

## Publication IV

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## Development of Hearing Conservation Program for Finnish National Opera

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### Abstract

**Methods:** The exposure measurements were performed among the orchestra singers, dancers, choir, and technical personnel. The needs and the attitudes towards hearing conservation were questioned. Also a technical inspection on the premises was performed.

**Results:** For technical personnel the radio communication system could cause a considerable exposure. The orchestra string players were exposed more during group rehearsals and performances than during personal training. For drummers and horn players the situation was the other round. Singers and choir members were exposed during personal rehearsals (100 dB) more than during performances. For dancers the exposure was always below 85 dB(A). According to the questionnaire the opera personnel was worried about their hearing but did still not use hearing protectors. People had difficulties in getting used to them.

**Conclusion:** Based on the results a hearing conservation program was developed. It consisted of information about hearing loss, training program how to get used with hearing protectors and continuous inspections as a method to avoid unnecessary exposure and to improve the working conditions.

### 1. Introduction

The approach to the protection of workers described in the directive 86/188/EEC is based on the identification of the risks in the workplace (Fig 1). If there is risk of NIHL, the employer must develop a Hearing Conservation Program (HCP). In HCP the first task is to evaluate the sources of noise and the possibilities to reduce the levels by technical means. If reduction of the noise source is not possible, the workers should be provided with Hearing Protective Devices (HPDs) and the workers should be informed about the risks and the correct use of the selected HPDs in an appropriate way.

The components of an effective hearing conservation program are as follows [1]:

1. measurement of work-area noise levels
2. identification of over-exposed employees
3. reduction of hazardous noise exposure to the extent possible through engineering and administrative control

4. provision of HPD if other controls are inadequate
5. initial and periodic education of workers and management
6. motivation of workers to comply with HCP policies
7. professional audiogram review and recommendations
8. follow-up for audiometric changes
9. detailed record-keeping system for the entire HCP
10. professional supervision of HCP

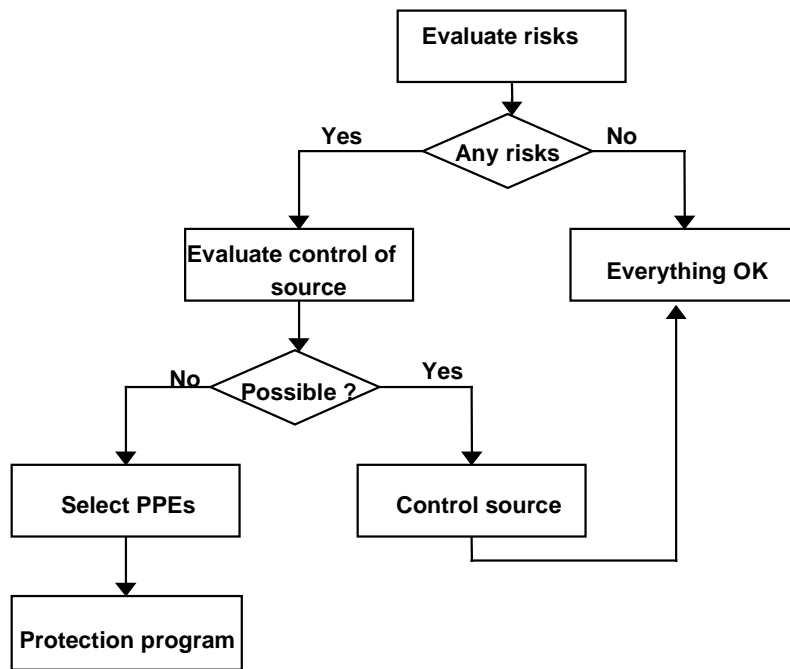


Figure 1. General approach to the hearing protection program for workers who are at risk to develop NIHL.

The use of HPDs gives best results with motivated users [2]). Users need training on maintenance, installation and use of HPDs. The motivation tends to decrease over time. To avoid this, the education and training must be repeated consistently

Among classical musicians the sound levels exceed the national action level of 85 dB according to several studies [3]. The performing artists are exposed to high sound levels in group rehearsals, performances, and personal rehearsals. This project started after the musicians of the Finnish National Opera complained about tinnitus after all performances of a modern atonal opera “Insect life” by Kalevi Aho. After a preliminary survey the administration of national opera decided that a HCP had to be developed to the performing artists of the Finnish National Opera.

## 2. Material and methods

The target group was the performing artists of the Finnish National Opera. First the sound exposure and the attitudes and possible problems in personal hearing protection of the artists was evaluated. Next in industrial hygienist evaluated the rehearsal and performing rooms for the possibility of reducing the sound levels Based on the findings a HCP was built-up.

The sound exposure of the personnel was evaluated first by measuring the sound level (either equivalent sound level of measurement, or for group the arithmetic mean of the equivalent sound levels measured), The annual sound exposure level for a year was evaluated as follows

$$L_{AEq,a} = 10 \lg \left( \frac{1}{T} \sum_{i=1}^2 10^{L_{Ai}/10} t_i \right) \quad (1)$$

where T is working hours per year, i=1 rehearsals and performances, and i=2 personal rehearsals, and exposure time respectively.

The orchestra was divided into 10 groups based on their instrument (table III). The sound level for each group was measured during personal rehearsals, group rehearsals and performances.

The choir was divided into bass, tenor, alto and soprano singers. The sound level was measured from nine representatives of tenors, seven of bass, six of sopranos, and seven of altos during personal rehearsals, group rehearsals, and performances. Single measurements was done among soloists, conductors and rehearsal pianists.

The attitudes and problems were screened using a questionnaire, which was sent to the performing artist of the opera. In the questionnaire were 25 questions. The results were collected and fed in a statistical program (SPSS 9.0).

Based on the above described exposure measurements an industrial hygienist checked the rehearsal rooms and stage of the opera to evaluate the possibilities to reduce the exposure.

### 3. Results

The results of the exposure measurements are given in tables I – III. Table I shows the sound levels measurements among rehearsal pianists, soloists and conductors. These results are not converted to annual exposures since the exposure times were not available. Highest sound levels were in rehearsals among sopranos. Table II shows the exposure among choir members. The sound levels were highest in personal rehearsals and they dominated the annual sound exposure (column three). Table III shows the exposure in the orchestra during personal rehearsals and group rehearsals and performances. The highest levels were found among brass players and drummers.

The questionnaire were answered by 65 % of the artists. About 76 % of the artists never used HPDs when playing alone. The use was more frequent in group rehearsal where most of the artists used HPDs at least sometimes. Only less then three percent used HPDs always. The use of HPDs is not related to exposure. 50 % of the musicians exposed to over 90 dB never used HPD while over 90 % of musicians with exposure less than 90 dB used HPDs in performances/rehearsals. According to the questionnaire 72 % of the musicians was worried about their hearing to some extent, 21 % was very worried. 80 % of the musicians have their hearing examined at least every 3 years and 20 % had the period between the examinations over 3 years or they cannot say. NIHL was reported in 20 % of the cases. There were no difference between men and women. The working environment was felt noisy by 56 % of the subjects and quite noisy by 41 % of the subjects. Loud music was often experienced to cause pain in 7 % of the cases and sometimes by 63 % of the cases. Of continuous tinnitus suffered 13 % of the musicians. Hearing loss and/or tinnitus was felt as a handicap in 16 % of the cases.



- Difficulties in setting on custom molded plugs Discomfort caused by the plugs
- Decreased hearing threshold in combination with plugs made impossible to hear Altered balance between own instrument and others instruments
- Dizziness

Instrument group	$L_{AEqP}$ (dB(A)) Die Walkurie	$L_{AEqP}$ (dB(A)) Insect Life	$L_{AEqP}$ (dB(A)) Don Giovanni	$L_{AEqP}$ (dB(A)) Swan Lake	$L_{AEqH}$ (dB(A)) (range)	$L_{AEq,a}$ (dB(A))
1. and 2. Violin (4)	89	88	88		86	86
Viola (3)	92	90	86	93	86 (84-88)	87
Cello (4)	90	95	86	88	88	86
Double Bass (4)	88	91	82		79	83
Flute/Piccolo (4)	95	98	97		96	95
Other wood instruments (6)	90	91	91		91 (91-92)	89
Trumpet(2)	96	93	88		97 (93-99)	94
Other brass instruments (9)	93	93	88	98	95 (92-99)	92
Harp(1)				87	89 (89-90)	87
Percussion instruments	93	91		90	99	95

Table III A summary of the exposure of musicians.  $L_{AEqP}$  is the average sound level of performances and orchestra rehearsals,  $L_{AEqH}$  is the average sound level of personal rehearsals, and  $L_{AEq,a}$  is the annual sound exposure level. If no range is given only one subject is measured. The total number of test subjects is given in parenthesis following the group name.

The industrial hygienist found the following problems in the performance and rehearsal rooms:

- The rooms for personal training were small and not designed for this purpose. Using damping materials the noise exposure could be reduced.
- The group rehearsal rooms usually small. By the use of the larger rooms which are available the distance between people can be reduced to decrease the exposure
- The sound levels at the conductor's location are smaller than anywhere else. This may lead to unnecessary exposure as the conductor may ask to increase the volume which is not needed.
- A wrong placement of the loudspeakers in the performances may cause unnecessary exposure of the orchestra and the choir.

#### 4. The hearing conservation program

According to the measurements the personal rehearsals are as important source of exposure than group rehearsals and performances. Still the artists did use much less HPDs in personal rehearsals than in group rehearsals in performances. Even then the usage rate is far from 100 % which would required for efficient personal protection. The artists were aware about the risks related to music since the majority of them were worried about their hearing and about one half felt that the working environment was noisy.

The Finnish National Opera had provided for the personnel musicians earplugs. After trying them many had abandoned them. The list of reasons for that reveals that taking the HDPs in use is not a simple straightforward task. Very little can be done to sound levels in the opera. Still unnecessary exposure can be avoided by properly setting the loudspeakers which are used in many performances.

Based on these findings the HCP of the Finnish National Opera was built of four modules:

- Motivation and training: An information package was made for the use of occupational health care and safety engineers. The package explains the noise levels in different tasks at the opera, the effects of noise to hearing and progress of NIHL. Also information about how to avoid unnecessary exposure is given. The package contains a demo CD with sound samples demonstrating the effect of noise.
- A tutorial how to take in use HPDs in the orchestra. The tutorial gives recommendations, which plugs to choose, how to start to use them gradually and what kind of problems can be expected and how to avoid them. This tutorial is given to every one who wants to have plugs.
- In every production a checking that no unnecessary exposure occurs in the performances. The check is made by a group performing artists during the construction of the performance
- Possibilities to make changes in rehearsal rooms and design of the stage are checked periodically to reduce the exposure
- The group rehearsals are timed in such a way that the larger rooms can be used

These activities are supervised by Hearing Protection committee. The committee is composed of the representants of different artist group and safety engineers. The committee plans follows the success of the on-going activities and plans the future activities. The personnel has the right to make suggestion for future improvements.

The HCP has been taken into use about half year ago. Yet it is too early to make final conclusions about the success of the plan. However the first reactions have been positive and awareness of the artist about the risks has increased.

## **Conclusions**

Based on the results a hearing conservation program was developed. It consisted of information about hearing loss, training program how to get used with hearing protectors and continuous inspections as a method to avoid unnecessary exposure and to improve the working conditions

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