20 years of using the Noise Exposure Indicator and new strategies in effective occupational noise management

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ABSTRACT

The Noise Exposure Indicator (NEI) is a risk-based tool for ranking and assessing occupational noise exposure in different parts or areas of a workplace. It was conceived by John Macpherson in about 1992 as part of the team undertaking the major revision of AS1269 -1989, and taken by the author and developed for use in occupational noise management. A paper describing the NEI was presented at the 1996 AAS conference. For some sites the method has been used to compare results and improvements over two sets of surveys 5 years apart. This paper describes its application over the long term. Information is also presented on recent observations and recommendations of how to take occupational noise management to the next level, where it is the responsibility of an accountable team from hygiene, engineering, maintenance and procurement departments at a workplace.

INTRODUCTION AND HISTORY

The NEI was initiated during development of a revision to AS/NZS 1269 in the early 1990s. John Macpherson developed the idea for a simple risk based equation for potential for hearing loss. He used the non-linear increasing hearing loss expected from 30 years of work exposure to linear increases in exposure levels, as published by Robinson [1988]. The equation was presented to the Standards technical committee involved. This was then taken by the author and used in occupational noise assessments of industrial sites. A joint paper on the development and application was presented to the AAS conference in 1996 [Macpherson and Tickell, 1996]. The paper is referenced in Part 2 of AS/NZS 1269 [Standards Australia 2005] as one method to consider in developing noise management strategies and prioritisation of control activities.

So since around 1992, the NEI approach has been used by the author to assist with preparation of occupational noise management plans. It has been used on two sites for two subsequent 5-yearly reviews of noise exposure. This has allowed the NEI to be used for comparisons of the same site over time to assess how conditions have changed and whether improvements have been made. In other cases it has been used by the same company to compare between the same types of site (aluminium smelters) in different countries.

Over a period of 30 years of work in the area, a number of factors have been identified in how, despite the best efforts of those preparing noise exposure management reports and strategies, very little in improvements are achieved. This paper presents some of the findings from the use of the NEI method and how a site can get more out of the occupational noise management reports they receive.

RISK RANKING AND THE NOISE EXPOSURE INDICATOR - NEI

In preparing occupational noise management strategies, a responsible person will most likely need to compare the risk to hearing between different groups of those exposed. This may be to identify priorities for where action needs to be taken – in most workplaces there will be a range of exposures and one principle for developing a strategy is to treat those areas with a higher risk than others. There may well also be other factors in the final determination of a strategy, including ease of implementation, cost and effects on production.

Noise exposure risk ranking combines the number of people exposed and their exposure level, in this case according to a calculation known as the Noise Exposure Indicator (NEI). This is a measure of the potential risk of hearing loss in each area. It is a combination of the number of employees exposed, the exposure level and the risk to hearing.

The overall assessment of the risk of noise induced hearing loss (NIHL) in a workplace needs to take into account both the numbers of employees affected and their noise exposure. For the calculation of the NEI, employee numbers are considered in 5 dB exposure ranges for convenience, with a separate category for exposures to peak sound levels above 140 dBC. A 5 dB exposure range is common for noise exposure mapping, which is used with the method.

Robinson's 1988 data was used to estimate relative risk of receiving a 30 dB Hearing Loss at age 60, for an employee exposed at the mid-point of each range i.e.: 83, 88, 93, 98 dBA. As Robinson's data only go up to 102 dBA, this value is used for the highest exposure range.

The Risk ratios developed from the data were relative to an arbitrary value of 1.0 for 88 dBA.

The risk ratios, which become coefficients C_i in the later version of the equation, are as follows:

- For $L_{Aeq,8h}$ in the range 81 to 85, C = 0.1
- For $L_{Aeq,8h}$ in the range 86 to 90, C = 1.0
- For $L_{Aeq,8h}$ in the range 91 to 95, C = 2.0
- For $L_{Aeq,8h}$ in the range 96 to 100, C = 4.0
- For $L_{Aeq,8h}$ in the range > 100, C = 5.0
- For L_{Cpeak} in the range > 140 Peak, C = 5.0

Later, a value for exposures in the range 70 to 80 dBA was added, with C = 0.05. Using the above ratios, the original NEI was expressed as follows:

$$\mathbf{NEI = 0.1\ N_{81\text{-}85} + N_{86\text{-}90} + 2N_{91\text{-}95} + 4N_{96\text{-}100} + 5N_{101} + 5N_{140pk}} \quad \mathbf{(1)}$$

where:

$N_{81\text{-}85}$: the number of employees exposed in the range $L_{Aeq,8h}$ = 81 to 85 dBA

$N_{86\text{-}90}$: the no. of employees exposed in the range $L_{Aeq,8h}$ = 86 to 90 dBA

$N_{91\text{-}95}$: the no. of employees exposed in the range $L_{Aeq,8h}$ = 91 to 95 dBA

$N_{96\text{-}100}$: the no. of employees exposed in the range $L_{Aeq,8h}$ = 96 to 100 dBA

N_{101}: the no. of employees exposed in the range $L_{Aeq,8h}$ = > 101 dBA

N_{140Pk}: the no. of employees exposed to peak levels of more than 140 dBC

These numbers can easily be obtained from the data in the noise assessment report. The use of the 5 dB range is seen as a practical compromise. The introduction of noise controls causing a reduction of 5 dBA or more would indicate a number of employees moving from a higher range into the next lower range.

The formula for NEI was developed further to include the measured average noise exposure of the group or area, to allow for the logarithmic scale of L_{eq}. The equation currently used is as follows:

$$\mathbf{NEI = \Sigma N_i.*C_i*L_i} \qquad \mathbf{(2)}$$

where:

- L_i is noise exposure $L_{Aeq,8h}$ measured or estimated, dBA
- C_i is the NEI coefficient for the range of noise exposure L_i
- N_i is the number of employees with exposure L_i.

The coefficients C_i are as given earlier.

For a workplace, the NEI is calculated for the different work areas and used to rank areas for their potential for hearing loss. Table 1 provides an example for a large department with its own despatch and maintenance group.

Table 1. Example calculation of NEI for a large department

Work Area	No. in area	$L_{Aeq,8h}$ dBA	NEI Coeff.	NEI	Rank
Plant room 1	4	92	2	736	2
Raw Mill area	3	87	1	261	4
Line area A	3	88	1	264	3
Intermediate Mill	3	86	1	258	5
Line area B	3	85	0.1	26	9
Finishing Mill	3	86	1	258	5
Run-out table	2	82	0.1	16	10
Strapping	4	83	0.1	33	7
Despatch	8	80	0.05	32	8
Maintenance	6	92	2	1104	1
Total	39			2988	

By comparing the NEI for each area (and with previous results), progress in reducing the potential for hearing loss can be identified. For example, if one area has a higher NEI than another area, then it could be ranked higher in priority when developing a control strategy budget.

The NEI for a department can be compared with that of another department in assessing priorities for budgets, or improvements compared by reductions in NEI. Different sites could also be measured or compared in this way. Table 2 shows a comparison between results for different departments on a site.

Table 2. NEI comparison for a large site

Dept.	$\mathbf{L_{Aeq,8h}}$.	$\mathbf{L_{AMax}}$.	$\mathbf{L_{Cpeak}}$	**No.**	**NEI**
Preparation	100	115	129	90	36000
Mills	90	106	122	44	3960
Coating	88	110	125	44	3872
Plate	93	116	129	18	3348
Strip	89	115	129	10	890
Painting	86	108	121	5	430
Warehouse	82	106	122	15	123
Services	82	115	135	18	148

The results can also be compared graphically for those who prefer visual comparisons. The results of Table 2 are shown in Figure 1. The L_{AMax} value is included here because some sites use it as an initial assessment. However, it is clear that it is not sufficient to correctly rank the noise sources contributing to $L_{Aeq,8h}$.

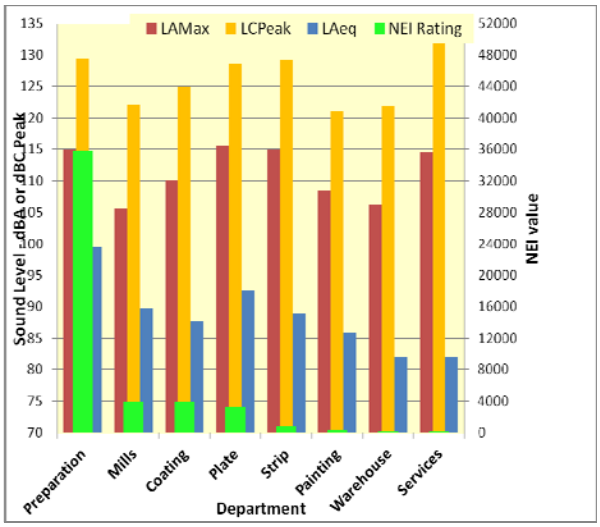

Figure 1. Comparison of Sound Exposure Level Parameters

The method can also be used for comparison of different sites for a company with operations in different countries or states.

Another useful method is for comparison of results before and after implementation of control measures, or just between surveys some years apart. If an area has a reduced NEI after treatment compared to previous measurements, then the reduction is an indication that the implemented noise controls have reduced the potential for hearing loss. An example is shown in Table 3 for another work site.

Table 3. NEI comparison before & after treatment

Dept.	No.	$L_{Aeq,8h}$.		NEI		
		Before	**After**	**Before**	**After**	**Ratio**
Single stand	3	92	90	552	270	0.49
Welding	5	90	88	450	440	0.98
Extruder	1	92.5	85	185	8.5	0.05
#2 Baths	2	90	84	180	16.8	0.09
Weaving	2	90	85	180	17	0.09
Netting	2	86	84	172	16.8	0.1
Packing	4	80	78	16	15.6	0.98
Total	**19**			**1735**	**784.7**	**0.45**

Use of this type of approach to risk ranking and comparison will provide an objective method of comparing workplaces or exposed populations. This data can then be combined with other aspects, such as budget, employee concerns, ease of implementation, and so on, from which a noise management action plan can be developed.

For the site described in Tables 1 and 2, the NEI ranking was used by the site in implementing their strategy for noise reduction at one department (shown in Table 1) in the first year after receiving the report. A work team comprising engineering, health and safety, operations and health and safety committee representatives was formed and implemented some of the recommendations. They advised they found it helpful to have an objective basis to the strategy. In a 5-year follow up, some exposure and NEI reductions were measured in that department. Other departments at the same site which did not implement any controls had no reductions in exposure or NEI.

The site where the data in Table 3 was obtained had a long history of an engineer interested in implementing noise controls for exposure management. The NEI data was helpful for that engineer to demonstrate to management a quantitative effect in reducing their risk to hearing loss. They kept a financial account of compensation liability based on bi-annual audiograms and the payment rate at the time – the NEI reduction was able to be used to show the reduction in liability of compensation cost to the company.

MISSING LINKS – FROM REPORTING TO IMPLEMENTATION – WHERE IS THE RESPONSIBIITY?

The current approach to managing noise exposure found at many larger sites may follow a number of paths, but commonly it is something like:

- Typically, if a complaint from the employees is made about high noise levels, a noise measurement is conducted. This may be by the health and safety or hygiene department or a consultant if a larger area is to be surveyed.
- A report is sent to the owner of the noise risk – assumed to be the Area Superintendent, and possibly engineering or maintenance departments. It is then up to either engineering to identify potential controls and follow-up, or maintenance to fix the problem.
- If the company has not specified a budget for noise control to date, the control method usually is limited to PPE (Personal Protective Equipment i.e. ear-plugs). In some cases there is probably no specific documented procedure for following up on noise control.
- There may or may not be a "Buy Quiet Procedure" which is applied to new projects.
- At some sites the report is left in a drawer or filing cabinet somewhere and that is the end of it until there is another complaint, or head-office arranges another 5-yearly assessment and the work is repeated.
- Responsibility appears to be in the hands of the Area Superintendents and engineering, who will say they have better things to do with their time running the operation.

It may appear to the employees at some sites that no one is really responsible for doing anything and following through with noise management. An assessment may be made and appropriate PPE provided, but it goes no further unless more complaints are made. The Health and Safety or Hygiene departments don't have any budget. The consultant has no authority. Maintenance has regular work to do. And so it is left.

Make a team responsible for noise

Personal experience has indicated that the best way to have a successful occupational noise management strategy for an existing plant, is to have someone or a team responsible for it, with accountability, authority and a budget. If it is a single person, if they have an interest in achieving improvements, success will be more likely.

Finding an interested person eager to do this task is difficult and in reality doesn't happen very often. If it does, then the business should count itself fortunate. The alternative to this person, and what has been recommended to a number of employers, is that there be a responsible group below Superintendent level to manage and implement noise control.

This involves identification of a responsible and trained "noise team" to be involved in all procurement for projects and plant, as well as following through on noise control projects. The team is recommended to include employees from

- Health, Safety Hygiene and environment;
- Engineering;
- Maintenance; and,
- Procurement

with sponsorship by a member of the senior management team at the site (or sites). The team should also develop a Buy Quiet Procedure relevant to the site, to be included with all specifications issued.

- HSE (health, safety and environment) involvement is required because of the need to identify objectives and effects.

- Engineering involvement is required because of their understanding of process, equipment, how things operate at the plant and how noise control engineering is applied.

- Maintenance personnel are required because of the need to ensure installed plant is operated and maintained effectively and the role that maintenance has in providing minimal noise emission.

- Procurement participation is required because of their role in project development, specifications, tendering, management of assessment of tenders and supply of items.

Leadership of the team could be determined through those involved and their experience, interest or other items, but

typically it is lead by a person from Engineering. The team would need to be sponsored by one of the senior management team at the site for review and support.

Special training will most likely be required for this group to allow it to be effective in its duties. A suitable course content is similar to that given in AS/NZS 1269.1. Experience at major industrial and resource development industries indicates that improvement in noise control will not occur without such a group or person responsible and accountable for its implementation.

Tasks for a noise team would include

- Identification of appropriate noise objectives for new plant or requested areas for improvement
- Identification of potential noise control methods (for site derived projects) and review of proposed methods for control on new plant.
- Identification of test methods to be applied to assess compliance with the noise objectives
- Assessment of proposed noise controls, life of control items if they are additional to the main item (e.g. silencer parts, lining material, etc.) and stores requirements;
- Assessment of the likelihood of the item achieving objectives (this would be based on knowledge learned and networking);
- Development of shop inspection methods for new plant
- Review of test results for acceptance after implementation or commissioning.

As noted above, this approach should apply to all items and projects intended for procurement at the plant.

Maintenance involvement in this process is an important aspect. It may also be identified through such a process of training and development of a noise team, that a specific part of the maintenance budget needs to be assigned purely for noise control measures. Many site noise sources observed are found to have a maintenance issue which is the cause of high noise levels. It may be compressed air leakage, worn bearings, impact zones not isolated properly, or poorly fitting doors and noise control enclosures.

Recommendations for consideration of noise control for existing plant items and areas would arise from either noise survey reports already completed, or from the response to complaints or reviews made by the HSE department for future plant.

New plant or retrofit?

Over the long term for an existing workplace, replacement of aged, out of life equipment with quiet plant is the most effective way to reduce noise exposures. Some plant items are amenable to retrofitting of noise controls and can be treated effectively. However there are often items, especially tools and mobile equipment, that are not cost effective for retrofitting and these are not generally recommended as improvement projects.

Buy quiet procedures and specifications

A Buy Quiet specification is an essential part of a long-term strategy. It should also be a required part of all technical specifications issued by a business for new or upgraded plant and equipment.

The understanding of practicability of control methods is also potentially subjective and what may be known to be practicable to an experienced noise control engineer may not appear so to a procurement officer or process engineer.
A noise specification should also include how a compliance assessment will be done. This should include:

- the conditions of operation,
- the location where the measurements will be taken,
- the method and standards to be used,
- instrumentation requirements,
- measurement tolerance and
- reporting requirements.

Without such items it may not be possible to demonstrate or assess compliance. It is recommended that these items be considered in a Buy Quiet Procedure

Further guidance in procedures and management of occupational noise exposure can be found in Standards and regulator Codes of Practices from other countries, including the Australian and New Zealand Standard AS/NZS 1269-2 Occupational Noise management – Part 2 Engineering noise control methods, as well as other codes of practice.

CONCLUSIONS

Use of the Noise Exposure Indicator (NEI) is one part of a risk assessment process that can be helpful when applied to noise exposure management and prioritising a strategy for implementing noise control at a site. It has been applied in the primary metals and resource development industries for 20 years and is recommended for consideration by hygienists and acoustical consultants.

What happens after a noise survey is completed is significant in determining whether there are improvements in noise exposure levels for employees. Experience has shown that there needs to be a person or a team responsible for noise management at a site, with direct accountability to senior management of the operation. Without accountability, reports and potential actions for improvements are more likely to languish.

A responsible, accountable and trained team of representatives from health and safety/hygiene, engineering, maintenance and procurement is recommended as one way to provide improvements. Use of a Buy Quiet procedure with effective technical noise specifications for all new and upgrade projects at a site provides what is considered to be the best chance for achieving improvements.

REFERENCES

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