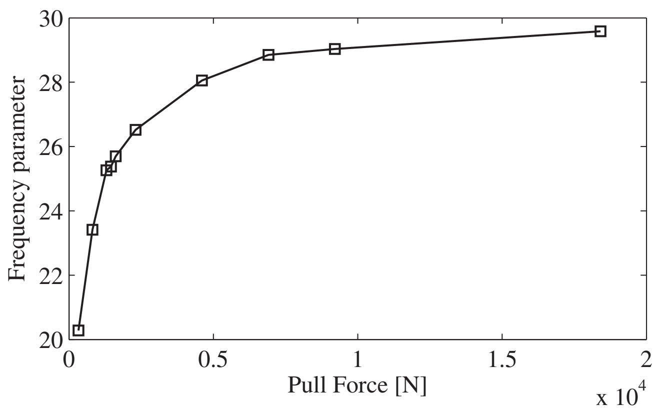

Figure 9. Experimental variation of the frequency parameter with the pull out force.

CONCLUSIONS

A method to relate the pull out force and the frequency parameter in plates with variable clamping strength was presented. The aim was achieved with two steps. In the first step a relationship between the frequency parameter and the fastening strength was found using standard modal analysis. The second step determined a relationship between the pull out force and the fastening torque by attaching weights to the bottom edge of the plate. The results were then combined in order to identify the variation of pull out force with the frequency parameter of the plate. Results can be scaled to plates with different material properties and thickness.

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Technical Note

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ASSESSING NOISE FROM LICENSED PREMISES – ARE WE ON THE SAME PAGE?

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INTRODUCTION

In New South Wales (NSW), noise from licensed premises, such as pubs, restaurants, nightclubs etc. can be regulated by both the local consent authority (Council or NSW Department of Planning) or via the NSW Office of Liquor, Gaming and Racing (OLGR). The requirements of the consent authority, including any relevant noise criteria that a development needs comply with, should be set out within a development's conditions of consent or notice of determination. A potentially complicating factor is that noise complaints can also be directed and mediated through the OLGR, through the NSW Liquor Act 2007 [1].

The purpose of this discussion note is to present some of the ambiguities and issues when assessing licensed premises. Given the sensitivity of noise emission and disturbances that can be generated by licensed premises, it would be beneficial if supporting documentation is available rather than reliance given to other Standards or policy to justify a specific noise assessment methodology. The OLGR have a standard noise condition which states as follows [2]:

"The L_{A10} noise level emitted from the licensed premises shall not exceed the background noise level in an Octave Band Centre Frequency (31.5Hz – 8kHz inclusive) by more than 5dB between 7:00am and 12:00 midnight at the boundary of any affected residence.*

The L_{A10} noise level emitted from the licensed premises shall not exceed the background noise level in an Octave Band Centre Frequency (31.5Hz – 8kHz inclusive) between 12:00 midnight and 7:00am at the boundary of any affected residence.*

Notwithstanding compliance with the above, the noise from the licensed premises shall not be audible within any habitable room in any residential premises between the hours of 12:00 midnight and 7:00am.

Interior noise levels which still exceed safe hearing levels are in no way supported or condoned by the NSW Office of Liquor, Gaming and Racing.

**For the purposes of this condition, the L_{A10} can be taken as the average maximum deflection of the noise emission from the licensed premises."*

The 'condition' has subsequently been stipulated by NSW consent authorities in development consents. On this basis, it becomes critical that there is consistency and transparency in the application of the standard noise policy.

Unlike noise policy issued by the NSW Department of Environment Climate Change and Water (DECCW), the OLGR condition is not supported by any other documentation or application notes. The purpose of this discussion note is to outline some of issues that are ambiguous or omitted in the condition, and to hopefully invoke discussion and review of the OLGR standard noise condition.

NOISE DESCRIPTOR

The descriptor stipulated by the policy is an L_{A10} and is also qualified or may be considered as the 'average maximum deflection' of the noise emission. It is assumed that the clause in the OLGR condition stems from Australian Standard AS 1055.1-1989 [3], section 3.7 'Average Maximum A-weighted sound pressure ($L_{Amax,T}$)' for which it is noted in the Standard that the $L_{A10,T}$ is commonly taken to be an approximation of $L_{AMax,T}$. The Standard refers to arithmetically averaging the maximum levels.

The methodology for applying or reporting the 'average maximum deflections' or the time period over which they are to be assessed is not defined in the OLGR condition and therefore the outcomes of any assessment could vary based on the individual assessor's approach, particularly in cases of intermittent noise events.

NSW noise policy has been moving towards consistent use of the L_{Aeq} noise descriptor, which was reinforced with the introduction of the NSW Interim Construction Noise Guideline (ICNG), Department of Environment and Climate Change (DECC) in 2009 [4]. L_{Aeq} is now the primary assessment metric for the assessment of road traffic, rail, industrial and construction noise and is referenced in the following policies:

- NSW Road Noise Policy , DECCW, 2011 [5];
- Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects, DECC, 2007 [6];
- State Environmental Planning Policy (Infrastructure), 2007 [7];
- NSW Industrial Noise Policy (INP), Environment Protection Authority, 2000 [8]; and
- NSW Interim Construction Noise Guideline (ICNG), DECC [4].

It is however noted that reference to maximum levels, impulsive weighting, C-weightings and the like are used in some instances to correct/penalise the measured L_{Aeq} level.

ASSESSMENT TIME PERIOD

An assessment or measurement period is not stipulated in the OLGR condition. In NSW, short-term noise level measurements are generally in the order of 10-15minutes, and as with the INP or ICNG, 15 minutes is the assessment period for intrusive noise impacts. A comparable time period for the assessment of licensed premises is considered reasonable.

ASSESSABLE NOISE SOURCES

The OLGR condition applies to activities within the licensed premise, including, patrons and music etc. It is understood that the condition is not to be used for the assessment of noise generated by people arriving and leaving premises, in car parks etc. However following the enforcement of the NSW Smoke-free Environment Amendment Act 2004 [9] in July 2007, an increase in development applications for low capacity outdoor patron and gaming areas has been observed. It could be considered that such areas differ in intensity and character to that commonly associated with licensed premises. In light of these changes it may be prudent to confirm the noise sources to which the condition applies.

It is generally understood that the OLGR condition does not apply to mechanical plant noise. However, whether the L_{A90} should be measured in absence of any mechanical plant from the site is an issue that can provide discrepancy in an assessment.

ASSESSMENT LOCATION

In accordance with the OLGR condition, assessment between 7am and midnight is to be made at the boundary of any residential premises, whilst assessment between 12 midnight and 7am applies both at the boundary, and inside any habitable room with regard to the inaudibility requirement.

No further detail is provided, however it is understood that internal assessment locations may be used pre-midnight where an appropriate external location is not available. This situation may arise, for example, where the receptor location shares a common wall, or floor with the licensed premise.

In addition, for the case of apartment buildings or upper levels of dwellings, external locations may be small, and 'free-field' conditions may not be obtainable. Whether measurements should be adjusted for the effect of facade reflections, or simply the as-measured results assessed, is unclear.

For internal locations, of concern is the size of openings to outside, building construction and modifications to dwellings etc. which may affect the resultant noise level inside a dwelling, and is ultimately outside the control of the licensed premise.

Whether windows and doors should be opened or closed is also of concern. If windows and doors are closed, should any mechanical ventilation be on or off? It is feasible for all possible scenarios to be tested for a thorough assessment; however it is important to define the parameters under which the receptor building has been designed.

ALTERNATIVE CRITERIA APPLIED BY CONSENT AUTHORITY

With the increase in mixed use development, promotion of vibrant city centres and policies such as the City of Sydney Late Night Trading Premises Development Control Plan (2007) [10], it is clear that Consent authorities may need to develop their own controls for managing the balance between potential noise impacts and vitality of the centres. Where licensed premises are concerned it would be necessary to confirm how any alternative noise conditions (or lack thereof) would be considered should complaints be directed through the Office of Liquor Gaming and Racing.

CONCLUSION

This technical note has presented some of the issues surrounding the application of the standard noise condition issued by the Office of Liquor Gaming Racing. It is hoped that this note may promote discussion within the profession, OLGR and consent authorities, with the aim of providing greater consistency in the assessment of noise emission from licensed premises in the future.

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NOISE ABATEMENT MEASURES IN DENMARK

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This technical note is a shortened version of a presentation by Gilles Pigasse to the NSW branch of the Australian Acoustical Society in December 2010.

INTRODUCTION

When constructing new buildings or roads in Denmark special consideration is given to traffic noise. A national noise mapping indicates that around 30% of Danish homes are exposed to noise levels that exceed the guideline value of 58 dB(A) (L_{DEN}) and that noise problems are concentrated in cities. Road traffic noise may impact people in different ways such as impacting communication, and interrupting sleep. Studies have shown that noise can contribute to an increased risk of cardio-vascular diseases [1]. The effects of noise are also of an economic nature because noise influences house prices. Furthermore, health related issues caused by noise also incur costs. The socio-economic costs related to road traffic noise have been calculated to amount to between 1.1 and 1.6 billion AUD annually in Denmark [2].

The first part of this article introduces noise guidelines, prediction of noise and socio-economic evaluation of noise. This is followed by a typical planning situation where noise can be considered in relation to planning a new highway.

TECHNICAL CONSIDERATIONS

Noise Guidelines

For many years, the noise indicator $L_{Aeq,24h}$ has been used in Denmark when assessing noise from road traffic. $L_{Aeq,24h}$ is an expression of the average noise level over the 24 hours of the day. The guideline for noise exposure outside at the façade of residential buildings has been 55 dB(A) (not including the noise reflected from the façade). On the background of a European Union Directive on environmental noise [3] the new indicator L_{DEN} was introduced by the Environmental Protection Agency in 2007 in a new guideline on road traffic noise [4]. With L_{DEN} the noise is predicted for the day, evening and night period. 5 dB is added to the evening time level and 10 dB is added to the night level in order to reflect the difference in sensitivity to noise during day and night time. The three time periods are defined as:

- Day: 07:00 – 19:00
- Evening: 19:00 – 22:00
- Night: 22:00 – 07:00

L_{DEN} is then calculated as the weighted sum of the adjusted noise levels for the three periods of the day using the formula

$$L_{DEN} = 10\log_{10}(12*10^{L_{day}/10} + 3*10^{(L_{evening}+5)/10} + 9*10^{(L_{night}+10)/10}) \quad (1)$$

According to [4] for a “normal” distribution of the traffic over the 24 hours of the day, L_{DEN} can be predicted by adding 3 dB to $L_{Aeq,24h}$

$$L_{DEN} = L_{Aeq,24h} + 3 \text{ dB} \quad (2)$$

Therefore the existing noise guidelines were adjusted by 3 dB when L_{DEN} was introduced in order to maintain the same level of noise protection as when $L_{Aeq,24h}$ was used. In other European countries other relations between L_{DEN} and $L_{Aeq,24h}$ are used [5]. The new Danish noise guidelines for road traffic noise, expressed as L_{DEN}, is as follows:

- Recreational areas on the countryside, summer houses, campsites, etc.: 53 dB(A)
- Residential areas, kindergartens, schools and education facilities, hospitals, outside recreational areas and parks: 58 dB(A)
- Hotels and offices: 63 dB(A)

It must be emphasised that these are guidelines and not mandatory noise levels that should not be exceeded anywhere along the highway and road network. These guidelines are generally used when planning and constructing new residential areas as well as planning new roads and highways.

The Noise Exposure Factor (NEF)

The Noise Exposure Factor (NEF) is the basis for all cost-benefit analyses of noise from road traffic in Denmark [6]. It is an expression of the accumulated noise load on all the dwellings in an area. It is calculated as the sum of the weighted noise loads on the individual dwellings in the area, so that dwellings with high noise levels weight more than dwellings with less noise.

The calculation of the NEF is based on noise levels outside the façade of the dwelling. It is calculated as free-field values on the facade and can be interpreted as the noise level to which the inhabitants are exposed, when the windows are open. The NEF is based on a dose-response relation called the annoyance factor and given by:

$$\text{Annoyance factor} = 0.01*4.22^{0.1(L_{Aeq}-K)} \quad (3)$$

where K=41 and L_{Aeq} starts at 55 dB for noise outside dwellings. The relation between the annoyance factor and the noise levels is shown in Figure 1.

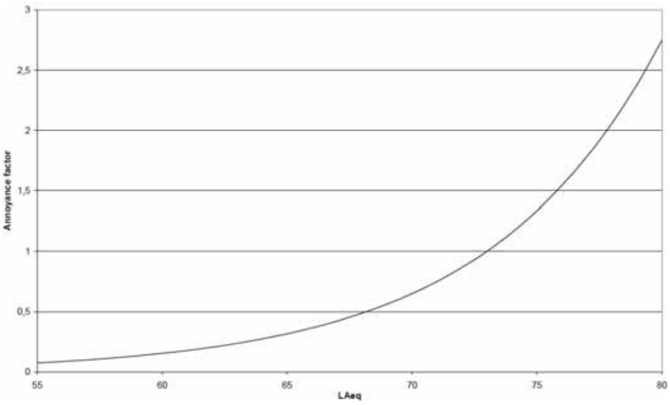

Figure 1: Relation between the annoyance factor and the noise outside dwellings.

The number of dwellings exposed to noise is calculated in 5 dB intervals using the NORD2000 noise prediction method [7, 8] and multiplied by the corresponding annoyance factor, see Table 1. The resulting values are summed to give the NEF for the investigated situation. An example for calculating the NEF is given in the next section.

Table 1: Annoyance factor in 5dB intervals for the ordinary dwellings (indoor).

Noise level dB(A)	Annoyance factor
55-60	0.11
60.1-65	0.22
65.1-70	0.45
70.1-75	0.93
75.1-80	1.92

The price of noise

A survey conducted by the Danish Ministry of Transport set the value of noise to AUD $6,519, based on the reduced value of the house price. Added to the costs to society due to health effects the total value of noise is thus AUD $10,704/year per NEF (2003 price level) [9-11]. A new evaluation of the price of noise is currently being conducted by the Danish Economic Council. The NEF makes it possible to compare the benefits of different noise reducing strategies such as noise barriers, noise reducing pavements and sound insulation.

APPLYING THE NEF TO THE PLANNING OF A NEW HIGHWAY

An important part of planning new highway sections in Denmark is to perform an Environmental Impact Assessment (EIA) study. Noise is normally one of the environmental components included in the EIA. A report by the Danish Road Directorate shows how noise was handled in the EIA conducted as part of the planning of a new highway in Denmark [12]. The first step is to predict the noise map of the existing road network as it would be in 2015, this takes into consideration an increase in traffic. In these examples the old L_{Aeq} noise levels are used. The existing road network includes the existing highway carrying the main traffic as well as other minor roads that might see a reduction of traffic of 15% or more if a new highway is constructed. This predicted situation is called the reference situation. Three different alternatives to this reference situation are proposed. They offer different traces and therefore different noise mapping. They are referred to as the main solution, alternative 1 and alternative 2. Noise mapping is conducted for these four situations. The number of dwellings exposed to different noise levels is counted based on the noise mapping and the NEF is then calculated. The results are found in Table 2. In the reference situation, 660 dwellings along the existing road network are exposed to more than 55 dB(A). This represents a NEF value of 153.8. For the main solution this is reduced to 562 dwellings with a reduction of the NEF by 31.5. Alternatives 1 and 2 represent slightly higher reductions of NEF, respectively 37.6 and 34.6. This shows that alternative 1 is the one offering the least noise exposure for the dwellings in the vicinity of that road.

Table 2: Number of dwellings exposed to noise, the NEF and the change of NEF in relation to the reference situation.

Scenario	Total of noise exposed dwellings					NEF	Change in NEF
	55-60 dB	60-65 dB	65-70 dB	>70 dB	Total		
Reference	272	153	197	38	660	153.8	
Main solution	189	159	214	0	562	122.3	31.5
Alternative 1	201	132	222	0	555	116.2	37.6
Alternative 2	222	133	221	0	576	119.2	34.6

This type of pre-study helps detecting which solution is best in terms of noise protection. This can be combined with the actual price of a road project [13]. The example below is from the M3 highway and it shows how the NEF can be used to choose between different types of noise barrier, as shown in Table 3. As expected the highest noise barrier (5m) brings more noise reduction to the dwellings and hence has the lowest NEF. The price of such a barrier needs to be taken into account to see which solution is best. A 5 m high barrier requires stronger foundation compared to smaller barriers. The overall cost of the three types of barrier and their respective NEF reduction is shown in Table 4. From this study it can be concluded that a 4-m high barrier provides the best “value for money” in terms of noise reduction. A similar study can be made with pavement offering different degree of noise reduction, different earth mound heights, etc. The completed M3 highway is presented in Fig. 2 and an example of noise level measurement using the statistical pass-by (SPB) method is shown in Fig. 3.

Table 3: Number of dwellings exposed to noise, NEF for different noise barrier heights and change of NEF in relation to the reference situation.

Scenario	Total of noise exposed dwellings					NEF	Change in NEF
	55-60 dB	60-65 dB	65-70 dB	>70 dB	Total		
Existing	6503	3244	482	76	10305	1717	
3m barrier	5472	2985	526	78	9061	1568	149
4m barrier	4766	1890	253	36	6945	1087	630
5m barrier	4027	1663	238	35	5963	948	769

Table 4: Evaluation of the price and cost effectiveness of the different barrier solutions [20].

Scenario	Total price [mil. AUD]	ΔNEF	ΔNEF per 1mil. AUD
3m barrier	25	149	5.9
4m barrier	31	630	20.3
5m barrier	39	769	19.7

Figure 2. The M3 highway once completed, with porous asphalt and tilted 3m and 4m noise barriers.

Figure 3: The Danish Road Institute measures the noise level at a test location for noise reducing pavement using the SPB method.

CONCLUSIONS

This article has presented the tools used in Denmark to mitigate road traffic noise. This includes noise guidelines, prediction of noise and socio-economic evaluation of noise. Different examples have been presented where the NEF was applied. It showed that the NEF can be a very helpful parameter to consider prior to major road projects.

A European noise group from the Conference of European Directors of Roads (CEDR) has published a list of fourteen recommendations to National Road Administrations for good governance regarding noise management and abatement [14]. The interested reader is referred to the free English publications of the Danish Road Institute available from www.roadinstitute.dk

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Acoustics 2011
BREAKING NEW GROUND
Gold Coast Australia

ACOUSTICS 2011, the 2011 Conference of the Australian Acoustical Society to be held on the Gold Coast in Queensland from 2 to 4 November, 2011, will be another excellent acoustics conference for the Australasian region. With its theme of “Breaking New Ground”, ACOUSTICS 2011 will include plenary sessions addressing the acoustical aspects of Major Infrastructure projects from transportation and construction in the urban context through to mining. Other major streams will address Underwater Acoustics/Marine Bioacoustics, Railway Noise and Vibration and Road Transport. All aspects of acoustics are open for discussion and ACOUSTICS 2011 will disseminate the most recent knowledge and practice.

Abstracts are due by the end of April 2010. See the Congress website for submission details:
http://www.mech.uq.edu.au/acoustics2011/.

Highlights will include the following plenary and keynote presentations:

Plenary Presentations:

- Professor David Thompson, Institute of Sound and Vibration, University of Southampton, UK on *The role of theoretical models in shaping railway noise policy and mitigation strategies*
- Dr David Hiller, Senior Consultant - Ground Vibrations and Tunneling, Arup Acoustics, UK on *The prediction and mitigation of vibration impacts of tunneling*
- Dr James Lynch, Senior Scientist, Applied Ocean and Physics Engineering, Woods Hole Oceanographic Institution, Massachusetts, USA, on *Underwater Acoustics*

Keynote Presentations:

- Professor Barbara Griefahn, Institute for Occupational Physiology, Dortmund University, Germany, on *Sleep disturbance*
- Mr Jørgen Kragh, Danish Road Institute, Copenhagen, Denmark, on *Noise-reducing pavements*
- Associate Professor John Smith, Musical Acoustics Research Group, School of Physics, University of New South Wales, Sydney, NSW on *Music acoustics*
- Mr Steven Wolfe, President, Wilson Ihrig and Associates, Emeryville, California, USA on *Major urban infrastructure noise and vibration*
- Dr Doug Cato, Maritime Operations Division, Defence Science and Technology Organisation, Pyrmont, NSW, on *Marine mammal acoustics*

Major themes of ACOUSTICS 2011 include:

- Major Infrastructure
- Underwater Acoustics / Marine Bioacoustics
- Railway Noise and Vibration and Road Transport

ACOUSTICS 2011 will include Special Sessions on:

- Aircraft Noise
- Architectural and Building Services Acoustics
- Low Frequency Noise
- Music Acoustics
- Wind Turbine Noise.

ACOUSTICS 2011 will also include Workshops in:

- Wheel Rail Noise Control
- Building Design for Transportation Noise
- Sleep Disturbance
- Low Noise Road Surfaces
- Wind Turbines and Low Frequency Noise.

A short course entitled *Environmental Noise Assessment* will be conducted on Wednesday 2 November, prior to commencement of the technical sessions.

Contact Professor David Mee, the Congress Secretary, at acoustics2011@uq.edu.au for any further information.

News

NSW Road Noise Policy

Following public consultation in 2010, a new NSW Road Noise Policy has been adopted which will replace the current Environmental Criteria for Road Traffic Noise. The NSW Road Noise Policy will take effect from 1 July 2011, following a transition period to allow for distribution and training in relation to the requirements of the new policy.

The Road Noise Policy facilitates a more streamlined assessment process for road projects with simplified criteria, increases protection for residents in quiet areas experiencing large increases in noise from road projects, and provides up-to-date guidance on strategies to minimise traffic noise. The policy applies to new road projects, upgrades of existing roads, and land use developments that generate traffic, such as quarries.

Prepared by the Department of Environment, Climate Change and Water in consultation with the NSW RTA, NSW Health, Transport NSW and the Department of Planning, the policy reflects the outcomes of the community consultation last year.

The policy can be downloaded from the Department's website at www.environment.nsw.gov.au/noise/traffic.htm

or a hard copy may be obtained by phoning Environment Line on 131 555

Lorraine Phillips

Manager, Noise Policy

NSW Department of Environment, Climate Change and Water

National Acoustic Calibration Laboratory takes over the business of RTA Technology

As of 1st January 2011, the calibration and repair business of RTA Technology was taken over by National Acoustic Calibration Laboratory (NATacoustic). NATacoustic is NATA accredited to ISO/IEC 17025:2005 for calibration of Sound Level Meters, Loggers, 1/3 and 1/1 Octave Band Filters and Calibrators. NATacoustic calibrates all instruments including B&K, Norsonics, Rion, Larson Davis, NTI, Pulsar, ARL, Sinus, RTA Technology, Svantek, 01dB, Cesva and CEL. NATacoustic will also continue to repair and service RTA Technology loggers. Contact details are: NATacoustic, 1/418A Elizabeth Street, Surry Hills, NSW 2010, Phone (02) 8218 0570,

email service@natacoustic.com.au

ICA, ISMA and ISRA 2010 Proceedings

The International Congress on Acoustics and the associated meetings were clearly successful activities and provided the opportunity to promote Australian acoustics to the rest of the world while gaining from the participation of international delegates. The proceedings of ICA 2010, ISMA 2010 and the abstracts from ISRA 2010 are now available free from the AAS website. They can be accessed from the AAS home page or directly to the link

http://www.acoustics.asn.au/conference_proceedings/ICA2010/

Safe Work Australia

Model workplace regulations and codes

In a key step toward making the harmonisation of OHS laws a reality, the National Review into Model OHS Laws (the Review) concluded in January 2009. The two Review reports made recommendations on the optimal structure and content of a model OHS Act that can be adopted in all jurisdictions. Work then began on development of Model work health and safety (WHS) Regulations, priority model Codes of Practice and a nationally consistent compliance and enforcement policy.

In December 2010 the public comment period for the draft model WHS Regulations and model Codes of Practice began and this closed on 4 April 2011. Safe Work Australia has processed a large volume of public submissions and all public submissions are available through the alphabetical index via the view public submissions on their webpage. The time line now is that by June 2011, Safe Work Australia to agree to model WHS Regulations package. The new Model Work Health and Safety Act and model WHS Regulations will then commence on 1 January 2012.

For more information on the background, the draft documents and the public comment go to the Model Regulations menu item on the Safe Work Australia website

www.safeworkaustralia.gov.au/

Prizes & Awards

AAS Education Grant

The AAS Education Grant has been established to encourage and enhance the study of acoustics in Australia and in particular to encourage research in acoustics. Projects will be judged on their originality and their likelihood of successful completion within reasonable timeframes. The potential for the outcomes to be published in the Acoustics Australia journal and/or presented at the annual conferences and technical meetings of the Society would be viewed favourably. The grant is open to educational institutions, companies and organisations and individuals for the purpose of financing special acoustic projects, providing scholarships, assisting projects with the purchase of software and equipment or any other worthwhile use involving acoustics. The total grant of $15,000 may be split between several projects. The closing date for submissions is the 30 June 2011 and the winning entry will be announced at the Annual General Meeting of the Society during November 2011. For more details visit

http://www.acoustics.asn.au/joomla/education-grant.html

Excellence in Acoustics Award

The CSR Bradford Insulation Excellence in Acoustics Award aims at fostering and rewarding excellence in acoustics. The entries will be judged on demonstrated innovation from within any field of acoustics. The prizes include a trophy and a gift to the value of $2,500 to the winner, and a certificate and gift to the value of $500 to the runner up. Entries are open to any professional, student or layperson involved or interested in any area within the field of acoustics who is a member of the Australian Acoustical Society at an appropriate grade. Group entries are also allowed. As this is an award that recognises excellence and innovation it is important that all submissions are representative of up to date technology, creativity and relevancy. Thus entries need to be recent and normally no older than three years at the time of submission. Projects which commenced prior to this time need to demonstrate important developments within the last three years. An entry form is to be completed with all relevant particulars included. The submission should be forwarded as an electronic word document attachment to the AAS General Secretary. The closing date for submissions is the 30 June 2011 and the presentation of the Award will be made at the Annual Conference of the Australian Acoustical Society.

For more details visit

http://acoustics.asn.au/joomla/excellence-in-acoustics-award.html

NSW Division Travel Award

The AAS NSW Division is offering up to three (3) awards to research students to attend the Acoustics 2011 conference at the Holiday Inn Hotel, Surfers Paradise, 2-4 November, 2011. The amount of each award is $1000 and is to be spent towards the conference registration fee, travel to and from the conference venue, and accommodation. The award is open to all research students who are AAS student members of NSW Division as well as research students endorsed by AAS members of NSW Division. The closing date for the applications is 3 June 2011. For more details visit

http://www.acoustics.asn.au/joomla/notices.html

Queensland Division Awards

The Queensland Division conducts an awards program to encourage and support education and research in acoustics in Queensland. Awards are granted on an annual basis in two divisions, a schools division and a tertiary division. The schools division is administered as part of the Queensland Science Contest and is open to students studying at Queensland primary and secondary schools. A $500 bursary will be presented for the best entry in the field of acoustics. At the discretion of the judges, this bursary may be split among a number of deserving entries (maximum of five).

The tertiary division consists of two awards: (1) the Acoustic Bursary, and (2) the RJ Hooker Bursary. For the Acoustic Bursary, $1500 will be offered for a proposed 4th year undergraduate or 1st year postgraduate research project. For the RJ Hooker Bursary, $1500.00 will be awarded for a proposed 4th year undergraduate or 1st year postgraduate research projects conducted with substantial industrial participation. This may take the form of a professional placement or it may be through the use of acoustical test facilities in industry for purposes critical to project outcomes. The awards are open to tertiary students studying full or part time at a Queensland university in subjects relevant to the field of acoustics. Submissions close 20 May 2011. Successful applicants will be invited to ACOUSTICS 2011 at Surfers Paradise, 2-4 November 2011, with complimentary student registration.

For more details on the Queensland Division awards visit: http://www.acoustics.asn.au/joomla/notices.html

David Bies Prize in Acoustics

The SA Division has established a David Bies Prize in Acoustics to recognize the contributions of David Bies to the science and practice of and education in acoustics. The prize is available each year and may be awarded to a member(s) of the AAS who is/are an acoustical practitioner(s) in South Australia, or has/have made a meritorious contribution to the discipline in South Australia. Nominations can be made via written correspondence to the AAS SA Division.

Meeting Reports

NSW Division

The NSW Division held their 2010 Christmas Breakfast on 16 December at the Vibe Hotel in North Sydney. During the breakfast a presentation was given by Dr Gilles Pigasse on road traffic noise abatement measures used in Denmark and Europe as well as the use of planning tools, criteria and current EU research projects. His presentation is described in a technical note in this issue of Acoustics Australia.

On 24 March 2011, Dr Warwick Williams of the National Acoustic Laboratories gave a presentation at the NSW Division technical meeting on the topic of expected output levels from personal stereo players. More information on this topic can be found in an article published in the December 2010 issue of Acoustics Australia.

South Australian Division

The SA Division held their annual Christmas Dinner Party at Regatta's Bistro at the Adelaide Convention Centre on Friday 26 November 2010, where about 40 people (members and partners) attended the event. At the dinner, a trophy was awarded to SA Division vice-chairman, Byron Martin, with the engraving "In recognition of your outstanding contributions to the society". Byron has been a dedicated member of the AAS on both a federal and state level. He was the SA Division's treasurer for 14 years, has been a state chairman, a federal secretary, chairman of the AAS 2009 conference, organising committee member of previous state conferences and workshops, and much more. Byron is a champion of the society, promotes it professionally, and also made it a social and enjoyable organisation. The SA Division wishes to extend our gratitude to Byron for his ongoing support.

Standards Australia

Deleting old Standards

As part of its review process, Standards Australia is removing some of the older standards. A very long list of acoustics standards was circulated to the individual members of the various acoustics committees seeking an individual response within a very short time or the standards would be deleted. While it is important to cull old standards the decision on the appropriate action needs time for consideration and consultation ideally with the committee and should not be done in a rush. For example, the AS 1055 series which form an important basis for much environmental regulation and legislation in Australia were on this list to be deleted and with no replacement proposed. Hopefully the advice from various committee members will be accepted and the majority of the "about to be deleted" standards will be reconfirmed and remain as valid Australia standards (till the next clean out).

However this highlights the importance of involvement with Standards Australia on a continuous basis of AAS members. The changes in the operating process of Standards Australia means that committees are not prompted to regularly review and update standards. Instead a project request has to be initiated with justification and, except in rare cases that will be internally funded, external or stakeholder funding provided. It is not a simple process. So if there are any AAS members who consider that there are standards which need to be updated or even if an ISO version needs to be adopted as an Australian Standard please bring these to the attention of the appropriate Standards committee chair and/or AAS representatives and be prepared to assist with the development of the case for the establishment of a project. Then if it gets the approval be prepared to assist with the committee work on the documents.

Marion Burgess

FASTS

The Federation of Australian Scientific and Technology Societies (FASTS) is a peak group that lobbies the government on issues affecting science. AAS is a member of FASTS. Our Society is ready to take on issues and concerns that members have which have a political dimension and then direct them to FASTS. To keep you current, here are some recent and future FASTS activities.

On 20 and 21 June, FASTS will be conducting a "Science Meets Parliament" day in Canberra. It is designed to demonstrate to politicians the value of investment in science and technology. Science Meets Parliament (SmP) is an annual event that takes science to government at Parliament House. It is designed to demonstrate the economic, political and social value of science and innovation. There are workshops and a range of people including ministerial advisers, journalists, policy makers and science communicators will speak. There's the chance to meet fellow SmP delegates and to learn how to effectively communicate with parliamentarians and the media. There are face-to-face meetings with parliamentarians, attendance at a National Press Club address and a joint dinner with MPs and senators. SmP provides a stimulating professional development opportunity. AAS, like every FASTS member society, is entitled to register 2 people (by 11 May) to attend SmP. Attendance by early and mid-career scientists who haven't participated in the past is encouraged. For more information please visit http://www.fasts.org/smp-registration/delegate_2011.php and contact the AAS General Secretary.

FASTS has been closely involved in the development of a research workforce strategy called "Research Skills for an Innovative Future". It was launched by Minister Kim Carr at Parliament House on 19 April.

FASTS is considering a name change. The "rebranding" is to give the organisation more public recognition. Alternative names are being considered by the FASTS board and executive following a broad request for suggestions. A short list of names will be released soon, and members will be asked for their reactions.

Andrew Bell, AAS representative on FASTS

FUTURE CONFERENCES & WORKSHOPS

ICSV18

The 18th International Congress on Sound and Vibration (ICSV 18) will be held in Rio de Janeiro, Brazil, 10-14 July 2011. ICSV is one of the leading world congress series in the fields of acoustics and vibration and therefore is a major opportunity for the presentation of latest results and learning about the most advanced theories, technologies and applications. ICSV is the annual premier world event organized by the International Institute of Acoustics and Vibration (IIAV). The congress includes invited and contributed papers on the range of topics of sound and vibration.

Deadlines: Abstract submission 20 December 2010; Paper and early registration 31 March, 2011

More information from http://www.icsv18.org

ICBEN 2011

The 10th International Congress on Noise as a Public Health Problem will be held in London, UK, 24-28 July 2011. ICBEN 2011 is organized by the UK Institute of Acoustics on behalf of the International Commission on the Biological Effects of Noise (ICBEN). This congress aims to present the current state of the art in research on the biological effects of noise on health and is suitable for research scientists, policy makers and industry concerned with the effects of noise. Papers and posters are welcome on topics including noise induced hearing loss, noise and communication, non-auditory physiological effects of noise on health, influence of noise on performance and behaviour, effects of noise on sleep, community responses to noise, noise and animals, interactions with other agents and contextual factors and noise policy and economics.

Deadlines: Paper submission is 16 May, 2011

More information from

http://www. icben2011.org

Inter-Noise 2011

The 40th International Congress and Exposition on Noise Control Engineering (Inter-Noise 2011) will be held in Osaka, Japan from 4-7 September 2011. The Congress is sponsored by the International Institute of Noise Control Engineering (I-INCE) and co-organised by the Institute of Noise Control Engineering Japan (INCE/J) and the Acoustical Society of Japan (ASJ).

It is nearly a month after the magnitude 9.0 earthquake and tsunami struck the Pacific coast of north-eastern Japan. The disaster devastated many cities and towns as well as damaging the Fukushima Dai-ichi Nuclear Power Station. The AAS has expressed our sympathy and condolences to all the people who have suffered due to the disaster. We have heard recently from the organisers of Inter-Noise 2011 to confirm that plans are still proceeding for this important conference. The conference venue of Osaka is more than 600 km southwest of Fukushima. The organisers advise that the congress venue is located with no danger from radioactive pollution and with no trouble with transportation, food, water, etc.

Many abstracts have been submitted for this conference and the committee is aiming to send all acceptances by mid April. The organisers look forward to the support and collaboration of the international acoustics community to provide a successful Inter-Noise 2011. Conference sessions will include the latest advancements in noise and vibration control engineering and technology, focusing on the congress theme of “Sound Environment as a Global Issue”. Inter-Noise 2011 will feature a broad range of invited and contributed papers, together with plenary lectures by distinguished speakers. There will be extensive exhibitions of noise and vibration control technology, measuring instruments, equipment and systems from all over the world.

Deadlines: Full paper submission: 1 June 2011; Early registration: 8 June 2011

More information from

http://www.internoise2011.com

ACOUSTICS 2011

The annual conference of the Australian Acoustical Society will be held in the Gold Coast 2-4 November 2011. This provides the opportunity for all those working in acoustics around Australia to meet and discuss recent work. The theme for this conference is “Breaking New Ground” and many of the papers will be highlighting the role of acoustics in the recent boom in large infrastructure projects around Australia. In addition to papers on this theme, papers on all aspects of acoustics will be welcomed including Underwater Acoustics and Architecture and Building Acoustics. There will be a technical exhibition, workshops and a great social program.

Deadlines:

30 June 2011:	Closing date for early registration
30 Sept 2011:	Registration and submission of final versions of all papers Closing date for standard registration
2 Nov 2011L:	Conference opening

For more information see

http://www.mech.uq.edu.au/acoustics2011/

NEW PRODUCTS

Marshall Day Acoustics is pleased to announce the recent release of INSUL version 6.4. The new version includes impact sound for light weight timber floors, sandwich panels with polystyrene or rockwool cores, porous material TL, improved profiled steel and aluminium panel predictions. INSUL can now predict the impact sound insulation of light weight floors. This is a very significant development from previous versions of INSUL which were capable of predicting impact sound insulation for massive floors such as concrete. Impact sound insulation predictions can now be carried out for different joist constructions including timber joists and Z girts. The prediction routines are sensitive to the dimensions of the joists, their mass and spacing and all of these variables can be set independently in INSUL. A range of floor linings is available including plywood, particle board, orientated strand board (OSB) and thin timber floor boards. INSUL can also predict the sound insulation of a variety of light weight sandwich panels. A typical example would be panels with thin steel or aluminium skins, with a polystyrene or mineral wool core. INSUL has improved the prediction of profiled metal panels, typically used for commercial and industrial buildings. INSUL can also predict the sound transmission loss of porous blankets either alone or as a facing for a construction. Typical constructions would include modular panels for acoustic enclosures that have a steel skin with a mineral wool infill and perforated steel internal facing. Further improvements to INSUL version 6.4 include compatibility with Windows 7 (including 32 and 64 bit) and users own logo can be displayed on printouts.

Currently costs for new licenses and license upgrades have been kept at last years rates. Please contact Marshall Day Acoustics (pheinze@marshallday.com.au) for further details.

SCANNING INTERNATIONAL NEWS

The European Environment Agency’s Good Practice Guide on Noise Exposure and Potential Health Effects was published in November 2010:

http://www.eea.europa.eu/publications/good-practice-guide-on-noise

The World Health Organization has published a teaching guide on Occupational exposure to vibration from hand held tools. http://www.who.int/occupational_health/publications/Protecting_Workers_Health_Series_No_10/en/index.html

The December 2010 edition of the International Journal of Acoustics and Vibration has five papers on advances in hearing protectors:

http://www.iiav.org/ijav/index.php?va=viewpage&vaid=177&id_number=56

DIARY

2011

22 – 27 May, Prague, Czech Republic
IEEE Conference on Acoustics, Speech, and Signal Processing (ICASSP 2011)
http://www.icassp2011.com

23 – 27 May, Seattle, USA
161st Meeting of the Acoustical Society of America
http://asa.aip.org/meetings.html

27 June – 1 July, Aalborg, Denmark
Forum Acusticum 2011
http://www.fa2011.org

4 – 6 July, Leuven, Belgium
Eighth International Conference on Structural Dynamics (Eurodyn 2011)
http://www.eurodyn2011.org

5 – 6 July, Paris, France
Buy Quiet 2011
http://www.bruit.fr/buyquiet/index.htm

10 – 14 July, Rio de Janeiro, Brazil
18th International Congress on Sound and Vibration (ICSV18)
http://www.icsv18.org

24 – 28 July, Tokyo
19th International Symposium on Nonlinear Acoustics (ISNA)
http://www.isna19.com

24 – 28 July, London, UK
10th International Congress on Noise as a Public Health Problem (ICBEN)
http://www.icben2011.org

27 – 31 August, Florence, Italy
Interspeech 2011
http://www.interspeech2011.org

4 – 7 September, Osaka, Japan
Inter-Noise 2011 - Sound Environment as a Global Issue
http://www.internoise2011.com

20 - 22 September, Buxton, UK
46th Annual UK Conference on Human Response to Vibration
http://www.hsl.gov.uk/health-and-safety-conferences/UKHRV2011/home.aspx

31 October – 4 November, San Diego, USA
162nd Meeting of the Acoustical Society of America
http://asa.aip.org/meetings.html

2 – 4 November, Gold Coast, Australia
ACOUSTICS 2011
http://www.mech.uq.edu.au/acoustics2011/

2012

20 – 25 March, Kyoto, Japan
IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP 2012)
http://www.icassp2012.com

13 – 18 May, Hong Kong, China
Joint meeting of the 163rd meeting of the Acoustical Society of America, the 8th meeting of the Acoustical Society of China, the 11th meeting of the Western Pacific Acoustics Conference and the Hong Kong Institute of Acoustics.
http:// acoustics2012hk.org

2 – 6 July, Edinburgh, UK
11th European Conference on Underwater Acoustics (ECUA 2012)
http://www.ecua2012.com

8 – 12 July, Vilnius, Lithuania
19th International Congress on Sound and Vibration (ICSV19)
http://www.iiav.org/index.php?va=congresses

12 – 15 August, New York, USA
Inter-Noise 2012
http://www.internoise2012.com

9 – 13 September, Portland, USA
Interspeech 2012
http://www.interspeech2012.org

2013

26 – 31 March, Vancouver, Canada
IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)
http://www.icassp2013.com

2 – 7 June, Montréal, Canada
21st International Congress on Acoustics (ICA 2013)
http://www.ica2013montreal.org

Meeting dates can change so please ensure you check the conference website: http://www.icacommission.org/calendar.html

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Full contact details are available from http://www.acoustics.asn.au/sql/sustaining.php

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www.acousticresearch.com.au

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www.acran.com.au

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www.acu-vib.com.au

ADAMSSON ENGINEERING
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www.aaac.org.au

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www.bksv.com.au

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www.csr.com.au/bradford

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www.embelton.com.au

ENERFLEX ENVIRONMENTAL
www.enerflexglobal.com

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www.howden.com.au

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www.colpro.com.au

NSW DEPT OF ENVIRONMENT & CLIMATE CHANGE
www.environment.nsw.gov.au

PEACE ENGINEERING
www.peaceengineering.com

PYROTEK NOISE CONTROL
www.pyroteknc.com

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www.skm.com.au

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