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A ONE YEAR NOISE SURVEY DURING REHEARSALS AND PERFORMANCES IN THE NETHERLANDS BALLET ORCHESTRA.

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1 INTRODUCTION

Since high sound levels can contribute to the development of hearing damage it is necessary to assess these sound levels very accurately, to quantify the risk of hearing damage. A lot of short investigations have been done in the field of sound levels in orchestras, but they are less representative for the orchestral situation because factors such as the physical condition of the orchestra pit, the orchestral arrangement and the repertoire played were not taken enough into account. In addition the length of the rehearsal or the performance plays an important role. It is only possible to assess the risk of hearing damage properly by making an investigation over a long period, so that all the factors described above are taken into consideration. For my investigation all activities of the Netherlands Ballet Orchestra, rehearsals and performances, were measured over a period of one year. Different repertoires and orchestral compositions were taken into account, and the measurements took place at (as far as possible) different positions within the orchestra. A symphonic orchestra was chosen because this type of orchestra represents an important group of musicians. As it was assumed that the sound in orchestral pits is louder than the sound on the stage, the Netherlands Ballet Orchestra was chosen for this investigation. The main task of this orchestra is to accompany ballet performances.

2 FACTORS THAT PLAY A ROLE IN THE SOUND PRESSURE LEVELS IN ORCHESTRA PITS

2.1 Physical conditions of the orchestra pit

Physical factors like the size of the orchestra pit, the absorption and the size of the overhang will influence the sound level. This implies that for small orchestra pits the orchestral composition has to be reduced simply because not all the musicians fit in the orchestra pit. For instance the orchestral composition can vary depending on the size of the orchestra pit. The strings can vary a lot for the same performance. That means that in some cases, for the same programme, the strings may vary from e.g. 24 strings in Den Bosch, a rather small theatre, to 36 strings in Maastricht for the same performance, as shown in table 1.

STRONG AND SMALL ORCHESTRAEQUIVALENT SOUND LEVEL L_{Aeq} IN dB(A)

INSTRUMENTAL GROUP	MAASTRICHT 36 STRINGS	DEN BOSCH 24 STRINGS
VIOLINS 1 FRONT	86	82
VIOLINS 2 BACK	91	86
OBOE/BASSOON	94	92
PERCUSSION	94	93

TABLE 1

IN TABLE 1 YOU CAN SEE THAT THE SOUND LEVELS IN THE THEATRE OF MAASTRICHT, WHERE 36 STRINGS CAN BE SEATED, ARE SIGNIFICANTLY HIGHER FOR THE SAME PERFORMANCE THAN THE SOUND LEVELS IN THE THEATRE OF DEN BOSCH, WHERE 24 STRINGS CAN BE SEATED.

By drawing a comparison to some theatres that have practically the same size, it will be clear that the physical factors influence the reflections and consequently the sound levels. As it was not the aim of the investigation to study the physical factors in detail, I cannot give reliable data of the different sound levels due to the size, the absorption, the shape of the overhang and other physical factors. While the factors such as playing time, repertoire and orchestral composition are the same, there is a substantial difference in sound level in the different theatres. So it is evident that there must be some connection with the physical factors. In table 2 it can be seen that, in spite of the fact that all the theatres of the table have practically the same size, there is a big difference in sound level.

EQUIVALENT SOUND LEVEL L_{Aeq} in dB(A)

INSTRUMENTAL GROUP	CITY THEATER AMSTERDAM 60 MUSICIANS	GRONINGEN 57 MUSICIANS	UTRECHT 58 MUSICIANS	ARNHEM 58 MUSICIANS	EINDHOVEN 57 MUSICIANS	BREDA 59 MUSICIANS
VIOLAS BACK	93	92	92	91	88	87

TABLE 2
TABLE 2 SHOWS THAT FOR THE VIOLAS AT THE BACK THE SOUND LEVELS OF THE THEATRES OF EINDHOVEN AND BREDA (RATHER NEW THEATERS) ARE MUCH LOWER THAN IN THE OTHER THEATRES. IN ALL THE THEATERS OF THE TABLE THE SAME REPERTOIRE WAS PLAYD.

2.2 Orchestral arrangement

The shape of the orchestra pit can influence the position where the musicians sit. In an orchestra pit there are basically two different ways that the musicians are placed. These basic arrangements are indicated with 1 and 2 and the main difference is the position of the woodwinds and the brass players. The sound levels for the second violins and the violas are lower than those of the first violins and the violoncellos when playing in arrangement 1. This is the opposite for arrangement 2. Table 3 shows the difference in sound levels for the second violins and the violas in the back, when the same repertoire is played with different arrangements.

ARRANGEMENT 1 AGAINST ARRANGEMENT 2 EQUIVALENT SOUND LEVEL L_{Aeq} IN dB(A) FOR THE SAME REPERTOIRE

INSTRUMENTAL GROUP	CITY THEATRE OF AMSTERDAM ARRANGEMENT 1 51 MUSICIANS	APELDOORN ARRANGEMENT 2 43 MUSICIANS	ARNHEM ARRANGEMENT 2 43 MUSICIANS	NIJMEGEN ARRANGEMENT 2 43 MUSICIANS
VIOLINS 2 BACK	82	87	84	86
VIOLAS BACK	84	86	85	88

TABLE 3
TABLE 3 SHOWS THAT IN SPITE OF THE FACT THAT THE CITY THEATRE OF AMSTERDAM IS A LITTLE BIT BIGGER THAN THE OTHER THEATRES, THE SOUND LEVELS AT THE VIOLINS 2 AND THE VIOLAS AT THE BACK ARE MUCH HIGHER WITH ARRANGEMENT 2 WHEN THE WOODWINDS AND THE BRASS PLAYERS ARE BEHIND THEM. IN ALL THE THEATERS OF THE TABLE THE SAME REPERTOIRE WAS PLAYD.

The two different arrangements are reproduced in table 4A and 4B.

ARRANGEMENT 1

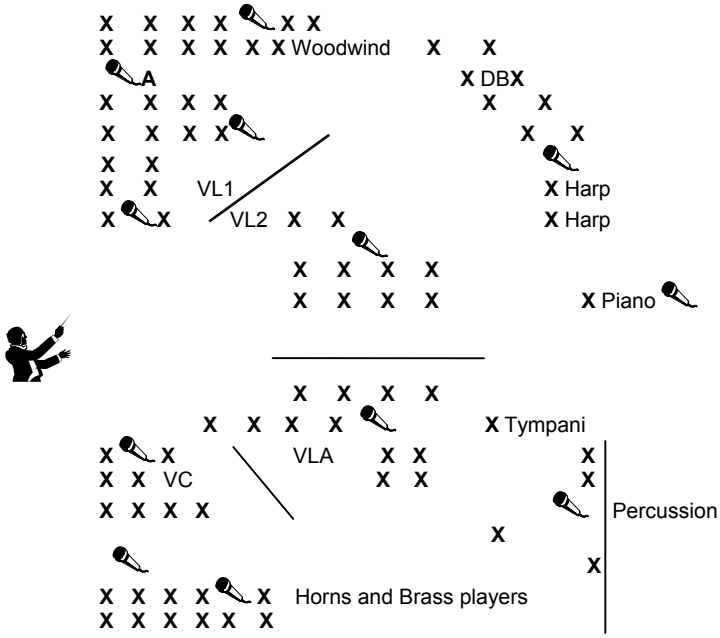

TABLE 4A

TABLE 4A SHOWS THAT THE POSITION OF THE WOODWIND IS ON THE LEFT HAND SIDE OF THE CONDUCTOR BEHIND THE FIRST VIOLINS, AND THE BRASS PLAYERS ARE AT THE RIGHT HAND SIDE OF THE CONDUCTOR. SO IT IS EVIDENT THAT WHEN THE VIOLONCELLOS ARE SITTING IN FRONT OF THE BRASS PLAYERS THE SOUND LEVEL WILL BE MUCH HIGHER THAN SITTING IN FRONT OF THE DOUBLE BASSES, AS IN ARRANGEMENT 2. IN THE SAME WAY THE SOUND LEVEL WILL BE HIGHER FOR THE FIRST VIOLINS IF THE WOODWINDS SIT BEHIND THEM INSTEAD OF NOBODY.

ARRANGEMENT 2

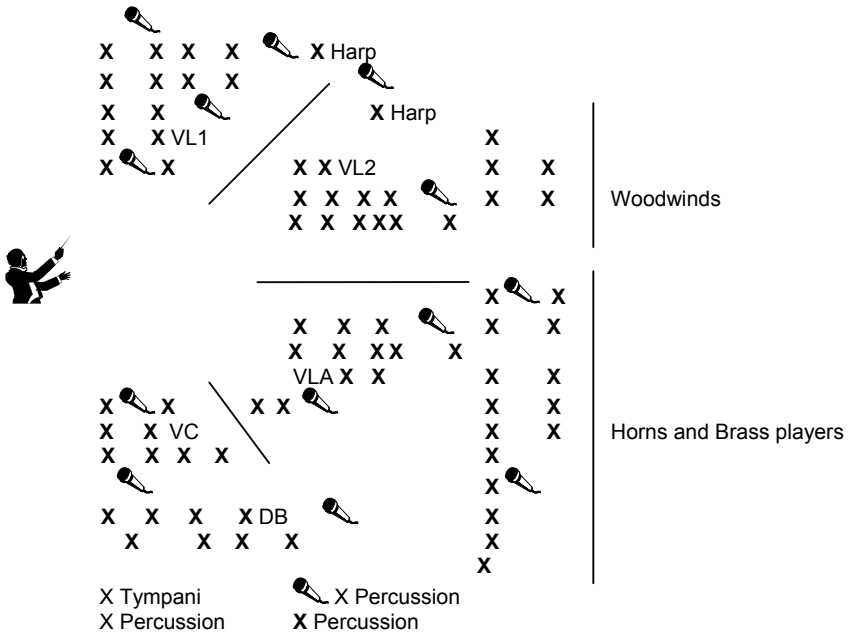

TABLE 4B

ARRANGEMENT 2 SHOWS THAT THE GREATER PART OF EAR STRAIN IN THE ORCHESTRAL GROUPS CAN BE FOUND AT THE BACK OF THE SECOND VIOLINS AND THE VIOLAS.

2.3 Repertoire

Next the repertoire has to do with the size of the orchestra (the older the music the smaller is the orchestral composition). But that also means that if the woodwind section and the brass section have a large contribution, the sound level will be much higher than e.g. when the orchestra seats only strings. Table 5 shows two performances in the same pit with different repertoires, but practically the same orchestral composition. In column two you can see some sound levels for different groups of the performance of Tsjaikofsky's Nutcracker played with 75 musicians. In column three you can see the sound levels for different groups of the gala performance for the queen's birthday when the orchestra played a part of the Bach suite 3 in D major, Strawinsy's Circus polka, the adagio of Mozart's Piano concerto in A major KV 488 , two pas de deux from Tsjaikofsky's Swan Lake and Nutcracker, Leseur variations for piano and Happy birthday for the Queen, played with 79 musicians.

DIFFERENT REPERTOIRE IN THE SAME PIT AND BOTH WITH ARRANGEMENT 1 EQUIVALENT SOUND LEVEL L_{AEQ} IN DB(A)

INSTRUMENTAL GROUP	NUTCRACKER AMSTERDAM 75 MUSICIANS	SHORT PIECES AMSTERDAM 79 MUSICIANS
VIOLINS 1 FRONT	85	82
VIOLINS 1 BACK	87	80
VIOLONCELLI BACK	90	82
DUBBEL BASSES	90	82
HARP	90	82
BRASS	95	87
PERCUSSION	92	86

TABLE 5
IN TABLE 5 THE DIFFERENCE IN SOUND LEVEL BETWEEN A LARGE ORCHESTRAL WORK LIKE TSJAIKOFSKY'S NUTCRACKER AND A PROGRAM WITH SMALL PIECES OF MUSIC.

2.4 The playing time

Finally the length of the rehearsal or the performance play an important role. As the ISO/Dis-standard 1999 describes, hearing loss depends on the combination of the time factor and the sound level factor. It is based on the idea of a limit of the sound exposure level of 80 dB(A) for a working day of eight hours. As every increase of the sound level of 3 dB means a doubling of energy, the exposure time has to be halved for every extra 3 dB. E.g. 8 hours exposure of 80 dB(A) has the same effect on the ears as 83 dB(A) in 4 hours and 86 dB(A) in 2 hours etc.

3 STANDARDS IN HOLLAND AND ISO STANDARDS

3.1 Legislation pertaining to labour conditions

The standard states an equivalent sound level of 85 dB(A) limiting value on the working place. When the sound level exceeds the 85 dB(A), some disciplinary measures should be taken by quietening the sound source or reducing the sound level at the working place. If these measures are not possible, one is obliged to wear hearing protection. When the sound exposure of the equivalent sound level during an eight hour working day doesn't exceed 80 dB(A), one can make an appeal to the so called "principle of reasonability", of which a short period exceeding 85 dB(A) should be allowed.
This law gives protection per day or per week; maintenance of this law can make it possible to take such measures that the equivalent sound level of 85 dB will not be exceeded.

3.2 ISO-1999 standard

This standard deals with the connection between the noise exposure over several years and the noise-induced hearing loss. It describes the Noise-Induced Permanent Threshold Shift (NIPTS). This standard predicts that there will not be any hearing damage caused by noise if the average exposure level during one year stays under 80 dB (A). The standard provides procedures for estimating the hearing impairment due to noise.

3.3 Dutch legislation versus ISO

These two standards seem to be in contradiction because of the different way of judgement. But one can see both standards as complementing each other; the Dutch standard is applicable on the short term and the ISO standard is applicable on the long term. In both cases hearing damage can be avoided by not exceeding the prescribed limit.

4 THE MEASUREMENTS

4.1 Population

Measurements were carried out at The Netherlands Ballet Orchestra. This orchestra's main task is to accompany ballet performances. Every year the orchestra plays about eighteen projects from which five projects have a small sized orchestral composition (less than 65 musicians), about six projects have a medium sized orchestral composition (roughly 70-80 musicians) and about six projects have a large sized orchestral composition (more than 80 musicians).

4.2 Locations

A great part of the rehearsals and performances of The Netherlands Ballet Orchestra take place at their home base, the opera building "The Amsterdam Music Theatre". In this building is a rehearsal room which is a rather small room where most of the rehearsals take place. In addition The orchestra often plays in the Lucent Dance Theatre. These theatres are almost the same size. Furthermore the orchestra travels throughout the whole country to different kinds of theatres, very small ones as well as larger ones. In the small theatres the orchestral composition is mainly reduced by the strings. During the investigation the orchestra played in the Amsterdam Concergebouw twice.

4.3 Methodology

The aim of the investigation was to obtain representative data of the noise exposure over one year for the different instrumental groups. For the measurements a number of instrumental groups have been defined. As many activities as possible (one activity is defined as being a rehearsal or a performance) were measured. In practice that meant that during 178 of the 258 activities eight different positions were measured. From each project there was a separate table. The acquisition of data was done by:

- A Direct measurement.
- B Calculated values deduced from measured values of identical circumstances; called first order extrapolation.
- C Calculated values deduced from measured values on a nearby position; called second order extrapolation.

The way the data was treated is shown for three different measurements.

A-WEIGHTED EQUIVALENT SOUNDLEVEL L_{Aeq} IN dB(A) AND THE PLAYING TIME

INSTRUMENTAL GROUP	MUSIC THEATRE ONLY STRINGS ARRANGEMENT 2	MUSIC THEATRE ARRANGEMENT 2	MUSIC THEATRE ARRANGEMENT 2
VIOLINS 1 FRONT	**79.8**	**83.3**	83.5
VIOLINS 1 BACK	**76.9**	**81.7**	82.9
VIOLINS 2 FRONT	77.3	*83.5*	*83.5*
VIOLINS 2 BACK	**75.6**	**84.9**	86.6
VIOLAS FRONT	*83.5*	*83.5*	*83.5*
VIOLAS BACK	**78.2**	**90.5**	90.4
VIOLONCELLI FRONT	**80.7**	*84.5*	*84.5*
VIOLONCELLI BACK	**77.1**	**83.5**	84.8
DOUBLE BASSES	*77.1*	*89.7*	*89.7*
HARP	⇔	⇔	88.7
FLUTE/CLARINET	⇔	*91.2*	*91.2*
OBOE/BASSOON	⇔	**88.4**	90.2
BRASS PLAYERS	⇔	**91.0**	93.7
HORNS	⇔	*94.7*	*94.7*
PERCUSSION	⇔	*92.0*	*92.0*
TYMPANI	⇔	**85.6**	92.0

TABLE 6
TABLE 6 SHOWS SOME EXAMPELS OF MEASUREMENT RESULTS.
⇔ = MUSICIANS OF THAT GROUP WERE NOT PRESENT.
BOLD: DIRECT MEASUREMENTS
NORMAL: FIRST ORDER EXTRAPOLATION
ITALIC: SECOND ORDER EXTRAPOLATION

For all the different projects the average equivalent sound level has been calculated over a year. Table 7 shows the mean values of three different projects.

MEAN VALUES OF THE EQUIVALENT SOUND LEVEL L_{Aeq} OF ALL PROJECTS OVER ONE YEAR FOR THE DIFFERENT INSTRUMENTAL GROUPS

INSTRUMENTTAL GROUP	HNB-2 ARRANGEMENT 1 26 DAYS	HNB-3 ARRANGEMENT 1 19 DAYS	HNB-4 ARRANGEMENT 1 11 DAYS
VIOLINS 1 FRONT	84	85	80
VIOLINS 1 BACK	86	87	85
VIOLINS 2 FRONT	84	85	80
VIOLINS 2 BACK	84	87	82
VIOLAS FRONT	85	86	81
VIOLAS BACK	91	90	82
VIOLONCELLI FRONT	84	85	80
VIOLONCELLI BACK	87	89	80
DOUBLE BASSES	85	87	81
HARP	85	89	⇔
FLUTE/CLARINET	88	86	85
OBOE /BASSOON	87	85	85
BRASS PLAYERS	91	94	86
HORNS	92	93	87
PERCUSSION	90	91	85
TYMPANI	90	91	85

TABLE 7
TABLE 7 SHOWS THE ENERGETIC AVERAGE A WEIGHTED EQUIVALENT SOUND LEVEL L_{Aeq} PER INSTRUMENTAL GROUP OF EACH PROJECT. IN THE TABLE YOU CAN SEE THE AVERAGES OF THREE PROJECTS. IN THE SAME WAY THE AVERAGE WAS TAKEN FOR THE 15 REMAINING PROJECTS.
⇔ = MUSICIANS OF THAT GROUP WERE NOT PRESENT.

Then the percentage of the time the 85 dB criterion was exceeded was calculated. Table 8 shows that five of the sixteen instrumental groups exceeded the 85 dB criterion for more than 70% of the time they played.

PERCENTAGE EXCEEDINGS OF THE EQUIVALENT SOUND LEVEL $L_{Aeq} \geq 85$ dB(A)

INSTRUMENTAL GROUP	PERCENTAGE WITH AN L_{Aeq} >85 dB 203 DAYS
VIOLINS 1 FRONT	11.7 %
VIOLINS 1 BACK	39.8 %
VIOLINS 2 FRONT	11.7 %
VIOLINS 2 BACK	37.6 %
VIOLAS FRONT	22.3 %
VIOLAS BACK	63.6 %
VIOLONCELLI FRONT	25.5 %
VIOLONCELLI BACK	57.0 %
DOUBLE BASSES	35.3 %
HARP	38.1 %
FLUTE/CLARINET	75.0 %
OBOE /BASSOON	42.7 %
BRASS PLAYERS	94.4 %
HORNS	94.8 %
PERCUSSION	72.0 %
TYMPANI	74.7 %

TABLE 8
TABLE 8 SHOWS THE PERCENTAGE THAT THE EQUIVALENT SOUND LEVEL EXCEEDED 85 dB (A) OF ALL THE PROJECTS THAT WERE PLAYED IN ONE YEAR. WHEN THE SOUND LEVEL EXCEEDS 85 dB (A) THE EMPLOYEE IS OBLIGATED TO WEAR HEARING PROTECTION, UNLESS THE ANNUAL DOSE IS LESS THAN 80 dB (A).

5 RESULTS

5.1 MEAN SOUND EXPOSURE LEVELS $L_{EX,PROJECT}$ OF EACH PROJECT

The sound exposure level $L_{EX,T}$ gives the average sound exposure of an employee during an average 8 hour working day. This quantity determines the risk of hearing impairment. This is followed by the maximum safe length of time spent in the area. In contrast the sound exposure of a project gives the average sound exposure of one project, that means the average over all the rehearsals and performances of that project. In general it can be stated that the rehearsals are about 1 to 3 dB lower than performances. The difference between small and larger theatres comes between 2 and 3 dB. The investigation focuses on hearing impairment, especially in the long term.
In table 9 the averages of three projects are given. Column five shows the average of all the projects over one year.

AVERAGE SOUND EXPOSURE LEVEL $L_{EX,PROJECT}$ OF SOME PROJECTS OVER ONE YEAR

INSTRUMENTAL GROUP	**HNB-2 ARRANGEMENT 1 26 DAYS**	**HNB-3 ARRANGEMENT 1 19 DAYS**	**HNB-4 ARRANGEMENT 1 11 DAYS**	**$TOTAL_{AVERAGE}$ OVER ONE YEAR**
VIOLINS 1 BACK	82	83	81	81
VIOLINS 2FRONT	79	81	76	80
VIOLAS BACK	87	86	77	85
VIOLONCELLI BACK	83	85	75	82
HARP	80	85	⇔	82
FLUTE/CLARINET	83	82	81	84
HORNS	87	89	82	87
PERCUSSION	85	87	80	85

TABLE 9
TABLE 9 SHOWS THE AVERAGE SOUND EXPOSURE LEVEL PER INSTRUMENTAL GROUP OF EACH PROJECT. HERE ARE ONLY A FEW GROUPS SHOWN FOR REASONS OF CLARITY. IN THE TABLE YOU CAN SEE THE AVERAGES OF THREE PROJECTS. IN THE SAME WAY THE AVERAGE WAS TAKEN FOR THE 15 REMAINING PROJECTS. THE LAST COLUMN SHOWS THE TOTAL AVERAGE OF ALL THE REHEARSALS AND PERFORMANCES PLAYED IN ONE YEAR. ⇔ = MUSICIANS OF THAT GROUP WERE NOT PRESENT.

5.2 NOISE INDUCED PERMANENT THRESHOLD SHIFT (NIPTS)

The NIPTS gives the relation between the sound exposure level and the shift of the hearing threshold from people of different ages. By calculating the NIPTS an estimation of the hearing loss due to noise can be made. In table 7 (NIPTS after 10 years) and table 8 (NIPTS after 30 years) column one shows the instrumental group, column 2 gives the average of the annual dose from which the NIPTS has been calculated. The columns 3 to 8 show the frequency range in Hz (Hertz) where eventually a threshold shift takes place. A 0 means no risk for impairment, a 1 (or more) means that the hearing threshold in that area has been shifted. That means the threshold, where one can just be aware of a sound, is one or more dB higher.

CALCUTATIONS OF THE POSSIBLE HEARING IMPAIRMENTOF THE MEANS OF THE MEASURED SOUND LEVELS AFTER 10 YEARS EXPOSURE

INSTRUMENTAL GROUP	$L_{EX,\ TOTAL\ AVERAGE}$ 0VER 260 DAYS	2000 Hz	3000 Hz	4000 Hz	6000 Hz
VIOLINS 2 FRONT	78	0	0	0	0
VIOLAS FRONT	81	0	0	2	1
VIOLONCELLI FRONT	84	0	2	4	2
DOUBLE BASSES	81	0	0	2	1
HARP	81	0	0	2	1
FLUTE/CLARINET	83	0	2	3	2
OBOE /BASSOON	82	0	1	2	1
BRASS PLAYERS	86	1	3	5	3
HORNS	86	1	3	5	3
PERCUSSION	84	0	2	4	2
TYMPANI	83	0	2	3	2

TABLE 10A
TABLE 10A SHOWS THE NIPTS, CALCULATED FROM THE MEAN EXPOSURE LEVEL $L_{EX,PROJECT}$ OF ALL THE PROJECTS AT A SOUND EXPOSURE OVER 10 YEARS. THE AVERAGE EXPOSURE LEVEL OF THE SECOND VIOLINS IS FAR BENEATH 80 DECIBELS AND THERE IS NO RISK OF HEARING IMPAIRMENT. THE INSTRUMENTAL GROUPS OF THE BRASS PLAYERS, THE HORNS, THE PERCUSSION AND THE TYMPANI SHOW A REAL RISK OF HEARING DAMAGE IF THEY WORKED FULL TIME.

CALCUTATIONS OF THE POSSIBLE HEARING IMPAIRMENTOF THE MEANS OF THE MEASURED SOUND LEVELS AFTER 30 YEARS EXPOSURE

INSTRUMENTAL GROUP	$L_{EX,\ TOTAL}$ AVERAGE 0VER 260 DAYS	2000 Hz	3000 Hz	4000 Hz	6000 Hz
VIOLAS BACK	84	1	3	5	3
HARP	81	0	1	2	1
FLUTE/CLARINET	83	0	2	4	2
OBOE /BASSOON	82	0	2	3	1
BRASS PLAYERS	86	2	5	7	4
HORNS	86	2	5	7	4
PERCUSSION	84	1	3	5	3
TYMPANI	83	0	2	4	2

TABLE 10B
TABLE 10B SHOWS THE NIPTS, CALCULATED FROM THE MEAN EXPOSURE LEVEL $L_{EX,PROJECT}$ OF ALL THE PROJECTS AT SOUND EXPOSURE OVER 30 YEARS. COMPARED TO TABLE 10A IT IS CLEAR THAT THE LENGTH OF THE EXPOSURE INFLUENCES THE HEARING THRESHOLD. THE INSTRUMENTAL GROUPS OF THE BRASS PLAYERS, THE HORNS, THE PERCUSSION AND THE TYMPANI SHOW A REAL RISK OF HEARING DAMAGE IF THEY WORKED FULL TIME.

6 CONCLUSIONS

The sound damaging effects were investigated over one year using the musicians of the Netherlands Ballet Orchestra. After the investigation I looked at whether there was a risk of hearing impairment. The result of the investigation is based on a full time job, meaning that all the activities of that year should have taken place. There was no attendance list, so the average exposure levels can not be linked to individual musicians. The investigation shows that, of all 20 instrumental groups, 9 instrumental groups (about 46 musicians including all the strings in the front and in the middle and piano) were exposed to an average daily dose under the limit of 80 dB(A) where hearing impairment may be expected. For five instrumental groups the average of the daily dose was slightly above the limit of 80 dB(A), for the daily exposure (violins and violoncellos in the back, oboes and bassoons). In the remaining groups the average annual dose is significantly higher than 80 dB(A). This means that for those groups of musicians of the Netherlands Ballet Orchestra that have an annual dose under 80 dB(A) they can appeal to the “principle of reasonability”. From the data of the investigations it can be concluded that the limit of 80 dB(A) for the exposure level as described in the ISO-1999 standard, was regularly exceeded for the instrumental groups of the brass players, the horns, the flutes, the clarinets, the tympani and the percussion. The reduction of sound levels to comply with the law, only needs to be reduced by a maximum of 10 dB. This means that sound reduction precautions do not have to have a major effect, they only need to be comfortable to wear and cause no side effects to the quality of hearing.

After finishing the investigation I have been thinking a lot about its value because from the results the following questions and thoughts arise:

- Is determination of the equivalent sound level the only right method for calculating the risk of hearing damage?
- Does musical sound need a raising of 5 dB like impulsive sound for the assessment?
- It should be in the character of the legislation pertaining to labour conditions to test the average daily dose of one project instead of the requirement for the weekly dose.
- The investigation is not only applicable to orchestral musicians but also to music teachers (group lessons in music schools).
- The investigation only predicts the risk of the threshold shift and does not take into account the consequences like tinnitus, hyper sensitivity to hard sounds and diplacusis which makes the listener aware of sound in a totally different way.
- The influence of nuisance should also be evaluated.

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