Discussion on noise control at workplaces

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ABSTRACT

In Finland noise exposure and hearing losses remain about the same level although it is said that the work is changing rapidly towards office work. The persons at productive workplaces say often that it is not possible any more reduce noise exposure. Have the workplaces have done all that is possible especially concerning technical noise control possibilities? The measurement technology has improved significantly over the last 20 years. Also, construction technology and structures have improved. Is the productivity, efficiency and machine technology more important than human health? Many organizations state that well-being at work is very important in improving productivity and result of the company. Then it is also said that workers do not care. What are the real possibilities in improving the safety culture and noise control at workplaces? Are we prisoners of prejudices, is it impossible to use modern technology to reduce noise at workplaces.

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1. INTRODUCTION

The amount of announced hearing losses in Finland in 2012 was 1 546, which is about 26% of all occupational diseases (3). The Finnish working population is about 2.2 million. Disturbing noise is reported to occur at work according questionnaires about 27% that means about 0.6 million Finnish workers (1). The amount of noise control programs in companies is modest (5). Most significant branches where noise exist are mining, construction and industry (1).

The noise seems to exits as a significant adverse parameter also in the future at work environment (2, 4, 11). The problem can even become bigger, because the working population is ageing and noise training is diminishing. Hearing losses reveal new problem areas, like communication, living habits, and disturbance and combined effects of noise with other adverse effects (7). Especially, in offices other effects than hearing losses are rising. There are difficult noise problems like low-frequency noise (ventilation, big machineries), very intensive noise sources (jet engines) and impulsive noise sources (heavy weapons, use of explosives). So in Finland noise exposure and hearing losses remain about the same at some industry areas, only economic depression has changed the statistics. Is it so that workplaces have done all that is possible especially concerning technical noise control possibilities? Is there a need for a re-evaluation (11-13)?

European framework directive 89/391/EEC states that the employer shall implement the measures on the basis of the following general principles of prevention that are also applied to noise (8):

a) Avoiding noise risks;
b) Evaluating the noise risks which cannot be avoided
c) Combating the noise risks at source;
d) Adapting the work to the individual, especially as regards the design of work places, the choice

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of work equipment and the choice of working and production methods, with a view, in particular, to alleviating monotonous work and work at a predetermined work-rate and to reducing their effect on health.

e) Adapting to technical progress; like enclosure, sheltering,

f) Replacing the dangerous by the non-dangerous or the less dangerous; replacement of noise sources

g) Developing a coherent overall prevention policy which covers technology, organization of work, working conditions, social relationships and the influence of factors related to the working environment;

h) Giving collective protective measures priority over individual protective measures; hearing protection

i) Giving appropriate instructions to the workers.

The noise directive 2003/10/EC (and national act in Finland VNa 85/2006) gives necessary guidelines to evaluate noise and to do the risk assessment, and then to carry out noise control actions (6). However, indirect parameters of noise are often forgotten like, for example, warning signs and labels of noise. Indirect parameters can be also ergonomic factors and difficulties coming from lacking communication.

What are the possibilities in improving the safety culture and noise control at workplaces? Noise control is thought to be expensive, and then the only possibility is thought to be hearing protection and the basic technical noise control is left undone. Hearing protection can be necessary and the worker must use them, when the noise is intensive, but it is not the basic idea of noise control. Additionally, it makes additional risk, when using hearing protection, because you don't hear properly. Therefore it would be better for productivity that we could make working environment where we don't need to use personal protection. We must re-evaluate the benefits and disadvantages of noise control actions. For example, in evaluating productivity, satisfied workers to sound environment were found to be only 25% of respondents (9). Hongisto et al have found that because of the noise, effective daily working time is lost in offices about 20 minutes, which means 1.5 hours of weekly work time that means in company of 20 workers about one month´s salary of one worker (10).

2. METHODS TO EVALUATION OF NOISE CONTROL

Evaluation of exposure.

Persons working in production are divided in units, and noise exposure for each unit is evaluated. If the noise exposure evaluation is less than 75 dB, the situation is documented. If the noise exposure is between 75 – 85 dB, an evaluation is done, especially if the exposure is more than 80 dB. If the exposure is between 80 - 85 dB, a more precise risk assessment of noise is carried out. If the exposure exceeds 85 dB, two things must be clarified immediately: 1) noise exposure must be less than 87 dB inside hearing protectors, and 2) a noise control program must be constructed.

Noise control program presents those work tasks, areas and persons, where noise exposure exceeds 85 dB as equivalent level or where peak level exposure exceeds 137 dB. After that, possible actions are carried out as proposed for example in Table 1. In doing the program it advisable to use persons who have skills to the work tasks, in addition to safety and health personnel. If we are unsure about the exposure, more specific evaluations or measurements are needed. Modern noise meters reveal easily daily noise exposure and also peak levels but also many sophisticated parameters.

Measurement technology has improved significantly over the last 20 years. If a person has skills in acoustics, he can measure many parameters of noise much easier and better than earlier. It is possible simultaneously to measure many parameters in parallel. Most of the information of measurements is, however, left unused. Most important parameters for noise control would be time series, frequency analyses and different triggering possibilities for most important noise events. By triggering it is also possible to make alarms of unwanted noise sources.

When considering noise control, we should make a difference between a static site noise exposure and the worker noise exposure. The personal noise doses can be significantly higher than the site exposure levels, because workers are using noisy tools and moving around. Personal exposure to noise also varies, and therefore it can give false information for technical noise control purposes. However, personal noise exposure is a basis for the legal evaluation of workplace noise. Therefore, both measurements of noise should be used, when noise control are to be evaluated. In addition, frequency analyses have developed, and measurement alarms and recognition systems have developed, and so unnecessary and false information can be filtered away from the measurement data.

One method in noise control is using check lists. Table 1 illustrates the possibilities according to the noise directive. These methods should be kept in mind when planning efficient noise control measurements.

Table 1. Noise control possibilities

Principle	Change Yes/No	Who is responsible	When will it be done	Ready xx.yy.20xx
1. Alternative work methods				
2. Development of ergonomics				
3. Tools diminishing noise exposure				
4. Development of maintenance				
5. Re-planning of worksites and placements				
6. Training and education				
7. Limit the duration of exposure and intensity				
8. Work/rest, intermittent noise exposure				

3. CASE WÄRTSILÄ

3.1 Background – Example, the Aures data logger (12)

APL Systems has developed an automatic online noise surveillance system "Aures", (ears in Latin), in close cooperation with Wärtsilä Finland. Wärtsilä has provided APL Systems probably the best methodology on how the system should be developed from expert point of view.

It has been well recognized to monitor the environmental noise, especially for industrialized area or facilities, the software has to be able to analyze the recorded data at least in 1/3 octave band. Moreover, there should be triggers to dispatch alarms for each 1/3 octave frequency band noise level as well as for the total noise level. Thus, by knowing the basic characteristic of different noise sources and setting up different alarm triggers for different 1/3 octave bands

There are several reasons why the triggers are demanded to be setup for 1/3 octave frequency bands instead of only total L_{Aeq} level. First, normally for urban-localized industrial areas, various noise sources expose. Inside the facility it may have various machinery noise, ventilation noise or low frequency noise from relevant mechanism. Outside the company, the noise can be from the traffic, wind gust or other natural sources. To distinguish the noise that an industry should take responsibility for, the recorded noise must be analyzed in frequency domain to investigate the components. To achieve this goal, the 1/3 octave band is considered as a must if narrower band is yet to be available. Moreover, although a plant's facility may easily fulfill the regulatory environmental noise limits under normal operation by law, the low frequency noise may still irritate neighborhoods to complain if that exists. In most cases, the low frequency noise is completely ignored if only the total L_{Aeq} level is taken into account because of the A-weighting curve. Thus, it is as important to analyze the 1/3 octave noise spectra in a linear scale so that the low frequency part can be emphasized.

As basic function, the Aures system is able to provide measured L_{eq} level for every second. The technology of frequency domain measurement and analysis has made it possible to understand better the components of certain noise source. With this feature, it is also possible to get more reliable measurement data when comparing to calculations.

The system includes Aures 2.0 unit and a server operating the Aures Analyzer software. The system will store the sound recorded by its high quality measurement microphones onto its internal memory. A huge internal memory, rugged, weather proof casing and reliable operation make Aures data logger eminently well suited to long term measurement projects in demanding outdoor conditions. It is especially well suited to environmental noise measurements often required by many industrial installations. The size of the Aures data logger's internal memory is 128GB. This is enough storage space for two weeks of continuous sound. The sound is PCM coded, meaning that the entire spectrum of the sound is retained.

The acoustic data will be retrieved from Aures 2.0 Data Logger's memory using Aures Analyzer 10 software. Aures Analyzer was developed by APL Systems for acoustic data analysis. After retrieval the data will be delivered to the client in whatever form they need. Using Aures Analyzer's web interface the clients may view and listen to the data online as soon as the data has been retrieved.

3.2 Daily noise exposure measurements (13)

The first time when Wärtsilä performed personal daily noise exposure measurement was at factory about twenty years ago. During that time a lot of information regarding with the factory noise has been attained and studied. Recent updated noise measurements for the new factory buildings started around 1.5 years ago. By using new measurement technology the noise spectra have been able to be attained. In Figure 1, an example of typical 1 min overall L_{Aeq} noise level is presented, which informs only the overall levels. Two different devices were used, Bruel&Kjaer standard noise dose meter which was fastened near a person's ear, and Aures unit at fixed location nearby the working place.

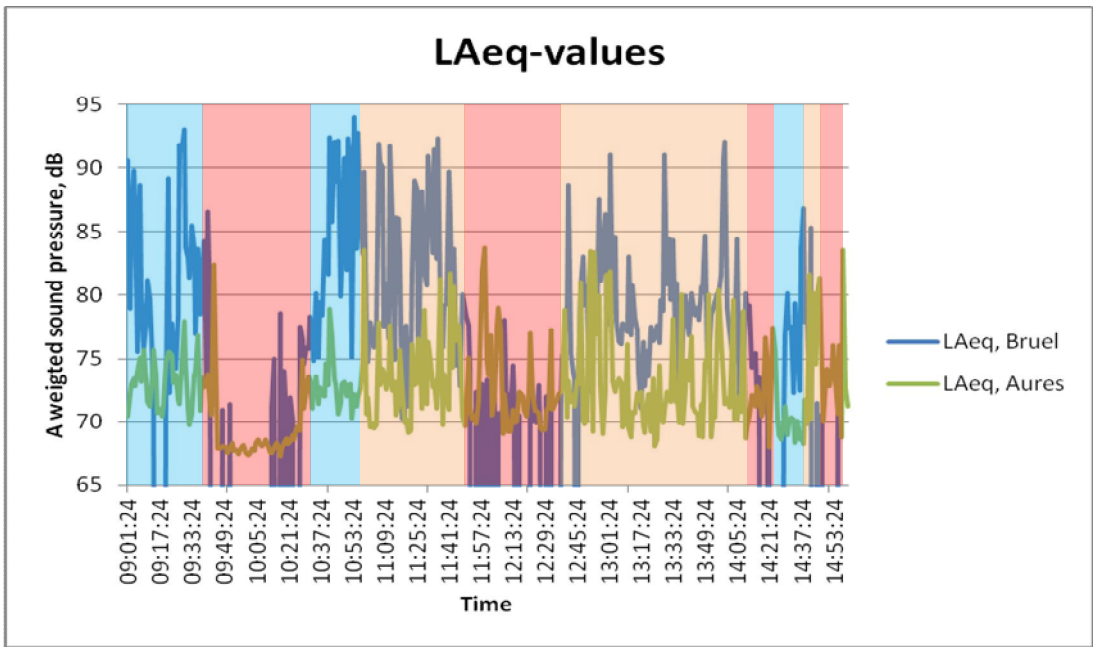

Figure 1 - an example of typical 1 min overall L_A(eq) noise level. Comparison of results between the one from standard noise dose meter and the one from Aures device.

It can be seen from Figure 1 that the results from two devices corresponds each other quite well. In certain time period, e.g. red-marked zones, both devices have recorded low noise level, which probably means the machinery nearby the investigated area for the worker is not in operation. In the time period e.g. orange-marked zones, both devices have recorded relatively high noise levels. This indicates that probably the noise that the worker has been exposed to is from the machinery nearby. One may also find the blue-marked areas have the feature that one device has high noise level and the other device has low noise level. This probably indicates that the noise that the worker has been exposed during that period of time is not related to the working machinery nearby.

Taking a closer look of the measured data, the following time periods were plotted in frequency domain in Figure 2; 1) 09.43.00 - 09.43.30 2) 10.58.00 - 10.58.30 3) 11.36.00 - 11.36.30 4) 12.04.00 - 12.06.00 5) 12.46.00 - 13.01.30 6) 14.40.00 - 14.47.00 7) 14.57.00-14.58.00

In general, the average daily noise levels tend to tilt up at high frequencies, and obviously at 1 kHz and 3.15 kHz 1/3 octave bands, there are some sources that create high noise level at certain periods of time during the day. By knowing the dominant frequencies, we have the hint of finding out the major noise challenge for the workers in their daily life and thus effectively reduce the major noise sources in order to protect our workers and providing a more comfortable working environment. Without the 1/3 octave band spectra, it will be extremely hard to make any further study on the noise components.

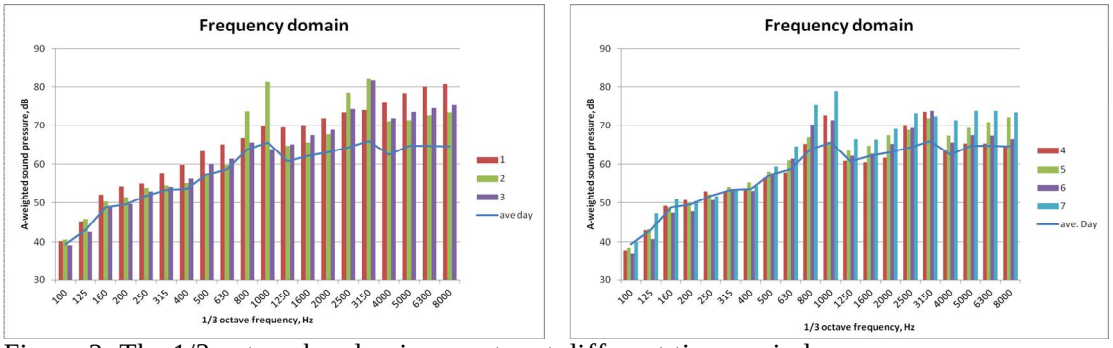

Figure 2. The 1/3 octave band noise spectra at different time periods

4. RESULTS

If we consider noise control, we have two separate situations. First, we could consider how machine systems can be controlled against noise. Secondly, we have to think, how the noise can be controlled when using hand driven tools. For hand driven tools it is possible to control the tool, sheltering the user by boxes or use ear protection. Typically, when noise control activities are done, we have several ways of doing it (Figure 3). Constructional noise control states specific requirements for walls, doors, windows, floors and other structures with respect to noise isolation and these requirements should be understood by all parties involved in the construction phase of a building. When new machines are bought, their noise properties should be considered. For example, the European Union has made guidelines for evaluating the noise of machines (8). The machine directive requires that for every machine that exceeds the noise level of 70 dB at the location of the operator or a peak level of 130 dB, the manufacturer must provide information on the noise in its technical specifications or in a commercial leaflet on the machine. Some companies use noise guarantees for their products.

It is always possible to reduce the noise emission of machinery, but doing so it also generally reduces the efficiency of the machinery. These two requirements are contradictory and therefore, the emitted noise is often the less important parameter with respect to the production. Since there are many excellent handbooks on noise control on the market, this presentation has not thoroughly covered technical noise control methods. In addition to technical and personal protection, there should be much interest in methodological noise control. This means avoiding noise, adapting the work to less noisy, developing coherent noise control program or giving appropriate teaching on noise. There should be more practical examples on those.

When persons are using tools, and their most significant noise exposure is coming from their use, the possibilities are; replacement of tools by more quiet ones, possibilities of tuning the work towards more quiet phases, making changes to acoustic environment, and using hearing protectors.

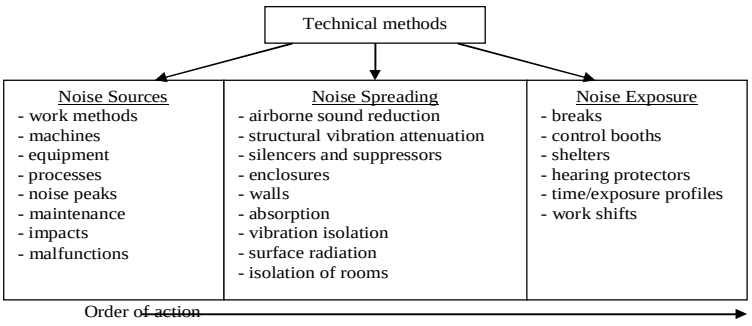

Figure 3. Principles of technical noise control

There are also many possibilities to improve the effect of personal protection like the types of hearing protectors, surveillance of use and maintenance of hearing protection. There are also many new inventions for personal protection in the area of communication, active noise cancellation systems, double protection etc.

Management of noise control is also needed, and following questions can be useful:

- Are control measures integrated into a well-managed programs?
- Is the workforce informed well and are they well educated?
- Is the maintenance well-organized?
- Are the responsibilities clear?

What is the realism of noise control at workplaces?

In Finland most workplaces have done many things for noise control. They have inserted acoustical absorption in ceiling and walls, there has been some discussion in purchasing new machinery. They have also been thinking, how to reduce noise exposure at work. Finally, most of the workers use ear muffs or ear plugs.

However, systematic noise control work has not been realized, and the main reason is probably that there are not enough skills to evaluate systematically all noise control solutions. There is a need for specialized acoustical experts, and there is need for a good teaching material for the workers. Therefore, we believe that there is work to be done at productive work, but also in office environments.

5. DISCUSSION

Noise control at the factory level is not the most complicated academic activity. On the contrary, basic noise control actions must be made and the noise control possibilities must be evaluated. The main goal is to reduce the worker´s noise exposure to so low level that all necessary information can be heard and there is no need to use personal protection. Secondly, disturbing and annoying noise must be evaluated if some progress could be made in order to help productivity. Third, if the noise exposure still exceeds action level values, personal protection is needed. In evaluating personal protection, most suitable and functioning muffs or plugs must be selected. If there is a need for communication, suitable protectors are available.

There can also be problems caused by noise control actions: loss of productivity, problems in service actions, difficulty in doing the work, problems of fire and electrical safety, costs and problems in ventilation or air conditioning.

Noise is a persistent global problem (4). New technologies can help in its management and control. Political commitment needed to build an acoustical culture for the companies. OHS is needed in the modern world more than ever. Distinct new policy needs in both in the ageing advanced and the underserved system. New contents and tools need to be developed. New competences and multidisciplinary activities must be done for the ageing systems.

What could be done?

Is it then, that productivity, efficiency and machine technology are more important than human health? Many organizations state that well-being at work is very important in improving productivity and result of the company. If there are challenges in these areas, it means that the safety culture must be reconsidered.

Quality and errors cost a lot at company level. One area also here are costs caused by noise. Culture of safety has its roots also in noise control.

How could we emphasize the importance of noise control? For example, if the only noise control action at the workplace is using of hearing protectors, should there be a penalty action that forces the workplace to do and describe also other actions?

Perhaps, the best principles could be in emphasizing the *positive effects* of noise control for the workplace and workers. The improvement of working conditions is a good target itself that also helps the production efficiency and marketing efforts. The success of noise control is advanced usually in short steps, where only few dBs can be set for annual target.

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