



Photo - Claire Tregaskis

A SOUND EAR II

THE CONTROL OF NOISE AT WORK REGULATIONS 2005
AND THEIR IMPACT ON ORCHESTRAS

Published by the Association of British Orchestras, February 2008

ABOUT THE AUTHORS

Alison Wright Reid is a safety adviser with an occupational hygiene background. In the early 90s she became involved in dealing with excessive but mostly wanted noise exposures in news gathering, headphone use and orchestras. She produced the original Sound Ear report for the ABO, developed and delivered training programmes for orchestras and musicians, and spent several years on the working group producing industry guidance.

Malcolm Warne Holland studied at the Northern School of Music and first played as a deputy with the RLPO in 1965 and from there went on to a playing career which lasted until 1986/7. He also had a brief encounter with management when in 1969 he became assistant personnel manager to Christopher Yates at the New Philharmonia, followed by a short time as assistant orchestra manager to John Cobb at the BSO and Bournemouth Sinfonietta. After playing in the BSO trombone section for 16 years and with many leading orchestras including the Philharmonia, BBC Symphony, CBSO, Hallé and RLPO, he moved into full time management with the BSO. He became Manager of the BBC Philharmonic in 1989 followed, after six years, by Orchestra Director at the Royal Opera House. He moved to Opera North in 1999 as Orchestra and Concerts Director and recently relinquished this position to develop his work as a freelance consultant in the orchestra and concerts management field.

ABOUT THE ABO

The Association of British Orchestras (founded in 1947) exists:

- To be an **advocate** for the orchestral community of the UK ensuring that the voice of British orchestras is heard by all relevant parties.
- To provide the principal means by which members **communicate** collectively with each other to facilitate shared knowledge, collaborative initiatives and problem solving.
- To provide accurate, timely and comprehensive **information** on issues and events that impact on the management, development and legal responsibilities of orchestras.
- To provide **training** and continuing professional development opportunities for all levels of orchestral management

ACKNOWLEDGEMENTS

The Association of British Orchestras is very grateful to the Musicians Benevolent Fund for supporting this publication. The ABO is funded by Arts Council England.



Association of British Orchestras

20 Rupert Street, London W1D 6DF

T 020 7287 0333 F 020 7287 0444 E info@abo.org.uk W www.abo.org.uk



Photo - Brian Tarr

FOREWORD

When the Association of British Orchestras published its ground-breaking *A Sound Ear: Exploring the Issues of Noise Damage in Orchestras*, written by Alison Wright Reid, in 2001, the ABO was very much seen as being in the vanguard of providing practical guidance on noise for employers and artists. With training for symphony orchestras following in 2004, it came as no surprise that the ABO was awarded a Good Practice Award by the European Agency for Safety and Health at Work in 2005.

Since then, the law has tightened still further with implementation of the *Control of Noise at Work Regulations 2005*, and with the two year extension granted to the music and entertainment industry coming to an end on 6 April 2008, the time is ripe for publication of *A Sound Ear II*. This revised guidance updates the scientific evidence analysed in the original *A Sound Ear* and looks at the lessons learnt from the training offered by the ABO in 2004 and the steps subsequently taken by a representative sample of orchestras to deal with the impact of the legislation.

Clearly the new regulations pose a challenge for orchestras, and with the reduction in noise exposure limits this challenge extends to the chamber orchestras as well. But nor, as proved by this publication, can anyone deny the dangers of noise exposure to musicians. Read in conjunction with the *Sound Advice* guidance to be launched later in 2008, developed by the employers associations and unions in collaboration with the Health & Safety Executive, the aim is to give the orchestral sector the tools to implement the regulations as is reasonably practicable, ensuring that the breadth of repertoire demanded by players and audiences alike survives and thrives.

Mark Pemberton
Director



CONTENTS

5	<i>A Sound Ear II</i> by Alison Wright Reid
30	After All The Training, Where Are We Now? An evaluation by Malcolm Warne Holland
36	Measurement of Noise Exposure to Musicians - A Methodology by Arup Acoustics
40	Appendix 1 – The Control of Noise at Work Regulations 2005
46	Appendix 2 - Bibliography



Photo - Claire Tregaskis

INTRODUCTION

In 2001 *A Sound Ear* set out a balanced overview of the risks and solutions relating to noise in orchestras. It was based on information in the public domain, unpublished reports held by orchestras here and in Europe, the informally expressed opinions of managers, players and researchers, and research involving more than 500 players.

A Sound Ear was funded by the Musicians Benevolent Fund (MBF), the European Union (EU), and the Association of British Orchestras (ABO) and assisted by the Musicians Union (MU). It was launched at the 2001 conference of the British Association of Performing Arts Medicine, and featured at a number of ABO conferences. The MBF also funded training for 10 symphony orchestras.

The production of *A Sound Ear II* has been prompted by the recognition of a need to provide a clearer map for actually managing noise control, and by the new lower legal limits for noise exposure which make noise control a daily issue for most orchestras. The MBF is, again, strongly supporting the work as they prefer to prevent avoidable harm rather than console musicians who reach the end of the road.

The over-arching lesson from *A Sound Ear* was that noise management must be integrated into the daily life of an orchestra, and be controlled by management in consultation with players. Noise control is not a one-off issue, nor is it something for the players to sort out: noise control requires permanent change, and is a core management function.



SUMMARY

Excessive noise damages hearing. Musicians may suffer less hearing loss than comparable industrial workers, but almost certainly suffer more from the effects of reduced frequency selectivity, hyperacusis, tinnitus, and confusion between changing pitch and intensity.

The Control of Noise at Work Regulations 2005 impact on almost all professional orchestras. The regulations are not new – we have had noise controls since 1989 – but they affect more ensembles because the various actions kick in at lower exposure levels. The special difficulties of controlling noise in orchestras were thoroughly aired during the drafting of the EU Directive on which the regulations are based, and orchestras were – in conjunction with the rest of the music and entertainment industry – given two years' grace to produce detailed guidance on compliance.

Control of noise risks in music is unusually difficult, but that does not excuse inaction. Musicians are unusually vulnerable to the consequences of noise damaged hearing, so we must act to protect them.

Ear plugs or ear muffs are always the last resort in controlling noise risks, but will often be the first recourse, and will often be required because it is not possible to reduce sufficiently the risks by other means. **Personal hearing protection will have to become a part of daily life for large numbers of musicians.**

MYTH BUSTING

ORCHESTRAS ARE NOT LOUD

Yes they are. So far attention has focused on the large ensembles, but early measurements on chamber orchestras indicate that they are not as quiet as we had hoped.

MUSIC IS NOT HARMFUL

There are studies showing that music you enjoy causes less damage than noise of the same energy – it is thought to be related to the effect of stress on healing mechanisms. However, we know about stress levels in musicians, and the same studies also showed that music you do not enjoy causes more damage than plain noise.

MUSICIANS DO NOT GO DEAF

Yes they do. Possibly not as much as you would expect (see later), but they suffer types of hearing damage that interfere with their ability to play accurately or to tolerate the wide dynamic range common in orchestras.

CONSENT

Time and again, people suggest they could just sign a note to say they do not want to be protected. That would be ineffective and unwise. In the first place, you cannot consent to be harmed at work. In the second place, any such note or agreement would be an illegal contract – not only is it unenforceable, it can also be evidence that both parties broke the law.

Be aware that UK health and safety law requires that employees (including freelancers for the time being working under the orchestra's control) cooperate with their employer to enable the employer to carry out legal duties.

FUNDING

One of the reasons for health and safety law is to ensure that the costs are largely borne by the producer of the risk, rather than society. Although some orchestras have been able to obtain grant funding for major programmes such as acoustic treatment of a pit, and the MBF has funded further orchestral training, there are no special grants for health and safety programmes – it is just part of the cost of running your business.

PRACTICABILITY

Noise control in orchestras is not easy – we cannot distance players from the dominant risk to their hearing (their own instrument), and nearly every measure to reduce risks presents side-effects. However, good management can largely obviate these side-effects, and some noise control measures create a brighter and more accurate sound, produced with a lower risk of career-ending musculo-skeletal injury.

FREELANCERS

The majority of musicians are self-employed. If they were not required to comply with the law, the playing field would be grossly distorted. UK health and safety law applies to the self-employed and to those who engage them. The situation is different in some EU states.

Photo - cbso-watsongallery.co.uk



IS MUSIC AS HARMFUL AS NOISE?

Study after study shows that orchestral musicians develop noise-induced hearing damage, but the damage is often less than it ought to be.

There are plausible explanations for musicians' less-than-expected hearing damage:

- Studies often used actual hearing losses but worst-case (rather than average) noise exposures.
- Studies used volunteers – so probably did not capture the players worried about their hearing.
- The intermittency of music may give the stereocilia frequent recovery periods, so there may be less overall damage.
- Musicians are accustomed to using their hearing, so they may perform particularly well on audiometric tests compared with the average population, who can be quite vague about whether or not they can actually hear a quiet noise.

As already mentioned, pleasing music can cause less damage than equivalent noise. We asked players what they think of the music.

- 5% of brass players spend all their time playing music they strongly dislike
- Overall, 10% of orchestral players (and nearly a fifth of woodwind) spend half their time playing music they strongly dislike.

Time Spent Playing Music I Strongly Dislike	All of my Working Time	Half my Working Time	One or More Days a Fortnight	At Least One Day a Month
% of Brass Players	5	13	38	55
% of Woodwind	2	18	52	64
% of Low Strings	1	10	41	57
% of High Strings	4	13	37	53

It was clear from additional comments that dislike was both aesthetic and to do with pain and annoyance. The woodwind are particularly affected by loud noise which is beyond their control (because it comes from other players).

Dislike of noise (for whatever reason) affects **estimates of loudness**: If I find it distasteful, or painful, or obstructive, I will over-estimate the risk. If I enjoy it, I will under-estimate the risk. Orchestras that have tried to assess pieces based on player estimates have found the exercise completely uninformative. (It might be more enlightening to ask how tiring it is).

Also:

- 16% of players suffer performance stress that affects their performance more than once a week;
- the majority of players have a rapid heart rate, sweating hands and increased muscle tension during performance;
- only 10% of players do not experience physical effects of stress while playing;
- 86% of players say loud noise interferes with their playing, with 23% saying this often happens;
- 79% experience pain because of loud noise, 14% doing so frequently.

Music might be less damaging than other noise, but only if you like it and not when you are stressed.

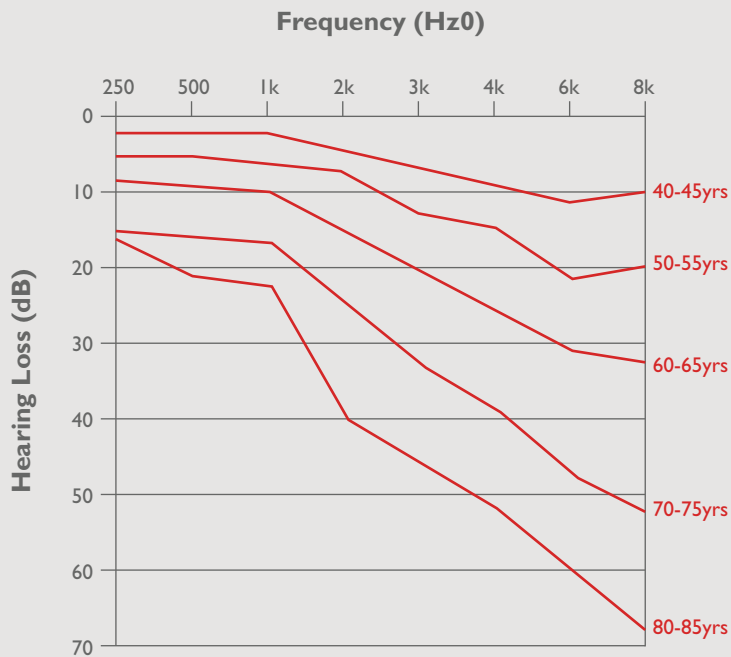
It is possible that brass players actually do experience less than expected hearing damage, since there are strong suggestions that they may have subconsciously learned to apply the aural reflex¹ when they are about to deliver a real belt. This ability declines as hearing damage increases.

¹ Three tiny bones bridge the air gap between the ear drum and the inner ear, being connected at each end by a muscle. If both muscles contract, the transmission of sound through the bones is reduced by about 30dB. This reflex stops your own voice drowning out other noise.

WHAT HAPPENS TO MUSICIANS' HEARING?

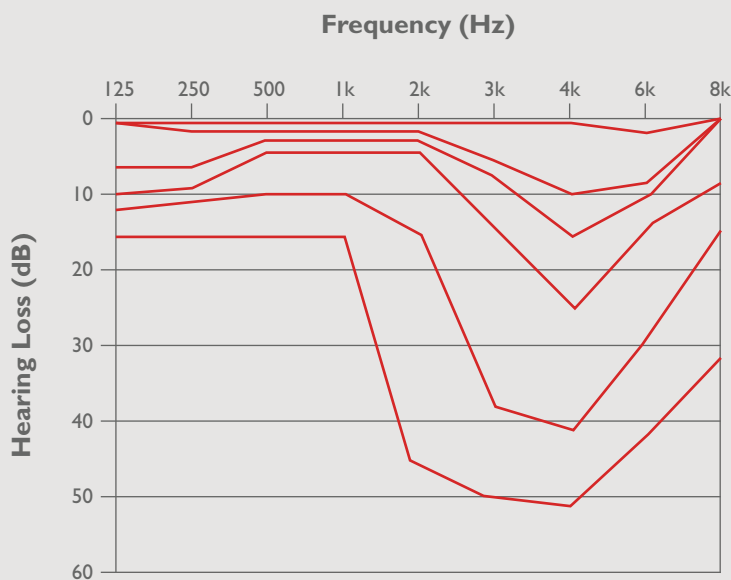
The most easily measured and most studied form of hearing damage is 'threshold shift'; a change in the quietest noise a person can hear at a given frequency.

AGE-RELATED HEARING LOSS



To varying degrees, we all get age-related threshold shift, characterised by a ski slope of increasing high-frequency loss, spreading into the mid-frequencies.

NOISE INDUCED HEARING LOSS PROGRESSION OVER TIME

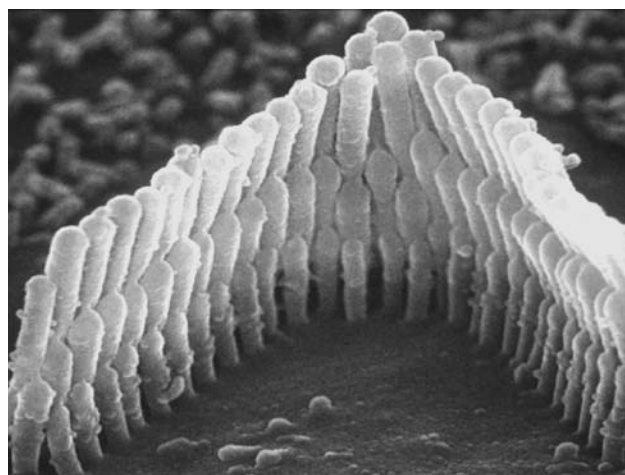
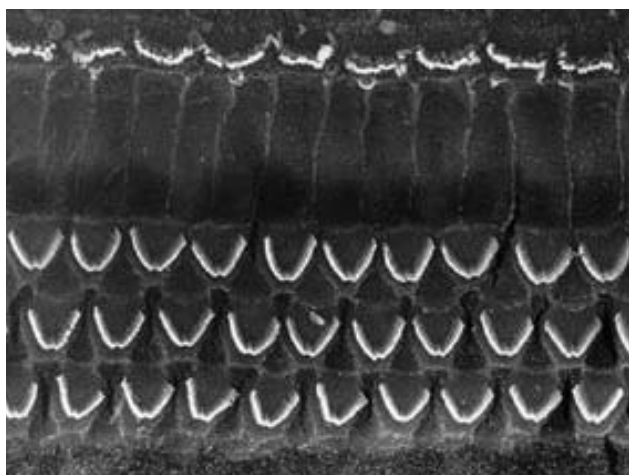


The threshold shift caused by excessive noise differs in that it is negligible at low and very high frequencies, and maximal at around 4kHz. When musicians develop noise induced hearing loss their 'notches' often centre on 6kHz, about 3-4 octaves above the A you tune to.

Age-related threshold shift and noise related threshold shift affect different parts of the ear, so you can suffer both (though it is not a simple 1+1 result).

There are other forms of damage which may be more significant for musicians. These include **impaired frequency selectivity, difficulty distinguishing changes of pitch from changes in intensity, tinnitus, hyperacusis, recruitment, cocktail party effect and diplacusis.**

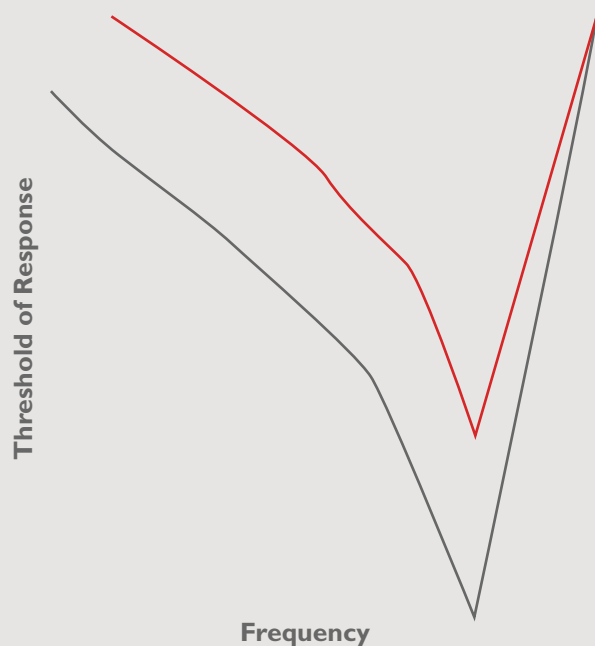
The tiny stereocilia are the last mechanical element in the hearing mechanism. Located in the cochlea, they are surrounded by fluid and embedded in 'hair cells'.



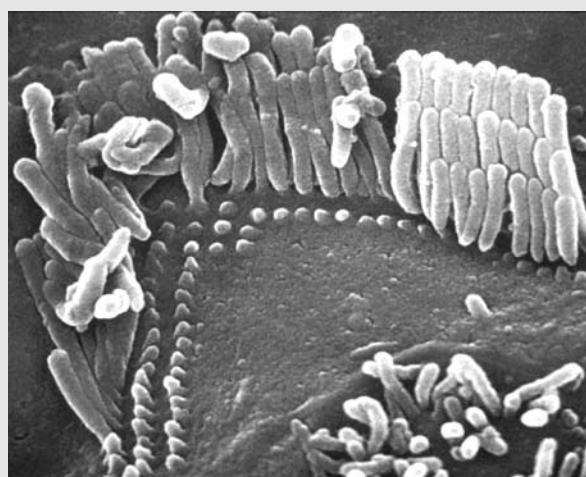
There are two sets of stereocilia: three rows of v shaped outer stereocilia, operating with a single row of inner stereocilia. Each set of outer stereocilia (v-shaped) have a favourite frequency, and dance energetically when they receive it. This 'dance' amplifies the signal to the inner stereocilia which react passively and signal the brain. An array of outer and inner stereocilia operates as a narrow-band amplifier - see the black curve below.

Damage to the inner stereocilia reduces sensitivity (red curve) - which is what most people think deafness is about - an overall reduction in volume.

FREQUENCY SELECTIVITY AND STEREOCILAR DAMAGE



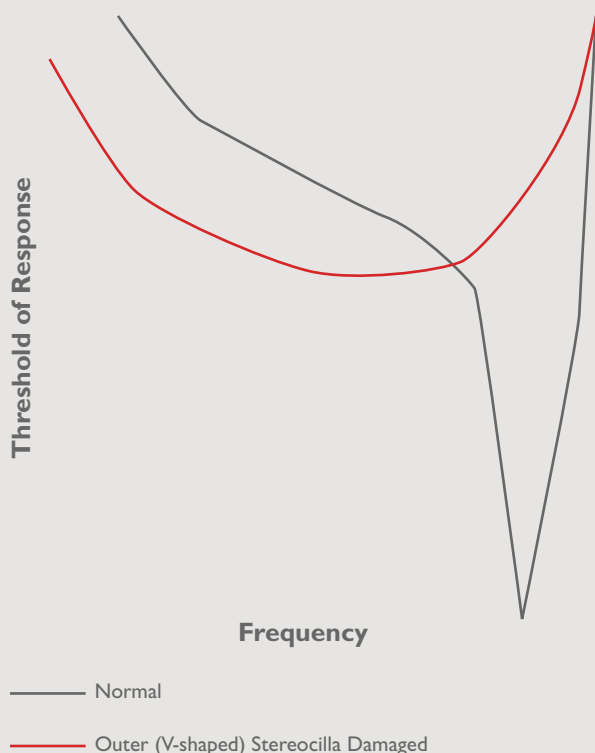
— Normal
— Inner (Straight) Stereocilla Damaged



But it is the hard-working outer (V-shaped) stereocilia which suffer, becoming floppy and stuck together

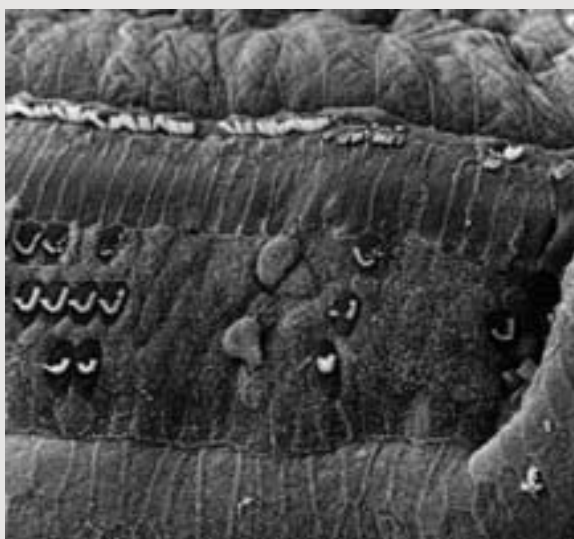
Images of stereocilia by kind permission of Dr J O Pickles

FREQUENCY SELECTIVITY AND STEREOCILAR DAMAGE



In this state, they do not 'dance' effectively and so there is less amplification of their favourite frequencies. The result is the red curve, where the fine tuning response has disappeared.

You would normally have 50% damage to a region of outer stereocilia before seeing any change in threshold shift (audiogram), and may suffer 75% damage before there is a change in threshold shift. Thus, the first consequence of noise damage is not deafness but 'blurred' hearing. NB: damage to the outer stereocilia can be gauged by otoacoustic emission testing (OAE) and while OAE results differ markedly from person to person, the change in an individual's results over time are useful for monitoring subtle noise damage. (See Health Surveillance).



Every cell has a write-off point and kills itself when too damaged. The stereocilia are part of a nerve cell, and are not replaced after write-off - they are only filled in by scar tissue.

When an array of stereocilia is damaged, the neighbours will normally also be damaged. A second look at the pink curve shows that it has shifted away from the original tip. When the brain receives information from damaged stretches, it can struggle to determine whether it is intensity or frequency that has changed so, for instance, it may seem that colleagues go sharp during a crescendo.

Notice that some stereocilia are not so much damaged as absent. Extremely high sound levels (above about 140dB) cause traumatic damage rather than metabolic fatigue, and stereocilia are ripped out. There is no recovery from this type of damage, which is why the law requires control of noise levels above 135dB regardless of how short a time they last.

HOW DOES THIS IMPACT ON MUSICIANS?

We asked about 400 full-time orchestral players if they thought their hearing had changed. (The MU distributed and collected questionnaires on our behalf). The figures in the following table are percentages within sections. (Rows add up to more than 100 because it is perfectly possible to have hearing that is both over and less sensitive).

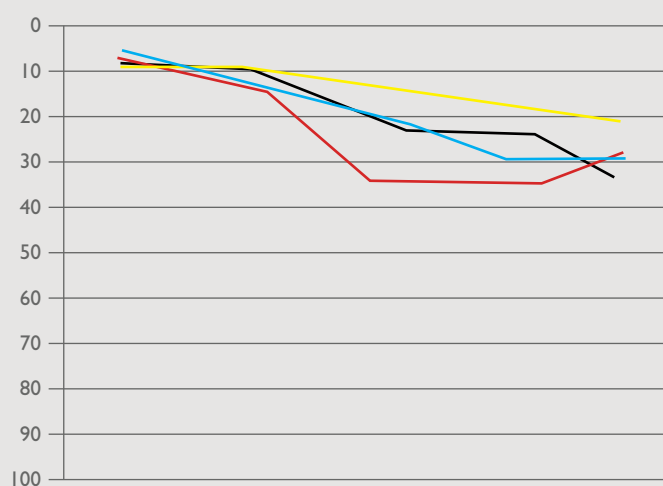
	Duller	Less Sensitive	Over Sensitive
Brass	32	47	18
Woodwind	31	39	27
Low Strings	30	25	18
High Strings	34	31	10

Dullness is a good description of age-related damage, and is broadly similar across all sections (the high strings had more older players than other sections).

Less-sensitive describes the blurring of noise-damage and is worst in the brass.

Over-sensitivity would normally be due to recruitment and therefore linked to either age or noise damage. It is not; instead it demonstrates the hyperacusis caused by exposure to intense, shocking neighbour noise.

50s BY SECTION



An analysis of musicians' audiograms showed that within the same age group (50s) the brass (red curve) had the greatest threshold shift (a mix of noise and age).

Since then, other studies have also shown high levels of hearing damage in musicians. Heili Laitinen found:

% of Respondents	Tinnitus	Hyperacusis	Distortion	Diplacusis
All	24	25	12	5
Women	18	31	14	6
Men	27	21	11	4

Eskko Topilla found that levels of threshold shift were similar to the general public, but tinnitus and hyperacusis were both four times more common.

TINNITUS² is triggered and aggravated by many factors, one of which is certainly noise. Two people with identical threshold shift will have quite different tinnitus experiences, but there is little doubt that increased noise exposure increases the risk of developing tinnitus, even if there is no clear correlation with the intrusiveness of that tinnitus (which is dependent at least as much on the character of the tinnitus as on its volume). We found that 35-40% of musicians have frequent or occasional tinnitus, with the woodwind being much more likely than other sections to report frequent tinnitus. Other researchers have found that a fifth of players have permanent tinnitus, and 2/3 have tinnitus after rehearsals or performances (demonstrating temporary hearing damage). Of the players with tinnitus, we found that 30% are bothered by it and 6% are very bothered (at least double the level for the general population).

HYPERACUSIS is an over-reaction to some noise. You will be familiar with the way your ears prick up when you hear your name mentioned, or hear a phrase that interests you: this is due to a survival mechanism in which the brain increases the volume of noise it considers to be important. This can be noise which has a special interest for you, which represents special responsibilities (eg. your child) or is associated with danger. Regrettably, noise associated with stress or pain is classified as dangerous. When players are exposed to noise that hurts them, or which increases performance stress by preventing them hearing their own output or actually preventing them playing for a moment (because of the shock), their brains activate the 'dangerous noise' defence mechanism – and make the noise seem even louder. More than a quarter of the woodwind report hyperacusis. The reflex can also activate the fight-flight mechanism, leaving a player shaking with adrenalin and with muscles tensed.

Hyperacusis is not ear damage, but a learned change in perception and with help it can, to a degree, be unlearned.

RECRUITMENT can seem to be the same as hyperacusis, but it is not. As the stereocilia become damaged, each one becomes less sensitive and less specific. This will happen to a group of stereocilia, with the result that none of them reacts to a very quiet noise. Eventually, as the noise increases, it hits the (new) trigger point of the damaged stereocilia. As the noise increases, an increasing number of neighbouring (damaged) stereocilia also start reacting – whereas in an undamaged ear the reaction would be restricted to a much smaller range of stereocilia. The consequence is that as a given noise level rises, the damaged ear hears nothing, nothing, nothing, something, lots, far too much – as the floor of your hearing rises, so too the ceiling of your hearing comes down.

COCKTAIL PARTY EFFECT occurs when hearing damage makes it difficult to distinguish a particular noise against high background noise levels. For many people, this is only a social disability but for musicians, it also means you cannot listen to particular instruments against the general sound of the orchestra.

DIPLACUSIS results from your ears having a significant difference in frequency selectivity, producing clashing interpretations of the tonal content of the noise. Because it is unusual to have the same damage in both ears, this is not uncommon.

² Tinnitus - the perception of abnormal sound whose location is within the body - is quite common. There are many, many causes but some occurs when regions of the brain tuned to frequency regions that have become damaged are reassigned to the same frequency regions of adjacent areas, leading to a sort of aural double-accounting: A high proportion of people have some experience of tinnitus: 10% of the under-50s and some 40% of the over-50s have tinnitus that is bothersome in the quiet. About 5% experience moderate to severe annoyance, 1% find it has a severe effect on their quality of life, and 0.5% suffer a severe effect on their ability to lead a normal life.

WHO IS WORST OFF?

Much of the time, own-instrument exposure dominates a player's exposure.

Other instruments are important, but they rarely add more than 2-3dB to a player's daily dose: that is, your own instrument generates more than half of your noise dose.

Studies of hearing damage agree:

The brass have the worst threshold shift, followed by the woodwind, then back strings, and finally front strings. Fiddles have more damage than comparable positions in other strings.

Percussion are a special case – their doses are low, but 'peak' exposures (transients above 140dB) result in damage in the brass/woodwind range. The range of response to this traumatic damage is much wider than the range of response to metabolic fatigue. Thus some percussionists have immaculate hearing, while others quit at a young age.

Why does it seem to be worst in the woodwind?

Generally, only very small children jump when they deliberately burst a balloon: aerobatic pilots never throw up, but their passengers frequently do so. The common factor is control.

The body is designed to fight or flee in response to sudden loud noise. If you are deliberately making the noise, its 'suddenness' is rather less of a surprise.

The people on the receiving end of 'blasts' from noisy sections are always going to be more startled than the people making the noise, and they are always going to be more aggrieved.

Pain is also a factor - most people's ears hurt at noise levels of 120dB. Some people experience pain at 110dB. Hyperacusis and recruitment lower the pain threshold. The brass and woodwind do not reach the instant damage level (140dB) but are very capable of exceeding the pain level – at their own position and, to a lesser extent, among their neighbours.

Although some woodwind (notably the piccolo) are unpopular with neighbours, it is clear that it is the woodwind themselves who are at greatest risk of hyperacusis. In an orchestra, it is important to manage the risks of hyperacusis in addition to those of actual ear damage.

Photo - John Watson



HOW LOUD IS IT?

At present no central database with representative noise measurements exists. However, from a range of measurements which have taken place in the UK and abroad, we can make the following generalisations:

We know that on a bad day brass players may reach an exposure of 100dB, as may a piccolo. We know that in general the brass have the highest exposures and the fiddles the lowest.

Essentially, the long term averages for symphony orchestras mainly working in Romantic or Contemporary repertoire are: brass about 90dB, woodwind about 88, back strings about 86, front strings about 84. Chamber orchestras, being less brass-driven, have exposures a couple of decibels lower. Pit orchestras are not significantly higher than symphonic, but by playing a less varied repertoire, have less room for manoeuvre.

We know that in general a player's own instrument dominates their exposure - although another player may drive up the overall playing intensity. We know that a pit is worse (about 3dB) than a stage. We know that repertoire and style are the critical factors. We know that layout is much more important than venue (although the venue clearly affects layout).

We know that percussion have excessive peak exposures, but we do not know how much or how often

To address this information gap, the ABO commissioned Arup Acoustics to develop a noise measuring protocol, which is included in this publication. This will give you some confidence about using the equipment, and allow orchestras to compare results. The ABO hopes to be able to develop a central database of these measurements which will be accessible to all members.

For now, we can offer the following illustrations:

Some Indicative Player Exposures		
Leq	Section	Piece
75	Brass	Haydn
80	Conductor	Carmen; Elektra
80-90	Brass	Schnabel I
80-85	Strings	Mahler I - Sectional
85-90	Strings	Mahler I
85-90	Middle of orchestra	Turangalila
90-95	Brass	Bruckner 5
90-95	Brass	Rigoletto
92-94	Chorus	Unspecified (Opera)
95-100	Brass	Mahler 9
100	Trumpet	Elektra
100	Piccolo	Nutcracker

Leq	Music Teachers - Indicative Exposures
94	Brass, wind and percussion ensemble; concert orchestra; junior orchestra
90	Trombone
89	Flute
85	Singer
82	Piano
92-95	Percussion
87	Recorder Group

Personal Practice Average noise levels measured during one study	
	Leq
Double Bass	79
Violin	85
Viola	86
Cello	88
Harp	89
Other Woodwind	91
Other Brass	95
Flute/Piccolo	96
Trumpet	97
Percussion	99 + Peak Exposures

There has been little research on the contribution of personal practice, but Laitinen et al's study (above) demonstrates the contribution of own-instrument exposure. For the woodwind upwards, personal practice was louder than rehearsal or performance, reflecting the lower proportion of time spent actually playing during most performances.

Sound level meters have to be the right type and on the right settings to accurately register peak exposures (the very high energy short-lived spikes capable of causing traumatic damage). A rule of thumb is to suspect a peak if a sound level meter not set to register peaks picks up anything above 125. The following list of 'spikes' recorded in orchestras does not necessarily suggest that the instrument mentioned was the source of the spike. However, peak exposures have been recorded in the teaching of woodwind instruments.

The percussion certainly exceed the peak exposure limit on occasions, but they have been very little studied. This issue would be an ideal subject for an experiment, rather than merely recording activity during a rehearsal or performance.

Spikes		
Piece	Player	Spike
Swan Lake	Trombone	>125
Mahler I	Double Bass	122
Mahler I	Brass	128
Beauty	Trumpet	139
Beauty	Viola	128
Beauty	Piccolo	145



KEY TERMS - NOISE LEVEL, AVERAGE NOISE LEVEL, EXPOSURE AND RISK

Noise is a fluctuation in air pressure, measured in Watts per square metre. The point of traumatic damage is 100,000,000,000,000 times the quietest sound detectable by a healthy ear. To cope with such large numbers, we count the noughts - so decibels (dB) are similar to the Richter scale for earthquakes (but with the decimal point shifted one place to make decibels look substantial). A 10dB change is a ten-fold change. A 3dB change is a doubling or halving. The 5dB reduction introduced by the new law is a 69% drop.

To take account of the particular sensitivity of the human ear the dB(A) scale gives more or less weighting to certain frequencies and is used for all risk measurements other than peak exposures.

Noise does not have a unit equivalent to Kilos or Calories – it only has the equivalent of mph. Rarely, a noise source produces a very steady level. Usually, it fluctuates so we need to know the **average** level (Leq). Wear and tear on the ears depends on the average level and the amount of time it lasted – called the **exposure**. When relating this to work, we calculate the actual exposure and normalise it to eight hours (a nominal working day) to give the **daily personal noise exposure**. Thus if someone does two sessions, their daily personal noise exposure will be lower than the combined Leqs, because 6 hours' exposure is averaged over 8. You can download an Excel macro from the Health & Safety Executive website <http://www.hse.gov.uk/noise/calculator> which is invaluable in calculating exposures and a useful educational tool (play around with the level and duration of exposure and see what difference it makes).

Exposure is about the noise level surrounding someone's head. Where daily personal noise exposure is/will be too high, people must be protected by wearing ear plugs or ear muffs etc, to reduce the noise entering their ears – ie. the **risk**.

If an ear splitting sound system is playing in an empty room, the average **noise level** may be extreme, but nobody is exposed. If someone runs into the room to switch off the system, their **exposure** may be low even though the Leq is high. If someone stays in the room to work on the system, and makes proper use of good ear protection, their exposure may be very high, but the **risk** could be low.

What exposure period do you use? If you pay someone for a session, can you average their exposure over eight hours? We think not. Orchestras of essentially full-time players may be able to average over the day, but in the main we suggest you should only average over the time you have bought.

What if a player has already used up their exposure for the day when they turn up for your session? You could make it a condition of booking that they manage their exposure so as to be able to incorporate your session (during which risks are controlled as necessary).

Most Health & Safety law applies to risks arising out of or in connection with work. In respect of noise, this could mean that calculations of exposure should include personal practice, since it is necessary for their work. There is currently no consensus on this issue, and to date all orchestral noise assessments have excluded personal practice.

Photo - Claire Tregaskis



HOW DOES THE LAW APPLY TO ORCHESTRAS?

The overarching duty is that the employer shall ensure that risk from the exposure of his employees to noise is either eliminated at source or, where this is not reasonably practicable, reduced to as low a level as is 'reasonably practicable'.

Reasonably practicable is about weighing the risks against the cost and effort etc. of taking action, and takes account of the state of knowledge and availability of measures to reduce risk. It would not be considered reasonably practicable to simply stop making music.

The Health & Safety Executive's L108 (the Guidance on the Control of Noise at Work Regulations) indicates that where exposures are below the lower levels, exposure reduction will only be reasonably practicable if it is very cheap and simple – so unlikely to be an issue for orchestras.

The Noise Regulations relate duties to three sets of noise levels.

AT THE LOWER LEVELS (LOWER EXPOSURE ACTION VALUE) - a daily personal noise exposure of 80dB(A) or a peak exposure of 135dB – the employer must:

- assess the risks;
- control the risks (as above);
- make hearing protection (ear plugs and ear muffs etc) available for voluntary use;
- provide employees with suitable and sufficient information, instruction and training.

AT THE UPPER LEVELS (UPPER EXPOSURE ACTION VALUE) - a daily personal noise exposure of 85dB(A) or a peak exposure of 137dB – the employer must:

- put more effort into reducing exposures, and;
- if exposures are still above the upper level, ensure that the people exposed make effective use of personal hearing protection.

THE THIRD LEVEL (EXPOSURE LIMIT VALUE) is less likely to be a concern to orchestras: the noise actually reaching the ear must not exceed a daily personal noise exposure of 87dB(A) or a peak exposure of 140dB - a reminder of the fallibility of personal hearing protection.

You are allowed to average exposures over a week, rather than a day, but you may find this creates more problems than it solves.

The regulations also require health surveillance for workers regularly exposed above the upper level (the point where you must wear personal hearing protection) and for workers exposed between the lower and upper levels who are particularly sensitive to noise. In practice, it may be easiest and most effective to include all players and ensembles.

If you are involved in noise management in orchestras, you are strongly advised to study the blue section of L108, as the above is very much a précis of the law.

RESPONSIBILITY - HOW FAR DOES THE LAW REACH?

The noise regulations apply to the employed, and to the self-employed (who have the duties of both the employer and the employee). So, whether a person is employed or freelance, the same things must be done – it is just a matter of ‘by whom?’

Employment for health and safety purposes is not the same as employment for tax or national insurance purposes. When a freelancer does a session for an orchestra, he or she is the orchestra’s employee (for Health & Safety purposes) for those three hours. Thus a small ensemble with two staff may have 600 Health & Safety employees in the course of a year.

In regard to noise assessment and control, the duty rests with the orchestra (meaning the managers, not the body of players). But what about health surveillance, personal hearing protection, and training? Clearly, it makes no sense for every orchestra to train and equip every player, but where to draw the line? This currently remains undecided.

HEALTH SURVEILLANCE

Where someone’s work can harm their health, and there is a way of detecting early signs of harm so that more or better-directed effort can prevent further damage, should you not set up a programme to detect these early signs?

Hearing tests can:

- indicate the extent to which an employer is successfully controlling risks;
- identify people who have so much existing hearing loss that additional noise related damage would be serious. (It can be necessary to protect someone out of work);
- identify people who seem to be especially sensitive to noise-induced damage³ and so need more protection than most.

The self-employed do not have to have their own health surveillance. However the official position is that they are “strongly advised to arrange for health surveillance if they think their exposure levels regularly exceed the Upper Exposure Action Value or they regularly have to wear hearing protection or have other concerns about their hearing”.

As before, it is likely that in practice health surveillance will apply to most musicians and most ensembles.

Employers can be given

- a statement of an individual’s fitness for work
- grouped, anonymised information

The Musicians Union subsidises hearing tests for its members, and this programme may be converted into a health surveillance scheme where information about trends etc. is fed back to the Union. It may be that non-members can enrol in the scheme for a fee, or that a parallel scheme is established, or that the programme is extended into a comprehensive scheme funded by both employers and the MU. Watch this space. Employers would either run their own scheme, or require that players show proof of participation in a recognised scheme (eg. by a certificate of testing/fitness to work issued within the last 2-3 years).

The point about health surveillance is that it acts as a back-stop: if your controls are working, your players’ hearing should at least stabilise. Where someone works for multiple employers, this feedback element may make little sense – or may provide useful information about a sector. However, even in the most fragmented situations, health surveillance is still worthwhile because it increases the individual’s sense of responsibility for their own hearing, and significantly improves their willingness to tolerate measures necessary to protect their hearing.

Musicians often dread discovering the state of their hearing, but if it is in poor condition that knowledge will not make it worse, whereas neglect may be career ending.

As noted earlier, Oto-Acoustic Emission testing provides a much earlier warning than audiometry. OAE testing is not difficult, and should form part of health surveillance for musicians. We do not have the same normal/not normal data for OAE results as we do for audiometry, but they provide powerful information for individuals, and the testing of tens of thousands of musicians should create a crucial research resource.

³ And there will be some, just as there will be people with ‘tin ears’ who show no sign of damage, and a range in between.

PERSONAL HEARING PROTECTION

The employee must use personal hearing protection when exposures exceed the upper levels. The employer must provide them, free of charge.

The cost of a pair of ear plugs ranges from about 30p to over £150, and the expensive ones have to be custom-made. Each orchestra must decide on the most reasonable and equitable way to provide players with suitable and sufficient hearing protection (more later). Some may choose to send players to a nominated service, some may distribute hi-fidelity off-the-shelf plugs (about £15-£20 a pair). Some may provide players with information and an ear plug allowance. Some may provide freelancers with information and require that they bring suitable ear plugs to the session. Players who do not come equipped for work could be provided with conventional industrial plugs (either foam or flanged) which will be sufficient but rather less suitable.

People often choke on the price of high quality ear plugs, but when off-set against tax and amortised over 3 years, they cost about 12p a day. Is anyone's hearing worth less?

TRAINING

Suitable and sufficient information, instruction and training must be provided, in paid time.

- Does a freelancer do one training session every three years, or endure forty or more sessions in a year?
- Must training be face-to-face, or can it be delivered by CD, or online?

The information, instruction and training should include:

- the likely noise exposure and the risk to hearing it creates;
- what you are doing to control risk and exposures;

Photo - Chris Stock Photography



- your noise policy and consultation arrangements;
- where and how people can obtain personal hearing protection (or a direction that freelancers bring their own);
- how to report defects in personal hearing protection and other controls;
- the employee's duties;
- the arrangements for health surveillance;
- symptoms to look out for, who to report to and how;
- managers must also understand how to carry out assessments, select and implement noise controls, monitor compliance and progress, etc.

Clearly, some of this is generic material which belongs in training sessions, while some is session-specific information to be provided when booked, or on the day.

Why train?

- Because noise control will be a major change for orchestras and musicians, and will founder if people are not convinced of the need – ie. the threat to their hearing and thus of their livelihood and pleasure.
- Because noise control is not simple, and people need to understand the pros and cons of the various options available.
- Because noise control is not optional, and people need to understand their responsibilities.
- Because managers need to understand how to make it all work, and go on working.

In terms of providing information, orchestras are:

- placing papers on music stands;
- putting notices by the stage;
- providing verbal announcements at the beginning of the session;
- including information in schedules;
- emailing everyone on their list;
- and more.

As with health surveillance, a national scheme may emerge. In the meantime, the essentially full-time orchestras might be expected to lead on rolling-out player training. Freelancers should not be drenched in training, and employers may choose to require (in time) that a player provide proof of having received appropriate training within the previous three years. Note that Health & Safety training normally has a three-year shelf-life.

CONDUCTORS

Regular conductors should be incorporated as far as you can manage – the more they understand, the more they are likely to engage with or initiate experiments in noise control. Orchestras which have trained their conductors have received enthusiastic support. Orchestras which have explained the situation (eg. by writing to all their conductors) have met general acquiescence.

CONSULTATION

Health and Safety is founded on consultation with employees or their representatives.

Where there is an established safety committee, it should be consulted on how best to develop the management and monitoring of noise control. The committee may choose to establish a sub-committee to deal with noise. Conversely, a noise committee may form the nucleus of an as yet unformed safety committee. Primarily freelance orchestras may identify a stable core of players who could be consulted in the course of routine meetings, or in time between adjacent sessions, or by email etc, and may liaise with any MU rep.

As well as players, you may need input from people such as responsible managers, conductors, resident composers, safety and occupational health advisers, and representatives from frequently visited venues.

ASSESSMENT

Where exposure is likely to exceed the lower levels (80dB for the day/session or 135 dB at all) the employer must assess and as necessary control the risks. Assessment is not an end in itself; it is a basis for action.

Because musicians are primarily exposed by the output of their own instrument, the dominant factors in noise exposure are the instrument, the music and the way it is played. Symphonic and pit orchestras will have to assess nearly all of their work. Some chamber orchestras may be low risk, but many will have to assess much of their work.

Assessment applies to all the orchestra's work – so it also includes educational and other outreach projects. Where the orchestra has laid on transport, that may also require assessment – for instance smaller aircraft are noisy.

WHO WILL DO THIS, WHEN, AND HOW?

Because the point of assessment is to achieve reasonable control, assessment of orchestral noise risks needs to be done before the performance, and will therefore usually not be based on strictly relevant measurements, or even any measurements. L108 states that you should assess exposure by means of:

- observation of specific working practices;
- reference to relevant information on the probable levels of noise corresponding to any equipment used in the particular working conditions;
- if necessary, measurement of the level of noise to which employees are likely to be exposed.

... and goes on to state:

“you are not required to make a highly precise or definitive assessment of individual employees' noise exposures ... Your assessment of exposure must be a reliable estimate with sufficient precision for you to be able to show whether EAVs are likely to be exceeded. Your assessment ... will only be reliable if it uses data which is reasonably representative of individuals' exposure. You would be expected to use data from measurements of noise where other sources cannot give you reliable and representative data.

Uncertainties in an assessment of exposure to noise can arise from variability in the level of noise and in the duration of exposure. If you assess exposure as being close to an EAV then you should proceed as if the EAV has been exceeded, or ensure that your assessment is sufficiently precise to demonstrate that exposure is below the EAV.”

In an orchestral context this means thinking about the pieces in the programme, how the conductor/leader will want it performed, whether any dominant personality is likely to drive up the noise level (several orchestras have noticed this), what layouts are possible in the venue(s), etc.

Other existing measurements can help to ball-park your likely exposures. If you have access to noise monitoring equipment, then measurements during rehearsal and performance will provide feedback for future assessments, or for subsequent performances of those pieces.

Noise assessment should start as early as possible – for instance, noise limitations will be one of the many considerations in arranging seasons and programmes, and in matching programmes to venues.

As the performance date nears, the detail of the assessment should increase, with more of an idea of the control measures to be applied, and how these will be managed.

After the performance, you may be able to refer to noise measurements, and should obtain feedback from a selection of people about the perceived effectiveness and acceptability of the various control measures.

Because of the range of inputs needed, and the range of things to be done, noise assessment will often be the work of a group rather than an individual. The group will probably operate in different formations for different purposes – for instance, the grouping needed to consider noise implications of long-range planning decisions may differ from that finishing the arrangements for tonight's concert. And the group should either incorporate or arrange for consultation with players or their representatives. However, one individual should have overall responsibility.

In a larger ensemble the noise group might include:

- chief executive
- conductor
- artistic planning
- stage management
- section reps
- safety reps
- venue reps

You should have a written noise policy, which may form part of your safety policy, or become the core of a safety policy. See <http://www.hse.gov.uk/smallbusinesses/must/policy.htm>

The noise policy should spell out:

- specific noise responsibilities, from the managing director downwards;
- how you manage noise assessments;
- how you manage noise control;
- how the noise group relates to your safety committee or other consultation arrangements.

An assessment should include consideration of:

- level, type and duration of exposure;
- exposure to peak sound pressure;
- effect on employees at particular risk;
- information from health surveillance;
- availability of personal hearing protection (php).

And will therefore include:

- knowledge of the works to be played - how loud; how long; composer's style;
- knowledge of the venue - space / restrictions / resources / acoustic;
- any valid measurements;
- analysis of the works - how energetic; extreme changes in dynamic; significant concentrations of energy; instruments that are masked etc;
- knowledge of the individuals - conductor / soloists / principals;
- feelings about the works - how painful / startling / unpleasant / tiring.

The output of the assessment is a statement of the things to be done to reduce risk, and by whom. Clearly this needs to dovetail with all the other activity on the day, so actions may need to be delegated. Some noise controls are unpopular, and you will need to check that they actually happen. If you do not check, you do not have a control system. Most noise controls have unhelpful side effects, and you should get feedback about the extent to which these side effects were successfully avoided. Where you measure noise levels, please share them with other orchestras via the ABO.

You should keep a written record of the assessment, sufficient to demonstrate that it was adequate, to provide others (including players) with the significant findings, to develop your action plan, to learn from it when doing later assessments, and to be able to share ideas with other orchestras. You should expect your record to include:

Date	Venue	Programme
Players	Conductor	Soloist(s)
Valid Data	Prominent Risks	Risk Ball-Park
Mandatory PHP Periods	What Controls	Managed by Whom
Checks Made	Did the Controls Work?	Measured Noise Levels

ACTION PLANS

Some noise controls are easy, some require long-range planning. All require management effort, and communication with the players and others. You will need to develop a plan for noise that identifies the new things to be done and the effort, persuasion and funding required, and lays out the stages towards attainment. Responsibility for and regular review of the plan should be incorporated into your noise policy.

NOISE CONTROL IS NOT EASY

If noise control was easy, orchestras would have done it years ago.

Most noise controls have side effects that cause difficulty in orchestras (see the menu of options for controlling noise): they need to be selected so the effects are minimised. Even then, there will be problems, which can be exacerbated or reduced according to the way in which they are introduced.

Effective noise control in orchestras needs careful management – of the combination of control measures, of measures to counteract side effects, of people's expectations and antipathies.

Without careful management, there will be little protection, the possibility of an overall worsening of noise and health risks, and increased resistance to further attempts at hearing protection.

The difficulties of using noise controls include:

- Some control measures may temporarily change the orchestra's sound, so you may want to consider the programme, venue and conductor involved when you introduce controls.
- Some control measures may be noticed by the audience – though it is astonishing how little they see .
- Earplugs, even the most suitable, alter the sound of your instrument, particularly for the brass and some woodwind. Players need to get used to them in private practice, then start using them in rehearsal.
- The introduction of noise controls is a major change management project, with all the stresses, resistance and rumour that involves.
- What are you going to do when people refuse to use control measures? Legally, they are obliged to comply with your instructions and a failure to comply can lead to disciplinary action. Practically, you need to emphasise the benefits, provide training, get people through health surveillance, work on those who are persuadable, and provide safe channels for feedback.

SELLING NOISE CONTROL

We all engage in future discounting and we all suffer from optimism bias, so we pay little heed to harm that might happen some time in the future, and assume that we will be some of the lucky ones. Noise control has more benefits than just preventing inaccurate hearing or tinnitus in coming years.

- Noise control should largely eliminate temporary threshold shift, so improving the day to day quality of players' hearing.
- One of the most effective noise controls is to improve projection. This allows the source player to produce the same effect with less effort, and it also makes them sound brighter. Currently, brass players rarely make it to retirement, their careers ended by over-playing injuries.
- The situation has changed since 2001, but some orchestras have found that noise training improved relationships within the orchestra, as players understood and felt less afflicted by each other.
- Ear plugs can actually make it easier to hear during loud passages.

OPTIONS FOR CONTROLLING NOISE

Each of the following control measures will provide some dose reduction, and be usable in some circumstances more than others. The worst daily dose on record is 98dB⁴, so the total amount of reduction needed is not that much (though still difficult to achieve). Shaving a bit off the dose here and there may be all that is possible, and as much as is necessary.

GET THE CONDUCTOR ONSIDE

ADD NOISE TO THE LIST OF CRITERIA IN DEVELOPING PROGRAMMES,

and at least avoid putting huge forces on small flat stages.

GET NEW COMPOSERS ONSIDE

PLAY LESS LOUDLY

- Sometimes the excitement can be increased but the exposures reduced by accentuating the quieter areas around very high power segments.
- Use practice mutes or practice pads during personal practice
- Keep piano lid down during personal practice
- When teaching, encourage students to keep it down
- When teaching in groups, avoid constant 'group practice'
- How loud does the rehearsal need to be?

USE LESS POWERFUL INSTRUMENTS – PARTICULARLY IN THE BRASS

Nobody is suggesting switching to period instruments, but different modern brass instruments have different power ranges. The more powerful instruments are popular, because they require less playing force. However, if they are played at high power they force up the dynamic of the orchestra. External observers do feel that orchestras have become louder in the last 30 years.

IMPROVE PROJECTION BY:

USING HIGH RISERS – AT LEAST 50CM ABOVE THE ROW IN FRONT

High risers – akin to a return to the old town-hall layout – are readily available in some venues. In others you may need to consider investing in your own (with the ensuing transport and handling and set up problems), or joining with other orchestras to lobby for improvements at the venue, or trying a different layout.

High risers make a considerable difference – in one orchestra, players thought the brass were pulling an elaborate practical joke by playing far too loud. In fact, they were playing as usual, but for the first time they were no longer obstructed by rows of human sound absorbers. Players on high risers need good feedback from the conductor, will not instantly turn down the sound, and may have difficulty if they keep having to switch between obstructed and unobstructed layouts.

NB, if an instrument's sound output goes downwards, high risers may increase the risk to neighbours.

PUTTING NOISY SECTIONS AT THE SIDES

Many chamber ensembles block the noiser sections at the side, rather than at the back. They are not completely unobstructed, but do have fewer rows of musicians in front, and fewer people in front feeling that they are being assaulted.

PUTTING NOISY SECTIONS AT THE FRONT

This sounds bizarre but has been tried by a number of ensembles, with considerable success. The orchestra can be laid out 'back to front', with the brass nearest the conductor and strings furthest.

ENSURING EACH NOISY INSTRUMENT HAS A CLEAR SOUNDLINE TO THE AUDIENCE

Where you have horizontal space, you can spread the orchestra out so that sound passes between players, rather than through them. Initially, this will affect ensemble, but orchestras that have tried it have strongly preferred the generous layout. Even where the whole orchestra cannot be dispersed, you may be able to develop sound channels for particularly high risk instruments.

⁴ There are plenty of 97 and 96 days, but the restrictions of lung-powered instruments seem to create a ceiling at 98. So far.

STANDING UP AND/OR PLAYING BELLS UP

Where high risers are not an option, the risks to both the players producing the noise and the folk in front of them may be reduced by standing up during critical passages. Players need to be able to raise the music stands as they get up. It is both showy and effective.

Where standing up is not appropriate, brass players (and others) may pay some attention to the output of their instrument in relation to their neighbours. This will reduce pain and obliteration (being unable to hear your own instrument because of the volume of noise from neighbours) experienced by neighbours, and also reduce the degree of force required to produce the sound.

IMPROVING FORWARD PROJECTION FROM THE HORNS

American orchestras have used baffles, angled at 45° to the horizontal, behind the horns so as to deflect more of their sound forward.

SACRIFICE INCOME TO EXTEND THE STAGE, GIVING MORE SPACE FOR CLEAR SOUNDLINES, OR TO ACCOMMODATE RISERS ETC.

Some ensembles have given up considerable box-office to create enough space for the orchestra: others pay to restore the extended stage to normal at the end of their run.

ADJUST PLAYING STANCE

- Play bells up
- Keep your head straight - fiddles and violas can reduce exposures and musculo-skeletal risks by modifying their posture.

SHARE THE NOISE DOSE AMONGST TWO OR MORE PLAYERS

This is a very expensive option, for a modest reduction in daily personal noise exposure (a 3dB reduction for a halving in the period of exposure).

MOVE PEOPLE AROUND, SO THEY SHARE THE MISERY OF SITTING IN NOISY POSITIONS

Neighbour noise does not dominate, but it can almost double your dose, and for many players the stress and pain of exposure from neighbours may be their major concern. Some orchestras have found this to be successful in reducing noise exposures and stress: others found that those who usually sat in noise hot spots were accustomed to it, while those who swapped-in were less able to tolerate the experience.

MARK THE SCORE

To a degree players can brace against a burst of loud noise from neighbours. They may have time to insert earplugs or fingers, or may at least prepare psychologically.

SINGLE RANK THE BRASS

The brass are usually the most highly exposed, and the worst daily exposures came from the front of two rows.

WITHIN A PROGRAMME OR SCHEDULE, BALANCE NOISY PIECES WITH SOMETHING QUIETER

PUT NOISY PLAYERS SOMEWHERE ELSE AND MIKE THEM IN

Orchestras that tried this suffered from tiny but significant time delays introduced by the electronics

KILL THE ACOUSTIC

No, not entirely. Expert use of well-designed acoustic insulation has been used to considerable success in pits and in rehearsal rooms (Royal Opera House, Birmingham Hippodrome, MOD). It has the effect of eliminating the 'old' noise bouncing around, leaving the 'fresh' noise passing from instruments to players and audience. Noise levels can be dramatically lowered. Players find it easier because they can hear themselves and their neighbours. Conductors report much improved playing quality because they can distinguish instruments and more effectively modify the sound.

SHIELD PLAYERS FROM NOISY NEIGHBOURS USING SCREENS

- Screens must be used with considerable care. They can provide useful reductions in both noise exposure and the experience of pain and shock. However, they can significantly increase the risks to the source player, and there have been instances where a screen has increased the exposure of the shielded player (because their own instrument reflects off it).
- Manufacturers have put a lot of effort into making manoeuvrable, non-reflectant screens, but orchestras continue to experience problems and some have stopped using them.
- If a screen obstructs the sound of the source instrument, that player may be forced to play louder to deliver the same noise. Simultaneously, s/he may be affected by reflection from the screen, and the conductor may complain the sound is flat (because the screen takes off high frequency noise which can make it sound as though the fundamental has dropped).
- It is too easy for a screen to do more harm than good. Consider a situation where both players are exposed at 85dB, and a screen is introduced which delivers 3dB protection to the player in front, but forces the source player to play louder – increasing his/her exposure by 3dB. At first sight you may think the total risk is the same before and after, but decibels are logarithmic so one exposure has halved while another has doubled, and the total risk has increased.
- Screen positioning must be carefully prescribed in the noise assessments.

USE AN APPROPRIATE SPACE

In educational projects, the acoustic of the room should be appropriate to the project.

STAY OUT OF THE LINE OF FIRE

- In educational projects, players should position themselves out of the line of fire of directional instruments.
- Do not let (for example) soprano soloists face the orchestra

Photo - Chris Stock Photography



PERSONAL HEARING PROTECTION

With the upper exposure action value at a daily personal noise exposure of 85dB(A) or a peak of 135dB, not many players will be able to entirely avoid personal hearing protection.

In factories, the main problem with ear plugs is social isolation, and some discomfort. In orchestras the problems are much more immediate.

- Players need to hear themselves and their colleagues, so isolation can affect quality and exacerbate performance stress. This is minimised by using no more protection than is necessary.
- Skull conduction creates significant treble loss for some players, so eliminating the tones they need in order to play accurately
- Where there are sudden changes in dynamic, players may be in hearing protection during extremely quiet passages and so hear almost nothing.
- During rehearsal, players in hearing protection may struggle to understand the conductor

It is important to avoid over-protection. When properly fitted (which is rare), the yellow roll-up style of plug provides far too much reduction – it is good for sleeping in a noisy environment, but not for most orchestral work.

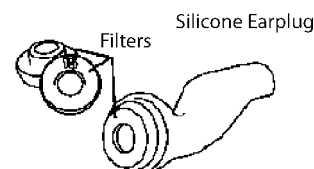


Flanged industrial plugs also over-protect when properly fitted, but the flanged design means they can be partially inserted to give less reduction. The problem is that you do not know how little, and it may be too little.

Bass players and cellists may prefer a style of plug that allows them to hear their own instrument, but reduces the treble from neighbours eg. Guymark Blue. Bespoke (custom-moulded) ear plugs can be 'vented' to give a similar transparency to lower frequency noise.

Strings may prefer uniform attenuation protection such as the EAR Ultratech, or the ER 9, 15 or 25. These plugs introduce a controlled amount of treble amplification so that the noise reduction is fairly even across all frequencies. The Ultratech is an off-the-shelf flanged plug, whereas the ER series are built into bespoke ear plugs. The advantage of bespoke ear plugs is that you can get a purer protection because the plug can be made to fill the whole ear canal (thereby eliminating resonance in the gap between the ear drum and an ear plug).

Bespoke ear plugs depend on getting a good mould of the ear canal. Some suggest as the mould sets, the player should move their jaw as though they were playing. The ER range of plugs can be constructed with swappable filters.



Players who have significant skull contact with their instrument (mainly brass and double-reeded woodwind) experience noise from both the ear drum and the skull. Skull noise is bass rich because the thick bone around the ears eliminates much treble.

You have probably failed to recognise a recording of your own voice because it was so tinny - unfortunately that is the real version: the rich noise you hear is because of the skull-conducted element. When an ear plug reduces noise reaching the ear drum, the skull noise remains constant. As a result, the bass/treble balance changes and this is exacerbated because bass noise interferes with your ability to hear treble. Thus some players hear remarkably little useful noise when they wear ear plugs. The distortion is minimised if the ear plug offers the minimum protection necessary, and if the ear plug fills as much of the ear canal as is possible.

Where a full-depth light-protection ear plug proves unusable, a different style of protection may work. Note that this style of protection is only effective if exposure is sufficiently spiky. Level-dependent or amplitude-sensitive protection is designed to offer negligible protection at moderate noise levels, but to almost eliminate very loud noise (usually above something like 105/110dB). The effect can be weird – a player may see percussionists working, but not hear the side drum – but creates less interference for most of the playing period. Level-dependent protection is normally the best option for percussionists, may be the best option for brass, and may work for some woodwind. It will rarely be suitable for strings players.

Level dependent protection is available in off-the-shelf flanged plugs, bespoke plugs and ear muffs.

Ear muffs may also be an option, and do not involve the problem of resonance in a blocked-up ear canal. There is a style of ear muff that supplies a controlled electronic version of the external sound field. When these were trialled, players were happy enough with the sound, but discovered that the electronics introduced a time delay. The delay was slight, but enough to put the players constantly behind the beat. So, currently not a solution unless all the players wear them.



Photo - Chris Stock Photography

RELUCTANCE

Personal hearing protection will often be necessary, but will not often be welcomed. If hearing protection is not supported by persuasion and management you fail to control risk. You will probably need to:

- Include the need to wear hearing protection in the noise/safety policy
- Provide appropriate training
- Encourage hearing tests, as this usually increases willingness to use protection
- Provide information on the arrangements for getting or claiming for hearing protection
- Define periods of compulsory use – ie. which player and when. It is easiest to make this all players for an entire session, but this is not fair, not necessary, and likely to increase resistance. Instead, you should try to define the periods of risk – perhaps by identifying periods which are clearly safe. Note that in terms of noise exposure, anything below 75dB is insignificant.
- Develop means of checking that players are wearing protection when required
- Set out a timetable for acclimatization and make it clear that after full implementation, increasingly firm action will be taken against those who do not comply
- Ensure managers and senior players set a good example
- Distribute HSE's card 'Protect your hearing or lose it!' to remind people to wear their hearing protection



Photo - Chris Stock Photography

AFTER ALL THE TRAINING, WHERE ARE WE NOW?

An evaluation by **Malcolm Warne Holland**

BACKGROUND

The publication **A SOUND EAR**, which the **ABO** commissioned from **Alison Wright Reid**, appeared in August 2001. It was well publicised, well received and widely distributed.

Many musicians had believed for years that their hearing could be at risk from simply doing the job they loved, and *A Sound Ear* confirmed their fears. But, others had never thought about it in those terms and confessed to enjoying the “noise” music made, secretly labelling the whiners as ‘cissies’.

The bald facts and figures presented by Alison Wright Reid to orchestral musicians, initially in the document and later during the training days set up by the ABO, came as such a shock that many were neither willing to accept them at face value nor consider the solutions and controls. The managements had been discussing the issues at ABO conferences and sector meetings for at least three years but for some reason the message did not hit home with all of the players.

The musicians were not prepared, and in many instances genuine concern was expressed about the future viability of the profession, given the perceived stringency of the new regulations. There were reports, from musicians and managers, of negative reactions during the training sessions. Some musicians responded so subjectively as to suggest all this was yet another cynical ploy to destabilise orchestras, or, at least, an EU directive that was ill-conceived and never likely to work.

SUMMARY OF FINDINGS

The good news is that three years on from the first official training sessions in Leeds (Orchestra of Opera North) there appears to be general consensus about the need to take action. Many initiatives have taken hold, and there is a rising level of good practice. Musicians have realised that the law is there to protect them, not to destroy orchestras, and have shared with management their views on the best way to take control of the problems. Misunderstandings have been resolved and most cynics won over to a method of trial and experiment. There is a slight risk that just a very small number of people in authority may think themselves above the law and intend to take no action to protect their players. This would be an arrogant and short-sighted view and could be against the interests of the whole profession. However, there does appear to be a strong and extremely positive movement across the sector towards training, understanding and action.

TRAINING

The announcement of the important training initiative launched by the ABO in 2004, with generous financial support from the MBF, received an enthusiastic response, especially from contract orchestra managements who were able to schedule the time for the sessions into existing plans, avoiding extra costs. Managements of freelance orchestras, although keen to offer the training to their core members, found it more difficult to organise because of the need to pay fees for the time involved, but nevertheless some, especially the self-governing London orchestras, found a way.

In the first wave of training, which started in December 2004, a cross-section of ABO members took advantage of the subsidised sessions with Alison Wright Reid. The choice of orchestras in this evaluation reflects the diversity.

The four orchestras: The Orchestra of the Royal Opera House, the Bournemouth Symphony Orchestra, Northern Sinfonia and the London Philharmonic Orchestra.

The purpose of this evaluation was to assess the value and the outcomes of the training to each of the orchestras, in order to give the ABO and the MBF clear guidelines about future initiatives, in relation to value for money and health and safety, and to inform the profession about action plans and best practice established post-training.

What was uncovered was a very interesting, encouraging, yet diverse range of responses and a surprising spectrum of opinions about the training and reactions to it. But the one common fact which emerged from discussions with orchestral musicians was that, whatever they thought about the quality, or even the delivery, of the sessions, they had all got the message. They may not all have liked it, but that is another matter. Here are some of the comments by players:

"The technical aspects of the ABO sessions were frighteningly clear but the solutions were not so obvious..."

"...the handouts were very useful in making us see the dangers to our hearing and general well-being, should we continue with the same working conditions."

"As a result of the training, people do feel more confident in actually standing up in rehearsal and saying that the noise is unacceptable ... the point was made (to the conductor) ... when rehearsing the opening of Janacek that it did not have to be played fortissimo in rehearsal. He was not too thrilled but took the point!"

"...the 'training day' has not proved particularly memorable for me. All the theory in the world does not alter the aural discomfort of a 'bad' seating position."

"No one could deny that the training taught us some uncomfortable facts and confirmed what many suspected, but we all got a bit hung up on the ear plug question, rather than what might be done before it comes to that."

"As for educating conductors ... I guess it is up to management to address long before the conductor gets anywhere near the orchestra. Because of our training, people are much more willing to confront a conductor in rehearsal than in the past. It should not ever be necessary though! Hopefully, gone are the days when Solti said to us in a 'FRAU' rehearsal - 'play anything you like as long as it is loud!'"

"There was some resistance but it helped that a small group had a preliminary session with Alison Wright-Reid."

"Our trumpets went into the training having been willing to use screens and came out refusing on the grounds that they were dangerous! I am not sure that was the intended message of the training...!!!"

All the musicians interviewed were determined to co-operate in finding ways of changing working practices to improve safety and to comply with the **Noise at Work Regulations**. Very little complacency was detected on the part of the

players. Even those in the Northern Sinfonia, where the problems are fewer, though nonetheless apparent, were eager to talk about how the working environment could be improved. The training had made them realise that they had a right to object if they were being bombarded with potentially 'controllable' noise.

Up to now, 13 orchestras have received the training: LSO, Opera North, Philharmonia, Halle, RLPO, BSO, Northern Sinfonia, LPO, RSNO and CBSO. Additionally the ROH and Royal Ballet Sinfonia had similar training to the rest but organised and funded it independently.

Of course, much work has also been done by the BBC with each of its orchestras and it has to be acknowledged that the question of measurement and solutions has been a live issue at the BBC since the early 1990s, when Alison Wright Reid, then part of the BBC's Health and Safety team at White City, established her interest in this area along with other colleagues. (see AR Woolf – Broadcasting and the Noise at Work Regulations – 1994 *Acoustics Bulletin*)

CASE STUDIES

BOURNEMOUTH SYMPHONY ORCHESTRA

The Bournemouth Symphony Orchestra is based in Poole, Dorset and serves the South West region with regular concerts in Exeter, Bristol Southampton, Basingstoke, Weymouth, Bournemouth, Portsmouth and its home venue, the Lighthouse Poole, plus many in other touring centres and summer outdoor venues. The BSO has an international profile and a large discography and is one of Britain's oldest orchestras dating back to 1893. It is a full time contract salaried orchestra with a core of approximately 76 musicians.

In Bournemouth there is plenty of awareness, with a noise team in place and a management representative working closely with the players to move things on. The senior manager responsible covers a wide brief within the organisation and additionally reports to the Board on all matters relating to Health and Safety. The urgency of the situation facing all orchestras, with the legislation taking effect soon (April 2008), is understood and the organisation is treating noise management as a priority. In common with many orchestras the BSO does not seem to have managed, as yet, to persuade its Music Director to embrace the issue of noise management, but it is not discouraged. Despite a strong will to succeed and much discussion between the various factions they have not yet arrived at an action plan to which everyone can subscribe, although it is believed they will in the very near future. Currently, they are considering experimenting with alternative seating positions and recently, have been enquiring about the 'new generation' protective screens. It could be argued that this does represent an action plan working towards a code of practice!

The BSO's home venue, **The Lighthouse, Poole** has a concert platform which is wide rather than deep, but it does offer some opportunities for experimentation with seating positions. Flexibility is difficult as the risers are at pre-determined heights and it would involve considerable expense to have extra risers custom made. The auditorium is also wide rather than deep and this causes strong reflections from the back wall in very loud music. It is conceivable that this has at least the positive effect of calming down the brass volume, except when encouraged by the conductor to push the limits.

Standard perspex screens are also available but not used as a matter of course. There seems to be some confusion about the placing of screens and concerns about the dangers of getting it wrong. Audiometric testing has been offered to all members, and the method of testing is under discussion. Strong links are being established with outside agencies to offer comprehensive screening and care.

The BSO *noise team* consists of a disproportionate number of brass players and is therefore not wholly representative. It would appear that woodwind players, particularly, did not volunteer for membership, which is a pity. The Chairman of the Orchestra Committee, with the encouragement of the main body of the orchestra, is now taking an active part in discussions with the management and the *noise team* and it is hoped that a greater degree of consensus might be reached in future.

Major challenges for the BSO over the next few years relate very much to its regular concert venues. The *noise team* has identified the halls where players are at most risk and believe a dialogue with the venue managements must follow.

ORCHESTRA OF THE ROYAL OPERA HOUSE

The Orchestra of the Royal Opera House is a large group of salaried musicians who serve both the **Royal Opera** and the **Royal Ballet** and other activities within the House, including Education and small scale work in the **Linbury Theatre**. The total number of players exceeds one hundred but the schedule demands rotation and therefore it would be rare for all members to be called together. The closest it gets is during Wagner's *Ring Cycle* when all players would be involved in at least two out of four operas.

At the Royal Opera House there is a management absolutely determined to make a contract with the musicians to monitor, record and control exposure to noise levels on an individual basis. Measures are being taken to explore and install the best and latest physical levels of protection at the ROH and it is apparent that everything that can be done is being done. Audiometric testing is available to all members and confidential health profiling is well under way.

Musicians of the **Orchestra of the Royal Opera House** were very open with their comments and it was possible to form a very full picture of the work being carried out. In September 2007 it was possible to observe a whole day of sessions about health and safety and noise at the Royal Opera House. These sessions, which were aimed at the whole orchestra and immediate orchestra management, were arranged for small groups over a period of two or three weeks and included periods of training, presentation and discussion. These events are established as a regular part of the 'Healthy Orchestra' regime at Covent Garden.

The challenges of working in the confines of a pit are so great that solutions cannot be found without taking full advantage of the best professional help available in the acoustics field. The ROH is leading the way in this respect and other opera and ballet orchestras will benefit from the sharing of the outcomes. 'In house' responsibility on a day to day basis is also crucially important. An Orchestra Operations Manager has recently been appointed and he comes with experience of the Sydney Opera House, where much has been done, both practically and experimentally, over the last few years in the control of noise. He is tasked, among other things, with advising the Orchestra Director, working out seating plans and organising the monitoring of noise levels in the pit.

Quote from a violinist: *"He seems clued up ... (and) is already producing specimen rotas for individual players, based on their potential exposure. In order for these to be accurate, measurements are planned within the pit to map the potential exposure in any area. It looks like a complete statistical nightmare to me ... However they are attempting it!"*

Critics will say that the Royal Opera is well funded (relatively) so the orchestra management ought to be ahead of the game. Maybe that is fair comment, but observations confirm that it is the commitment and the quality of the work being done that is impressive and this cannot be underestimated. Even the cynics in the orchestra, and there are some, agree that the management seems to be doing everything possible to maintain momentum. They have come a long way since the ABO training and are taking further professional advice from many quarters. They do not have a formal *noise team* but there are those within the orchestra who have been involved from the beginning and continue to be part of the team along with the elected representatives and H&S professionals within the House.

LONDON PHILHARMONIC ORCHESTRA

The London Philharmonic Orchestra was founded in 1932 by Sir Thomas Beecham from the best players in the country, with the intention of rivalling those in Vienna and Berlin. In 1990 it became a Resident Orchestra at the **Royal Festival Hall** in London. The Orchestra's versatility is evident from its pioneering education and community programme, its international trail blazing tours and its comprehensive recording catalogue. The Orchestra is resident at **Glyndebourne Festival Opera** during the summer months.

The Orchestra is self-governing and seven players serve on the board along with seven non-executive members. The core membership is between 85 and 90 players.

The **Healthy Orchestra Charter** (<http://www.abo.org.uk>) and the publication on the web of the **Sound Advice** consultation document (<http://www.soundadvice.info>) has been the spur to a flurry of activity at the London Philharmonic Orchestra. On their own admission, the management and players coasted along after the ABO training, providing standard ear plugs and screens on request and generally acknowledging the need to move towards a policy. But, in addition to the effect of Sound Advice, playing in a smaller London space during the closure of the Royal Festival Hall has also encouraged new dialogue about noise levels, seating and repertoire.

A team, made up of players and staff, is in the process of drawing up the Orchestra's policy response to the Sound Advice consultation, and a new handbook containing general working and H&S policies has been published. A specific policy on noise management will be added when it has been agreed. Matters under discussion include the damping of sound at Henry Wood Hall (the Orchestra's principal rehearsal space), following up on acoustic tests at Glyndebourne,

where the orchestra is resident throughout the summer, and exploring possibilities on the RFH platform now that hydraulic lifts have been fitted. Research into more effective earplugs is being carried out and different types are being purchased. A generic seating plan has been drawn for the RFH which will, of course, be varied according to the needs of repertoire, but nevertheless has taken into account the high exposure areas and as far as possible provided some distance and isolation. The LPO's new principal conductor understands the issues and is willing to co-operate in finding solutions.

After a slow start the LPO is taking noise matters very seriously and in planning future schedules consideration is being given to awarding a free day following a very noisy day, when possible, to help with the reduction of average noise dosage. Discussions have also taken place concerning the importance of talking to visiting conductors about the issue.

NORTHERN SINFONIA

The Northern Sinfonia is the only full time salaried chamber orchestra in the UK. It is resident in Newcastle/Gateshead at The Sage and will celebrate its 50th anniversary in 2008. In addition to its commitment at The Sage the Orchestra gives concerts throughout the North of England, overseas and in many other parts of the UK.

It has been said by some that we do not need to worry about chamber orchestras since their musicians do not play enough loud music, and even when they do it would not be enough to raise their average dose above the limits. Up to a point that may be true but it rather encourages complacency and that could pose dangers.

Much contemporary music is written for smaller orchestras and groups, such as the Northern Sinfonia, for reasons of choice, clarity and, probably, financial economy. New music can be very loud and sustained, using high frequencies and large percussion set-ups. Chamber orchestras generally play in smaller spaces than symphony orchestras, and often in halls with a reverberant acoustic such as churches and sports halls.

The Northern Sinfonia is now in the enviable position of being resident in the amazing Norman Foster designed **Sage Gateshead** but also travels far and wide to a variety of 'difficult' halls. In addition to concert giving, many of the Sinfonia players contribute to the wide programme of community work within the Sage. Much of the performing space for the community work is in the public area of the building which is extremely impressive architecturally but very resonant acoustically.

What this leads to is the contention that with this community work and New Music added to teaching in confined rooms, which is also part of the new remit at the Sage, and private practice and other work, the Sinfonia players may well have similar exposure to many symphonic musicians. Also, it is quite common these days for the Sinfonia to venture into the symphonic repertoire of Beethoven, Brahms and Schumann with added extra horns and trombones. The orchestra also occasionally works with singers in opera and does film nights with full rhythm section.

The orchestra chairman believes that the biggest challenge for them is the stage layout. Despite their relatively small size they find it difficult to work out a system of sharing the dosage for string players on the receiving end of brass and timps. Traditionally, chamber orchestra players tend to sit very close to each other, especially when being 'directed' rather than conducted; to change this culture of intimacy in the interests of noise management is hard to achieve. It was noticed that, even when using four horns and trombones, the whole orchestra except for the trumpet section was squeezed onto the flat of the stage.

Not surprisingly, a large number of screens are used and the players believe they need more available to them. They also would like more professional advice about earplugs, and audiometric testing which, of course, is mandatory from 2008 onwards. The training has given the players the confidence to challenge such things as amplification in rehearsals (fold-back particularly) and singers facing inwards at rehearsals; the volume of which, at close quarters, can be very painful.

The orchestra representatives expressed an ambition to create closer links with the other major groups and users in the Sage and to contribute to a code of practice for the centre. It was clear that the main hall was being run efficiently in health and safety terms and the H&S advisor on the technical team certainly inspired confidence. The orchestra could only benefit from having her as part of a noise management team. There is a high degree of awareness at the Sinfonia but action seems to be on a reactive basis. The players are not critical of management; on the contrary they say the management is quick to act when challenged. What is needed is an action plan towards a code of practice driven by the management with the co-operation of the players and input from the Sage.

The value of *noise teams* was questioned by more than one orchestra during the evaluation process. There was a view expressed that *noise teams* are not necessarily the best way to deal with the issues dispassionately. The claim is that only those with a strong vested interest are likely to volunteer, whereas the general orchestra committee, plus management and elected H&S representatives, is likely to have more authority and command the respect of the

whole orchestra. It might be reasonable to have some sympathy with this view; after all, the noise team idea was just a suggested way of giving responsibility for monitoring noise to a specific group of people, who were willing to accept further training as and when it became available, and were willing to embrace a code of practice which they could insist was followed. It was intended as a way to get management, musicians and music directors, collectively, to take the matter seriously. If individual orchestras have found a better way for themselves they should be encouraged.

Where *noise teams* have been active it would seem that the elected representatives for H&S have not always been included within the group. **H&S elected representatives should always be involved in all matters which affect the wellbeing of the musicians, as should those who are responsible for making risk assessments.**

TOP TEN TIPS

- 1 Get your heads together! Management and players should pool ideas and take joint responsibility. It sounds obvious, but discussion about the music should come first, as it is the source of the noise.
- 2 Always assess the risks and record them with recommendations.
- 3 Have courage to take action to provide protection when it is needed. Do not wait and see! Musicians get angry if they think managers have not thought about the problem.
- 4 Always have a supply of various ear defenders available even if you have provided individual custom-made plugs for your players. You need to protect your extras as well!
- 5 Make sure you carry enough screens, shields and absorbent materials to all venues and be proactive in placing them in appropriate positions.
- 6 If possible carry individual risers and general rostra with you to give flexibility of seating.*
- 7 Negotiate better acoustic controls, and build a dialogue, with your regular venues.
- 8 Agree a safe seating plan well in advance and discuss this with the conductor (who should be allowed a view but not have a veto!)
- 9 Integrate noise management into a general policy of health screening and profiling – this way it makes more sense and changes attitudes.
- 10 Be open to all new initiatives from the commercial sector even if you have to reject the ideas and equipment after fair trial.

*It will cause many orchestras, especially the smaller ones, some financial hardship if carrying extra equipment means hiring or purchasing a larger van. It may be possible to persuade venues, over time, to provide what is needed and to keep it on site. As the message begins to sink in, many venue managements will feel some responsibility to contribute to the noise management policy of regular clients and partners.

CONCLUSIONS

There is no doubt that the profession, if not yet up to the mark, is rising to it very rapidly. In addition to the orchestras visited there are many others, and this is clear from applications to the Healthy Orchestra Charter, which are actively making changes, experimenting with seating, providing audiometric testing and ear plug advice, supplying earplugs and investing in screens and acoustic panels, and organising their own training with expert contributors. Others have applied for ABO training and a new round has just begun. Any who are still unsure where to begin, and there cannot be many, should contact the ABO immediately as there is now much expert advice available within and without the business. Remember that the law applies from April 2008 – there are no exclusions and no exemptions.

Malcolm Warne Holland

Director, MWH ASSOCIATES - Orchestra Management Consultants.

November 2007



Photo - Chris Stock Photography

MEASUREMENT OF NOISE EXPOSURE TO MUSICIANS - A METHODOLOGY by ARUP Acoustics

INTRODUCTION

At the time of writing, employers in the music and entertainment sectors are required to comply with the Control of Noise at Work Regulations 1989. These regulations were primarily written for employers in industrial sectors, and do not specifically refer to musicians.

From 6 April 2008, employers in music and entertainment will be required to comply with the Control of Noise at Work Regulations 2005. These contain more stringent requirements than the previous regulations, and contain specific references to the music and entertainment sectors.

It is the legal responsibility of the employers of musicians to monitor the sound level exposure to their employees during performance and rehearsal and take steps to control these levels in line with the requirements of the Control of Noise at Work Regulations. Clearly the musicians themselves need to play their part in cooperating with their employer.

As the management of the orchestras across the UK prepare for the introduction of the new regulations, the Association of British Orchestras (ABO) is seeking to create a database of sound exposure levels at different locations within orchestras across the spectrum of repertoire and performance/rehearsal spaces. The aim is for representatives of orchestras to carry out their own measurements, contributing the findings to a central database.

To help develop a comparable set of noise levels in the database, this document serves to define a standard specification for measurement equipment and a set method for the measurement of noise levels within orchestras.

EQUIPMENT

Measurement equipment shall meet the following specification:

- Individual noise monitoring devices shall be designed to securely fix to the clothing of the musician without risk of damage to delicate clothing. Tripods shall not be used for mounting measurement equipment to measure noise exposure of musicians.
- When attached, the device shall not cause any restriction to movement for the musician wearing it.
- Devices shall be compliant with BS EN 61252:1997 *Electroacoustics. Specifications for Personal Sound Exposure Meters*.
- Devices shall measure and record L_{Aeq} up to at least 130dB L_{Aeq} .
- Devices shall measure and record peak levels up to at least 140dB(C).
- Devices shall measure time histories of the above parameters averaged across 1 minute time intervals.
- Devices shall not emit any noise during operation or standby.
- Devices should not emit any light during operation. If light is emitted, the light source shall be covered with a non-translucent tape during measurements.
- All devices must be calibrated bi-annually using equipment referenced to the British Calibration Service, and the National Physical Laboratory.

Examples of equipment which meets the requirements are:

- Cirrus Research CR:110A doseBadge Person Noise Meter with RC:110A Reader Unit
- Casella CEL-350 dBadge Noise Dosimeter

In addition to the personal noise monitoring devices, a single sound level meter shall be mounted on a tripod next to the conductor's desk, ensuring that the tripod does not restrict access to any of the performer positions. The sound level meter shall have all of the functionality described for the personal noise devices and shall comply with BS EN 61672-1:2003 *Electroacoustics. Sound level meters. Specifications*.

MEASUREMENT METHOD

All musicians shall be made aware of the dates of monitoring at least a week in advance. The specific musicians to be monitored shall arrive in good time before the start of the rehearsal or performance (ideally 15-20 minutes) to have their personal devices fitted.

All clocks on the measurement devices shall be synchronised before fitting to musicians.

To obtain a reasonable record of the sound level distribution in the pit, a minimum of seven personal devices shall be used, in addition to the sound level meter at the conductor's position. For large orchestras, more devices are recommended.

Personal devices shall be fitted to either shoulder of the musician as close to the ear as possible without restricting movement.

Personal devices must remain running during intervals/breaks. They would preferably remain fixed to the musician during this time. Musicians should be aware that they do not record conversations, just statistical data. If devices are removed during such breaks, they must be refitted in the same location before playing recommences.

If different works are performed during a single performance, the software provided with the equipment shall be capable of isolating the different time histories for the different pieces.

At the end of the session, devices must be left on music stands for collection by the noise monitoring coordinator.

The calibration of all measurement equipment must be verified before and after use (using an internal acoustic calibrator to IEC 60942:2001 Class 2) and any observable drift noted.

MEASUREMENT LOCATIONS

Measurement positions shall be selected to cover a reasonably even spread across the orchestra, not just the anticipated loudest locations. In addition to the conductor position, typically this might be:

- 3 strings (including desk closest to piccolo)
- 1 woodwind
- 2 brass
- 1 timpani

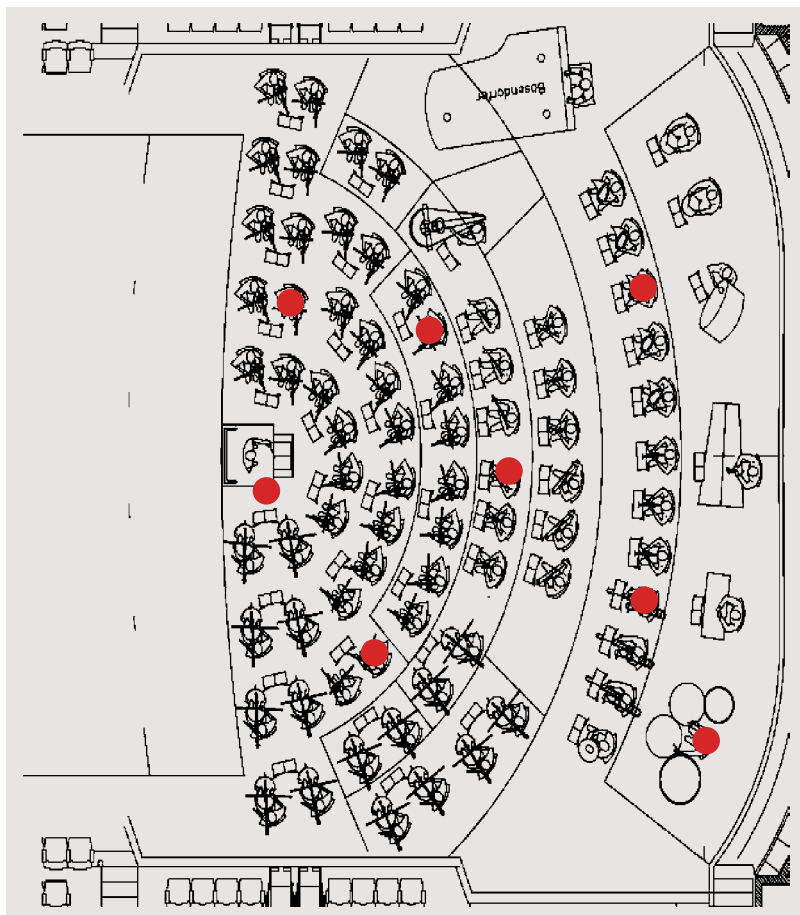


Figure 1: Suggested measurement positions

POST PROCESSING

For each position (including the conductor's position), the following information shall be determined:

- Length of the session in hours and minutes
- Peak noise level during the session in dB(C)
- Equivalent Continuous noise level during the session in dBLAeq

This equipment should then be submitted to the database along with:

- A plan of the orchestra layout marked with the location of the monitoring positions for each session measured
- Name of performance/rehearsal space
- Repertoire performed/rehearsed
- Name of orchestra
- Name of conductor

EXAMPLES

Example Equipment

Measurements were performed using the following equipment:

- Kit of 7 CR:110A doseBadges (Cirrus Research Plc)
- Brüel & Kjær Type 2236 Precision Integrating Sound Level Meter

The doseBadges meet the requirements of IEC 61252:1993 *Personal Sound Exposure Meters*.

Example Results

The results of the measurements are tabulated below:

	Musician	L_{Aeq} dB	Peak Level dBC
1	Second Violin, desk 5	82.8	121.5
2	Double Bass 4	79.8	<120.0
3	Bassoon 1	87.3	134.7
4	Horn 4	93.1	130.8
5	Viola 6	89.5	133.3
6	'Cello 4	88.9	128.5
7	Timpani	89.2	137.1
8	Conductor	83.1	121.3

Table 1: Measured pit noise levels 28 March 2007 (evening performance)

The duration of the performance, including the interval was 2 hours 45 minutes. The values presented above are over the period 1920 to 2215, which includes a 10 minute warm up.

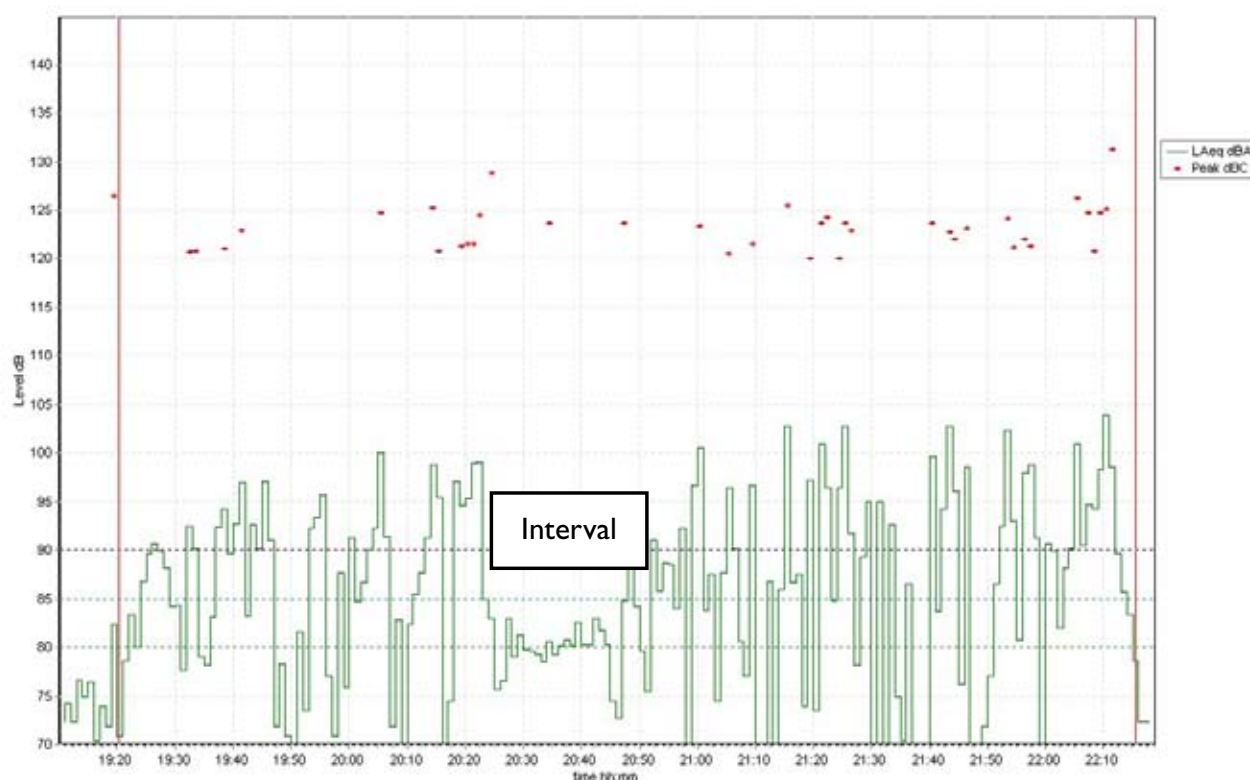


Figure 1: Noise time history at Position 4 (Horn 4)

APPENDIX I

THE CONTROL OF NOISE AT WORK REGULATIONS 2005

© Crown Copyright 2005

Citation and commencement

1. These Regulations may be cited as the Control of Noise at Work Regulations 2005 and shall come into force on 6th April 2006, except that -

(a) for the music and entertainment sectors only they shall not come into force until 6th April 2008; and

(b) subject to regulation 3(4), regulation 6(4) shall not come into force in relation to the master and crew of a seagoing ship until 6th April 2011.

Interpretation

2. (1) In these Regulations

“daily personal noise exposure” means the level of daily personal noise exposure of an employee as ascertained in accordance with Schedule 1 Part 1, taking account of the level of noise and the duration of exposure and covering all noise;

“emergency services” include -

(a) police, fire, rescue and ambulance services;

(b) Her Majesty’s Coastguard;

“enforcing authority” means the Executive or local authority, determined in accordance with the provisions of the Health and Safety (Enforcing Authority) Regulations 1998[2];

“the Executive” means the Health and Safety Executive;

“exposure limit value” means the level of daily or weekly personal noise exposure or of peak sound pressure set out in regulation 4 which must not be exceeded;

“health surveillance” means assessment of the state of health of an employee, as related to exposure to noise;

“lower exposure action value” means the lower of the two levels of daily or weekly personal noise exposure or of peak sound pressure set out in regulation 4 which, if reached or exceeded, require specified action to be taken to reduce risk;

“the music and entertainment sectors” mean all workplaces where -

(a) live music is played; or

(b) recorded music is played in a restaurant, bar, public house, discotheque or nightclub, or alongside live music or a live dramatic or dance performance;

“noise” means any audible sound;

“peak sound pressure” means the maximum sound pressure to which an employee is exposed, ascertained in accordance with Schedule 2;

“risk assessment” means the assessment of risk required by regulation 5;

“upper exposure action value” means the higher of the two levels of daily or weekly personal noise exposure or of peak sound pressure set out in regulation 4 which, if reached or exceeded, require specified action to be taken to reduce risk;

“weekly personal noise exposure” means the level of weekly personal noise exposure as ascertained in accordance with Schedule 1 Part 2, taking account of the level of noise and the duration of exposure and covering all noise; and

“working day” means a daily working period, irrespective of the time of day when it begins or ends, and of whether it begins or ends on the same calendar day.

(2) In these Regulations, a reference to an employee being exposed to noise is a reference to the exposure of that employee to noise which arises while he is at work, or arises out of or in connection with his work.

Application

3. (1) These Regulations shall have effect with a view to protecting persons against risk to their health and safety arising from exposure to noise at work.

(2) Where a duty is placed by these Regulations on an employer in respect of his employees, the employer shall, so far as is reasonably practicable, be under a like duty in respect of any other person at work who may be affected by the work carried out by the employer except that the duties of the employer—

(a) under regulation 9 (health surveillance) shall not extend to persons who are not his employees; and

(b) under regulation 10 (information, instruction and training) shall not extend to persons who are not his employees, unless those persons are present at the workplace where the work is being carried out.

(3) These Regulations shall apply to a self-employed person as they apply to an employer and an employee and as if that self-employed person were both an employer and an employee, except that regulation 9 shall not apply to a self-employed person.

(4) These Regulations shall not apply to the master or crew of a ship or to the employer of such persons in respect of the

normal shipboard activities of a ship's crew which are carried out solely by the crew under the direction of the master; and for the purposes of this paragraph "ship" includes every description of vessel used in navigation, other than a ship forming part of Her Majesty's Navy.

Exposure limit values and action values

4. (1) The lower exposure action values are -
- (a) a daily or weekly personal noise exposure of 80 dB (A-weighted); and
 - (b) a peak sound pressure of 135 dB (C-weighted).
- (2) The upper exposure action values are -
- (a) a daily or weekly personal noise exposure of 85 dB (A-weighted); and
 - (b) a peak sound pressure of 137 dB (C-weighted).
- (3) The exposure limit values are -
- (a) a daily or weekly personal noise exposure of 87 dB (A-weighted); and
 - (b) a peak sound pressure of 140 dB (C-weighted).
- (4) Where the exposure of an employee to noise varies markedly from day to day, an employer may use weekly personal noise exposure in place of daily personal noise exposure for the purpose of compliance with these Regulations.
- (5) In applying the exposure limit values in paragraph (3), but not in applying the lower and upper exposure action values in paragraphs (1) and (2), account shall be taken of the protection given to the employee by any personal hearing protectors provided by the employer in accordance with regulation 7(2).

Assessment of the risk to health and safety created by exposure to noise at the workplace

5. (1) An employer who carries

out work which is liable to expose any employees to noise at or above a lower exposure action value shall make a suitable and sufficient assessment of the risk from that noise to the health and safety of those employees, and the risk assessment shall identify the measures which need to be taken to meet the requirements of these Regulations.

(2) In conducting the risk assessment, the employer shall assess the levels of noise to which workers are exposed by means of -

- (a) observation of specific working practices;
- (b) reference to relevant information on the probable levels of noise corresponding to any equipment used in the particular working conditions; and
- (c) if necessary, measurement of the level of noise to which his employees are likely to be exposed,

and the employer shall assess whether any employees are likely to be exposed to noise at or above a lower exposure action value, an upper exposure action value, or an exposure limit value.

(3) The risk assessment shall include consideration of -

- (a) the level, type and duration of exposure, including any exposure to peak sound pressure;
- (b) the effects of exposure to noise on employees or groups of employees whose health is at particular risk from such exposure;
- (c) so far as is practicable, any effects on the health and safety of employees resulting from the interaction between noise and the use of ototoxic substances at work, or between noise and vibration;

(d) any indirect effects on the health and safety of employees resulting from the interaction between noise and audible warning signals or other sounds that need to be audible in order to reduce risk at work;

(e) any information provided by the manufacturers of work equipment;

(f) the availability of alternative equipment designed to reduce the emission of noise;

(g) any extension of exposure to noise at the workplace beyond normal working hours, including exposure in rest facilities supervised by the employer;

(h) appropriate information obtained following health surveillance, including, where possible, published information; and

(i) the availability of personal hearing protectors with adequate attenuation characteristics.

(4) The risk assessment shall be reviewed regularly, and forthwith if -

(a) there is reason to suspect that the risk assessment is no longer valid; or

(b) there has been a significant change in the work to which the assessment relates,

and where, as a result of the review, changes to the risk assessment are required, those changes shall be made.

(5) The employees concerned or their representatives shall be consulted on the assessment of risk under the provisions of this regulation.

(6) The employer shall record -

(a) the significant findings of the risk assessment as soon as is practicable after the risk assessment is made or changed; and

(b) the measures which he has taken and which he intends to take to meet the requirements of regulations 6, 7 and 10.

Elimination or control of exposure to noise at the workplace

6. (1) The employer shall ensure that risk from the exposure of his employees to noise is either eliminated at source or, where this is not reasonably practicable, reduced to as low a level as is reasonably practicable.
- (2) If any employee is likely to be exposed to noise at or above an upper exposure action value, the employer shall reduce exposure to as low a level as is reasonably practicable by establishing and implementing a programme of organisational and technical measures, excluding the provision of personal hearing protectors, which is appropriate to the activity.
- (3) The actions taken by the employer in compliance with paragraphs (1) and (2) shall be based on the general principles of prevention set out in Schedule 1 to the Management of Health and Safety Regulations 1999[3] and shall include consideration of -
 - (a) other working methods which reduce exposure to noise;
 - (b) choice of appropriate work equipment emitting the least possible noise, taking account of the work to be done;
 - (c) the design and layout of workplaces, work stations and rest facilities;
 - (d) suitable and sufficient information and training for employees, such that work equipment may be used correctly, in order to minimise their exposure to noise;
 - (e) reduction of noise by technical means;
 - (f) appropriate maintenance programmes for work equipment, the workplace and workplace systems;

(g) limitation of the duration and intensity of exposure to noise; and

(h) appropriate work schedules with adequate rest periods.

(4) The employer shall -

(a) ensure that his employees are not exposed to noise above an exposure limit value; or

(b) if an exposure limit value is exceeded forthwith -

(i) reduce exposure to noise to below the exposure limit value;

(ii) identify the reason for that exposure limit value being exceeded; and

(iii) modify the organisational and technical measures taken in accordance with paragraphs (1) and (2) and regulations 7 and 8(1) to prevent it being exceeded again.

(5) Where rest facilities are made available to employees, the employer shall ensure that exposure to noise in these facilities is reduced to a level suitable for their purpose and conditions of use.

(6) The employer shall adapt any measure taken in compliance with the requirements of this regulation to take account of any employee or group of employees whose health is likely to be particularly at risk from exposure to noise.

(7) The employees concerned or their representatives shall be consulted on the measures to be taken to meet the requirements of this regulation.

Hearing Protection

7. (1) Without prejudice to the provisions of regulation 6, an employer who carries out work which is likely to expose any employees to noise at or above a lower exposure action value shall make personal hearing protectors available upon request to any employee who is so exposed.

(2) Without prejudice to the provisions of regulation 6, if an employer is unable by other means to reduce the levels of noise to which an employee is likely to be exposed to below an upper exposure action value, he shall provide personal hearing protectors to any employee who is so exposed.

(3) If in any area of the workplace under the control of the employer an employee is likely to be exposed to noise at or above an upper exposure action value for any reason the employer shall ensure that -

(a) the area is designated a Hearing Protection Zone;

(b) the area is demarcated and identified by means of the sign specified for the purpose of indicating that ear protection must be worn in paragraph 3.3 of Part II of Schedule 1 to the Health and Safety (Safety Signs and Signals) Regulations 1996[4]; and

(c) access to the area is restricted where this is practicable and the risk from exposure justifies it,

and shall ensure so far as is reasonably practicable that no employee enters that area unless that employee is wearing personal hearing protectors.

(4) Any personal hearing protectors made available or provided under paragraphs (1) or (2) of this regulation shall be selected by the employer -

(a) so as to eliminate the risk to hearing or to reduce the risk to as low a level as is reasonably practicable; and

(b) after consultation with the employees concerned or their representatives

Maintenance and use of equipment

8. (1) The employer shall -
 - (a) ensure so far as is practicable that anything

provided by him in compliance with his duties under these Regulations to or for the benefit of an employee, other than personal hearing protectors provided under regulation 7(1), is fully and properly used; and

(b) ensure that anything provided by him in compliance with his duties under these Regulations is maintained in an efficient state, in efficient working order and in good repair.

(2) Every employee shall -

(a) make full and proper use of personal hearing protectors provided to him by his employer in compliance with regulation 7(2) and of any other control measures provided by his employer in compliance with his duties under these Regulations; and

(b) if he discovers any defect in any personal hearing protectors or other control measures as specified in sub-paragraph (a) report it to his employer as soon as is practicable.

Health Surveillance

9. (1) If the risk assessment indicates that there is a risk to the health of his employees who are, or are liable to be, exposed to noise, the employer shall ensure that such employees are placed under suitable health surveillance, which shall include testing of their hearing.

(2) The employer shall ensure that a health record in respect of each of his employees who undergoes health surveillance in accordance with paragraph (1) is made and maintained and that the record or a copy thereof is kept available in a suitable form.

(3) The employer shall -

(a) on reasonable notice being given, allow an employee access to his personal health record; and

(b) provide the enforcing authority with copies of such health records as it may require.

(4) Where, as a result of health surveillance, an employee is found to have identifiable hearing damage the employer shall ensure that the employee is examined by a doctor and, if the doctor or any specialist to whom the doctor considers it necessary to refer the employee considers that the damage is likely to be the result of exposure to noise, the employer shall -

(a) ensure that a suitably qualified person informs the employee accordingly;

(b) review the risk assessment;

(c) review any measure taken to comply with regulations 6, 7 and 8, taking into account any advice given by a doctor or occupational health professional, or by the enforcing authority;

(d) consider assigning the employee to alternative work where there is no risk from further exposure to noise, taking into account any advice given by a doctor or occupational health professional; and

(e) ensure continued health surveillance and provide for a review of the health of any other employee who has been similarly exposed.

(5) An employee to whom this regulation applies shall, when required by his employer and at the cost of his employer, present himself during his working hours for such health surveillance procedures as may be required for the purposes of paragraph (1).

Information, instruction and training

10. (1) Where his employees are exposed to noise which is likely to be at or above a lower exposure action value, the employer shall provide those employees and their representatives with suitable and sufficient information, instruction and training.

(2) Without prejudice to the generality of paragraph (1), the information, instruction and training provided under that paragraph shall include -

(a) the nature of risks from exposure to noise;

(b) the organisational and technical measures taken in order to comply with the requirements of regulation 6;

(c) the exposure limit values and upper and lower exposure action values set out in regulation 4;

(d) the significant findings of the risk assessment, including any measurements taken, with an explanation of those findings;

(e) the availability and provision of personal hearing protectors under regulation 7 and their correct use in accordance with regulation 8(2);

(f) why and how to detect and report signs of hearing damage;

(g) the entitlement to health surveillance under regulation 9 and its purposes;

(h) safe working practices to minimise exposure to noise; and

(i) the collective results of any health surveillance undertaken in accordance with regulation 9 in a form calculated to prevent those results from being identified as relating to a particular person.

(3) The information, instruction and training required by paragraph (1) shall be updated to take account of significant changes in the type of work carried out or the working methods used by the employer.

(4) The employer shall ensure that any person, whether or not his employee, who carries out work in connection with the employer's duties under these Regulations has suitable and sufficient information, instruction and training.

Exemption certificates from hearing protection

11. (1) Subject to paragraph (2), the Executive may, by a certificate in writing, exempt any person or class of persons from the provisions of regulation 6(4) and regulation 7(1) and (2) where because of the nature of the work the full and proper use of personal hearing protectors would be likely to cause greater risk to health or safety than not using such protectors, and any such exemption may be granted subject to conditions and to a limit of time and may be revoked by a certificate in writing at any time.
- (2) The Executive shall not grant such an exemption unless -
- (a) it consults the employers and the employees or their representatives concerned;
 - (b) it consults such other persons as it considers appropriate;
 - (c) the resulting risks are reduced to as low a level as is reasonably practicable; and
 - (d) the employees concerned are subject to increased health surveillance.

Exemption certificates for emergency services

12. (1) Subject to paragraph (2), the Executive may, by a certificate in writing, exempt any person or class of persons from the provisions of regulation 6(4) and regulation 7(1) to (3) in respect of activities carried out by emergency services which conflict with the requirements of any of those provisions, and any such exemption may be granted subject to conditions and to a limit of time and may be revoked by a certificate in writing at any time.
- (2) The Executive shall not grant such an exemption unless it is satisfied that the health and safety of the employees concerned is ensured as far as possible in the light of the objectives of these Regulations.

Exemptions relating to the Ministry of Defence

13. (1) Subject to paragraph (2), the Secretary of State for Defence may, by a certificate in writing, exempt any person or class of persons from the provisions of regulation 6(4) and regulation 7(1) to (3) in respect of activities carried out in the interests of national security which conflict with the requirements of any of those provisions, and any such exemption may be granted subject to conditions and to a limit of time and may be revoked by a certificate in writing at any time.
- (2) The Secretary of State shall not grant such an exemption unless he is satisfied that the health and safety of the employees concerned is ensured as far as possible in the light of the objectives of these Regulations.

Extension outside Great Britain

14. These Regulations shall apply to and in relation to any activity outside Great Britain to which sections 1 to 59 and 80 to 82 of the 1974 Act apply by virtue of the Health and Safety at Work etc. Act 1974 (Application Outside Great Britain) Order 2001[5] as those provisions apply within Great Britain.

Revocations, amendments and savings

15. (1) In -
- (a) regulation 3(3)(e) of the Personal Protective Equipment at Work Regulations 1992[6]; and
 - (b) regulation 12(5)(d) of the Provision and Use of Work Equipment Regulations 1998[7],
- for the reference in each case to the Noise at Work Regulations 1989[8] there shall be substituted a reference to these Regulations.

(2) The revocations listed in Schedule 3 are made with effect from the coming into force of these Regulations.

(3) In respect of the music and entertainment sectors only, the amendments and revocations in paragraphs (1) and (2) shall not come into force until 6th April 2008 and the provisions covered by those paragraphs shall continue in force, where applicable, until that date.

Signed by authority
of the Secretary of State

Philip A. Hunt

Parliamentary Under-Secretary of State
Department for Work and Pensions

18th June 2005

BIBLIOGRAPHY

NB, a range of assessments and other reports have been contributed by orchestras and are not cited in this bibliography

2007; Ceranic B; The value of otoacoustic emissions in the investigation of noise damage; *Audiological Medicine*, 5(1):10-24

2007; Kovacic K, Somanathana R; Ototoxicity and noise trauma: Electron transfer, reactive oxygen species, cell signaling, electrical effects, and protection by antioxidants: Practical medical aspects;

2007; Pyykko I, Toppila E, Zou J, Kentala E; Individual susceptibility to noise-induced hearing loss; *Audiological Medicine*; 5(1) 41-53

2007; Widén S, Erlandsson S; Risk perception in musical settings - a qualitative study; *International Journal of Qualitative Studies on Health and Well-Being*, 2(1): 33-44

2007, Kurmis AP, Apps SA, Occupational acquired noise induced hearing loss: a senseless workplace hazard, *International Journal of Occupational Medicine and Environmental Health*, 20(2):127-136

2006; Behar A, Wong W, Kunov H; Risk of hearing loss in orchestral musicians: review of the literature; *Medical Problems of Performing Artists*; 21(4): 164

2006; Bernstein J, Oxenham A; The relationship between frequency selectivity and pitch discrimination: sensorineural hearing loss; *the Journal of the Acoustical Society of America*; 120(6) 3929-3945

2006; Chesky K, Dawson W, Manchester R; Health promotion in schools of music; *Medical Problems of Performing Artists*; September 142-144

2006, Cunningham D, Curk A, Hoffman J, Pride J, Despite high risk of hearing loss, many percussionists play unprotected, *The Hearing Journal*, 59(6):58-66

2006; Curk A, Cunningham D; A Profile of Percussionists' Behaviors and Attitudes Toward Hearing Conservation; *Medical Problems of Performing Artists*: 21(2): 59

2006; Hoffman J, Cunningham D, Lorenz D; Auditory Thresholds and Factors Contributing to Hearing Loss in a Large Sample of Percussionists; *Medical Problems of Performing Artists*; 21(2):47

2006; Reuter K, Hammershoi D; Distortion product otoacoustic emission of symphony orchestra musicians before and after rehearsal; *The Journal of the Acoustical Society of America*; 121(1): 327-336

2006; Williamon A, Thompson S; Awareness and incidence of health problems among conservatoire students; *Psychology of Music*; 34(4) 411-430

2005; Bies D; Why noise-induced hearing loss of industrial workers is dramatic while that of similarly assessed musicians has been described as trivial; *The Journal of the Acoustical Society of America*; 118(3)

2005; Hagberg M, Thiringer G, Brandstrom L; Incidence of tinnitus, impaired hearing and musculoskeletal disorders among students enrolled in academic music education – a retrospective cohort study; *International Archives of Occupational and Environmental Health*; 78(7) 575-583

2005; James A, Thompson A, Rees I; School music rooms – designing beyond BB93; *Proceedings of the Institute of Acoustics*

2005; Jodee A, Pride J, Cunningham D; Early evidence of cochlear damage in a large sample of percussionists; *Medical Problems of Performing Artists*; 20(3) 135

2005; Lee Jb, Behar A, Kunov H, Wong W; Musicians' noise exposure in orchestra pit; *Applied Acoustics*; 66(8): 919-931

2005; Marijtje L, et al; Expectancy effects on omission evoked potentials in musicians and non-musicians; *Psychophysiology* 42(2) 191-201

2005; Peters C et al; Noise and hearing loss in musicians; produced for Safety and Health in Arts Production and Entertainment (SHAPE), Vancouver

2005; Tufts J, Molis M, Leek M; Perception of dissonance by people with normal hearing and sensorineural hearing loss; *The Journal of the Acoustical Society of America*; 118(2) 955-967

- 2004; Behar A, et al; Noise exposure of music teachers; *Journal of Occupational and Environmental Hygiene*; 1(4) 243-247
- 2004; Kähäri K, Zachau G, Eklöf M, Möller C; The influence of music and stress on musicians' hearing;
- 2004; Kähäri K; Axelsson A; Hellström PA; Zachau G; Hearing development in classical orchestral musicians. A follow-up study; *Journal of Sound and Vibration*; 277(3): 627-631
- 2004; Lapsley Miller J, Marshall L, Heller L; A longitudinal study of changes in evoked otoacoustic emissions and pure-tone thresholds as measured in a hearing conservation program; *International Journal of Audiology*, 43(6): 307-322
- 2004; Widen SE, Erlandsson SI; Self reported tinnitus and noise sensitivity among adolescents in Sweden; *Noise and Health*; 7(25) 29-40
- 2003; American Academy of Audiology; Position statement – Preventing noise-induced occupational hearing loss
- 2003; Brashears SM, Morlet TG, Berlin CI, Hood LJ; Olivocochlear efferent suppression in classical musicians; *Journal of the American Academy of Audiology*; 14(6) 314-324
- 2003; Borchgrevink H; Does health promotion work in relation to Noise? *Noise and Health*; 5(18) 25-30
- 2003; Deatherage P; Effects of Music on Extended High Frequency Hearing; University of Miami MA thesis.
- 2003; DiSalvo M; Effects of Cardiovascular Health on Hearing Levels Among Musicians; University of Miami MA thesis.
- 2003; HSE; CD 196 – Proposals for new control of noise at work regulations.
- 2003, Laitinen HM, Toppila EM, Olkinuora PS, Kuisma K, Sound exposure among the Finnish National Opera Personnel, *Applied Occupational and Environmental Hygiene*, 18(3):177-182
- 2003; Peters R; The role of hearing protectors in leisure noise; *Noise and Health*; 5(18) 47-55
- 2003; Shand Shelton; A guide for safe working practices in the New Zealand theatre and entertainment industry
- 2002; Baker R, Rosen S; Auditory filter nonlinearity in mild/moderate hearing impairment; *The Journal of the Acoustical Society of America*; 111(3): 1330-1339
- 2002; Eaton, S; Gillis, H; Review of orchestra musicians' hearing loss risks; *Canadian Acoustics* 30(2) 5-12
- 2002; Fujisaki W, Kashino M; The basic hearing abilities of absolute pitch possessors; *Acoustic Science and Technology*; 23(2) 77-83
- 2002; Kahari K, Eklof M, Zachau G, Sandsjö L, Moller C; Associations between hearing and psychosocial working conditions in rock/jazz musicians.
- 2002; Meyer JD, Chen Y, McDonald JC, Cherry NM; Surveillance for work-related hearing loss in the UK; *Occupational Medicine*; 52(2) 75-79
- 2002; Occupational Safety and Health Service, Dept of Labour, New Zealand; Approved code of practice for the management of noise in the workplace
- 2002; Starck J, Toppila E, Pyykko I; Impulse noise and risk criteria; *Nordic Noise 2002*
- 2002; Strasser H, Irle J, Legler R; temporary hearing threshold shifts and restitution after energy-equivalent exposures to industrial noise and classical music
- 2002; Syka J; Plastic Changes in the Central Auditory System After Hearing Loss, Restoration of Function, and During Learning; *Physiological Reviews*; 82, 601-636
- 2002; Popping pill may prevent hearing loss; *New Scientist news service*, 13 August
- 2001; Chasin M; Hear the music – hearing loss prevention for musicians; www.musiciansclinics.com
- 2001; Doncaster Music Support Service; Survey of noise levels in daily teaching situations.
- 2001; Kähäri K, Axelsson A, Hellström P, Zachau G; Hearing development in classical orchestral musicians. A follow-up study; *Scandinavian Audiology*; 30(3): 141-149
- 2001; Kahari K, Axelsson A, Hellstrom P, Zachau F; Hearing assessment in classical musicians; *Scandinavian Audiology*; 30: 13-23
- 2001; Murray N, LePage E; Nine years' progress report of study of inner ear damage in an orchestra; *Research & Development Annual Report 200/2001*; National Acoustic Laboratories, Australia

- 2001; Safety and Health in Arts Production and Entertainment (SHAPE); Listen while you work – hearing conservation for the Arts
- 2001; University of Southampton; Occupational exposure to noise and hearing difficulties in Great Britain; HSE Contract Research Report 361
- 2001; Zeigler MC, Taylor JA; The Effects of a Tinnitus Awareness Survey on College Music Majors' Hearing Conservation Behaviors; Medical Problems of Performing Artists; 16(4):136
- 2000; Fearn R; Hearing loss in young people from music and other noise; Woodland Press, Leeds
- 2000; Henschel M, Chesky K; Sound exposure levels experienced by a college jazz band ensemble: comparison with OSHA risk criteria; Medical Problems of Performing Artists; 15(1): 17
- 2000; Radcliffe D; Is hearing loss increasing at younger ages: Many think so, but it is hard to prove; The Hearing Journal; 53(5) 23-29
- 1999; Chasin M, Chong J; Localization problems with modified and non-modified ER-15 musician's earplugs; Hearing Journal; 52(2) pp 38-40
- 1999; Worksafe Western Australia Commission; Noise in the music entertainment industry
- 1998; Administrative Decisions Tribunal, Equal Opportunities Division, New South Wales, Australia; Complainant G Carr, Respondent Opera Australia.
- 1998; Boothroyd A; Recruitment and dynamic range in sensorineural hearing loss; Hearing Loss; February
- 1998; BBC; Noise awareness for orchestral musicians; leaflet;
- The Hearing Journal; 51(4);68-78
- 1998; Berger EH, Kladden CA; Noise and hearing conservation films and videotapes: reviews and availability; EA RCAL
- 1998; Chasin, M; Musicians and the prevention of hearing loss; Hearing Journal; 51(9) pp10-16
- 1998; Economist; Deaf Defying; 31 January p99
- 1998; Gade AC, Mortensen B; Compromises in orchestra pit design: A ten-year trench war in The Royal Theatre, Copenhagen; The Journal of the Acoustical Society of America; 103(5): 2786
- 1998; Gischia CF, Hartmann K; ER-15 musicians earplugs in the armed forces: customer satisfaction/fitting practices; Spectrum Suppl. 1, 15; p25
- 1998; HSE; Reducing noise at work – Guidance on the Noise at Work Regs 1989; ISBN 0 7176 1511 1
- 1998; Lamm K, Arnold W; The effect of prednisolone and non-steroidal anti-inflammatory agents on the normal and noise-damaged guinea pig inner ear; Hearing Research; 115 pp149-161
- 1998; Le Page E, Murray N; Latent cochlear damage in personal stereo users: a study based on click-evoked otoacoustic emissions; www.mja.com.au
- 1998; Mulroy MJ, Henry WR, McNeill PL; Noise-induced transient microlesions in the cell membranes of auditory hair cells; Hearing Research; 115 pp 93-100
- 1998; Namyslowski G, Krzysztof M, Trybalska G, Urbaniec P; Comparison of DPOAE in musicians, noise exposed workers and elderly with presbycusis; Medical Science Monitor 4(2):314-320
- 1998; Obeling L, Poulsen T; Audiograms of Symphony Orchestra Musicians; Proceedings 7th International Congress on Noise as Public Health Problem, Noise Effects '98, Sydney, Australia, pp67-70
- 1998; Pirzanski CZ; Diminishing the occlusion effect: clinician/manufacturer-related factors; 1998; Teie PU; Noise-induced hearing loss and symphony orchestra musicians: risk factors, effects, and management; Maryland Medical Journal; 47(1); pp 13-18
- 1998; White DR, Boettcher FA, Miles LR, Gratton MA; Effectiveness of intermittent and continuous acoustic stimulation in preventing noise induced hearing and hair cell loss; Journal Acoustic Society of America; 103(3) pp1566-1572
- 1997; Behrooz KB, Luz J; Noise related ailments of performing musicians: A review; Medical Problems of Performing Artists; March p19-22
- 1997; BPAMT; Musicians' Survey Questionnaire – Full Analysis

- 1997; Henderson D, Steinman H, Kopke R; Pharmacological intervention with noise-induced hearing loss; Acoustical Society of America, 133rd Meeting
- 1997; Ibell R; Health and safety in the New Zealand Symphony Orchestra; BAPAM York
- 1997; Maran AGD; Deafness in musicians; BAPAM York
- 1997; Maran GD; Performing arts medicine – an orphan?; BAPAM York
- 1997; Mitchell SA; Ears and hearing loss in the flutist; BAPAM York
- 1997; Moore BCJ; A compact disc containing simulations of hearing impairment; British Journal of Audiology; 31 p353-357
- 1997; Rietveld B; The Dutch Performing Arts Clinic in the Westeinde Hospital in the Hague; BAPAM York;
- 1997; Rosanowski F; External auditory canal in-situ measurement of sound pressure in a violinist with bilateral tinnitus; BAPAM York
- 1997; Tyler RS; Perspectives on tinnitus; British Journal of Audiology; 31 pp 381-386
- 1997; Tyler RS; Tinnitus: Current theories and treatments; The Hearing Journal; 50 (8) August p10-19
- 1997; van Hees OS; Hearing impairment in musicians; BAPAM York
- 1997; Zaza C; A Report on the Canadian Network for Health in the Arts; BAPAM York
- 1996; Chasin M; Musicians and the prevention of hearing loss; Singular Publishing Group, Inc; ISBN 1 56593 626 4
- 1996; Early KL, Hortsman; Noise exposure to musicians during practice; Applied Occupational and Environmental Hygiene; 11(9) pp 1149-1153
- 1996; Kampe SD, Wynne MK; The influence of venting on the occlusion effect; Hearing Journal; 49(4) pp59-66
- 1996; Malcore D; Hyperacusis; Spectrum Suppl; 1, 13, p 34
- 1996; Strauss S; Piccolo peril; Globe and Mail, Toronto; 18 May
- 1996; Woolf A; Earphone limiters, questions and answers; Canford Audio plc
- 1995; Chasin M; Four environmental techniques to reduce the effect of music exposure on hearing; Medical Problems of Performing Artists; June, pp 66-69
- 1995; Hall J, Santucci M; Protecting the professional ear; ENT News; 4(2) May/June pp30-31
- 1995; Miki K; Orchestral music: An assessment of risk; Acoustics Australia; 23(2) pp 51-55
- 1995; Sabesky IJ, Korczynski RE; Noise exposure of symphony orchestra musicians; Applied Occupational and Environmental Hygiene; 10(2); pp131-135
- 1995; van Hees OS; ER15 in symphony orchestras; thesis
- 1994; Bies DA; An alternative model for combining noise and age induced hearing loss; J Acoust Soc Am; 95 (1) January p563-565
- 1994; Brodsky W, Sloboda JA, Waterman MG; an exploratory investigation into auditory style as a correlate and predictor of music performance anxiety; Medical Problems of Performing Artists; December, pp 101-112
- 1994; Evans EF; Auditory frequency selectivity: A physiologist looks at the engineering of the ear; Acoustics Bulletin; July/August pp 5
- 1994; Kahn SW and Shield BM; Noise measurements during performances at an opera house; Institute of Acoustics Conference
- 1994; Kahn SW; What is an acoustically correct performance? Music and the Noise at Work Regulations; Institute of Acoustics Conference
- 1994; Kivimaki M; Job perceptions and well-being among symphony orchestra musicians: a comparison with other occupational groups; Medical Problems of Performing Artists; September, pp 73-76
- 1994; Loth D, Avan P, Menguy C, Teyssou M; Crossed acoustic middle-ear muscle reflex and attenuation of low-level pure tones in man; Acta Acustica; 2 pp149-155
- 1994; Occupational Safety & Health Service, Dept of Labour, New Zealand; Noise induced hearing loss of occupational origin – a guide for medical practitioners

- 1994; Ostergaard O; Danmarks Radio – use of earplugs; private communication
- 1994; Palin SL; Does classical music damage the hearing of musicians? A review of the literature; Occupational Medicine; 44 pp130-136
- 1994; Robinson DW, Lawton BW and Rice CG; Occupational hearing loss from low-level noise; HSE Contract Research Report no 68/1994
- 1994; Schmidt JM, Verschure J, Brocaar MP; Hearing loss in students at a conservatory; Audiology; 33 pp185-194
- 1994; Woolf AR; Broadcasting and the noise at work regulations; Acoustics Bulletin; March/April pp42-46
- 1994; Wright RD; Hearing at risk: Identification of enhanced risk of hearing damage; Institute of Acoustics Conference
- 1993; BBC; Limited headphones (Canford Audio)
- 1993; Beilin J, Jensen GR; Recent developments in hearing instrument technology; 15th Danavox Symposium
- 1993; Garfield Davies D; Doctor, what causes the noise in my ears; leaflet – American Academy of Otolaryngology
- 1993; Garfield Davies D; Noise, ears and hearing protection; leaflet – American Academy of Otolaryngology
- 1993; Harman SE; Medical problems of marching musicians; Medical Problems of Performing Artists; December, pp 132-135
- 1993; Holley M, Kachar B; Hi-fi cells at the heart of the ear; New Scientist; 27 March pp27-30
- 1993; HSE; Noise at work – advice for employees; leaflet
- 1993; Sataloff RT; Occupational hearing loss; Book. Marcel Dekker inc, New York
- 1992; Chasin M, Chong J; A clinically efficient hearing protection program for musicians; Medical Problems of Performing Artists; June, pp 40-43
- 1992; Langendorf FG; Absolute pitch: Review and speculations; Medical Problems of Performing Artists; March, pp 6-13
- 1992; Management of Health and Safety at Work Regulations, plus Approved Code of Practice; ISBN 0 7176 0412 8
- 1992; McBride D et al; Noise and the classical musician; British Medical Journal; 305 pp 1561-1563
- 1992; Revit LJ; Two techniques for dealing with the occlusion effect; Hearing Instr; 43(12); pp16-18
- 1992; Smith DWE; Medical problems of orchestral musicians according to age and stage of career; Medical Problems of Performing Artists; December pp132-134
- 1992; Zaza C; Playing related health problems at a Canadian music school; Medical Problems of Performing Artists; June, pp 48-51
- 1991; Chasin M, Chong J; An in situ ear protection program for musicians; Hearing Instr. 42(12) pp 26-28
- 1991; Chong MD, Zaza C, Smith MB; Design and implementation of a performing artists' health program in Canada; Medical Problems of Performing Artists; March, pp8-10
- 1991; Hellstrom PA; The effects on hearing from portable cassette players: A follow-up study; Journal of Sound and Vibration; 151(3) pp461-469
- 1991; Nilsson R; The effect of rest periods on temporary threshold shift (TTS) after noise exposure; Journal of Sound and Vibration; 151(3) pp437-440
- 1991; Moore DR, McAlpine D; Biology of hearing and noise-induced hearing loss: A review; Acoustics Bulletin; April
- 1991; Ostwald P, Avery M; Psychiatric problems of performing artists; p319
- 1991; Royster JD, Royster LH, Killion MC; Sound exposures and hearing thresholds of symphony orchestra musicians; Journal Acoustic Society of America; 89(6) p2793
- 1991; Sataloff RT, Sataloff J; Hearing loss in musicians; Textbook of Performing Arts Medicine, Raven Press; p301
- 1991; Sataloff RT; Hearing loss in musicians; American Journal of Otology; 12(2) pp122-127
- 1991; Tecca JE; Real ear vent effects in ITE hearing instrument fittings; Hearing Instruments; 42 (12) pp10-12
- 1990; Bies DA, Hansen CH; An alternative mathematical description of the relationship between noise exposure and hearing loss; Journal Acoustic Society of America; 88(6) pp2743-2754

- 1990; Cailliet R; Abnormalities of the sitting postures of musicians; Medical Problems of Performing Artists; December, pp 131-135
- 1990; Santucci M; Musicians can protect their hearing; Medical Problems of Performing Artists; December, pp 136-138
- 1990; Wolfe ML; Relationships between dimensions of musical performance anxiety and behavioural coping strategies; Medical Problems of Performing Artists; December, pp 139-144
- 1989; Ostri B, Eller N, Dahlin E, Skylv; Hearing impairment in orchestral musicians; Scand Audiol; 18 pp 243-249
- 1989; Procter PH; Free radicals and human disease; CRC handbook of free radicals and antioxidants; Vol 1 pp 209-221
- 1989; Smith DWE; Ageing and the careers of symphony orchestra musicians; Medical Problems of Performing Artists; June, pp 81-85
- 1988; Killion M, DeVilbiss ED, Stewart J; An earplug with uniform 15dB attenuation; The Hearing Journal; 41 (5) May, pp14-17
- 1988; Pickles JO; An introduction to the physiology of hearing; Academic Press; ISBN 0 12 554754 4
- 1988; Robinson DW; Tables for the estimation of hearing impairment due to noise for otologically normal persons and for a typical unscreened population, as a function of age and duration of exposure; HSE Contract Research Report no 2/1988
- 1987; Robinson DW; Noise exposure and hearing, a new look at the experimental data; HSE Contract Research Report no 1/1987
- 1987; Swanson SJ et al; The influence of subjective factors on temporary threshold shifts after exposure to music and noise of equal energy; Ear Hear; 8(5) p288-291
- 1987; Woolford D; Hearing problems in orchestras; Acoustics Australia; 15(3) pp 78-79
- 1985; Johnson DW, Sherman RE, Aldridge J et al; Effects of instrument type and orchestral position on hearing sensitivity for 0.25 to 20kHz in the orchestral musician; Scandinavian Audiology; 14 pp215-221
- 1985; Robinson DW; The audiogram in hearing loss due to noise: A probability test to uncover other causation; Annals of Occupational Hygiene; 29(4) pp 477-493
- 1983; Borg E, Nilsson R, Engstrom B; Effect of the acoustic reflex on inner ear damage induced by industrial noise; Acta Otolaryngol; 96 pp 361-369
- 1983; Karlsson K, Lundquist PG, Olaussen T; The hearing of symphony orchestra musicians; Scandinavian Audiology; 12 p257-264
- 1983; Lindgren F, Axelsson A; Temporary threshold shift after exposure to noise and music of equal energy; Ear and Hearing; 4(4) pp197-201
- 1981; Atherley G; Audiometry The ultimate test of success; Annals of Occupational Hygiene; 27(4) pp 427-447
- 1977; Robinson DW and Shipton MS; Tables for the estimation of noise induced hearing loss; NPL Acoustics Report Ac 61
- 1970; Burns W, Robinson DW; Hearing and noise in industry; HMSO
- Dingle AF, Flood LM; Occupational hearing loss in the United Kingdom; pp723-731
 - Magne S, Sound transmission between musicians in a symphony orchestra on a concert hall stage; www.akutek.info
 - Sataloff and Sataloff; Tape simulation of hearing loss; pp 733-738
 - Sataloff and Sataloff; Hearing loss in musicians; pp 583-594
 - HSE; Exposure to noise in the entertainment industry
 - HSE; Health surveillance in noisy industries, advice for employers
 - Tinnitus A way out; BBC Music Magazine; Tinnitus Special
 - Harding RAI, Owens DT; Sound pressure levels experienced by conductors in collegiate music rehearsal settings; a paper submitted to the Hawaii international conference on arts and humanities.
 - Hazell J; Tinnitus perception, habituation and retraining therapy
 - Foster M; Symphony orchestra noise, sound levels and hearing conservation; Acoustics Australia; 17 (1); 23
 - Somerset Music Third tier health and safety code of practice for Somerset instrument tutors
 - Woolford DH; Hearing loss in orchestral musicians a dilemma; Acoustics Australia; 17(1) p22

SOME USEFUL WEBSITES

http://en.wikipedia.org/wiki/Auditory_filters
<http://osha.gov>
<http://web.idirect.com/~cnha> - Canadian network for health in the Arts
<http://www.abo.org.uk>
<http://www.cccd.edu/faq/tinnitus/prevent> - tinnitus
<http://www.acoustics.org>
<http://www.bpamt.co.uk/>
<http://www.chs.ca> - Canadian Hearing Society
<http://www.hear-the-world.com/>
<http://www.hearnet./com> - Hearnnet Hearing Education and Awareness for Rockers
<http://www.hse.gov.uk/noise/index.htm>
<http://www.soundadvice.info> - the Sound Advice website
<http://www.hse.gov.uk/noise/research.htm> - HSE commissioned research
<http://www.mbf.org.uk>
<http://www.musiciansclinics.com>
<http://www.oticonus.com>
<http://www.rnid.org.uk>
<http://www.sensaphonics.com> - hearing protection
<http://www.tinnitus.org>
<http://www.tinnitus.org.uk/>
<http://www.uic.edu/sph/glakes/webcasts/musicians>

SOME HSE PUBLICATIONS

Controlling noise at work. Guidance on the Control of Noise at Work Regulations 2005. L108, ISBN 0-7176-6164-4 HSE Books
 - This book replaces the 1998 edition of L108 Reducing Noise at Work. Guidance on the Noise at Work Regulations (ISBN 0-7176-1511-1).

HSE's free employers leaflet Noise at Work - Advice for employers INDG362 (rev 1) - This leaflet is for employers on good practice and considering what they need to do

HSE's free pocket card Protect your hearing or lose it! INDG363 - Contains notes on good practice which you may find helpful.

A guide to audiometric testing programmes HSE Guidance Note MS 26 ISBN 0 7176 0942 1.

Introducing the Noise at Work Regulations - IND(G)75(L)(rev)

Management of health and safety at work Approved Code of Practice ISBN 0 7176 0412 8

No 2: Legal duties of designers, manufacturers, importers and suppliers to prevent damage to hearing L3 ISBN 07176 0454 3

Selecting an health and safety consultancy HSE free leaflet IND(G)133(L) <>

Surveillance of people exposed to health risks at work HSE guidance booklet HS(G)61 ISBN 0 11 885574 3 <>

The safety representatives and safety committee Regulations 1977 (The Brown Book) ISBN 0 11 883959 4