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

[1] Elizabeth Satherely and [2] Stuart J Mclaren

[1] Advanced Student at Massey University and Wellington Suburban On-board Staff Member, KiwiRail, Wellington

[2] Email: S.J.Mclaren@massey.ac.nz

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.

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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 Pa^2
$E_{A\ 1.3h}$ = 6.3Pa^2 x 1.3h = 8.19 Pa^2h
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

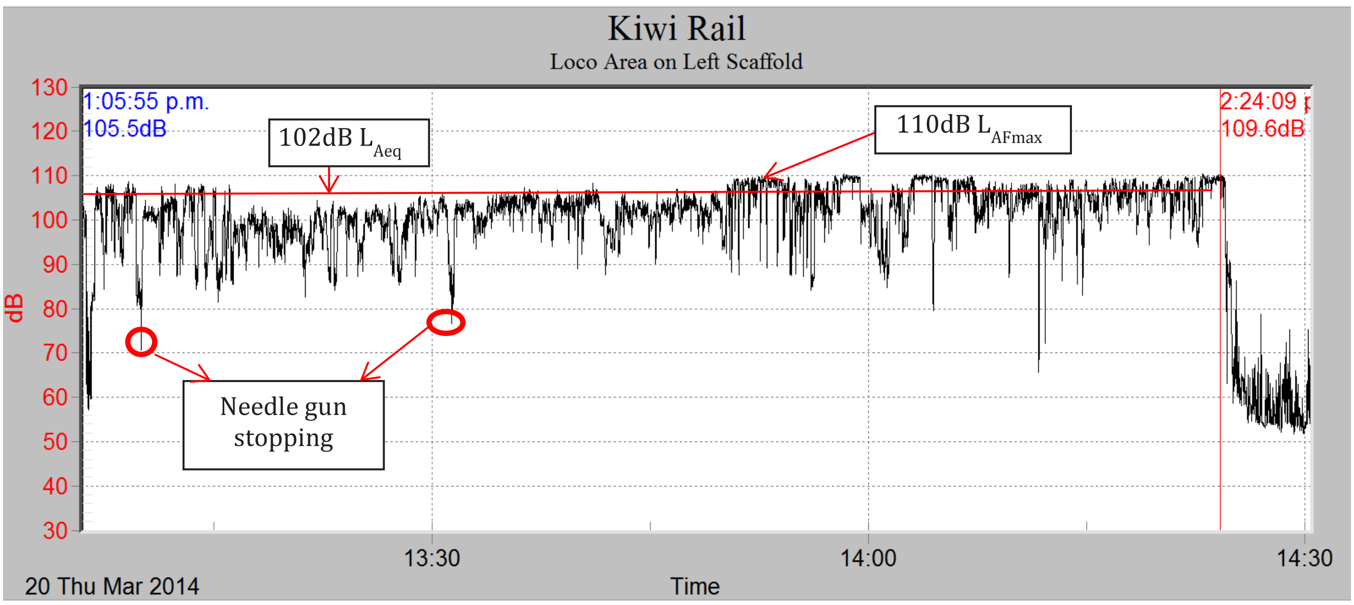

Figure 2: Time History of sound pressure levels in the locomotive panel preparation area

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.

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