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Common failings of inter-disciplinary studies on noise and the potential solutions

Evaluation of occupational noise exposure levels on the Wellington Suburban Tranz Metro Rail Service

Evaluation of occupational workplace noise levels in an enclosed workshop at KiwiRail

2nd Quarter

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Features

Regulars

Cover Image: Photo of blue English Electric, Ganz-Mavag, red English Electric and Matangi trains - Wellington Suburban.

Source: Photo by Chris Gordon http://vicsig.net

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From the President and the Editor's

President's Column

Dear ASNZ Members, Associates and Fellows,

The gears are turning, and momentum is increasing in the long lead up to our conference in Brisbane on 9-11 November 2016. This is to be an historic event for ASNZ - our first conference held abroad, and thanks to our friends in the Australian Acoustical Society (particular Michael Hayne and his team in the Queensland Division), it is shaping up really well.

I gave a pretty good run down in the last journal, but just in case you missed it..!

We have four plenary addresses, six keynote speakers, 14 invited papers and 132 contributed papers to look forward to... as well as two technical tours, social functions and a trade show that, as of last week, is completely sold out!

In addition, there are three short courses to choose from on 9 November (earlier on the day of the official conference opening). The short course topics are "*Classroom Acoustics - How Innovative Learning Environments are changing the Educational Playing Field*" (which I am organising), "*Sound Perception - Application to Acoustic Practice and Design*" and "*Noise Control Hints and Success*". Everything the inquisitive acoustical mind could hope for!

The ASNZ Council will be offering some funding packages to encourage ASNZ members to head across the ditch, so stay tuned for details on that!

Please visit www.acoustics2016.com.au and see all the details.

In other business, I'd like to offer an apology that the Society's administrative wheels have been rather jammed over the last 9 months or so. Moving our administrative systems from Google Docs to Xero has been a positive step but has taken a very long time, and we aren't yet reaping the benefits of (what will be) a more autonomous system that will rely less on calendar reminders and people's memories! We are behind in invoicing for membership subs, and our processing (well, more importantly... communication!) relating to CPD submissions. Over the next few months we will be making contact directly to iron all this out. Please bear with us!

And now (he says, taking a deep breath...) it's time for me to announce that this will be my last presidential column in the journal, because I will be stepping down at our AGM in November. I have served the maximum two terms permitted in the society rules, so it's time for me to hand over the wheel. I won't be going too far though... the rules also require that I stay on the council for another term, and I'm looking forward to getting stuck into helping in the engine room to support the new president - whoever that may be. We will be calling for nominations for positions on the council and in the executive ahead of the AGM, so it could be you!

I've really enjoyed my time serving as president, reaching out and getting to know more and more NZ acousticians. The numbers show that membership has grown under 'my watch', and I look forward to seeing that continue. There are some exciting changes on the horizon which will ensure that acoustic professionals in NZ are supported, and held to a high standard.

I wanted to sign off with a Monty Python quote, but found it only works if you read it out loud in a silly voice. I know that some of you might enjoy that opportunity, but this time I'll refrain... and offer you a Truman Burbank instead (before stepping out through a door in the sky).

"*Good morning, and in case I don't see ya: Good afternoon, good evening, and good night!*".

Yours faithfully,

James Whitlock

Editor's Column

Welcome to the second issue of the Journal for 2016 (Vol 29 #2). This issue begins with an interesting paper from Inter-noise 2014 dealing with issues that arise in reported inter-disciplinary research on the adverse effects of noise. Of particular interest to those who write noise reports is the issue of using consistent and unambiguous notion for the reported noise measurements.

Then, for the first time as Editors of the journal, we are very pleased to be able to provide some student work. We have two papers by two undergraduate Massey University students, the first paper by Ka'isa Beech reviews occupation noise exposure on locomotive engineers and on-boards rail staff on suburban passenger rail in Wellington while a second paper authored by Elizabeth Satherley looks at an evaluation of occupational workplace noise in a KiwiRail workshop space. Both of these papers were derived from the reports they were required to complete for their undergraduate noise paper in 2015 when the previous health and safetyl legislation was in force.

Lindsay & Wyatt journal@acoustics.org

Journal Feedback and Comments

If you have any feedback on what you would like to see in future issues or even things you don't like to see, please share with us via email to **journal@acoustics.org**, we would like to hear from you! All comments and feedback is treated as confidential by the Editors.

The Acoustical Society of New Zealand

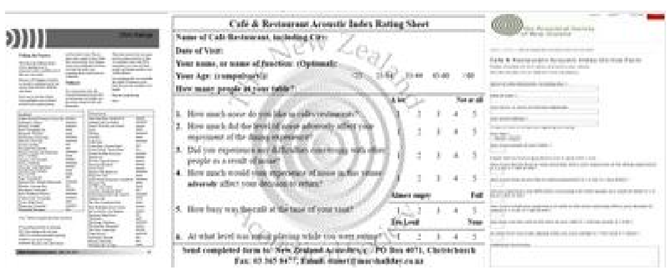
www.acoustics.org.nz

The ASNZ webpage contains a host of information including information on Membership, Journal Information and Journal Articles, Continuing Professional Development, Cafe and Restaurant Acoustic Index, Standards Committees and Standards, the Latest News and Discussion and Contact details of the Society.

Why not visit for yourself?

Cafe and Restaurant Acoustic Index (C.R.A.I.)

The Cafe and Restaurant Acoustic Index, C.R.A.I., is now completely online with all results and online forms able to be viewed and download from the acoustics.org.nz website under the C.R.A.I tab.



Acoustic testing on Orion spacecraft

Acoustic Engineers have successfully completed the first of a series of acoustic tests on the Orion Multi-Purpose Crew Vehicle (MPCV) ground test vehicle. More than 600

...Continued on Page 11

Common failings of inter-disciplinary studies on noise and the potential solutions

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Abstract

Inter-disciplinary research has been published on the adverse effects of noise in health, education and other areas. These studies often produce findings that on close examination are ambiguous; display flawed methodology and conclusions not supported by the measurements. This paper highlights common anomalies and errors in noise assessment which have passed through the peer-review process to publication in journals. Often ambiguity in the findings is the result of using incorrect notation and terminology, combined with a poor understanding of appropriate noise descriptors. It is common practice to perform the statistical analysis on the sound levels in decibels. But this leads to an underestimation of the effect because adverse health effects of noise typically display a dose response to the product of the sound pressure squared and time. Methodologies are often described without reference to best practice or existing standards that typically describe in detail robust measurement procedures. There is a need to educate researchers involved in noise studies about the need for competency in noise measurement and assessment. It also highlights to journal editorial staff about the need to include in their peer review process someone with appropriate expertise in noise.

Keywords: *noise descriptors, acoustics notation and terminology. I-INCE Classification of Subjects Number(s): 80, 81, 56.2*

Originally publish at the 43rd International Congress on Noise Control Engineering November 16-19, 2014

1. Introduction

Noise is ubiquitous and pervasive in most aspects of modern society. As the adverse effects of excessive noise on human health and learning in education environments become more widely known, it is evident that issues of noise will cross many other disciplines and situations. These include the effects of noise on learning and educational performance, particularly for individuals experiencing disabilities such as autistic spectrum disorders (ASD) and hearing impairment. It also includes the effects of noise producing consumer products such as toys, fireworks and power tools.

In the case of educational facilities for children, hearing and auditory specialists have indicated that acoustics must be considered in the design of the learning environment and have called for noise experts and those delivering education to work together to improve the learning environment [1-3]. As a result, there has been an increase in the number of studies on noise in educational environments in reputable peer-reviewed journals. Some of these articles contain fundamental errors, including: incorrect use of equipment and calibration procedures; incorrect notation leading to confusion in interpretation; flawed study design; and use of assumptions and data processing which have questionable validity.

This paper will critically examine a number of articles from peer-reviewed journals where serious errors are evident and also investigate how the noise and acoustics discipline can address the flawed review process which allows such errors to pass undetected. Such articles are generally not published in specialist acoustic journals such as the Noise Control Engineering Journal, Acoustica, Noise and Health or the Journal of the Acoustical Society of America. If they were, competent reviewers in the discipline would recognize such deficiencies as part of the review process and they would be addressed before publication. It is clear in cases where fundamental errors are present that those who reviewed the article had little knowledge of the scientific concepts of sound and acoustics and have therefore taken this component of the paper as being accurate. There appears to be a belief among some researchers that they can conduct a complex noise study with little or no knowledge of the science involved. It also appears that these researchers have little appreciation of the procedures and established standards in the use of sound level measurement equipment and believe they can acquire such instrumentation and operate it competently with the minimum of instruction. Furthermore, some authors have demonstrated a fundamental lack of understanding of the decibel scale when applying statistical calculations and interpretation of data.

2. Case Studies

2.1 Noise in education – Case 1

A study by Maxwell and Evans [4] in 2000 examined the links between chronic noise exposure and reading skills in early childhood education. Ninety children aged 4-5 years were tested on cognitive measures of pre-reading skills in a learning space with poor acoustical quality. Sound level measurements were taken to establish a measure of the acoustical quality of the learning space. In the following year, some acoustical treatment of the learning space was applied and then the tests of both sound levels and testing of the children's pre-reading skills were repeated. The study reported that the cohort in the quieter environment performed better than those tested before the acoustic treatment of the space was carried out.

The first indication that should have raised questions with the reviewers came from the use of the term *decibel meter* and *decibel level*. The correct or formal terminology should be *sound level meter* and *sound pressure levels* measured in decibels.

The study refers to time-average levels ($L_{Aeq\ t}$) using the notation *Leg* throughout the document. Acoustical quality of the learning space was assessed by measuring the sound pressure levels generated in the early childhood center during a specified time. The noise descriptors were described as "*Average decibel level and Peak decibel level*". We interpreted these to be the arithmetic average of the $L_{Aeq\ t}$ readings in decibels for each session. The peak decibel values do not appear to be true peak levels although the instrument used in the study (a B&K 2236) is able to measure peak levels using C or linear frequency weighting (now replaced with Z weighting on modern meters).

The study states that "*Peak and average Leg noise readings were obtained by placing a decibel meter (B& K model #2236) in each classroom for 4 hours duration during similar classroom activity periods*". From this and the use of the term *Leg*, we assume the measurements were the time-average level, $L_{Aeq,4h}$. Consulting the user manual for the sound level meter, *Leg* is probably a mistyped version of *Leq*, the continuous equivalent sound level now known as the time-average level, L_{Aeq}.

While no frequency-weightings were explicitly stated by the authors, they quoted Kryter (1985) [5] stating "*that steady noise at 45 dBA or peak noise (aircraft, cars etc.) at 55 dB A will interfere with speech communication*". Kryter did quote peak levels as A-frequency weighted but in the mid-1980s, instruments capable of measurement of true peak levels were very scarce and what was quoted then were probably the A-frequency weighted, F-time weighted maximum sound pressure levels (L_{AFmax}). However, by the time of the reported study was undertaken, sound level meters such as the one used by the authors could measure peak levels, which are very different from the A-frequency weighted peak values referred to by Kryter, some 15 years earlier. One contributing factor as outlined by Narang and Bell [6] explained that the old IEC 56061 standard for specifications of sound level meters made no reference to the frequency weighting so that such measurements were often done using A or linear frequency weightings rather than the C weighting today.

2.1.1 Confounding factors

The readers would be entitled to question how differences in classroom activities and other confounding factors in the testing regimes before and after treatment were accounted for. Children are not machines and therefore are not going to make exactly the same level of noise from one day to the next. To give an example, in childcare centers which have outdoor play areas, such factors as seasonal weather conditions which may confine children indoors will probably result in very different sound levels to those times when children can go to outdoor play areas. Rates of absenteeism due to sickness are expected to vary greatly throughout the year, affecting the number of children present. Such issues are major confounding factors which will contribute to overall noise levels.

2.1.2 Attenuation with acoustic treatment

There was little explanation in the article of the acoustic treatment applied. It was stated that "semi-height partitions were raised to full height to prevent noise intrusion from other rooms" and that acoustic panels where hung from the ceiling trusses. All certified acoustic treatment materials such as composition panels, ceiling tiles and so forth have an acoustic rating known as a noise reduction coefficient (NRC). Such information would have been useful to any reader contemplating similar acoustic treatment for their facilities.

2.1.3 Appropriate determination of acoustical quality

It is unclear as to why the authors of this study chose peak levels as a measure of acoustical quality. They rightly stated in the text that an appropriate measure of acoustical quality was reverberation time. Commonly, reverberation time is the primary measure for the evaluation of acoustical quality of a room (RT60) [7]. It was not used in this study, presumably because the equipment was not available to make the measurements. While it is well known that reverberation time only gives limited indication of room suitability for speech intelligibility [8], Bradley et al. [9] emphasize the importance of avoiding excessive reverberant sound. These authors found that the reflection pattern is very important in determining the level of speech intelligibility, rather than the measured reverberation level.

2.1.4 Application of statistics to logarithmic values

There were questions about the statistical calculations performed. The decibel scale is a logarithmic scale and has the effects of greatly condensing the sound pressure level range when compared to the original linear units of pressure expressed in Pascal-squared (Pa^2). The human dose response to sound energy received is typically a linear relationship [7] so a doubling of the sound pressure level increases the dB value by only 3 dB. If levels are expressed in dB units, it is essential from a dose perspective that the dB values are converted back to their linear equivalents before performing statistical analysis.

2.2 Noise in education – Case 2

A similar recent research article by Kishimoto in 2012 [10] involved the acoustic treatment of an early childhood center learning space in Brazil. The author is from a College of Education and an acoustic laboratory service was engaged to make the sound measurements. However, there appears to be little acoustic technical input into the interpretation of the sound level data. The author describes "audiometers" as the equipment used (to measure noise levels) to achieve a first evaluation of the situation which also involved measurement of sound levels after applying acoustic insulation to the space. There is clear confusion as to the difference between an audiometer used for hearing evaluation and a sound level meter for measurement of sound pressure levels.

The Brazilian Technical standards for noise were quoted and yet these lacked basic components. A sound pressure level of 40-50 dB A (40-50 dB LpA) was given. However it was not explicit if this was an unoccupied (background sound pressure level) criteria or during education activities where the children and their teachers were present. From experience, this was likely to be an unoccupied background level as if the children were present, they would have had to be very quiet. The values should have been expressed in $L_{Aeq,t}$ dB with a specified time interval. A sound pressure level was given in the Brazilian Labour Standards Regulation "*of up to 65 dB (A), as the limit for comfort*". Finally, a Brazilian Labour Regulation was quoted "*as the limit above 85 dB (A) presents risk of hearing impairment*". This is likely to be the adoption of the international workplace criteria of an A-frequency weighted time-average level of no more than 85 dB over an 8 hour working day ($L_{Aeq\ 8h}$ < 85 dB). This workplace criterion may apply to teaching staff as workers, but it is not applicable to children. In the absence of specific criteria for children, it is common practice to take an existing standard and make some adjustments for children but the limitations of undertaking this practice need to be stated. A similar statement was made in Coppla, Enns and Grandin [11] , "*this exceeds OSHA regulation for workers (90 dB A)*".

This study attempted to use noise measurements in the learning space as a measure of improved acoustic quality. This is problematic due the many confounding factors which must be taken into account. The sound descriptors used were not defined. It would appear from the article that 10-minute time-average levels ($L_{Aeq\ 10min}$ dB) were used but this is not explicitly stated. Five rooms were evaluated by taking sound level measurements in each. An A-frequency weighted time-average level over a full session of an hour or more of 82 dB would be of concern, but this would not be the case for an isolated event producing a maximum sound pressure level (L_{AFmax} dB) of this value. The highest noise level quoted was in room 3 at "*92 dB A*" in the morning session. Four years later in 2011, some type of acoustic treatment in the form of "*anti-noise gypsum plaster modules*" were acquired and were fitted to the ceiling. If these were certified noise insulation materials, then an NRC value should have been quoted to indicate the effectiveness of the material and also allow readers who might be considering a similar treatment to source equivalent performing materials.

The author stated "*The 2011 data (after treatment was carried out) showed a significant decrease in dB (A), compared to the ones in 2007 before treatment was carried out. Most values are between 54 and 58 dB (A) with a reduction of the maximum distance between minimum and maximum indexes of up to 6 points (60-66 dB[A]) when compared to values obtained in 2007, which reached a 32 point difference (60-92 dB[A])*". This of course assumes that the same groups of children in 2007 and 2011 made exactly the same level of noise over the testing regimes and that any noise reduction was due to the attenuation of the learning space.

The results as presented were confusing when comparing the two sets of data from different years. For example data recorded before acoustic treatment in the mornings of Room 1 is shown as a noise level of 60-70 dB (13 June 2007) and 63-75 dB A (18 June 2007) whereas the data recorded after treatment in the morning sessions of Room 1 shown as noise readings of 57/59 dB A (09 March 2011) and 58/62 dB A (15 March 2011). One has to presume that the second data set expressed a range of 57-59 dB A as indicated in the first data set.

2.2.1 Confounding factors

There is a major time difference of 4 years between the two sets of measurements and it is necessary to ask how the obvious confounding factors were addressed. The two sets of measurements were done in different seasons (June and March) which could be a significant confounding factor. If outdoor plays areas are provided, weather may have a major part in confining children indoors due to harsh weather conditions. If sound pressures levels are being measured inside while a number of children are outside playing, this will obviously have an effect on measured sound pressure levels. If education delivery is highly structured (this varies from country to country), observations and activity logs would need to be done with sound level measurements to describe exactly what was happening in the learning spaces and what was generating the noise. There was no reporting of this being done and no information provided about how such obviously confounding factors were addressed. Non-observed sound level measurements are of limited value for this reason.

As for the previous case, reverberation time (RT60) should have been the primary measure of acoustic quality and any sound level measurements should only be used as additional supporting information.

2.3 Peak levels and Maximum sound pressure levels

A common point of confusion often occurs between peak levels (using C or Z-frequency weighting) and A-frequency weighted maximum sound pressure levels (L_{AFmax}). A number of papers quote peak levels as "*A-weighted*" which in a modern context is clearly incorrect. A study by Yarechuk et al. [12] in 1998 in which a range of toys were screened using an instantaneous analogue sound level meter, followed by detailed measurements using a Larsen-Davis sound level meter model 800B, measuring L_{Aeq} dB and peak levels. In trying to determine what the actual descriptors used were, we obtained the manual for the Larsen and Davis 800B sound level meter to ascertain whether or not the meter was capable of measuring an un-weighted (linear) peak level and if so, if there was a lock-out on the meter to prevent the incorrect weighting being applied. The meter was capable of measuring both un-weighted (linear) or C-frequency weighted peak level but there was no lock-out mechanism to stop a user from choosing A-frequency weighting for peak level measurement. As an A-frequency weighted peak level was reported, one has to assume that this was what was actually measured even if it was an incorrect choice. Other publications where similar confusion between peak levels and maximum sound pressure levels include Coppla, Enns and Grandin [11] where peak levels were quoted as A-frequency weighted.

2.4 Notation

Unlike other well established disciplines such as chemistry where the same notation is universally accepted and used, a range of notation styles exist in the noise and acoustics disciplines. Notation can even vary between different international standards such as the ISO (International Organization for Standardization) standard for the safety of toys [13], the ISO standard for the determination of occupational noise [14] and the ISO standard for the determination of environmental noise [15][16]. The A-weighted time-average level (formerly the equivalent continuous sound pressure level) descriptor in the above standards on the safety of toys and determination of occupational noise exposure, use the notation $L_{pAeq\ T}$, with the use of a subscript 'p' to indicate that the level is pressure. There is even considerable variation and inconsistencies between different parts of the same standard as exists between Parts 1 and 2 of the ISO standard on determination of environmental noise levels [15][16]. Peak sound pressure levels are defined without any explicit frequency weighting in Part 1. Similarly frequency weighting for the Sound Exposure (L_E) is not stated, whereas it is most likely A-frequency weighted, while A-frequency weighting is explicitly stated for the continuous equivalent sound exposure level ($L_{Aeq\ T}$).

However, in Part 2 the notation is generalized to $L_{eq\ T}$ where the frequency weighing can be A or C weighting or that of a defined bandwidth. If different frequency weightings are permitted this should be explicitly included in the definitions perhaps with the notation $L_{Xeq\ T}$ where permitted X-frequency weighting are defined. In addition, the above environmental noise standard uses the notation $L_{eq,T}$ omitting the 'p'. There are a variety of other notation styles in common use such as $L_{Aeq,\ (t)}$ dB in the New Zealand Standard for the measurement of environmental noise [17] and the style L_{AeqT} dB in the Australian and New Zealand standard on occupational noise management [18]. The traditional style (now considered obsolete in many jurisdictions) of 'Leq dB A' where the time interval it not included, is still widely used. Apart from standard prefixes, the International System of Units (SI) rules do not allow the addition of suffix or prefix qualifiers to units such as the decibel [19]. While this has been common practice in acoustics and engineering disciplines for many years before the adoption of SI units, the use of notations such as dBA, dBC, dBu or dBm, is not permitted under SI protocols. Such variations can only be confusing to the readers who are not specialists in the domain of application. Ideally it should be mandatory that an international body such as ISO, uses a consistent nomenclature throughout all of its standards.

3. Discussion

It is the experience of the authors that in some cases reviewers and journal editors who are not experienced in noise measurement and so do not understand the technical nature of the subject, demand simplified text to ensure it better fits with their readership. In such situations significant care has to be taken in simplifying the language and notation to ensure it complete and not misleading. Ideally the core technical information should be included for those readers requiring it but done in such a way to not put off the general readership that might be from another discipline such as education. This can be most effectively achieved using a side-panel (containing a glossary of terms and definitions), so not to disturb the flow of the main text.

In the articles reviewed in this paper, confusion often exists between peak sound pressure levels (typically using C-frequency weighting) and maximum sound pressure which use A-frequency weighting. Articles by Maxell and Evans [4], Yaremuchuk et al [12] and Coppla, Enns and Grandin [11] all referred to peak levels as A-frequency weighted. Despite the dates when some of these articles were written, such errors should not have been made given that the instrumentation used in these studies was capable of measuring peak levels correctly. In legal articles, care must be taken over use of terminology in the general sense where there are specific legal definitions which will always take precedence. Authors of articles in sound and acoustics must take care when using such terms as maximum and peak when describing results in a general sense as this can lead to confusion. An example occurs in the paper by Kishimoto [10] which refers to "*peaks of noise*". This can create confusion between the genuine peak sound level descriptor and a local maxima in a time history graph of a particualr descriptor.

Another common issue is the statistical analysis of results expressed in decibel units when the underlying dose-response is a linear relationship between the product of the square of the sound pressure (Pascal-squared) and time. Since decibel units greatly condense the dynamic range, applying statistical analyses to dB values will greatly underestimates the true variance of the dose.

Often decibel values are shown to two-decimal places for results based on taking the arithmetic average of a number of readings. This level of apparent precision is simply not achievable even for a class 1 sound level meter. The New Zealand Standard for the measurement of environmental sound (17) requires in accordance with accepted best practice that decibel values used in calculations are performed to the resolution of the instrument (one decimal place) and all final values are rounded to the nearest whole number for reporting. There is a common "*rule-of-thumb*" guide for ligation purposes which is known as the '3-5-7 rule'. Any sound pressure level measurements taken for compliance purposes which are up to 3 dB in excess of a prescribed legal noise rule or standard are deemed to be compliant because they are within the margin of error. If an activity or operation generates noise which exceeds by up to 5 dB the prescribed legal level, then a formal notification as to the transgression can be made. However, legal proceedings or resolution by a judicial process should not be taken unless the breach is 7 dB or greater due to the level of uncertainly and the robustness of evidence required by the courts.

In the Australian and New Zealand standard for occupational noise measurement [18] the instrument is to be field calibrated with a reference sound source immediately before and after a sequence of measurements are made and if the prescribed variation is exceeded then all measurements taken in between the successive calibration are to be considered invalid. This is standard practice when using sound level meters but in this case the prescribed discrepancy is only +/-0.5 dB, which is unrealistic and probably beyond the manufacturer's specification. In the New Zealand environmental noise standards [17] a discrepancy of 1 dB is prescribed which is considerably more realistic. The occupational noise standard also requires that "*where such a level of discrepancy is recorded, the tester shall ascertain the reasons for minor variations*", which is clearly unreasonable. Environmental noise measurements are usually made over short durations (15-30 minutes) at different times of the day, whereas

personal sound exposure measurements are usually continuous and extend over a working day (8-12 or more hours) where many more confounding factors can come into play.

An article submitted to an acoustics journal concerning the findings of the acoustic treatment of a childcare center learning space are likely to be readily reviewed and technical issues identified by the reviewers. However if the same article is submitted to an educational journal where the focus is say on the improvement in learning outcomes of the children, this level of technical oversight may not occur. Thus it is essential in such a case that professionals with noise experience are engaged by the authors in the write up of the findings and not just in performing the measurements. Noise and acoustics should never be considered an exclusive science or discipline that belongs to a few as the often profound health effects from noise can be harmful and debilitating. It is critical to strive towards the sharing of expertise and dissemination of information in a manner which is meaningful without compromising the integrity of the data by oversimplification.

A review paper by Basner et al. [20] in the Lancet, is an excellent example of how to present and disseminate up-to-date information on noise to those who are not experts in the field. Embedded in the paper were a series of panels explaining the terminology and key noise descriptors such as sound pressure level, the logarithmic decibel scale and the WHO criteria for night noise levels. The authors have used current modern notation and have provided explanations where confusion may occur. This paper alone demonstrates that it is possible to write a high quality robust report and effectively disseminate information to those who may not be specialists in the science of noise and acoustics.

Finally, notation is highly varied and often leads to confusion and ambiguity. Different ISO standards use varying notation which is clearly not defensible in this age of international harmonization of standards. As a start, international bodies such as ISO should ensure consistent notation among all their standards and documents. There is now a need for the development and promulgation of a universal standard for noise and sound descriptors terminology. This notation should then be strictly applied and used by all.

4. Conclusions

The health effects of noise have now become a major issue of concern and due to the serious implications of the adverse health and wellbeing effects of noise, it is imperative that all studies involving noise and health effects are carried out in a scientific and robust manner. Serious errors in taking measurements, processing of data and reporting of findings can negate the value of such studies and important findings which could affect the populations may not be reported. It is also necessary to ensure that such noise studies are reported in a way to enable easy dissemination of the information and findings to a wide range of readers and not just those with expertise in the acoustics discipline.

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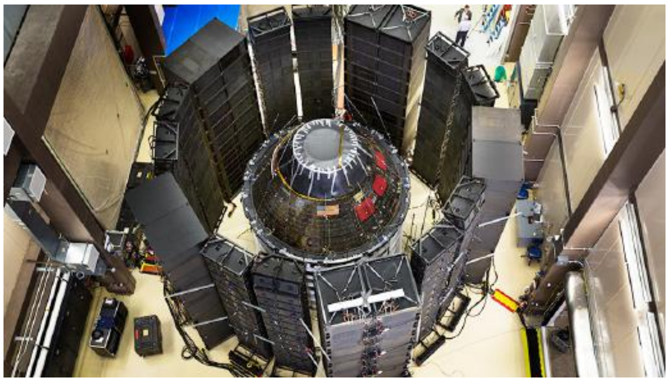
instruments, 500 accelerometers and 100 microphones were placed throughout the Orion crew module/launch abort system stack to test critical components of the spacecraft such as avionics, propulsion and crew life support.



Acoustic Engineers also surrounded the Orion capsule with 1,500 speakers [as pictured] that will duplicate the noise during a launch using one megawatt of power. The series of tests being conducted at Lockheed Martin's Reverberant Acoustic Laboratory near Denver, Colorado, USA, expose the spacecraft to acoustic forces as high as 150 dB being the sound energy a human would experience standing about 50 yards from a jet aircraft. For further information see www.sciencedaily.com

Strengthening of the New Zealand standards system

STANDARDS NEW ZEALAND
PAEREWA AOTEAROA

As of 1st March 2016 Standards New Zealand became a business unit within the Ministry of Business, Innovation and Employment (MBIE) when the Standards and Accreditation Act 2015 came into force. The Act provides that the role and functions of the Standards Council will now be performed by the New Zealand Standards Executive within MBIE from this date. A new Standards Approval Board also started on 1st March 2016.

As part of a government agency, the Standards New Zealand website address will change to www.standards.govt.nz

Clinton campaign blasts reporters with white noise

The MailOnline has reported that Hillary Clinton's campaign has used white noise generator during a fundraiser speech apparently to keep reporters from hearing what is said. The report states that journalists were straining to hear Clintons remarks at a Colorado fundraiser as they found themselves unable to listen when white noise was blasted at them through a powerful speaker. Reporters could hear a band playing but the sound-camouflaging noise engulfed their ears before Ms Clinton began talking. For further information see www.dailymail.co.uk

NCS Acoustics upgrade to webpage

NCS Acoustics
DESIGN · MANUFACTURE · INSTALL

Following on from the name change some years ago, the well established Auckland based NCS Acoustics Limited recently re-launched their website. Over the last 9 months a total of 15 brochures have been released, a combination of revised and new brochures covering Rectangular Attenuators, Cylindrical Attenuators, Acoustic Louvres, Cross Talk Attenuators and NSC's small AFA150 acoustically treated ventilation unit. Also available [after registering] is the NCS Rectangular Attenuator Selector. Brochures under development for future release include Acoustic Doors and Industrial Mufflers, with Acoustic Enclosures following. We recommend that you log-on and look, download and use. Feedback to NCS is welcomed.

For further information see: www.ncsacoustics.co.nz

...Continued on Page 34

Evaluation of occupational noise exposure levels on the Wellington Suburban Tranz Metro Rail Service

[1] Ka'isa Beech and [2] Stuart J McLaren

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Abstract

An occupational noise evaluation study was carried out by Massey University students on locomotive engineers and on-board staff on the two main train sets operating on the Wellington Rail Suburban Network. All measurement results conducted as part of the study show full compliance with the criteria for workplace noise exposure prescribed within the Health and Safety in Employment Regulations 1995. The health and safety noise criterion level permits a maximum dose of 100% which is equivalent to 85 dB L_{Aeq} for a normalised 8 hour working day. The highest measured sound exposure was 13% of the total permitted exposure. All occupational noise measurements were observed and written accounts were taken by the three person investigation team. Observations revealed atypical behaviour of one participant which likely compromised one set of readings. This atypical result was removed from the analysis and therefore did not alter the study conclusions. Regardless, such observed behaviour from the study team, reinforces the value of observed real time field monitoring during collection of data.

Original peer-reviewed student paper

About Ka'isa Beech

Age 23, is training to be a Train Traffic Controller with KiwiRail. She first developed an interest in workplace Health and Safety after joining KiwiRail in 2011, becoming a Health and Safety representative on the Health and Safety Action Team, as well as volunteering for various positions within the Rail and Maritime Transport Union (RMTU). She is currently the elected Assistant Secretary of the Wellington Branch of the RMTU. Her other interests include music. She graduated from the New Zealand School of Music in 2014 with a Bachelor of Music specialising in Ethnomusicology and performs with various groups around Wellington.

Kaisa recently participated in a project to undertake a comprehensive assessment of the Palmerston North heavy engineering KiwiRail workshops and has also developed and delivered a training and education seminar to at risk workers in KiwiRail.

She has now met all the prescribed criteria to be recognised and certified as a "Competent Person" in noise management and assessment under the Approved Code of Practice for Management of Noise in Workplace.

1. Introduction and purpose of assessment

The Tranz Metro Rail Passenger Service is operated by KiwiRail and funded by the Greater Wellington Regional Council [1]. This paper includes summary details of a field investigation and related sound pressure level measurements into an Occupational Health and Safety investigation into the sound pressure levels employees of the Tranz Metro Rail Passenger Service are typically exposed to while performing their duties. This investigation was carried out on five locomotive engineers (also commonly known as '*train drivers*') and five on-board staff (also commonly known as conductors or ticket collectors) while working on the trains. Measurements were based on exposure to staff while predominately inside the train cabin or engineers cabin, however limited periods outside for on board staff while performing platform based duties was also collected.

The investigation was undertaken in general accordance with the Australian/New Zealand Standard 1269:1:2005 *Measurement and Assessment of Noise Immission and Exposure* [2]. The study compares the measured sound pressure level data gathered in order to assess whether the two selected staff types of Tranz Metro staff (Engineers and On-Board Cabin Crew) when exposed to occupational noise (throughout a typical 8 hour working shift) comply with the criteria of Regulation 11 of the Health and Safety in Employment Regulations 1995. This requires that all practicable steps must be taken to ensure employees are not

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exposed to a time average sound pressure level exceeding 85 dB $L_{Aeq\ 8h}$ over normalised 8 hour working day, and not exposed to any single sound pressure level in excess of 140 dB L_{Cpeak} at any time, regardless of their daily sound exposure. Unlike the of 85 dB $L_{Aeq\ 8h}$ exposure limit, the peak level is not based on the daily noise exposure but an absolute exposure limit at any time throughout the working day. The reasoning behind this is that any sound event equal to and in excess of 140 dB L_{peak} level can potentially cause permanent hearing loss.

2. Method of investigation

The method of investigation involved measurement of sound pressure levels via the use of personal sound exposure meters. The method chosen was to place one single personal sound exposure meter on the shoulder of each of the five locomotive engineers as well as on each of the on-board staff members. The field measurements took place over the working day on Thursday 10th April 2014 between the hours of 10.40am and 6.40pm (10.40 hrs-16.40 hrs).

Tranz Rail, operate two types of electrically powered train units, the older 'Ganz Mavag Units' and the recently acquired 'Matangi Units'. As both types of units are operated in service, measurements focused on sampling sound pressure levels across both types of units. Measurements were conducted across five return passenger train trips across the network of four lines (Kapiti, Johnsonville, Meilling and Hutt valley). The Ganz Mavag Units have been in service for more than 50 years and are gradually being decommissioned and replaced by the modern Matangi Units which will make up the entire Wellington based passenger fleet as the older Ganz Mavag Units are phased out. Remodelled units from the older Ganz Mavag units known as the SuperGanz Unit are also in operation, but were not studied because there are very few in operation. There are also two regional passenger services being the "*Wairarapa Line*" operating between Wellington and Masterton and a "*Capital Connection*" commuter service operating between Wellington and the Palmerston North. These regional passenger services were also not included in the study due to time constraints. Both the Wairarapa and Capital Connection Lines are of rolling stock pulled by diesel locomotives and hence further study would be worth investigating.

3. Overview of units tested

Matangi is the Maori word for wind. The Korean built Matangi Units are technically called the "*FP/FT Matangi Units*" which are a class of electric multiple units consisting of a single FP unit and FT unit. The FP Unit is the power car and an FT is trailer or dummy car. The units were built by Hyundai Rotem especially for New Zealand. The Matangi Units were progressively introduced from 2004 to allow for the retirement of the remaining DM/D class "English Electric" multiple units that were introduced between 1949 and 1954. Multiple units can be coupled together depending upon demand such as peak hour. The passenger compartment of one unit can seat up to 147 people. Figure 1 is a composite photo set of the exterior, interior passenger carriage area and locomotive engineer's cabin of the Matangi Unit.

Figure 1: Matangi unit

The Ganz-Mavag Units are technically called the "*EM/ET Class Units*" which are a class of electric multiple units consisting of a single EM unit and ET unit. The EM Unit is the power car and an ET trailer or dummy car. The Ganz-Mavag units are named after the manufacturer being the Ganz-Mavag of Budapest, Hungary. As with most units, multiple units can be coupled together depending upon demand such as at peak hour usage. The passenger compartment of one unit can seat up to 148 people. Figure 2 is a composite photo set of the exterior, interior passenger carriage area and locomotive engineer's cabin of the Gavz -Mavag unit.

Figure 2: Ganz-Mavag unit

4. Overview of internal wagon noise

There are two types of internal wagon or compartment noise - airborne and structure borne transmission.

Airborne noise sources include:

- Air-conditioning (Matangi units)
- Bogies
- Engine and auxiliary equipment

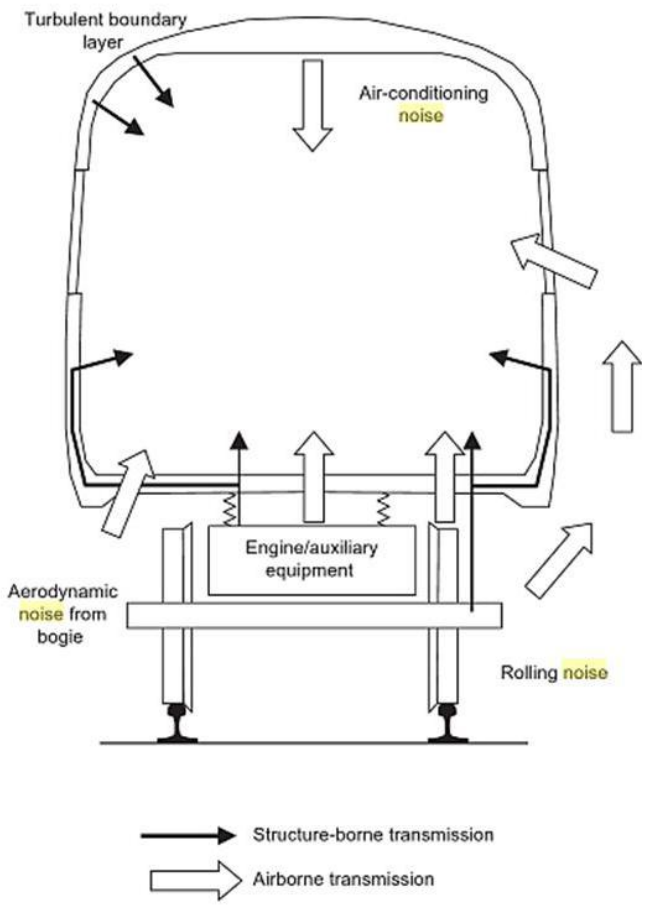

Figure 3: Noise transmission pathways

- Rolling noise noting that which enters through windows especially if the unit has opening windows (Ganz-Mavag units)

Structure borne noise conduction includes

- Engine and auxiliary equipment
- Bogies
- Noise from turbulent boundary layer
- Rolling noise from wheels, track and bogies

The new Matangi units have no opening windows due to air conditioning being fitted except in the engineer's cabin and areas where passengers do not have access. The non-air-conditioned Ganz Mavag Units have windows throughout which can be opened.

Other noise sources will include that generated by occupants such as passengers and crew, external noise sources such as passing over bridges, through tunnels, and warning signals such as horns and sirens. As much the testing was done at off peak hours, the trains were not crowded, with less than half the seated capacity occupied at any one time.

The most noticeable noise in all the trips carried out was the track squeal on the Johnsonville line which is due to the tight curvature of the tracks. While it was not of sufficient sound pressure level to be an occupational noise issue, the audible characteristic of this noise has been reported as causing annoyance to nearby residences. Similar issues have been reported in Australia where Transport for New South Wales (TfNSW) has undertaken an intensive study on track squeal which has been reported by Hanson et al. [3].

5. Measurement equipment

Four Digitech QM1599 Class 2 sound level meters were used to collect data for the study. While these instruments were not specifically designed as personal sound exposure meters (dosimeters) they were able to be adapted as screening student training meters by building a shoulder mount with a leather pouch which was pinned to the shoulder. Prior to beginning the assessment, the dosimeters were calibrated using a Pulsar101 Calibrator (set at 93.7 dB). Measurements were taken in general accordance with the Australian/New Zealand Standard AS/NZS 1269.1:2005 Occupational Noise Management. While the instruments were not independently certified as required by AS/NZS 1269.1, the calibrators used were internally calibrated under laboratory conditions with a certified Class 1 sound level meter with current laboratory verification. Comparative tests have shown that these instruments had +/- 3 dB accuracy for L_{Aeq} dB measurements which is what can be expected from a Class 2 instrument. These instruments were unable to give true L_{Cpeak} dB levels but a non-standardised peak value was given. We have assumed that this is reasonably close to a true peak level for the purposes of this study. Regardless, there are no apparent noise sources in this work environment that would create a peak level at or above 140 dB L_{Cpeak}.

The dosimeters were attached to the shoulder of the individual and were placed as close to the ear as possible. All the staff members we approached were willing to participate. Staff were selected based on the type of unit and line they were working on and to fit into the limited time available for the testing schedule. Each measurement period was typical of a return train trip from the Wellington Railway Station terminal.

As the instruments did not automatically calculate sound exposure, these were calculated by converting the L_{Aeq} dB values to their linear equivalents (Pa^2 values) and multiplying by the run time (in hours) to give sound exposure in pascal squared hours (Pa^2h). Conversion to a percentage gave the % dose values.

A comprehensive log was recorded by the investigators who were seated in the passenger areas on all the trips. It was not possible for the investigators to be present in the driver's cabin due to a strict the health and safety policy while the units are in operation. Sources of noise only heard by the locomotive engineers could therefore not be identified but observations proved invaluable in describing the types of noise in general and detecting any actions or atypical behaviour which might compromise results/ or tapping the device. If such actions were clearly observed occurring, recordings were discarded.

6. Weather conditions

The weather conditions during the field testing on Thursday 10th April 2015 were overcast with rain and light wind while at Wellington Station. It is possible for the microphone to also pick up the sound of rain and wind (especially wind shear across the microphone) and this may interfere with measurements. While weather conditions can be variable to where the train travels, changes were not sufficient enough to remove dosimeters to prevent damage from the weather or to a cause undue interference from rain and wind noise.

7. Measurement and Assessment

7.1 Individual Trip Data

The following presents measurement data collected on Thursday the 10th of April 2015 between 10.40 am and 6.40 pm.

7.1.1 Trip One

10.44 am train to Waikanae (terminal), all stops to Waikanae. 12:00 pm train from Waikanae, all stops to Wellington; Matangi 4 car set.

Table1: Results for Trip One

Time / run-time Sound measurement	Locomotive engineer One 1041 – 1304 (2 hours 23 mins)	On-board staff member One* 1047 – 1301 (2 hours 14 mins)
L_{Aeq}	75 dB	85 dB
L_{peak}	115 dB	119 dB
Dose %	3 %	28 %

* The staff member concerned was observed continually singing and talking into the dosimeter in an abnormal way. These results were not included in the study but listed here to demonstrate the value of observed monitoring where such incidents would otherwise go undetected.

The L_{peak} value of 115 dB for locomotive engineer one, appears high and is probably a false peak due to the dosimeter accidently touching a wall or other object while being worn.

7.1.2 Trip Two

11.02 am train to Johnsonville (terminal), all stops to Johnsonville. 11.30 am train to Wellington all stops to Wellington. Matangi 4 car set.

Table2: Results for Trip Two

Time / run-time Sound measurement	Locomotive engineer Two 1055 – 1157 (1 hour 2 mins)	On-board staff member Two 1047 – 1301 (2 hours 14 mins)
L_{Aeq}	69 dB	73 dB
L_{peak}	101 dB	101 dB
Dose %	0.3 %	1.8 %

7.1.3 Trip Three

3.57 pm train to Upper Hutt, express to Waterloo/express to Taita/all stops from Taita. 4.45 pm from Upper Hutt, express to Wellington. Ganz Mavag 4 car set.

Table3: Results for Trip Three

Time / run-time Sound measurement	Locomotive engineer Three 1553 – 1713 (1 hour 20 mins)	On-board staff member Three 1541 – 1714 (1 hours 33 mins)
L_{Aeq}	74 dB	73 dB
L_{peak}	100 dB	101 dB
Dose %	1.3 %	1.5 %

7.1.4 Trip Four

4.17 pm train to Melling, all stops to Melling. 4.41 pm train from Melling, all stops to Wellington. Matangi 4 car set.

Table 4: Results for Trip Four

Time / run-time Sound measurement	Locomotive engineer Four 1555 – 1648 (54 mins)	On-board staff member Four 1552 – 1648 (56 mins)
L_{Aeq}	75 dB	69 dB
L_{peak}	115 dB	101 dB
Dose %	1.1 %	0.3 %

7.1.5 Trip Five

5.50 pm train to Taita, all stops to Taita. 6.07 pm train from Taita, all stops to Wellington. Ganz Mavag 4 car set.

Table5: Results for Trip Five

Time / run-time Sound measurement	Locomotive engineer Five 1748 – 1842 (54 mins)	On-board staff member Five 1749 – 1841 (52 mins)
L_{Aeq}	74 dB	74 dB
L_{peak}	98 dB	102 dB
Dose %	0.8 %	0.8 %

7.1.6 Results summary

The results across all trips can be summarised as follows:

Locomotive Engineers

L_{Aeq} 69 -75 dB

L_{peak} 98 – 115 dB

% Dose 0.3 – 1.1%

On – board staff

L_{Aeq} 69 -74dB

L_{peak} 98 – 115 dB

% Dose 0.3 – 1.8 %

The sound exposure (% dose) calculation for Locomotive Engineer (worst case scenario):

$L_{Aeq\,2.4h}$ = 75dB => 0.0126 Pa^2

0.0126 x 2.4 = 0.0302 Pa^2h

Sound exposure ($E_{A\,t}$) = 2.4 x 0.0126 = 0.030 Pa^2h

%Dose = 0.03 x 100 = 3.0 %

Dose corrected for an 8 hour working day = 3.0 x 8/2.4 = 10 % (assuming that the same level of noise was received over a full 8 hour working day).

7.2 Health and Safety in Employment Legislation

The Health and Safety in Employment Act 1992 (HSE 1992) was the principal health and safety statute in force when the investigation was carried out. The object of the Act is to promote the prevention harm occurring in the workplace, including potential harm from noise. Duty holders [employers] are required to take all practicable steps to remove, control, or otherwise manage hazards in the workplace including noise.

The Health and Safety in Employment Regulations 1995 (Regulation 11) requires that employers must take "*all practicable steps*" to ensure employees aren't exposed to a noise exposure level $L_{Aeq\,8h}$, of 85 dB(A) and a peak noise level, L_{peak}, of 140 dB, regardless of whether the employee is wearing hearing protection.

Sub-clause (3) of Regulation 11 states that where an

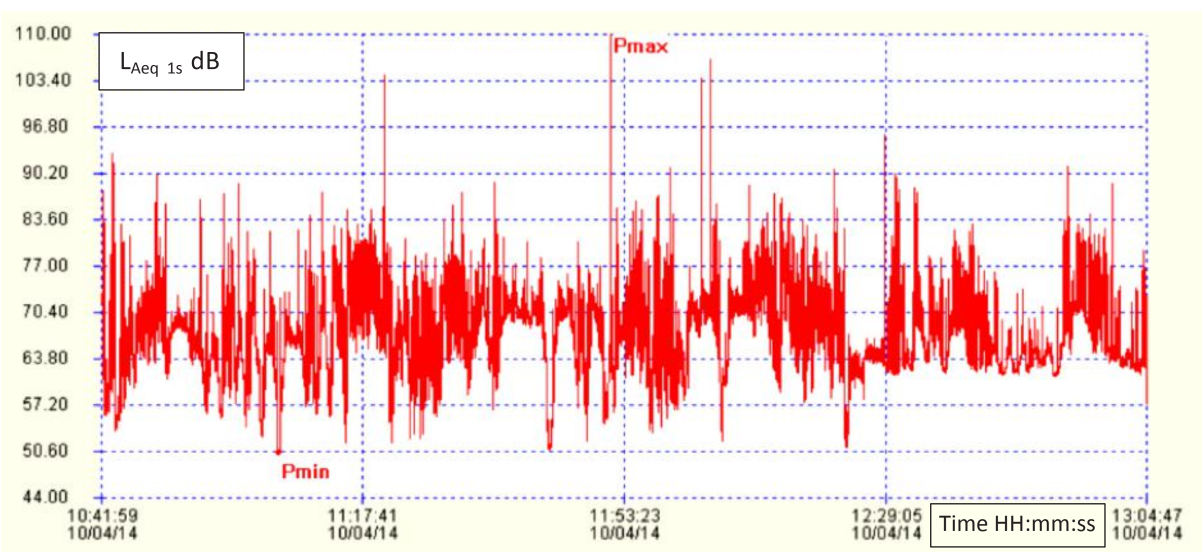

Figure 4: Time history for locomotive engineer (Trip One - 10.44 am return trip to Waikanae)

employer has taken all practicable steps to ensure that no employee at any place of work under the control of that employer is exposed to noise above the levels specified in subclause (1) but has not eliminated the risk that any employee may be exposed to noise above those levels, the employer shall communicate clearly, by way of signs, labelling of machinery, or other appropriate means:

a) the fact that noise levels at the place of work are or are likely to be hazardous; and
b) the sort of personal hearing protection device that is suitable to protect against the noise levels
c) where such a device may be obtained.

8.3 Assessment

Based on the selected testing, all results were well within the criteria of Regulation 11 the Health and Safety in Employment Regulations 1995. While the equipment was of Class 2 specification, it is likely that there is full compliance with the legislation on these units and operations, as sound levels recorded were well below the above legal criteria.

The sample results indicate a highest L_{Aeq} dB value of the locomotive engineers was measured at 75 dB L_{Aeq}, and for on-board staff this was 74 dB L_{Aeq}. The highest peak level of the locomotive engineers was 115 dB L_{peak} and of the on-board staff at 98 dB L_{peak}. It is however noted that these levels are an estimate due to the limitations of the Class 2 equipment and actual L_{peak} levels would be expected to be well below the 140 dB L_{peak} criterion in a test environment such as this. Even taking the worst case scenario of an estimated daily noise dose reaching 10%, this is well below the maximum permitted dose of 100% which is equivalent 85 dB $L_{Aeq\ 8h}$. It is worth noting that if occupational noise levels approached the criteria prescribed in Regulation 11, it would be extremely uncomfortable for passengers and a serious hindrance to staff in carrying out their duties.

During the running of the units, locomotive engineers predominantly stay within the driver's cabin, it is possible to open the window and the locomotive engineers carried out this function during some of the assessments. The locomotive engineers also leave the cabin and walk outside the units for inspection before departing the station. As this occurs before each departure, this exposure is included within the measurement results. Staff were briefed to carry out their duties as normal and not do anything different while wearing the dosimeters.

When considering the operation of the train for on-board staff, although staff members are seated within the passenger compartment in between stations, they are required to step off the train at each station to check that passengers have completely disembarked or boarded the train. They are also required to walk in between the sets when the train is moving to collect fares. A comprehensive log was recorded by the investigators who were seated in the passenger areas on all the trips, but it was not possible for the investigators to be present in the driver's cabin due to the health and safety policy. Sources of noise only heard by the locomotive engineers could therefore not be easily identified.

Observations can be invaluable in describing the types of noise in general and also detecting any actions or atypical behaviour which might compromise results. These include deliberate talking, singing into the microphone or otherwise tampering with the dosimeter being worn.

In regards to the typical operations and noise exposure, the units may stop at all stations and in some cases only stop at selected stations.

7.4 Second tier health effects (Non-auditory effects)

It is well documented that there are additional health risks relating to both health and productivity that should be managed in terms of occupational noise that may not cause auditory damage [4]. Non-auditory effects of noise may be defined as all those effects on health and well-being which is cause by the exposure of occupational noise with the exclusion of effects on the hearing organ [ear]. These non-auditory effects can themselves have a host of second tier health effects including sleep disturbance and also inducing physiological and physiological stress. In all cases, the level of effect depends on a host of factors including levels of sound, types of sound and also exposure times. However annoyance and stress, for example, do not necessarily relate to or depend on the absolute sound pressure level. The potential of annoyance from occupational noise may need to be considered in regard to health effects. Such potential effects can be compounded by a host of other factors including age, existing hearing disabilities or other medical conditions.

7.5 Limitations

These results presented here were undertaken as a student project and had various limitations including the type of equipment and limited sample size. Results included only the Tranz Metro employees operating the Ganz Mavag and Matangi Units for only a limited test time. No other measurements were taken while undertaking other typical other duties that are performed over an average working day, due to time constraints. Based on the sound exposures recorded and the length of time of the typical shifts, there are unlikely to be any significant non-compliance issues with these units, as all measurement were well within the criteria prescribed in the legislation.

These measurements also excluded the regional services, Wairarapa and Capital Connection service (to Palmerston North) which use locomotives and carriages which are a completely different type of train to the Matangi and Ganz Mavag electric multiple units. The SuperGanz train, a remodelled version of the Ganz Mavag was also excluded from this assessment.

Equipment used was a limitation of accuracy, as the dosimeters did not fully meet the Occupational Noise Management standard AS/NZS1269:2005, as they are provided as training equipment. However internal calibration and verification under laboratory conditions revealed an accuracy of +/- 3 dB which is an acceptable tolerance for a Class 2 meter. The dosimeters were unable to record true peak levels, however the equipment was able to give a reasonable estimation suitable for screening purposes that both L_{Aeq} and L_{peak} levels were unlikely to be exceeded.

8. Conclusion

The results gathered from assessing the noise exposure of locomotive engineers and on-board staff performing limited duties on the Tranz Metro Rail Passenger service showed full compliance with the noise criteria set within Regulations 11 of the Health and Safety in Employment Regulations 1995. An unexpected finding of the study reinforced the value of carrying out observations with personal sound exposure measurements as a participant was observed singing and talking into the dosimeter – something that may have otherwise not been detected.

9. Recommendations

After completing this investigation and considering the limitations and findings of the results it is recommended that:

1. An investigation is carried out on the Wairarapa line, Capital Connection and on the SuperGanz train sets. These include train sets which staff had identified as being reasonably loud and there were no measurements taken on these trains.
2. Measurements need to be taken to measure the other duties that locomotive engineers and on-board staff members are required to carry out during their average day of work. This assessment only measured the levels of noise employees were exposed to while they were running the passenger service. However, it is important to measure the other duties. The employees work on a rotating shift, which means some days they may mainly be driving trains, while other days they are mainly relaying trains between the yard and the platform.
3. It would be important to measure the noise on-board staff are exposed to on the “school trains.” Staff members have reported noise levels as quite loud and find it hard to concentrate. If this is identified, practicable measures to minimise the noise could be investigated.

10. Acknowledgments

We would like to thank all the staff who contributed to this study by wearing personal sound exposure meters (dosimeters). In addition we would like to thank the management team Scott Sargent, (Health and Safety Advisor), Patrick Maney, (Injury Prevention and Wellness Manager), Rob Gordon (Metro Manager), Scott Brooks (Former Metro Manager), Natalie Thompson,(Tranz Metro On-Board Manager), and Mike Fenton (Tranz Metro Operations Manager) for their assistance and permission to undertake this study.

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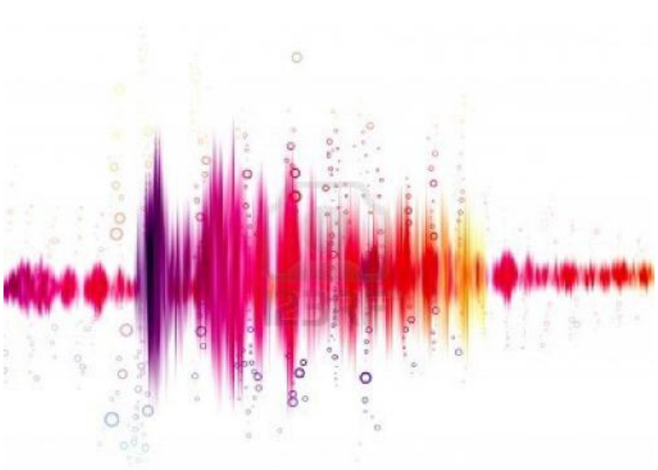
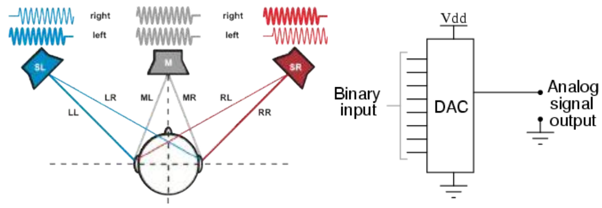


Fifteen Question Quiz

"The hammer never complains of the noise"



Q1. What is the symbol for acoustic impedance and what are its SI units ?

Q2. In Building Acoustics, what do the two terms "STC" and Rw stand for?

Q3. True or False, L_{peak} and L_{max} mean the same thing?

Q4. Why might two crying babies be perceived as being more than twice as loud as one?

Q5. Briefly describe the differences between an '*anechoic chamber*' also referred to as 'Full anechoic chambers' and a 'semi-anechoic chamber' and give an example of when a semi-anechoic chamber may be used.

Q6. The 'incus' is a term used for the middle of the three bones in the middle ear, what is another name for 'incus'

Q7. True or false 'sone' and 'phon' are both units of loudness?

Q8. What does the term "DAC" stand for?

Q9. Briefly explain what is meant by the term "Sound Insulation".

Q10. Briefly explain what is meant by the term "Frequency Weighting".

Q11. Briefly explain what is an "audiogram".

Q12. What are the key factors that limit the practicable attenuation of an acoustic barrier to about 15 dB?

Q13. Name the two basic forms of sound level meter (SLM) design approved under IEC 61672.

Q14. Two small and extremely quiet sound sources with a measured sound pressure level of 7 dB each, are placed next to each other. What is the notional combined sound pressure level of the two sources?

Q15. What is facade correction and when would you apply it?

Find the answers on Page 37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• Renhurst
• Seismic Solutions
• Rondo suspended ceiling systems
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• Rondo partition
• Monz partition
• Autex cube panels
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In the later part of 2015 and the start of this year there were a notable number of Environment Court decisions in which acoustics issues were prominent. Several involved multiple decisions being issued prior to finalisation. Following are brief summaries of these proceedings but full copies of these decisions can be found on the RMA Net website at: www.rma.net

In the Environment Court

QUIETER PLEASE (TEMPLETON) INC, CANTERBURY CAR CLUB INC - Appellant

CHRISTCHURCH CITY COUNCIL - Respondent

WARWICK & MARIANNE WRIGHT, CHRISTCHURCH INTERNATIONAL AIRPORT LIMITED, CHRISTCHURCH SPEEDWAY ASSOCIATION INC – s274 parties

[2015] NZEnvC 167, 81p, [206] paras, 23 September 2015 - First Interim Decision

[2016] NZEnvC 012, 20p, [47] paras, 27 January 2016 - Second Interim Decision

[2016] NZEnvC 044, 14p, [18] paras, 15 March 2016 – Final Decision

Summary of Facts

Plan Change 52 (PC52) sought to address noise emission problems to nearby residents from the Ruapuna Motorsport Park just outside of Templeton, Christchurch, whilst not unreasonably restraining the Park's use. The appeals concerned the proposed provisions of PC52, with the key issue being which of the parties provisions best ensured that noise emitted from the Park did not exceeded a reasonable level. The Court was asked to consider two sets of provisions; one from the Car Club, which was largely supported by the Council and the Speedway Association, the other from Quieter Please. The fundamental differences centred around the frequency, duration and level of the noise emissions that should be permitted under PC52 as well as proposed development controls on surrounding land said to be for reverse sensitivity purposes.

The Court discussed the background to PC52, the Park's surrounding environment, and set out a broad overview of PC52 before discussing the legal and planning framework. The Court noted the timeliness of the decision was affected by the streamlining processed available to the Council's Replacement District Plan under the Canterbury Earthquake (Replacement District Plan) Order 2014, as well as the consideration of the Court's jurisdiction over certain provisions under s293.

The Court had three key issues for determination;

(a) Were the proposed objectives and policies appropriate? - The Court held that a new Motorsport Objective and Policy were appropriate.

(b) What maximum noise level, duration and frequency controls should be applied to the Park? - Overall the Court held the other parties' proposed version comprised an appropriate mix of potentially available measure and controls and was satisfied that the mitigation measures proposed would result in a reasonable noise environment for residents between the Inner and Outer Noise Boundaries.

(c) What controls should be placed (if any) on noise sensitive activities between the Inner and Outer Noise Boundaries? - The Court determined it would not be a proportionate response to maintain an unamended version of Rule, but noted the Car Club's preferred approach possibly required consideration under s293 and as such the Court reserved its determination.

The Court also endorsed and adopted other amendments including provisions for quieter vehicles on Mondays, "Monday free" provisions, 10 weekend-free days and the requirement for Noise Management Plans. Overall the Court was satisfied that the rules it approved would provide the appropriate balance to enable those who enjoyed the Park activities and those who lived nearby to provide for their social and economic well being.

Court held:

Appeals by the Canterbury Car Club Inc and Quieter Please (Templeton) Inc allowed in part.

Parties directed to lodge submissions and prepare changes to the District Plan in relation to s293 considerations discussed including consulting relevant parties as to changes to PC52.

Further Decisions

Subsequently the parties continued to dispute the weekday noise provisions that should apply; the definition of noise-sensitive activities; and whether or not the boundary logger was the most appropriate place for noise monitoring. In decision [2016] NZEnvC 012 a key question for the Court was which of the proposed provisions provided a "bucket of noise" that enabled the Court to reach the conclusion that, overall, the noise emitted from the site was reasonable. The Court agreed that it was difficult to separate weekday and weekend noise as they were interrelated and went on to detail the number of days and noise levels acceptable. The Court confirmed and directed the Council to amend the definition of "noise sensitive activities" and agreed with the Council's position in relation to the data logger and that a second logger was not required. In decision [2016]

NZEnvC 044 the Court reviewed and was satisfied that the condition amendments met the changes identified in the interim decisions and confirmed changes to PC52 as outlined in Appendix A.

In the Environment Court

ZJV (NZ) LIMITED - Appellant

QUEENSTOWN LAKES DISTRICT COUNCIL - Respondent

SKYLINE ENTERPRISES LIMITED - Applicant

[2015] NZEnvC 205, 74p, [208] paras, 25 November 2015 – Decision
[2016] NZEnvC 090, 26p, [44] paras, 12 May 2016 – Final Decision
[2016] NZEnvC 091,11p, [31] paras, 12 May 2016 – Cost Decision

Summary of Facts

In 2011 Skyline was granted consent to extend its helicopter landing area adjacent to the Skyline Gondola Building on Bob's Peak within the Ben Lomond Recreation Reserve above and west of central Queenstown. ZJV, the owner of a neighbouring commercial recreation activity appealed the consent.

The overall proposal was a discretionary activity. The Court assessed the relevant provisions of the District Plan and the Ben Lomond Reserve Management Plan (BLRMP) and considered the Civil Aviation Rules. Positive effects of the proposal were agreed to be for approved helicopter operators and their customers and a novelty/enjoyment factor for those watching. Negative effects included dust and odour emissions, visual effects and effect on landscape, noise, effects on safety and cumulative effects. The Court went onto focus on the noise issues including short term noise effects, average sound levels over a twenty four hour period, cumulative noise with the existing noise environment and the fact that the helipad had been in use for forty years. The Court also discussed the effects of the activity on safety, including fire risk and interaction with pedestrian, cyclists and paragliders.

The Court considered that the effects fell under two areas; amenity and safety. It accepted that too many movements would have an adverse effect on the use and enjoyment of the surrounding environment and the quality of ZJV's client's experience. The Court also found the location and operation of the helipad in relation to other nearby activities was compromising levels of public safety. The Court concluded that limiting the working noise limit to 60 dBA Ldn and a maximum of four flights per day would adequately deal with the adverse effects, achieve the objectives and policies of the District Plan and be consistent with the BLRMP. The Court instructed parties to revise the conditions in light of the decision.

Court held:

Resource consent confirmed for 5 years for a maximum of 4 flights per day subject to amended conditions attached.

Remainder of the appeal refused.

Further Decisions

Final decision [2016] NZEnvC 090 focused on resolving remaining issues in relation to the Helicopter Management Plan. In cost decision [2016] NZEnvC 091 the Court ordered Skyline to pay ZJV $18,000.00 towards their costs.

In the Environment Court

FRIENDS OF MICHAELS AVENUE RESERVE INCORPORATED (FOMAR), CO-OPERATIVE AND ASSISTED ASSOCIATION NZ (ANDERSON HOUSE) - Appellants

AUCKLAND COUNCIL - Respondent

AUCKLAND COUNCIL (PARKS SPORTS AND RECREATION - Applicant

[[2016] NZEnvC 005, 44p, [96] paras, 15 January 2016 - Decision
[2016] NZEnvC 082, 4p, [10] paras, 10 May 2016 - Decision
[2016] NZEnvC 113, 44p, [96] paras, 10 June 2016 –

...Continued on Page 32

Evaluation of occupational workplace noise levels in an enclosed workshop at KiwiRail

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Summary

An occupational workplace noise evaluation was carried out of in the engineering shop and locomotive stripping and preparation areas of KiwiRail shop in Hutt City. Five hand draw cutting saws were evaluated. Measured sound pressure levels (at the position of the operator's ear) increased substantially for four of the saws as they were put under load. Overall the measured sound pressure levels ranged from 88 dB to 101 dB L_{Aeq} *for the duration of trial. One saw emitted a sound pressure level of 101 dB* L_{Aeq} *unchanged when operating under free running conditions and loading.*

An evaluation of the locomotive striping and preparation area revealed general steady sound pressure levels ranging from 100 - 102 dB $L_{Aeq\ 1.5h}$ *as measured by four fixed sound level meters placed around the study area. The nature of the work and protective clothing worn did not permit personal sound exposure meters (dosimeters) to be fitted to the workers during the evaluation. An alternative method prescribed in the Australian and New Zealand Standard AS/NZS 1269:2005 for Occupational Noise Management, was therefore adopted. Class 5 hearing protectors were provided, but found not to be fitted correctly by the employees.*

As this is a high risk operation for excessive noise exposure, a number of recommendations have been made which included: an alternative form of hearing protection for the workers due to the nature of the work that is done; the implementation of a training and education programme as outlined in the approved code of practice for the management of noise in the workplace; and adoption of a 'Buy quiet' policy when replacing tools and equipment.

Original peer-reviewed student paper

About Elizabeth Satherley

Elizabeth is a student completing her Bachelor of Health Science majoring in Human Health and the Environment. She now works as an on-board staff member and a Train Manager on the Wellington Suburban passenger rail network. She is completing her studies on a part time basis and is a mother of two young children.

This work was a practical component of the Massey University Course, 'Bio-physical Effects of Noise Vibration' at 300 level. Elizabeth recently participated in a project to undertake a comprehensive assessment of the Palmerston North heavy engineering KiwiRail workshops and has also developed and delivered a training and education seminar to at risk workers in KiwiRail. She has now met all the prescribed criteria to be recognised and certified as a "Competent Person" in noise management and assessment under the Approved Code of Practice for Management of Noise in Workplace.

1. Introduction

KiwiRail is a state owned enterprise and a statutory enterprise that operates as a single entity with multiple business units. The different elements of the KiwiRail operation include freight, interisland ferry operations; suburban passenger trains services, long distance passenger services and extensive freight rail services throughout New Zealand. KiwiRail is also a tourism operator, as well as being a property owner and developer. The corporation operates a number of heavy industry workshops in main centres of New Zealand for repairs, maintenance, refurbishing and refitting of locomotives and rolling stock.

This report is based on a health and safety investigation into noise levels of selected workshop operations and related tools in the heavy engineering workshop of KiwiRail, located in Hutt City, Wellington, New Zealand. Sound pressure level measurements were taken while locomotive panels and the supporting structure were being stripped of paint and rust with the surface being prepared for repainting. Further sound pressure measurements were taken for five different metal cutting draw saws that staff identified as producing significant levels of noise within the enclosed workshop space. The measured data was analysed according to the Australian and New Zealand Standard for Occupational Noise Management (AS/NZS 1269:2005)[1,2].

2. Evaluation

An occupational noise evaluation was carried out in select locations and on selected plant. The scope of the study included:

- Five different metal cutting draw saws were each assessed for estimated noise levels received by the operators when free running and under load.
- Locomotive preparation area - paint and rust stripping using hand held grinders, sanding machines and needle guns.

The panel stripping work generates a high level of noise and dust so a full range of protective clothing was worn, including:

- Full eye and hearing protection (ear muffs)
- A full body disposable overall, including a bonnet covering the head
- Protective footwear

Due to the bonnet covering the ears, ear muffs were observed being worn over the bonnet which would prevent an air tight seal between the cup and the head reducing their effectiveness.

2. Methods of investigation

All sound pressure level measurements were carried out using a "Center 332 Sound Level Meter" used by students at Massey University for training and teaching purposes. These sound level meters are manufactured to a Type 2 specification. Field calibrations was carried out in accordance with the standard procedures in the Occupational Noise Management Standard AS/NZS 1269:2005.

The sound level meters were not verified by an external laboratory (as they are student training instruments which is the normal requirement for compliance testing required by the "Occupational noise management" standard (AS/NZS 1269:2005). However these sound level meters and calibrators were internally verified against a Class 1 laboratory verified sound level meter with current certification in acoustic laboratory conditions. The time average readings taken by the instruments were assessed to have an accuracy of +/-5dB L_{Aeq} which is the level of accuracy expected for a Type 2 instrument in field work.

Each sound level meter was set to 1 second logging time. Field reference checks were performed before and after measurements using a standard tone of 94 dB @ 1kHz.

2.1 Noise source I: Assessments of machine metal cutting saws

The sound level meter was positioned at the approximate location of the operator's ear in order to estimate the likely sound pressure levels and exposure levels received by the operator of the machine throughout a typical 8-hour working day. Sound pressure level measurements were taken for sample periods of 1 minute during free running conditions and also under typical loading while cutting.

2.2 Noise source II: Locomotive preparation area

Personal sound exposure measurements (using dosimeters fitted to the worker's clothing) could not be done due to the nature and type of work carried out in the workshop which generated a high level of dust and debris from the stripping operation. The protective clothing worn by employees did not allow the attachment of personal sound exposure meters and neither could they be adequately protected from the level of dust and dirt generated. Four employees worked their way around the locomotive attending to areas that needed attention.

Clause 9.7 "Noise Exposure of Groups" of the Occupational Noise Management Standard Part 2 [2] was applied as this was assessed to be a space of uniform sound pressure level. Two sound level meters were placed on the left side of the locomotive, one positioned on the movable scaffolding at the front of the unit and one positioned on the movable scaffolding at the rear. Two sound level metres were also placed on the right of the locomotive, one on the movable scaffolding at the front, and one on the movable scaffolding at the rear. This was done in order for the sound level meters to be within close proximity to where the employees were working as they progressively moved around the locomotive.

The measured sound pressure levels were generally steady and uniform being within a range of +/-2 dB. Based on the observations during the evaluation, these steady sound pressure levels were likely as the workshop space is an enclosed area with hard reflective surface areas. This allows a build-up of sound within the workshop space with very little sound absorption to reduce the levels of sound energy present.

While time average levels were recorded, impulse sound (dB L_{Cpeak}) could not be measured due to the type of sound level meter used and its limited capacity.

3. Legislative requirements

Noise in the workplace may be regarded as a potentially serious hazard if not managed appropriately. Workplace noise is defined in the Health and Safety in Employment Act 1992, the principal health and safety statute in force when the investigation was carried out. The noise exposure criteria is set out in Regulation 11 of the Health and Safety in Employment Regulations 1995.

A cornerstone of the Health and Safety in Employment Act 1992 is Clause 6 which requires an employer to take 'all practicable steps' to ensure the health and safety of employees while in the workplace. Clause 7 of the Health and Safety in Employment Act 1992 requires the systematic approach to the identification and management of hazards. Clauses 8 to 10 propose a hierarchical approach to how hazards are to be managed (often referred to elimination, isolation and minimisation).

Regulation 11 of the Health and Safety in Employment Regulations 1995 embodies the international noise exposure criteria used in most jurisdictions. This regulation states:

> Every employer shall take all practicable steps to ensure, in relation to every place of work under the control of that employer, that no employee is exposed to noise above the following levels:
> (a) a noise exposure level, $L_{Aeq,8h}$, of 85 dB(A); and
> (b) a peak noise level, L_{peak}, of 140 dB whether or not the employee is wearing a personal hearing protection device.

In current notation and descriptors the criteria can be expressed as:

(a) An A-weighted time-average level of no more than 85 dB $L_{Aeq\ 8h}$ (8-hour working day)
(b) A peak level of no more than 140 dB L_{Cpeak}.

Sound exposure (E_{AT}) is a measure of the sound energy received at the ear which is a combination of sound pressure levels and the exposure time. This is calculated by converting sound pressure levels (in dB) back to the linear equivalent (Pa^2) and then multiply by the exposure time in hours to give Pa^2h. The conversion of 85 dB = 0.126 Pa^2 and multiplied by 8 gives 1.0 Pa^2h.

4. Measurement results

4.1 Noise source I: Metal cutting draw saws

Five cutting draw saws were evaluated in free running (idling) and under load (cutting) conditions. The results are given in Table 1 and the saws are shown in Figure 1.

The measured sound pressure levels emitted increased significantly when the tools were placed under load except the Friction cut saw A where the sound pressure levels emitted were similar in the free run and under load conditions.

The preliminary assessment of the different saws at Hutt Workshops showed variable results. Some saws emitted

A) 10042578 B) 8630 C) 1055 D) 7534 E) 20120505

Figure 1: The cutting draw saws assessed

Table 1: Data from the preliminary assessments of cutting draw saws

Description	KR ID # No	Free run dB L_{Aeq}	Under load dB L_{Aeq}
Friction Cut Saw (A)	10042578	100	101 dB
Friction Cut Saw (B)	8630	74	*91 – 100
Machine Saw (C)	1055	77	88
Machine Saw (D)	7534	71	92
Cold Saw (E)	20120505	70	83

* The sound levels varied greatly as the trial proceeded, so the sound pressure level range is given. When the tool came under increasing load the sound levels increased.

higher sound pressure levels and were potentially more hazardous than others. In cases such as the Friction Cut Saw A, where the L_{Aeq} was measured at 100 dB, there is a risk of permanent hearing damage after a maximum time period of 15 minutes usage of this machine without adequate hearing protection. This saw caused significant speech interference as it was nearly impossible to maintain communication between those present without shouting which suggests the level of noise emitted was high. This demonstrated that a potential hazard is not just to the person using Saw A, but consideration needs to be given to others working nearby that may not normally use hearing protection. Noise can also be potentially hazardous to other employees other than the machine operator using the Saw due to the residual noise effects. While hearing damage is dependent on an individual's susceptibility, it is considered that when the level of noise is in excess of the recommended criterion noise level, hearing damage may begin to occur depending on the length, and level of exposure. Saws with results close to L_{Aeq} of 85 dB should also be included in future detailed assessments as set out in the Occupational Noise Management Standard AS/NZS 1269-2005 in order to verify if they do present any hazard under typical use. Cold Saw E had the lowest levels, causing some speech interference when under load.

4.2 Noise source II: Locomotive stripping and preparation

High sound pressure levels were measured for during the locomotive stripping activity resulting in measures sound pressure levels ranging from 100 - 102 dB $L_{Aeq\ 1h}$. Figure 2 below shows a time history and summary data of the measured sound pressure levels for a locomotive panel stripping activity.

Measured sound pressure level summary:

Date sampled: 20 March 2014
Start Time: 1305 hours
Duration: 79 minutes (1.3 h)
Time average level = 102 dB $L_{Aeq1.3h}$
Maximum sound pressure level =110 dB $L_{AF\ max}$

A sample calculation of the data processed to derive the occupational sound exposure level for the locomotive stripping activity in terms of percent dose is given below.

Noise exposure (E_{At}) % dose:
L_{Aeq} of 102 dB = 6.3 Pa²
$E_{A\ 1.3h}$ = 6.3Pa² x 1.3h = 8.19 Pa²h
Dose = 819 %

If this work was to continue for a full 8 hour day (819x 8/1.3hours) = 5040 % dose.

The measured sound pressure levels from the four sound level meters used to sample the locomotive stripping activity were very similar. A sound pressure level measured between 100 to102 dB L_{Aeq} during the stripping process which confirmed a constant and uniform level of sound through the workspace. Approximately 8 to 15 minutes of unprotected exposure at this sound pressure level is equivalent to a time average level of 85 dB over an 8

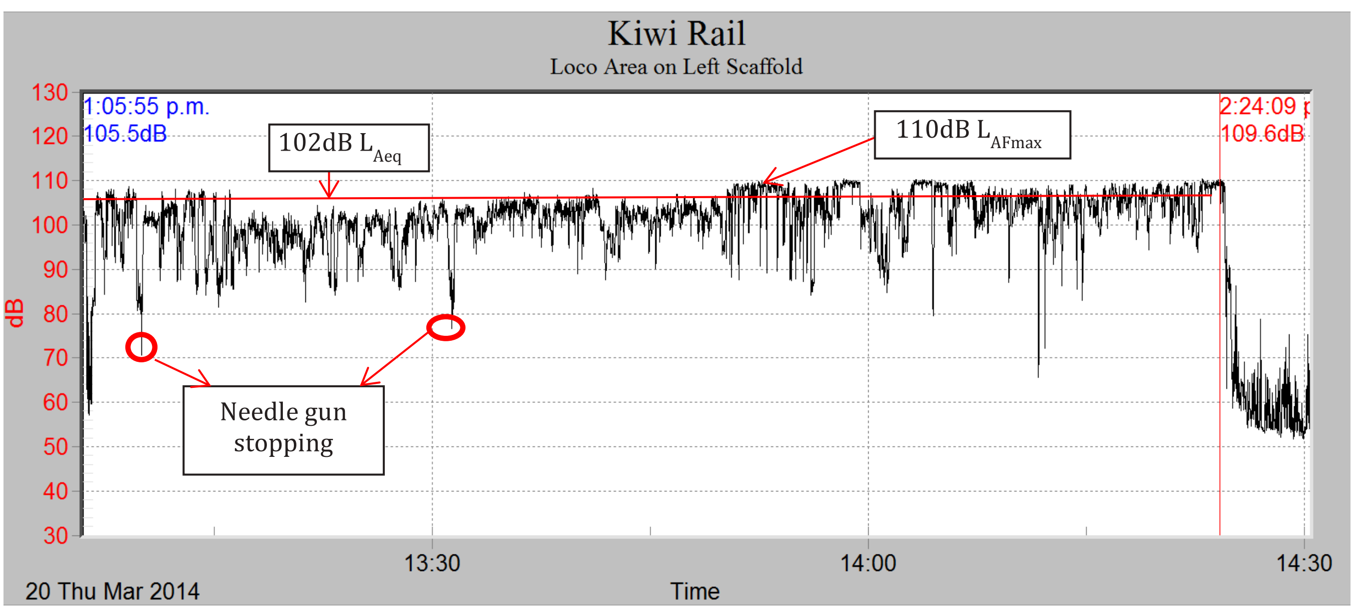

Figure 2: Time History of sound pressure levels in the locomotive panel preparation area

hour day (or 100% dose) [3]. At a sound pressure level of 100 to102 dB L_{Aeq}, the level of speech interference was severe as it was impossible to effectively communicate by typical vocal effort or even when shouting. When noise exposure is over a 100% dose, this is likely to result in temporary hearing loss, as indicated by a temporary threshold shift in hearing sensitivity. Recovery from a temporary threshold shift usually takes the typical person with healthy hearing between 16 to 24 hours. When people are repeatedly exposed to high levels of noise above the criteria of Regulation 11, Health and Safety in Employment Regulations 1995, the threshold shift may become permanent which can result in noise-induced hearing loss [3]. The measured sound pressure levels conducted in this evaluation from locomotive stripping indicate a potential hazard to the health and safety of those employees exposed, if there is inadequate protection and/or insufficient rest time.

All employees working on this locomotive were noted to be wearing Class 5 hearing protectors which provide up to 30 dB attenuation by SLC_{80} method. When fitted properly, Class 5 hearing protectors should attenuate sound pressure levels of 102 dB down to approximately 72 dB. It was observed that the employee's stripping the locomotive wore their Class 5 hearing protectors over the top of their overall bonnets. Some employees also wore head bands over their ears, under their bonnets and then their ear muffs over top. Wearing these devices over top of anything breaks the air seal and reduces the effectiveness of these protectors. Hearing protectors need to be worn 100% of the time when excessively noisy tasks are taking place. When excessive noise exposure is frequent, and hearing protectors are not fitted correctly, there is a potential risk of noise-induced hearing loss.

Under the Health and Safety in Employment Act 1992, every employer has the duty to ensure they have effective methods in place for systematically identifying existing and new hazards in the workplace and regularly assessing each hazard to identify if a significant hazard. Based on the calculated noise exposure from the directly measured sound pressure levels in this evaluation, the exposure criterion level 85 dB $L_{Aeq\ 8h}$ has been exceeded.

In such circumstances the legislation requires the application of the hierarchical principle in managing hazards as outlined in Clauses 8-10 of the Health and Safety in Employment Act 1992. As a first line of defence, the employer is required to take '*all practicable steps*' to eliminate the noise hazards. Where elimination is not practicable, significant hazards to employees are to be isolated as a second line of defence. If isolation is also not practicable, then the hazard is to be minimised. Given the nature of the work that has to be undertaken in order to strip a locomotive, the authors understand that elimination of the significant hazard is not a practicable option because the tools cannot easily be silenced as noise is generated by the friction necessary to strip paint and remove corrosion. Isolation is also not possible because they are required to operate the hand held tool which brings them close to the source of noise. Minimisation by hearing protection is the only practicable option. The Occupational Noise Management Standard AS/NZS 1269.3-2005 [2] requires that noise exposure of 100 to 105 dB $L_{Aeq\ 8h}$ requires Class 4 hearing protectors, so in theory, employees are over protected by about 5 dB if they are supplied with Class 5 hearing protection. However, as their hearing protectors were not fitted correctly, these employees may not be achieving sufficient levels of attenuation.

Hearing protector effectiveness can be degraded in the presence of significant vibration. The term *hand-arm* *vibration syndrome* also known as *white finger* refers to vascular, neurological and musculoskeletal disorders associated with exposure to excessive hand-transmitted vibration. This can induce disturbances in finger blood flow, and in turn neurological and damage the motor function of the hand and arm." (International Standard –Mechanical Vibration - Measurement and Evaluation of Human Exposure ISO 5349-1:2001) [4]. This may present another significant health hazard for the employees involved in stripping paint and rust due to the types of tools they use. This is a potentially serious hazard and needs further investigation. It also should integrate with protection of noise for users of these tools. The Canadian Centre for Occupational Health and Safety [4]. has reported that as the majority of vibrating tools and machines emit noise, a worker is likely to be exposed to both vibration and noise simultaneously. Studies of hearing loss among timber workers found that for equal noise exposure, those with vibration-induced white finger (VWF) suffered a higher level of hearing loss than those without the condition. The reasons do not appear at present to be fully understood.

5. Limitations

A number of limitations during this evaluation should be considered. As it was not known in advance when the locomotive would arrive and be ready for work, evaluation of the workshop area was limited. There was also limited time to set up the suite of sound level meters, and little time to do background noise measurements of the workspace. In addition, it would have been ideal to assess the overall acoustical quality of the workspace if the instrumentation had been available. However based on the visual observation, this may have provided little benefit as the work areas are a highly reverberant spaces with hard reflective surfaces and little acoustic treatment.

The sound level meters used to take the measurements were Type 2 and not verified by an independent laboratory as set out in the Occupational Noise Management Standard AS/NZS 1269.1-2005. However, an internal calibration was carried out under laboratory conditions using a certified instrument which indicated an accuracy of +/- 3 dB. The sound level meters used were also not able to record peak level values (L_{Cpeak}) which is available in more sophisticated Class 1 sound level meters. The decision was made to use sound level meters instead of dosimeters due the nature of the work being done, the clothing worn by the employees which made secure fitting difficult, the potential to be knocked damaged or switched off accidently and the contamination by dirt and debris. However, this meant that the meters were not able to record sound received next to the workers' ears. However the Occupational Noise Management Standard AS/NZS 1269:2005 permits an alternative approach for this situation which was adopted here. The meters were placed as close as practicable to the employees without compromising safety. The sound level meters were mounted on moving scaffolds that were as close as practicable to the employees. The results shown in this report also suggest that the level of noise is of a reasonably consistent level throughout the work space. Because the prescribed Class 5 hearing protectors were not fitted correctly, it is not possible to accurately calculate how much attenuation they provided for employees from the measured sound pressure levels. However it is reasonable to assume that attenuation could be significantly negated.

There is a tendency to supply hearing protectors with a higher attenuation than is required. This practice is discouraged as providing higher levels of protection than required can interfere with such aspects as speech communication and warning sounds including alarms and the like. In such cases, over protection may potentially lead to a health and safety issue by placing employees in danger if not able to hear alarms for example. There is also an increased tendency with higher class hearing protector for workers to remove these when trying to communicate with others which defeats the purpose of hearing protection. To minimise this necessity, it is important to attenuate only to the level required.

6. Conclusions

A health and safety evaluation of workplace noise levels took place in accordance with the relevant legislation, Code of practice for management of noise in the workplace and the Occupational noise management standard AS/NZS 1269.1-2005. There were some noise levels of concern on a selection of the cutting saws which require further investigation. The results from sound pressure level measurements taken while a locomotive was being stripped of paint in preparation for repainting showed that the noise levels in that area of the workshop well exceeded, the workplace criteria for the period that monitoring occurred. An 800% dose was calculated which is well in excess of the 100% dose equivalent to 85 dB $L_{Aeq\ 8h}$. Class 5 hearing protectors were prescribed and worn by the employees stripping paint and rust from the panels and structure of locomotives, but the effectiveness could not be determined due to incorrect fitting. Due to the nature of the work being done, the typical noise levels received and the nature of the protective clothing being worn, Class 4 ear plugs (correctly fitted) have been recommended as the most suitable form of hearing protection. As this is a high risk area, appropriate training and education programme of staff as outlined in the approved code of practice is necessary in this workspace and it strongly recommended.

7. Recommendations

The following recommendations have been proposed and a number have already been implemented.

1. Carry out a detailed measurement and assessment of

the workspace where noise has been identified as a potential hazard. This work should be carried out by a person meeting the requirements of a "competent person" under the approved code of practice for management of noise in the workplace Appendix B1. This evaluation should also include:

- Detailed measurement and assessment on the saws and cutting equipment that were measured and discussed in this report. This will verify the level of risk created by these tools.
- A comprehensive detailed assessment of the noise levels and potential harm to employees needs to be conducted in the surface preparation area (stripping paint and rust removal). This should include the mitigation measures that can be taken and acoustic treatment of the area.

2. Employees working in the surface preparation area when high level of noise and vibration are present, should wear properly fitted Class 4/SLC80 ear plugs (22-25 dB attenuation) which will give the required level of hearing protection needed.
3. An investigation of the likelihood of injury from hand vibrating tools should be integrated with noise preventive and protection measures.
4. An investigation of practicable acoustic treatment options of the locomotive preparation area. Professional advice will be necessary to ensure sufficient attenuation is achieved.
5. The "Approved code of practice for management of noise in the workplace" recommends a training and education programme for workers exposed to high levels of noise on the effects of noise exposure and the prevention noise-induced hearing loss. This would include training on the selection of appropriate hearing protection and the correct use of that provided.
6. Regular audiometric screening is required for the workers who are regularly exposed to high levels of occupational noise. For high risk workers such as this group, this should be done on an annual basis.
7. An on-going programme should be implemented (if not already done so) to "Buy Quiet" when equipment is due for replacement as outlined in the Code of Practice and the Occupational Noise management standard.

8. Acknowledgments

We would like to thank Mr Carl Bouterey, Manager-Hutt Workshops, Russell Beaumont , Health and safety adviser and staff of the Hutt Workshops. We would also like to thank Mr Patrick Maney, Injury prevention officer and Mr Scott Sargent HSE Advisor, KiwiRail, for all the help and advice received. We also thank KiwiRail for giving permission to publish this paper.

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Summary of Facts

The Applicant applied for discretionary activity consent to authorise noise levels generated by organised winter sports on both fields at Michaels Avenue Reserve, to install 18 lighting poles with floodlights in the lower fields and construct four sound barriers in the upper fields. FOMAR's appeal focused upon the effect of activities on the residential amenity of neighbours, particularly in relation to noise and the compromise of amenity. The Court noted the case raised issues in relation to the appropriate balance between more intensive but improved use of existing and scarce reserve resources in Auckland and the appropriate protection of residential amenity values.

The Court noted the playing fields were visible from most of the surrounding residents and that the Reserve had significant usage from both passive recreation and formal organised sports. The site was zoned Open Space 3 and 4 in the Operative District Plan and the playing of soccer and cricket were both permitted activities provided they met relevant noise controls. The major concern for the residents was the duration and frequency of noise from the sporting activities with the use of lights extending these periods as well as the visual amenity of the lighting structures. Two methods were adopted to control the noise, these being attenuation structures and control on the hours of operation.

The Court discussed the control measures and concluded that the use of a Management Plan approach was the key mechanism to enable the intensification of sporting use on the site while achieving residential amenity at an appropriate level. Such a Plan would enable control on noise, hours of operation and various other activities including addressing broader issues such as odour and traffic. The Court held that consent for the modified range of hours proposed by the Council at the end of the hearing and extensions to acoustic fences were appropriate and directed Council to redraft the consent, conditions and plans for discussion with the various parties.

Court Held:

Court confirmed in principle the grant of consent, subject to refinement of consent conditions and new plans. Council to prepare final draft conditions after appropriate consultation with the other parties.

Costs reserved, but not encouraged.

Further Decisions

In decision [2016] NZEnvC 113 the Court focused on two main matters which parties could not reach agreement on and required clarification;

1) Noise descriptor and noise levels;

2) The position of the fence on the north-eastern side of the Upper artificial field.

Other issues included operation conditions around extensions for grace periods, competition game extensions in exceptional circumstances, control of summer games, attenuation of noise levels from the Lower Fields and issues about the management plan and its relation to review conditions.

In relation to the noise descriptor and level, the Court was prepared to accept a L10 dBA limit of 58dB given to the conditions that were then imposed relating to attenuation fencing and if necessary, in respect of noise levels to be met in internal areas of properties. The Court noted that the north-eastern side of the Upper playing field was one of the areas with the most significant noise impacts modeled. It was not possible to construct a wall immediately adjacent to the generators which left the requirement for the fence to be located nearer to the affected properties. The topography of the site dictated that the fence was required to be located along the line of the existing footpath near 74 Michaels Avenue in order to ensure that all the properties received some benefit. Changes to the proposed conditions of consent were annexed as A.

In the Environment Court

HAYDEN AND VANESSA RICHMOND - Appellant

KAPITI COAST DISTRICT COURT – Respondent

HELPET HOLDINGS 2014 LIMITED – Applicant

[2016] NZEnvC 001, 19p, [10] paras, 8 January 2016 – Interim Decision

[2016] NZEnvC 041, 20p, [8] paras, 10 March 2016 – Final Decision

Summary of Facts

The Richmonds' appealed a decision of the Council to grant Helpet consent for the establishment of a childcare centre on a property at 17 Alexander Road, Raumati Beach. Parties reached a tentative agreement relating to various conditions concerning the operation of the centre, in particular provisions of a Noise Management Plan (NMP) to which the Court found acceptable. However agreement was subject to receiving a preliminary indication from the Ministry of Education that it would grant an operating licence on the basis of conditions of consent.

Court held:

Court to make final determination upon receipt of Ministry's advice.

Further Decision

Subsequently in decision [2016] NZEnvC 041 advice was received from the Ministry and the Court approved the disputed provisions. Consent was granted subject to the appended conditions.

In the Environment Court

MCLELLAN FREIGHT LIMITED, RUSSELL VALDEMAR LUND & HC TRUSTEES 2010 LIMITED - Appellant

DUNEDIN CITY COUNCIL - Respondent

[2015] NZEnvC 192, 5p, [14] paras, 11 November 2015 – Stay Application Decision
[2015] NZEnvC 221, 11p, [41] paras, 21 December 2015 – Interim Enforcement Order
[2016] NZEnvC 007, 5p, [10] paras, 20 January 2016 – Procedural Decision
[2016] NZEnvC 014, 3p, [4] paras, 29 January 2016 – Amendment to Enforcement Order

Summary of Facts

In decision [2015] NZEnvC 192 the Court granted a stay of an abatement notice issued by the Council in respect of noise generated by trucks at a site at 61 North Taieri Road, Dunedin which was used by the company for the storage, transportation and distribution of goods centred around the meat industry. The Court subsequently ordered ex parte that from 19 January the occupier McLellan Freight must cease using, and the owners Mr Lund and HC Trustees 2010 Ltd must cease allowing, truck and forklift operations between 9pm and 7am the following day until further order of the Court. Leave was reserved for McLellan to lodge an application for a declaration as to existing rights and for any party to set aside or vary the Orders. Subsequently in decision [2016] NZEnvC 007 the Court suspended the order, provided noise control conditions were complied with and the Respondents served the Council with final information in support of a s139A certificate application and a full resource consent application. Costs reserved. In decision [2016] NZEnvC 014 the Court ordered amendments to the enforcement order, relating to truck and forklift operations between 9pm and 7am the following day in order to allow compliance with the order prior to an automatic door being installed.

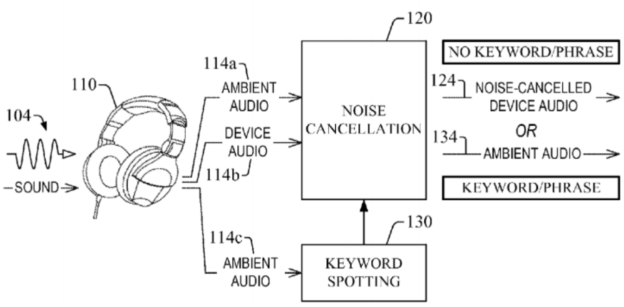
Disclaimer - *This article has been provided to help raise an initial awareness of some recent cases involving acoustic issues. It does not purport to be a full listing of all decisions which have acoustic issues, nor does it replace proper professional advice.*

...Continued from Page 11

Olympian banned for fight over noise

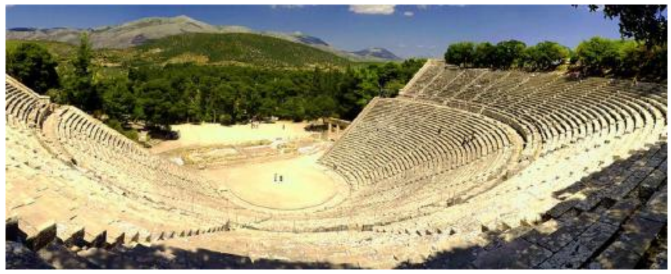
The International Skating Union (ISU) has banned two time Olympian Mitchell Whitmore of the United States for one year after a late night fight with a Netherlands coach outside a team hotel. The ISU says its disciplinary panel found the 26 year old speed skater guilty of misconduct in December during a World Cup meet in Germany. The ISU's ruling says Dutch team coach Stefano Donagrandi alleged Whitmore assaulted him after he complained about noise. Whitmore is banned from "*participation in all ISU activities*" through March 2017, the ISU says.

Amazons new feature to noise canceling headphones



It is reported that Amazon are apparently working on a new system for noise-canceling headphones that would allow them to suspend their noise cancellation effect upon hearing select keywords. At least, that much is suggested by a patent awarded to the ecommerce giant spotted by CNN. Amazon first filed for the patent, titled "suspending noise cancellation using keyword spotting," back in July 2014. The patent's background description gets at why this might be useful. It states how noise-canceling headphones isolate their user from their environment, making it so "including the operator in a discussion with another party or otherwise attracting the operator's attention can be difficult or otherwise convenient." That all this suggests is a future where someone could shout your name [or other phrases] and not be totally ignored while you're wearing your noise-cancelling cans. This might make things safer, too — it probably wouldn't hurt to hear someone yelling the next time you're head-down and unwittingly walking into traffic.

Ancient Greek Amphitheatre: Why you can hear from the back row



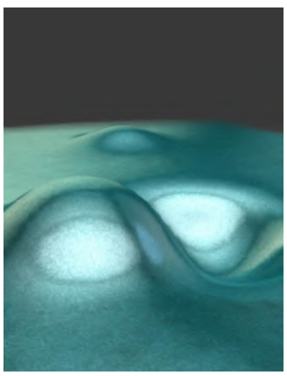
Researchers at the Georgia Institute of Technology have pinpointed the elusive factor that makes the ancient amphitheater an acoustic 'marvel'. It's not the slope, or the wind, it's the seats, yes the seats. The rows of limestone seats at Epidaurus form an efficient acoustics filter that hushes low-frequency background noises like the murmur of a crowd and reflects the high-frequency noises of the performers on stage off the seats and back toward the seated audience member, carrying an actor's voice all the way to the back rows of the theater. The research, done by acoustician and ultrasonics expert Nico Declercq, an assistant professor in the Woodruff School of Mechanical Engineering at Georgia Tech and Georgia Tech Lorraine in France, and Cindy Dekeyser, an engineer who is fascinated by the history of ancient Greece, appears in the April issue of the Journal of the Acoustics Society of America. To find out more see www.gatech.edu

Coffee bean acoustics

T Preston S. Wilson is a coffee aficionado and acoustician in his role as an associate professor in The University of Texas at Austin's Cockrell School of Engineering, has been researching the potential of using the "*cracking*" sounds emitted by coffee beans during the roasting process. As Wilson reports in the Journal of the Acoustical Society of America, he found three parameters of the crack sound that could be exploited. Near the end of the roasting process, sounds known as "*first crack*" exhibit higher acoustic amplitudes than the "*second crack*" sounds that are emitted later. Finally, the rate of cracks in the second crack chorus is higher than the rate in the first crack chorus. To find out more see Preston S. Wilson. Coffee roasting acoustics. The Journal of the Acoustical Society of America, 2014; 135 (6): EL265 DOI:10.1121/1.4874355

Drum beats from a one atom thick graphite membrane

The Tata Institute of Fundamental Research has reported that researchers demonstrate the ability to electrically manipulate the vibrations of a drum, of nanometer scale thickness, a million times smaller than that of human hair.



These drums vibrate a whopping 100 million times a second (MHz), which cannot be heard by the ear but can be sensed using small circuits. This can be used to make new kinds of mass sensors. The work, recently published in the journal Nature Nanotechnology, made use of graphene, a one-atom thick wonder material, to fabricate drums that have highly tunable mechanical frequencies and coupling between various modes. Coupling between the modes was shown to be controllable which led to the creation of new, hybrid modes and, further, allowed amplification of the vibrations. Photo: Artists impression of two coupled vibration modes of graphene drum. For further information see:

www.tifr.res.in

Noisiest cities in the World

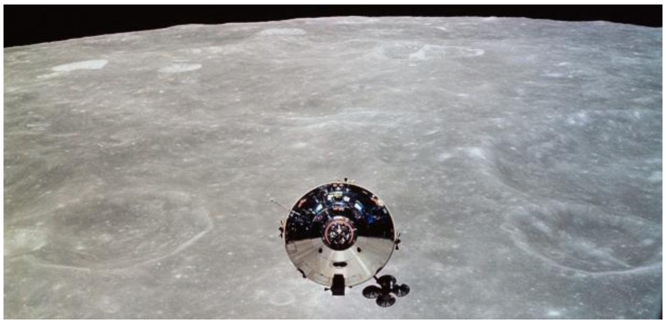
What is the noisiest city in the world? Apparently Mumbai, India is. Mumbai also known to some as Bombay has around 13 million people. Known as the entertainment, commercial fashion and financial capital of India, Mumbai's harsh city traffic and overpopulation has lead to high level of noise and it has been declared the noisiest city in the world in many studies. The worst offenders for the sources of noise are of course ever-continuing construction, loudspeakers, firecrackers, festivals, honking, rickshaws and taxis. So if Mumbai is the noisiest city what's the quietist city? Well there is not a host of scientific research or studies on this topic at present, but if you go far enough in the middle of nowhere, of course, things get pretty quiet. Try it some time.

Concert hall acoustics influence the emotional impact of music

Aalto University researchers found that the emotional impact experienced by music listeners depends on the concert hall's acoustics. Earlier research has shown that the strongest emotional experiences by music listening may elicit shivers or goose bumps in the listener. Much weaker reactions can be detected from the variations in the electrical skin conductance. Based on this knowledge, the researchers presented the test subjects an excerpt of Beethoven's symphony with the acoustics measured in different concert halls. During listening, the skin conductance was measured with sensors attached in the listeners' fingers in order to record the magnitude of the emotional reactions to different acoustic conditions. For more information see Journal Reference Jukka Pätynen, Tapio Lokki. Concert halls with strong and lateral sound increase the emotional impact of orchestra music. The Journal of the Acoustical Society of America, 2016; 139 (3): 1214, DOI:10.1121/1.4944038

Mysterious sounds heard by NASA astronauts on dark side of the Moon

The crew of NASA's Apollo 10 mission in May of 1969 set the groundwork for showing that Apollo 11's moon landing would be possible. They flew around the moon and practiced separating and descending the lunar module to better understand potential issues with landing. But they crew heard some mysterious sounds in the process, an eerie whistling that they couldn't understand and weren't sure how to report.



The eerie whistling described in many articles as a "weird music" heard by Apollo 10 astronauts during a trip round the dark side of the Moon in 1969 is getting a mass public airing, after NASA had shelved the recordings for decades. For further information see www.techinsider.io

Still waters: United States to crack down on ocean noise that harms fish

The ocean has become noisier for decades, with man-made noise from oil drilling, shipping and construction linked to signs of stress in marine life that include beached whales and baby crabs with scrambled navigational signals but the United States aims to change that as a federal agency (NOAA) prepares a plan that could force reductions in noise-making activities, including oil exploration, dredging and shipping off the nation's coast. The draft plan calls for developing noise limits and setting up a standardised listening system. It would also call for the creation of an online archive of noise data that could hold thousands of hours of recordings, which scientists could then cross-reference against data on where marine life congregates. The draft plan urges more research on the effects of noise on sea creatures and more coordination with environmental and industry groups, the military and government. For further information see www.noaa.gov

Answers

To the Fifteen Question Quiz (on page 20)

A1. Z, being a measure of the opposition that a system presents to the acoustic flow resulting of an acoustic pressure applied to the system; Units: Pa.s m^{-3} or rayl m^{-2}

A2. *STC* is an acronym for the term *Sound Transmission Class* while "Rw" is an acronym for the term "Weighted Sound Reduction Index"

A3. False, L_{peak} is not the same as L_{max} however, they are often confused

A4. The perception of how loud a sound is complex – as well as depending on physiological differences in the hearing acuity (including age related and noise related exposure effects), the level of emotional and informational engagement in the sound can significantly change the perceived level. Crying babies are almost universally perceived as louder than other common sounds, and two babies more so.

A5. A full anechoic chambers absorbs sound energy in all directions while a semi-anechoic chamber has a solid floor that acts as a supporting work surface thus an example of a semi-anechoic chamber is to support heavy items, such as cars or industrial plant.

A6. *Anvil* is another common term used for 'incus'

A7. True

A8. "DAC" is an acronym for the term Digital-to-Analogue Converter which coverts digital signals into analogue signals.

A9. *Sound Insulation* is the ability of a building element, components or structure to reduce sound transmission.

A10. *Frequency Weighting* is an electronic filter built into a sound level meter, for example the "A-weighting filter" covers the approx human audio range of 20 Hz to 20 kHz and the shape is similar to the response of the human ear.

A11. An *audiogram* is a chart or graph showing hearing sensitivity level against frequency, usually in dBHL (Hearing Level).

A12. Assuming the acoustic barrier is solid and free from gaps, the factors that limit the practical attenuation are: the height and width of the barrier; sound flanking around the barrier edges; and reflections from nearby objects/surfaces.

A13. The two basic types of SLM are exponentially-averaging and integrating (or averaging-integrating). An exponentially-averaging SLM noise descriptor for continuous sound involves the use of a time weighting filter (F or S) to approximate the human perception response with time. The L_{AF} value is averaged over the measurement time to produce the final reading. An integrating SLM noise descriptor integrates the square of the sound pressure over the integration period to produce the final equivalent reading. An integrating-averaging SLM differs in that it produces short L_{Aeq} readings (typical 1 second each) and then averages these to get the final equivalent reading for the total measurement period.

A14. Double the sound pressure level, only add 3 dB, so 7 dB + 7 dB = 10 dB

A15. Facade correction is one of the several adjustments to the measure sound presure level that may be made in accordance to NZS 6801/02:2008 to get the radting level. When making measurements close to a sound reflecting surfaces (other than the ground), the sound field near the microphone will not approximate free-field conditions, resulting in a higher measured sound presure level.

Future Events

2016

Inter-Noise 2016. Hamburg, Germany. 21st to 24th August 2016.
www.internoise2016.org

International Congress of Theoretical and Applied Mechanics [ICTAM]. Montreal, Canada. 21st to 26th August 2016.
www.ictam2016.org

22nd International Congress on Acoustics [ICA 2016]. 5th to 9th September 2016. Buenos Aires, Argentina.
www.ica2016.org.ar

International Symposium on Music and Room Acoustics [ISMRA 2016]. La Plata, Argentina. 11th to 13th September 2016
www.ica2016.org.ar

International Workshop on Rail Noise [IWRN]. Terrigal, NSW, Australia. 12th to 16th September 2016.
www.iwrn12.acoustics.asn.au

2nd Australasian Acoustical Societies Conference. 9th to 11th November 2016, Brisbane Convention Exhibition Centre, Brisbane Australia.
www.acoustics2016.com.au

2017

Acoustics 2017 Joint meeting of the Acoustical Society of America and the European Acoustics Association. Boston, USA. 25th to 29th June 2017.
www.acousticalsociety.org

24th International Congress on Sound and Vibration [ICSV24]. London, UK. 23rd to 27th July 2017.
www.icsv24.org

2017 International Congress on Ultrasonics. Honolulu, Hawaii, USA. 18th to 20th December 2017.
http://www4.eng.hawaii.edu/~icu2017

2018

175th Meeting of the Acoustical Society of America. Minneapolis, USA. 7th to 11th May 2018.
www.acousticalsociety.org

EURONOISE 2018. Heraklion, Crete, Greece. 27th to 31st May 2018.
www.euracoustics.org/events/eaa-conferences

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The Deadline for material for inclusion in the journal is 1st of each publication month, although long articles should ideally be received at least 4 weeks prior to this.

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- Regular mailing of Noise News International
- Reduced charges for local and national Society events
- Priority space allocation for trade stands at society events
- Discounted rates on selected acoustic products

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