

AN ORCHESTRAS' NOISE EXPOSURE

G Zepidou Sound Research Laboratories Ltd, 70 Cowcross Street, EC1M 6EJ
S Dance Acoustics Group, FESBE, London South Bank University, London SE1 0AA

1 INTRODUCTION

With the introduction of the new Control of Noise and Vibration regulations in 2006¹, entertainment noise was given a temporary exemption until 2008. Unfortunately classical music was caught by the legislation, even though it is the point of the activity rather than a side effect, as is the case for industrial noise. In 2009 to address the problem joint research with the London Philharmonic Orchestra (LPO) was undertaken. The project, assisted by the full cooperation of the LPO management, administrators, musicians and conductor, included dosimetry measurements during rehearsals and performances; audiometric testing of musicians in accordance to Health and Safety guidance; room acoustics measurements; education seminars and information. This paper discusses only the dosimetry measurements and results.

2 DOSIMETRY

The season's rehearsal and performance schedule was examined so that a representative sample of concerts and rehearsals could be measured. Twenty sessions were eventually selected from the 2008/2009 season's programme. The selection procedure was undertaken jointly by the orchestra and London South Bank University (LSBU).

Each session consisted of an orchestral rehearsal, dress rehearsal or performance; the duration of which was approximately 3 hours. For each session 10 noise badges were worn by the musicians. The noise badges, Cirrus Research CR 110², were worn on the unimpeded shoulder of a selection of musicians. The badges were switched off for the interval or rehearsal break in order to make an accurate assessment of the musicians' noise exposure from the music played.



Figure 1 Dosimetry measurements at the London Philharmonic Orchestra.

The musicians were not comfortable wearing a noise badge during a performance as they felt it would be very noticeable from the audience. To overcome the problem, the Acoustics Group requested from the manufacturer a black version of the badge to match the musicians' attire. Cirrus Research now offers the black version of the noise badge (see Figure 1).

3 NOISE EXPOSURE RESULTS

The noise exposure of the musicians was established over each session. The results are presented as an $L_{Aeq,T}$ for the duration of the rehearsal/concert. The legal limit is 85 dBA over 8 hours or $L_{EP,8hr}$ = 85 dBA or 87 dBA, as averaged over a working week assuming an 8 hour day. Above the upper exposure limit value, which includes a peak level which must not exceed 140 dBC, there are several legal duties:

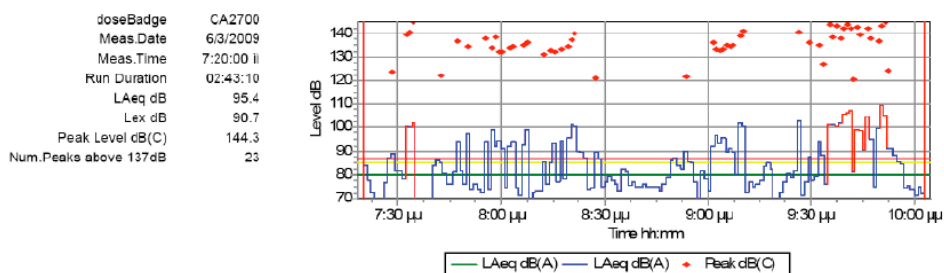
- i. To provide hearing protection,
- ii. To provide education,
- iii. To develop or seek to develop all practical means of reducing the exposure,
- iv. To undertake regular health surveillance.

The table below presents lowest and highest noise exposure for a sample of instruments recorded in terms of $L_{Aeq,T}$, where T is the duration of the rehearsal or concert also given in the table for each session. Please note that rehearsals (R) and concerts (C) took place in the following venues: Henry Wood Hall (HWH), Royal Festival Hall (RFH), Royal Albert Hall (RAH) and Brighton Dome.

Instrument	Lowest Exposure dBA	Date/Venue/Piece	Highest Exposure dBA	Date/Venue/Piece
Trombone	87.4 (2h 32')	06/11/08 HWH (R), Tchaikovsky (<i>Piano Concerto 2, Suite 3</i>)	94.2 (7h 43')	14/04/09 RAH (R+C), <i>Lord of the Rings I</i>
Trumpet	86.6 (3h)	02/09/08 HWH (R), Stravinsky (<i>The Fire Bird</i>)	93.6 (6h 59')	14/04/09 RAH (R+C), <i>Lord of the Rings I</i>
Tuba	94.2 (1h 17')	07/03/09 Brighton Dome (C), Berlioz (<i>Symphonie Fantastique</i>)	96.4 (1h 55')	06/03/09 RFH (R), Berlioz (<i>Symphonie Fantastique</i>)
Horn	84 (2h 50')	02/09/08 HWH (R), Stravinsky (<i>The Fire Bird</i>)	91.8 (5h 10')	14/04/09 RAH (R+C), <i>Lord of the Rings I</i>
CBassoon	82.9 (3h)	02/09/08 HWH (R), Stravinsky (<i>The Fire Bird</i>)	89.1 (6h)	14/04/09 RAH (R+C), <i>Lord of the Rings I</i>
Bassoon	83.4 (2h 07')	09/10/08 HWH (R), Mussorgsky (<i>Pictures at an exhibition</i>)	88.8 (3h)	26/03/09 RFH (C), School Concert
Clarinet	87.9 (2h 42')	26/03/09 HWH (R), Opera Rara	90.5 (2h 29')	06/11/08 HWH (R), Tchaikovsky (<i>Piano Concerto 2, Suite 3</i>)
Piccolo	90.6 (1h 50')	06/03/09 RFH (R), Berlioz (<i>Symphonie Fantastique</i>)	90 (4h)	05/03/09 HWH (R), Berlioz (<i>Symphonie Fantastique</i>)
Percussion	86.8 (1h 33')	09/04/09 HWH (R), <i>Lord of Rings I</i>	91.9 (3h 49')	26/03/09 RFH (C), School Concert
Timpani	85.6 (2h 24')	06/11/08 HWH (R), Tchaikovsky (<i>Piano Concerto 2, Suite 3</i>)	95.4 (2h43')	06/03/09 RFH (C), Berlioz (<i>Symphonie Fantastique</i>)
Violin I	83.9 (3h)	06/03/09 RFH (R), Berlioz (<i>Symphonie Fantastique</i>)	83.2 (5h 33)	05/03/09 HWH (R), Berlioz (<i>Symphonie Fantastique</i>)
Violin II	84.6 (5h 33')	05/03/09 HWH (R), Berlioz (<i>Symphonie Fantastique</i>)	84.6 (5h 56')	09/10/08 HWH (R), Mussorgsky (<i>Pictures at an exhibition</i>)
Viola	87.9 (1h 45')	06/03/09 RFH (R), Berlioz (<i>Symphonie Fantastique</i>)	89.2 (3h 12')	26/03/09 RFH (C), School Concert

Table 1 Noise exposure results for a sample of instruments.

The amount of noise exposure depends on the duration and the loudness of the piece played by each musician. Proximity to other musicians, the positioning of a musician inside the space and the acoustic properties of this space are also very important. Based on the years' results and available literature [3], [4], it is well established that string instruments receive the lowest noise dose and are therefore quite protected from excessive noise levels. This excludes any string musicians who are positioned in front or very close to loud instruments, as the brass or piccolo. This was also apparent in the orchestral layouts showing recorded noise levels during each rehearsal/concert for each musician assessed. On the contrary, highest noise levels were recorded for the brass instruments and the timpani. In the case of the timpani, the problem of peaks above the 140 dBC limit is also apparent, see Figure 2. Highest noise exposure was measured for the trombonist during the dress rehearsal and concert of the Lord of the Rings I in the Royal Albert Hall (14/04/09).



Notes: TIMPANI - RFH Concert, Tchaikovsky Piano Concert Nr 1 and Berlioz Symphonie Fantastique

Figure 2 Noise exposure time history (Tchaikovski/Berlioz, RFH concert, timpanist)

During most of the rehearsals and after concerts, musicians were commenting on the noise levels and the contribution of the space, and their location within the space, to the overall levels. Amongst problems noted were lack of required space, wrong positioning on stage (extra sound reflections in the corners increase noise levels), lack of clarity due to excessive noise levels (especially in the case of the brass on the Royal Festival Hall stage during loud concerts), lack of absorption on the rear stage walls (behind percussion, the timpani and brass), etc.

The contribution of the space during rehearsals and concerts can also be seen on Figure 3 below.

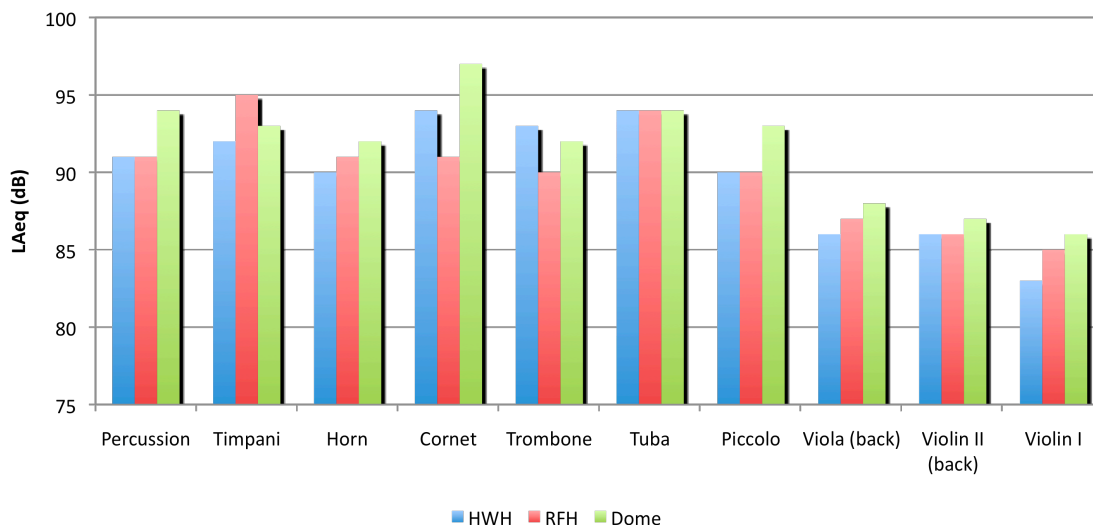


Figure 3 Space contribution to the overall noise exposure during same repertoire.

This is a direct comparison of noise levels during two identical concert programmes (Berlioz, *Symphonie Fantastique*) at the Royal Festival Hall and the Brighton Dome. As shown, levels for all musicians (except for the timpanist and the tubist) were found higher at the Brighton Dome, due to the smaller stage and consequent different seating arrangement, when compared to those at the Royal Festival Hall. This came as a surprise to the musicians who admitted that they usually play at a lower dynamic during concerts at the Dome. The contradiction between higher recorded noise levels and lower playing dynamics revealed the contribution of the CARMAN system to the overall levels and consequently noise exposure.

Dosimetry results were presented to all members of the orchestra including management and the principal conductor. The orchestra was informed on all aspects associated with noise exposure, the noise levels produced, worst noise exposure cases and available but also practical noise exposure mitigation measures.

4 CONCLUSION

Collaboration between the Acoustics Group of London South Bank University and the London Philharmonic Orchestra was formed in order to address the problems and challenges created by enforcement of the Control of Noise at Work Regulations on classical musicians. London Philharmonic Orchestra, a prestigious and leading orchestra, already working on the noise problem and aware of the dangers associated with noise, has assisted by the full cooperation of the management, administrators, musicians and conductor.

Various aspects have been investigated including dosimetry, hearing tests, room acoustics and education. A long-term plan to include noise into the season's programming has been discussed. Extended dosimetry measurements during the whole season have identified the levels of noise exposure, the noisiest pieces and the locations within the orchestra layout with the greatest noise exposure. In addition, the contribution of space and that of seating arrangements have been investigated and discussed with the orchestra management in order to take actions when programming in the future. Dosimetry results were presented to all members of the orchestra. Mitigation measures discussed and implemented included educational seminars, discussions on when and where to use earplugs of various types, room acoustic design to improve the natural acoustic of the hall in order to enhance the orchestras' rehearsal time and consequently the quality of performance.

5 FUTURE WORK

Future collaboration between the Acoustics Group and the London Philharmonic Orchestra will include continuation of dosimetry measurements to establish a profile for each instrument section for a range of musical pieces and venues. Educational seminars and further audiometric study is required in order to raise awareness and to monitor the musicians' long term hearing acuity.

It is of both the Acoustics Group and the LPO intentions however that any future work will be focused on noise exposure mitigation measures such as:

- The improvement the acoustics of the orchestra pit using computer modeling techniques to assess the various practical noise control solutions;
- Investigation on the acoustics of the other regularly used venues for performance and rehearsals;
- Testing the viability of various types of earplugs for practice/rehearsal/performance/gigs and;
- Testing various types of acoustic screens as a practical solution for brass and timpani for both stage and orchestra pit.

6 REFERENCES

1. Health and Safety Executive (2005), *Controlling noise at work. The control of noise at work Regulations 2005*, Guidance on Regulations, HSE
2. Cirrus Research plc [online], available from: <http://www.cirrusresearch.co.uk/index.php> [accessed: 16.02.10]
3. R. Canham, *The noise exposure for classical musicians*, MSc Thesis, London South Bank University, 1998
4. G. Zepidou, S. Dance, C. Nestoras Analysis of two orchestral rehearsal rooms in Thessaloniki, Greece, International Congress on Acoustics, Madrid, Sept 2007