

MUSICIANS' GUIDE TO NOISE AND HEARING

PART II: TOOLKIT FOR MANAGERS



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PART II: TOOLKIT FOR MANAGERS

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This version incorporates feedback from the sector and the Health & Safety Executive.

■ “The BBC is a significant employer of musicians. As an organisation it therefore has a duty of care towards them, not least to help them to look after their hearing. In recent years we have been playing a leading part in developing thinking in this area. I am delighted that our 2008 research initiative looking at noise exposure in our five orchestras and the BBC Singers has evolved into an important cross-sector collaboration from which many more musicians (and the musicians of the future) can benefit.” – Roger Wright, Controller, BBC Radio 3 and Director, BBC Proms

This guide was written by Ruth Hansford, BBC Safety, in partnership with these organisations. The HSE was a consulted stakeholder. See the acknowledgments section for details of editorial group membership.



ROYAL
OPERA
HOUSE



Welsh National Opera



The Federation of Scottish Theatre provides support, including Health & Safety advice, for the Royal Scottish National Orchestra, the Scottish Chamber Orchestra, Scottish Ballet and Scottish Opera. The FST represented them on the editorial group for this guide.



London
Philharmonic
Orchestra

ABOUT THIS DOCUMENT

Part II of the guide 'Music, noise and hearing' is intended for managers of ensembles and venues. It supplements the HSE publications *Controlling Noise at Work* and *Sound Advice*. It builds on these two publications in response to requests from the sector, as well as the Association of British Orchestras' (ABO's) February 2008 publication *A Sound Ear II*. It also assumes some knowledge of the broader principles of Health & Safety at Work legislation.

Sound Advice was developed in the lead-up to the application of the Noise Regulations to the Music and Entertainment sector and was published in July 2008. In the intervening three years much has been done in the UK orchestra sector: the BBC Performing Groups funded a year-long investigation and collected a dataset of musicians' noise exposure and potential reductions across a range of scenarios. Many other orchestras have taken measurements, devised experiments and explored solutions. In July 2010 the BBC organised a seminar in partnership with the HSE and the ABO, to share these experiences and look to the future.

Since 2008 we have built up a considerable knowledge base: more figures, the benefit of experience, and ideas are regularly exchanged through formal and informal networks. But we also have a greater financial challenge. Fortunately, though, not all of the solutions to controlling noise and protecting musicians' hearing have a high cost. True, high-tech acoustic treatments and custom-moulded earplugs may not be cheap, but the low-tech solutions –: talking, sharing and building on experiences – all play a vital part.

The Noise Regulations pose particular challenges for our sector. Solutions for acoustic music are not 'one-size-fits-all'; there are many variables: repertoire, venues, instrument, conductors, and individual musicians. Differentiated solutions must be found, and it is vital to act and experiment. It requires a sustained team effort, and the Regulations should be seen as an opportunity for all involved in making music to work together.

The guide as a whole aims to facilitate dialogue and empower all musicians and managers, and as such represents current good practice around the sector. While Part I, the musicians' section, is arranged to cater for their information needs, Part II, the managers' section, is arranged according to the structure of the CNAW Regulations.

Many colleagues have contributed case studies with a view to sharing strategies and solutions. Even if they raise more questions than they answer we hope they will inspire further developments.

■ “Everyone here today appreciates that doing the right things the right way delivers improved productivity, increased workforce commitment and enhanced reputation. We also recognise that these things will only be achieved by everyone working together towards a set of common goals – goals that are reasonable as well as practical.” – *Hugh Robertson, HSE board member, at 'Classical Music, Noise and Hearing' seminar, July 2010*

UNDERSTANDING AND ASSESSING THE RISKS FROM NOISE

(CNAW REGULATION 5)

TOWARDS A STANDARD RISK-ASSESSMENT PROCESS

It is desirable to work towards an industry-wide consensus as to what everyone can expect in a risk assessment. There is no one way of presenting this, beyond ensuring that you have covered the five steps outlined in *Sound Advice*. This should be used as a guide both to drawing up your own risk assessments and to deciding whether the risk assessment of a third party (staging supplier, sound engineer for amplified music, concert hall or studio), anticipates, and provides appropriate solutions for, noise risks.

A generic risk assessment document might be based on the ensemble's noise policy or noise protocols, which outlines roles and responsibilities. This may be supplemented for a specific project, tour or venue with information that has come out of a stage-management or tour-planning meeting, for example.

You first need to be clear about what it is you are assessing, whether it be a single project or a series. Then you should set about addressing the following questions:

FIVE STEPS TO ASSESSING RISK:

- Is there a risk due to noise?
 - Who might be harmed and how?
 - Evaluate the risk and decide on precautions.
 - Record the findings and implement them.
 - Fine-tune as you go, and review after the event.
-

1. IS THERE A RISK DUE TO NOISE?

Yes. The link between prolonged noise exposure and hearing problems is long established. Musicians are exposed to high sound levels and there is some evidence of noise-induced hearing loss among certain groups of musicians. However, our understanding of musicians' hearing is incomplete.

2. WHO MIGHT BE HARMED AND HOW?

Figures collected by the BBC over a period of a year showed that just over 50% of the musicians in an orchestra have a daily noise dose at or above 85dB(A) $L_{EP,d}$. By virtue of their location in the ensemble, or the instrument they play, certain musicians are more consistently 'at risk' than others. Risk from instantaneous peaks was found to be relatively rare compared to the risks from prolonged noise exposure in this context.

There are many variables: layout and position in the ensemble; instrument played (woodwind and brass players being more exposed than others); venue; repertoire; individual differences. No two concert halls or studios are alike; one piece performed in two venues may create different challenges. Each repertoire piece or programme has its own noise risks; with standard repertoire musicians can draw on experience – but with new works the conductor, composer and artistic planning team are the only ones with the complete picture. Finally of course, no two musicians are alike.

So rather than thinking globally, we must consider risks that relate to individual musicians. This sounds like a lot of work, but there is a great deal of knowledge and experience to draw from, among musicians, managers and venue managers, so it doesn't mean starting with a blank page each time.

3. EVALUATE THE RISKS AND DECIDE ON PRECAUTIONS

To help evaluate the risks you can use existing knowledge of musicians' noise exposure. Figures are only an indication, but measuring the risks helps you to be explicit about describing them. To evaluate the risk for a health problem with a long latency it may also be helpful to look at a bigger picture: it may be helpful to talk in terms of the project, or likely exposure over a working week. Some figures can be found in the musicians' section of this guide, and both musicians' and managers' sections explore controls, with some indication of noise-reduction potential, checklists to use when considering them and examples of how these controls are being implemented in the real world.

4. RECORD THE FINDINGS AND IMPLEMENT THEM

The resulting document need not be overly complicated. It is a record of significant findings; some projects have more risks associated with them than others (the *Rite of Spring* vs. Rodrigo's *Guitar Concerto*, for example). Write down the findings of the risk assessment process and state what you intend to do to eliminate or minimise the risks. The document should be signed off by the senior person responsible for health and safety.

A risk assessment record should be retained for a defined period (eg. six years), in case of subsequent civil or criminal claims. It is also good practice to have the documentation accessible so you can refer back to what you have done on previous projects.

Ensure the contents are communicated to everyone who needs to know. If there is no reason to keep it confidential (for example, when an individual's health is involved) an announcement to the whole ensemble may be sufficient. For example: *'There are some loud passages in this programme – be sure you have your earplugs with you and if you haven't, there is a supply in x'* or *'There is a supply of screens available. If you're not sure how to set one up ask for help.'* Or section leaders or the conductor might take a moment before the first rehearsal to tell the ensemble where the loud passages are, so that those affected can mark up their score. These are examples of how the managers and musicians need to work together to reduce the risk from noise exposure. Clearly these are dependent on managers having made this possible beforehand – by providing screens, thinking about suitable stage layouts, discussing with the conductor, and so on. Control measures are discussed in the section 'Eliminating and controlling risk'.

5. FINE-TUNE AS YOU GO, AND REVIEW AFTER THE EVENT

Use the risk assessment as a living document (what is known as dynamic or ‘on-the-spot’ risk assessment), and after the event use it as a learning tool: What could we have done better? What should we remember for next time? Should we modify the action plan in the light of what we have tried out? With time you can build up a picture of risks associated with different venues and different repertoire or programmes. These, and the solutions (plus your thoughts about their success) can be shared among colleagues inside and outside your own ensemble.

PEAKS

Instantaneous peaks at or above the maximum Exposure Limit Value of 140dB(C) as set out in the CNAW are thankfully very rare, but levels do not have to be high to bring about an adverse reaction. If peaks are in the score they can be predicted. An accidental loud burst of noise (from an on-stage monitor, for example) is unlikely to be at or over 140dB(C), but there are measures that can be put into place to avoid these. Ensure that the sound test takes place while musicians are not on the stage, and prepare musicians for loud sounds in the piece of music by giving them time to mark up their score (the orchestral librarian can play a role here too). It is also important to have a procedure for reporting and following up such incidents, as with any other accident or near miss. See below for a suggested procedure.

HOW MUCH DETAIL SHOULD GO INTO A RISK ASSESSMENT?

On the one hand it is important to think about the specific risks involved (which means you don’t just cut and paste without thinking about its relevance) and on the other hand you don’t want to spend time rewriting something that has routine elements in it – especially when the risks are related to exposure over time. But you *do* want your risk assessment to refer to the specifics of the venue and the repertoire – and to individuals’ needs. Of course, it is better to cut and paste something that is tried and tested and fit for purpose, rather than write the perfect risk assessment and then run out of time to implement the controls.

QUESTIONS YOU CAN ASK:

- Do the musicians know what’s in store?
- Has everyone had noise awareness training?
- Is the repertoire known to be noisy?
- Is there any amplification?
- Do you know the venue?
- Does the venue have flexible risers?
- Does the venue have adequate acoustic treatments?
- Do you have a range of controls at your disposal?
- Are there extras/deps whose playing style you don’t know?
- Do you have any acoustic screens?
- Do you provide disposable earplugs?

A TEMPLATE FOR A RISK ASSESSMENT

This template has been developed in the BBC. It may be freely copied and adapted to suit individual scenarios. But bear in mind there's no substitute for your own thinking process

RISK ASSESSMENT DETAILS	ACTIVITY DETAILS
<ul style="list-style-type: none"> ▪ What is being assessed? A series, a project or a part of a project? ▪ Dates the assessment refers to. ▪ Location details. ▪ Name of person who carried out the risk assessment. ▪ Name of manager who signs off the risk assessment. ▪ Names of people to whom the document should be circulated. ▪ Any other related risk assessments (eg third parties). 	<p><i>Activity title:</i> Performing Groups: rehearsing, performing and/or recording music</p> <p><i>Scope and description:</i> For example: This risk assessment applies to noise risks to musicians associated with the rehearsal and live or recorded performance of orchestral and choral music. This activity may take place at a BBC venue or at an external venue and this assessment assumes the venue is already set up for this activity. In cases where the venue is built or modified especially for the project (the minority of cases), these issues must be considered at the design stage. This assessment does not cover associated risks such as manual handling, long hours, trips and slips, etc.</p> <p><i>Who is at risk from this activity?</i> (names and/or numbers)</p>

HAZARDS How could someone become hurt or made ill?	CONTROL MEASURES How are you going to prevent this from happening?
<p>Hazard: Exposure to high levels of noise that may cause noise-induced hearing problems.</p> <p>Description: Over the course of a career in a noisy environment, exposure to noise levels above 85dB(A) over the course of an eight-hour working day can cause irreparable damage to the cells of the inner ear. This may result in a threshold shift (a decreased ability to hear certain frequencies) which is known as noise-induced hearing loss, or in other problems that cannot be measured in a hearing test, such as tinnitus or hyperacusis.</p>	<ul style="list-style-type: none"> ▪ At the artistic planning stage, managers to ensure the repertoire is suitable for the venue. Note that even if the platform is big enough to accommodate the orchestra (/choral) forces required, the acoustic volume may be insufficient. If this information is not already known by the ensemble managers, the venue should provide it. ▪ Rehearsal schedule to be drawn up to provide adequate rest periods (eg, 15' break after 1 ¾ hrs; 12-16 hrs advisable after a loud concert). ▪ Stage layout to be designed to provide adequate vertical separation: louder, more directional instruments to be placed on risers if possible (ideally c.20cm for each row of woodwind; c.36cm higher for brass). ▪ Stage layout to optimise horizontal separation between noisier and more vulnerable sections of the ensemble: provide space in front of trumpets and trombones, between horns and percussion section, and between woodwind (especially piccolo) and the back desks of the string section. ▪ String sections should be rotated and where appropriate brass sections single-ranked. ▪ Acoustic screens to be made available and stage managers to ensure these are positioned in a way that optimises the protection of vulnerable players without adding to the noise dose of others. These must not be moved (or removed) without permission from the management. ▪ Managers to make announcements at the beginning of the rehearsal warning musicians of potential noise risks associated with the repertoire being played (including likely sound levels); to inform them of the steps they have taken and to remind musicians of their own responsibilities. ▪ Conductor to avoid repetitions of loud passages during rehearsal. ▪ Where appropriate, musicians to be allowed to leave the stage when not required for a passage. ▪ Managers to remind musicians of the importance of wearing hearing protection and to make earplugs available to all. ▪ Musicians to wear hearing protection, either their own or that provided

HAZARDS How could someone become hurt or made ill?	CONTROL MEASURES How are you going to prevent this from happening?
	<p>by the management.</p> <ul style="list-style-type: none"> ▪ For amplified projects, on-stage foldback to be avoided and wearing of in-ear monitors by the solo artists strongly advised. Front-of-House PA to be directed away from the stage. Stage should have been designed to minimise transmission of unwanted (especially low-frequency) sounds from amplified to acoustic sections (clear space; rubber matting). Sound check to take place when there are no musicians (or any staff who do not need to be there) in the area. ▪ Managers to provide hearing health surveillance to contract staff; musicians to attend regular hearing tests as set out in their contracts. (NB though this is not a 'control' it is important in evaluating the effectiveness of noise management strategies).

WHAT MAKES A GOOD RISK ASSESSMENT?

Here are some characteristics of a good risk assessment:

- Drawn up and authorised by someone who is competent (who has sufficient experience and knowledge).
- Begun in good time.
- Completed before the activity begins.
- Specific and clear about what it is covering.
- Specific about what other assessments and procedures it refers to.
- Identifies the significant hazards.
- Clear about who might be harmed and how
- Controls are specific and appropriate.
- Key information is communicated to those affected.
- Controls are implemented.
- Checks are made to ensure controls are implemented.
- Dynamic assessment undertaken and recorded if required.
- Assessment reviewed.

VENUE ACOUSTICS DATABASE

Venue managements will have carried out their own risk assessment and you should have sight of this, but you may consider supplementing it with information that is specific to your ensemble's requirements. Ideally the venue's website should provide some information about dimensions of the space, surface area of the stage, reverberation time, and so on, but in practice this may not be available.

This table shows what is currently known about the relevant acoustic characteristics of venues used by British ensembles. It draws on published measurements as well as results of exercises commissioned by the venues, plus observations made by staff and users of the venues. The headings are the kind of things you should ask a venue when making a booking. Use your knowledge of existing spaces to work out where you can rehearse and perform comfortably. In time it is hoped that this list will become more complete as more information becomes available. In the meantime, fill in any gaps on your own copy. Send updates to the BBC Safety Advice Line ask.al@bbc.co.uk.

TEMPLATE FOR A VENUE ACOUSTICS DATABASE: FILL IN THE GAPS

Venue	Shape / characteristics	Volume m ³ (est.)	Length / width / height, m (est.)	Platform area m ²	Risers	Rehearsal reverb time @ 1kHz, sec. (approx)	Choir seating	Info for promoters on website?
Aberdeen Music Hall	Shoe box				Y			
Aberystwyth Arts Centre	Small – flat stage							
Ayr Town Hall	V small ‘bathtub’				Y			
Bangor Prichard-Jones Hall								
Basingstoke Anvil,		14000						
Birmingham Symphony Hall		25000	40/27/23	279	Y / flexible	1.85	Y	
Birmingham Town Hall								
Cardiff BBC Hoddinott Hall	Elongated octagon	8600	30/22/14	250+	Y / flexible	1.6-2.4 (variable)	Y	
Cardiff St David’s Hall	Octagonal – thrust stage – overhang	22000	48/34/18	179	Y	1.9 (1983)	Y	
(pit) Cardiff Wales Millennium Centre								
Carlisle Sands Centre								
Cheltenham Town Hall								
Chichester Festival Theatre	Thrust stage	6585			None	1.0		
Croydon Fairfield Halls	Rectangular	15400	48/26/15	165		1.75 (predicted)		
Edinburgh Usher Hall	Horseshoe	16000	52/24/17	120		1.75	Y	
Glasgow City Halls		8200	40/18/11.4	200max		1.9-2.4 (variable)	Y	
Glasgow Henry Wood Hall	Former church							
(pit) Glasgow Theatre Royal								
(pit) Glyndebourne				109				
Hanley Victoria Hall								
Huddersfield Town Hall					Y – v steep			
Inverness Eden Court Theatre	Theatre							
Kendal Westmorland Centre	Stage almost flat				Small riser for back row			
Lancaster University	Flat stage – steeply raked auditorium				N			
(pit) Leeds Grand Theatre								
Leeds Town Hall								
Liverpool Philharmonic Hall	Rectangular	13560	50/27/12	148		1.45		
Llandudno Venue Cymru	Stage extension built to prevent sound going up fly tower							
London Abbey Road Studio I		4480			N			
London Barbican		17750	44/34/11	157	Y - flexible	1.65 (1983)		

Venue	Shape / characteristics	Volume m ³ (est.)	Length / width / height, m (est.)	Platform area m ²	Risers	Rehearsal reverb time @ 1kHz, sec (approx)	Choir seating	Info for promoters on website?
London Henry Wood Hall	Former church	6080			Y		Y	
London LSO St Luke's	Square former church – v resonant							
London Mermaid Theatre	Very dry acoustic	5000		220max	N (BBC CO provides staging)	0.80		
London Maida Vale Studio 1	Low ceiling	6138	31/22/9	260+		1.4		
London Maida Vale Studio 2		1700	21.5/13.5/6	120+		1.25		
London Queen Elizabeth Hall	Fan	9600			Y	1.8		
London Round House	Former turning shed. Circular	4828			Staging built for specific projects	1.2		
London Royal Albert Hall	Large oval	86650	67/47/36	104	Y	2.4	Y	
London Royal Festival Hall	Rectangular	21950	52/32/15	163	Y	1.8 (1970)	Y	
(pit) London Royal Opera House				89				
London St Giles Cripplegate							Y	
London St Paul's Cathedral								
London St Paul's Knightsbridge							Y	
London Wigmore Hall		2900				1.5		
Manchester Bridgewater Hall		24000	30/26/24	276	Y	2 (mids)	Y	
Manchester NBH Studio 7		8150	26/22/14	225+	Y	1.6		
Nottingham Royal Concert Hall		17500	50/26/17	155	Y flexible	1.95 (predicted)	Y 186	
Perth Concert Hall								
Sage Gateshead								
Salford, BBC Philharmonic Studio		8600	26/21/15.8	225+	Y flexible	1.45-1.85 (variable)		
(pit) Salford, Lowry								
Sheffield City Hall	Circular						Y	
Snape Maltings		7590						
St David's Cathedral								
Swansea Brangwyn Hall								
Watford Colosseum		11600	42/22/12.5	230+	Yes on stage, if used	2.0		
Wrexham William Aston Hall								

MONITORING AND MEASURING

A risk assessment should include some indicative noise exposure figures, based on prior knowledge and experience in a risk assessment. The precise figures will be hard to predict, because of the many variables involved (venue; repertoire; how loud everyone plays on the day...). However, it may be possible to quote measurements that have been taken in the past for similar programmes. The chart in the musician's section gives a broad indication of typical daily doses measured in the past, and the knowledge base will continue to grow as orchestra managers do more measuring and share data.

Bearing in mind a studio, pit or concert platform is not a laboratory, it is nevertheless good practice to measure similar projects and collect comparative figures over time, to see what progress has been made as policies are taking effect. If you expect to do noise monitoring on a regular basis, it is advisable to undertake noise-assessor training, but here is a checklist of things to consider when carrying out monitoring.

PLANNING

- Be clear about what you're trying to find out: eg, to develop a string-rotation policy, or to initiate discussions about noise management and effectiveness of control measures among the musicians and between musicians and managers.
- Don't underestimate the amount of work involved: you need to concentrate on noise monitoring and avoid distractions on the day.

BEFORE

- Decide *how* to measure (hand-held meter or preferably dose badges attached to the musician).
- Set up a database so you have somewhere to store the figures.
- Make sure the musicians understand what the aim of the measuring is and how the results will be used.
- Reassure the musicians that a dose badge only records sound levels and does not record actual speech (or wrong notes).
- Make sure the dose badges are charged.
- Calibrate the badges (make sure the meter's calibration certificate is still valid as well as doing your own calibration).
- Make a note of who has badges; draw a plan of where they're sitting, or take a photo.
- Attach the badges securely and close to the musician's ear (so that the readings reflect the actual dose, but ensuring the badge does not get in the way when playing).

DURING

- On your plan of the ensemble, also make a note of what happens when (eg conductor talk) and when the orchestral breaks are.
- Don't stop the badges during the breaks as it makes it hard to calculate an $L_{EP,d}$.
- Note any events that might affect the readings (badge drops, musicians hitting them, etc).
- Note on the layout plan any controls such as drapes (closed / open), use of screens, etc.
- Note use of hearing protection.

AFTER

- Collect the badges at the end of the session / day. Download the data and convert it to a format that people can read (pdf).
- Disseminate the results to the relevant people; let the musicians know what their dose was and use the opportunity to talk about hearing protection.

A PROCEDURE FOR LOW-TECH OR AD-HOC NOISE MONITORING

In the event you want to do a quick spot-check, you can take a more low-tech approach. Though it would not be sufficient for the purposes of a risk assessment, it would give you an indication of likely exposure, the effectiveness of controls or the need for more detailed measurements.

- A basic hand-held noise meter (if you are going to use a phone meter, you need to spend £10 at least to get something that is reliable). Remember though that these meters do not conform to any British Standard. They should be used for information purposes only and if you use them to estimate noise exposure levels in a risk assessment you must be clear about the instrumentation that was used.
- A clock or watch with a second hand.
- A camera.
- Describe the circumstances (location, repertoire, forces used and position of musicians in question).
- Note the levels recorded and the length of time you measured.
- Bear in mind measurements need to be taken as close as possible to the musician's ear.

ELIMINATING AND CONTROLLING RISK (CNAW REGULATION 6)

- Aim of noise control measures: to eliminate the risks from noise or to reduce the risks to as low a level as is *reasonably practicable*.
 - Collective measures should take priority over individual measures.
 - Make sure one control doesn't cancel out another.
 - Managing noise often requires working in partnership with third parties.
-

The actions agreed as a result of a risk assessment aim to eliminate the risks from noise or reduce the risk from noise to as low a level as is *reasonably practicable*. It is important to ensure that one action, or control, doesn't negate another. For example, a screen or acoustic treatment that reduces one musician's noise exposure whilst increasing the dose of a colleague.

When the noise (or sound) is the deliberate end product of the activity, elimination of the *noise* is not a viable or appropriate outcome, though elimination of the *risks* is. Nevertheless there may be some scenarios where it is possible and desirable to eliminate unnecessary noise in amplified projects (see below).

Collective measures take precedence over individual measures. In music, that means the ideal would be to design the perfect concert hall that provides a comfortable acoustic environment for the musicians as well as the perfect blend for musicians and audience alike. In the real world, we have to find solutions for individuals, and in practice this requires collaboration between managers and musicians. The three possible types of solution are:

- **technical** measures (engineering the noise out)
- **organisational** measures to manage noise exposure (actions that require collaboration within the ensemble and with managers)
- **individual** measures (including personal protective equipment, non-work exposure and personal choices).

The Noise Regulations recognise that interventions bringing both measurable and non-measurable benefits are important. This section covers actions that bring about a measurable reduction in exposure as well as those actions that help to prevent an accumulation of temporary threshold shift (TTS) by providing adequate rests away from the noise, and those that help minimise unhealthy stress. This reflects the fact that some hearing problems can be measured while others (like tinnitus) are not measurable.

WHAT WORKS?

There is rarely one simple solution. If there were, we would all know about it by now. The reality is that many of the actions described in the pages that follow may only reduce exposure by 1-3dB (if a figure can be put on it). But a combination of actions can make the figures add up – and the non-measurable things can play a huge part in improving general health inside and outside the workplace.

The attenuation figures quoted below were collected in real-life situations, and so should only to be used as a rough guide. They may prompt you to devise other data-collection exercises. The process of investigating is useful and thought-provoking in itself – and it all adds to our collective knowledge.

WHAT CAN MANAGERS DO TO MAKE A DIFFERENCE?

This section is intended to be read in conjunction with the section in the musicians' part of the guide 'Assessing and controlling noise risks'. The Guidance to the Noise Regulations gives a hierarchy of controls as follows: technical measures ('engineering the problem away'); next, organisational measures; individual measures. The list that follows adapts this, starting with the strategic actions, as experience shows the first step is to create the right environment. We then explore the more practical control measures, and finally move on to looking to the future and investing in the next generation. Sound bites and case studies are included for inspiration.

- Strategic: contracts, protocols and code of conduct, artistic planning
- Day-to-day management: schedules, layout options (vertical, horizontal separation, rearranging sections, string rotation), acoustic treatments and screens, rest periods
- Working with third parties: amateur and children's choirs, amplified projects, looking to the future and working in partnership.

CONTRACTS: CONDUCTORS / ALL MUSICIANS

There may be a measurable noise reduction (eg if a conductor allows a screen, or if a musician avoids practising in the studio). There is potential for intangible benefits (reducing stress by the way a conductor manages a rehearsal).

- A 'noise' clause in all contracts (example below) can serve as a reminder of responsibilities with respect to noise. We should aim for a common understanding between conductors and the ensemble; some conductors may need reminding as they usually have a lower noise exposure than anyone who is playing or singing.

■ From the autumn of 2011 all contracts of engagement for musicians on BBC contracts contain a clause referring to their responsibilities under the Noise Regulations. The clause has been drawn up by the BBC in consultation with IAMA and the MU. It requires all musicians to do everything reasonably possible to work in accordance with the requirements of the Noise Regulations and to comply with any specific requests from the producer as appropriate.

■ Rather than finish a *Rite of Spring* rehearsal with the ‘Sacrifice’ music, the conductor (Thierry Fischer) spent five minutes working on the quiet beginning of the piece. The contrast was appreciated by the players and, when questioned, the conductor said he instinctively felt he should not end the rehearsal on the loudest sections of the piece.

■ Barry Wordsworth, on conducting a new commission in the Royal Opera House pit with the trumpets, trombones and percussion to his immediate right at the front by the pit rail: “Now I really know what levels of sound the players are sometimes exposed to in the pit. Standing to conduct in the full force of that sound has been a revelation and will make me far more understanding about noise problems in future. Every conductor should have to stand on the podium in that level of noise and experience it.”

NOISE PROTOCOLS / CODES OF CONDUCT

Some measurable reductions, eg around 3dB by discussing position and angle of acoustic screen; 1dB reduction in $L_{EP,d}$ by not practising during breaks. Main benefits are to orchestral harmony.

- In order for these protocols to have any meaning, they need to be negotiated jointly and the principles agreed by all.
- They should cover managers’ and musicians’ responsibilities and can set out the behaviours that have been agreed to be appropriate.
- Once finalised, the resulting document can form part of the induction pack for new members of the company. It can also be given to any freelance musician.
- Occasional reminders can be made to keep it current and relevant.

Noise protocols at Welsh National Opera

■ “The noise protocol was initially drafted in order to clarify boundaries and responsibilities of the parties concerned with audiometric testing. From this it became clear that if a document existed as an appendix to the WNO / MU agreement, it would help all parties to understand the measures being taken to comply with the Noise at Work Legislation. If these are contractually binding it also means we are in a stronger position to demonstrate our response to the issue.” – *Phil Boughton*

■ The BBC orchestras held meetings to discuss what musicians and managers would like to see in a code of conduct. The areas included in the document, and working practices, were jointly agreed so there is a common understanding of what is expected.

ARTISTIC PLANNING: REPERTOIRE CHOICE AND COMMISSIONING

Repertoire and performance planning is a useful tool in mitigating noise exposure. Larger orchestral (and choral) forces required for certain repertoire

can be balanced across the season by repertoire requiring smaller forces. This is also an issue when commissioning new works.

- The BBC Symphony Orchestra has a ‘buddying’ scheme called *Sound and Music* whereby composers are ‘embedded’ in the orchestra. They can see at first hand why it is not possible to write a piece where the piccolo is in the middle of the violin section.
 - The BBC SO’s Senior Producer routinely goes through the score of a new commission and if necessary discusses with the composer potential noise issues in a new piece.
-

ARTISTIC PLANNING: MATCHING REPERTOIRE TO VENUE

For certain players this has considerable noise-reduction potential (eg 3-6dB by increasing space between piccolo / brass and back desks of strings).

- There are some pieces that won’t fit physically in some concert halls, but there are other instances where the stage will accommodate large forces but the venue is not acoustically appropriate – for example if the surface area of the platform is adequate but the ceiling is so low that the sound has nowhere to go.
 - A stage with risers that are the right height can reduce the exposure for the viola players in front of the trumpets by at least 3dB (for example).
 - The figure often quoted is a space requirement of 25-30 cubic metres per instrument, which means 2,000 m³ for an orchestra of 60 or more (in rehearsal). However, the chart in the Risk Assessment section shows that commonly used studios and rehearsal venues are two or three times larger than that. In addition, the reverberation time can play a part in musicians’ perception of sound levels and consequently how loudly they play.
 - This applies to the rehearsal as well as the performance. A big choral piece will increase noise levels: in rehearsal for Mahler 8 in the Bridgewater Hall exposure for instrumentalists was 2dB higher across the board once the choir were in place.
-

■ When large-scale works such as Berlioz *Te Deum*, Mahler 8 have been performed at the BBC Proms, the orchestra-only rehearsal was at Maida Vale studios and the full rehearsals have taken place in bigger spaces: Watford Colosseum, the Royal Albert Hall itself.

■ When the BBC Philharmonic and the Hallé collaborated on Mahler 8, rehearsals with the choruses took place in the Bridgewater Hall rather than the studio. As well as providing extra acoustic volume and therefore more comfort for all, it also helped musicians to get used to the acoustic of the space early in the rehearsal process.

■ A piece called *Hekla*, with 22 percussion including gunshots, anvils, etc (inspired by the eruption of a volcano) was performed at the Royal Albert Hall where the galleries could be used to separate the percussion from the main orchestra.

■ Matching repertoire and venue at WNO: “We are fortunate in Wales Millennium Centre that we have world-class facilities including an excellent pit (using three different sizes) which we designed ourselves. It has plenty of floor-space and air-space between the players so the main issue that confronts us on tour in some of the more problematic theatres is avoided completely. When we tour to the more space-restricted orchestra pits like Llandudno, Plymouth and Swansea, we start by having a smaller string section in order to try to replicate the general comfort that the home theatre and some of our other touring theatres provide. As a management, you have to be careful with this one, though. Some conductors are not keen to see their string section reduced...” – Peter Harrap

SCHEDULING

Noise reduction potential: intangible rather than numerical benefits to arranging the schedules with a view to giving the musicians’ ears a rest.

■ Organising the schedules with noise in mind means leaving sufficient gaps between periods of exposure to minimise the risk of temporary threshold shifts. This includes avoiding scheduling a morning rehearsal after a noisy concert the night before.

■ For planning the schedules, managers at the BBC Philharmonic have devised a ‘starring system’. It is similar to the way marketing departments predict box-office appeal for a concert or programme. To predict noise levels in a programme, managers use four levels: *piano*, *mezzo-piano*, *mezzo-forte* and *forte*. A *forte* programme in a small venue might drop to *mezzo forte* in a bigger venue, or a particular musician’s rating might vary in different venues. “This process helps to vary the noise exposure and also engages musicians and managers in discussion about the issues.” – Richard Wigley

ORCHESTRA LAYOUT: VERTICAL SEPARATION

Noise reduction potential: at least 3dB. This is the most effective measure in terms of reducing exposure of the musicians in the vulnerable positions.

- Increasing vertical spacing is the single most effective control measure. If the sound of the trumpets can go over the heads of the players in front, not only are the string players out of the firing line, the brass players don’t have to blow so loud to send their sound into the audience: there is less exposure and it is easier on the embouchure.
- Risers should be flexible to suit a range of orchestral layouts and, ideally, hydraulically powered to save on manual handling and time. If you are consulted by a venue where improvements to the acoustic are being discussed, this is something you can suggest.



Risers at RSNO's Henry Wood Hall (photo: Euan Turner)

- Risers should be deep enough to accommodate the music stand, ideally 1.25m for upper strings, 1.4m for celli and basses, 0.8m for choir if seated, 1.4m for timps and percussion (figures from AC Gade).
- Risers should not be so high that they create a fall hazard or a manual handling problem for the stage crew and players of heavy instruments (36cm is common).
- The surfaces of the risers should be solid to ensure the right amount of projection with no 'overkill' for the brass or 'rattle' for the low-frequency instruments.
- Risers are more complicated in a pit: if there is no headroom risers will be out of the question, and even if there is enough physical space it will be uncomfortable if the sound has nowhere to go. Sometimes string risers are used in a pit to help the sound from the upper strings to get out.

ORCHESTRA LAYOUT: HORIZONTAL SEPARATION

Noise reduction potential: 3dB per doubling of distance (with multiple noise source, as in an orchestra).

- Increasing horizontal separation is less straightforward. On the one hand you can reduce the exposure from a noisy instrument by 3dB if you double the distance in front of the 'noise source' (there will be more leg room for the player too). Note that 'classical acoustics says 6dB, but this is with a single 'noise' source –rarely the case in an orchestra, hence 3dB is more realistic. On the other hand it is possible that this benefit will be cancelled out by a tendency of the musicians to play louder to 'fill' the space. As ever, there is a balance to be found between physical and aural comfort and ensemble sound, and this should be the result of ongoing discussion about what is acceptable.
- A gap between the front of the orchestra and the audience helps with projection of the sound and stops overplaying – which means a reduction in exposure. Also whilst the horns and percussion should not be too close to a back wall, an *angled* reflective surface behind them can help with projection.
- Here is a list of average floor-space requirements for instrument groups (from Gade):

upper strings / wind	1.25 m ²
cello / large wind	1.5 m ²
double bass	1.8 m ²
timpani	10 m ²
other percussion	20 m ²
trombones	180cm in front and 30cm behind
trumpets / brass	[spacing requirement is about noise].

Space sound bites

- “We are always looking for solutions to suit individual musicians, rather than particular instruments.” – *Fiona McIntosh, BBC Philharmonic*
- “Though Mahler 8 comes up time and again in these conversations, Tchaikovsky 5 presents more problems and the artistic imperative vs noise issues are very hard to balance. Where do you put the trumpets? They need to be part of the ensemble but if you put them too close it creates a very serious problem for the back row of the woodwinds.” – *Simon Webb, CBSO*
- “The Royal Opera House works closely with its musicians and Music Directors in order to provide plenty of variety in seating arrangements in the Orchestra Pit whilst not compromising the conductor's musical aspirations. Twice a year 'pit planning' meetings are held, with the orchestra and ballet music directors invited, where the pros and cons of various seating arrangements are debated, to try and alleviate some of the more regular issues we have in the pit. However, the most positive aspect of the meeting is highlighting the issues to the Music Directors, whose eyes have been opened to the difficulties that the musicians face.” – *Matthew Downes, ROH*
- “When we stood with more space between us, we felt more like soloists, and instinctively wanted to fill the space.” – *BBC Singers (see Noise Day experiment)*

REARRANGING SECTIONS

Noise reduction potential: 3dB per doubling of distance (in an orchestra).

- Moving horns away from wind can reduce exposure by 3dB (and prevent bleed for microphones in a recording).
- Single vs. double ranking the brass: ideally the trumpets and trombones should be in a straight line as it is preferable to have more space in front; if there is limited space (and if risers permit it) a curved line can help to increase lateral space. On the other hand if there is too much space the brass ensemble suffers and it increases the number of string players in the firing line.
- It is common practice to vary layout from one project to another (within the limits of what is appropriate for the repertoire), in order to vary the dose of the affected musicians.

STRING ROTATION

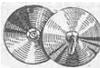
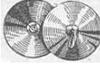
Potential reduction: up to 9dB between back row of first violins and front of (non-rotated) violins.

- Measurements have shown string rotation can make up to 9dB difference between back desk and desks nearer the front – for those players who ‘rotate’. This benefits relatively few players and in reality it is often the freelance string players occupying the back desks who tend to be in the noisy positions most of the time. If the rota is done by a musician it can be good for stimulating discussions and sharing experiences.

ACOUSTIC TREATMENTS, BAFFLES AND SCREENS

Noise reduction potential varies, but it is important to ensure one solution doesn't cancel out another.

- Acoustic treatments to venues take a long time to implement and are expensive (as are any mistakes). All users of a venue should collaborate with venue managements to identify what is needed. There will be many demands and inevitably the final result will involve some compromises.
- It is very hard to put an attenuation figure on acoustic screens because so much depends on the way they are used. Managers must facilitate open discussions about this and ensure that players are trained in how to place them for best protection and fewest negative externalities. Screen use is discussed in Part I of the Guide.
- With this in mind, it can be useful to carry out some ad-hoc experiments with screens before committing to large amounts of expense. Although not totally scientific or controlled, this testing can help you identify what might work, and what probably doesn't, with different permutations of instruments and screens. The examples below are from such an ad-hoc experiment at Scottish Opera, where the aim was to find out the attenuation different screen setups give with a range of percussion instruments.

Xylophone (average levels for 30" exposure)			Cymbals		
97.3		88.9	101.4		94.7
95.8		89.3	100.9		93.3
96.2		89.5	101.3		93.8
At right ear		At 2m	At right ear		At 2m
Snare Drum			Timpani		
99.9		95.7	99		90.5
100.6		94.5	97.6		92.7
99.5		95.8	99.2		91.9
At right ear		At 2m	At right ear		At 2m

(With thanks to Euan Turner of the Federation of Scottish Theatres)

The Scottish Opera percussion experiment illustrated above was carried out in the space used by the orchestra using a hand-held noise meter taking 30-second samples with and without the screens in place at the following locations:

- at the musician's ear to see if screens had an effect on them (ie, noise being reflected back)
- 2m away to see what effect, if any, the screen would have over and above the decrease in noise that comes with distance.

It demonstrates how the effectiveness of acoustic screens varies, particularly in relation to the sound source and angle of screen and, equally importantly, how simple experiments carried out *in situ* can throw up unexpected results, and help inform choices. Screens can be seen by some as a default, but this shows their use need to be planned and all the options considered.

REHEARSING OUTSIDE THE PIT

Noise reduction potential: (in theory) c.3dB by increasing space between certain instruments.

■ "Rehearsing outside the pit can help to limit the noise exposure of opera and ballet orchestra players. The major positive benefit is having the space to separate sections more than usual so that individuals near noisy colleagues get lower readings. The negative side of this, however, is that the acoustics outside the pit are invariably very different. This can mean that the rehearsal time is not as useful to the production as a whole as it would have been had it taken place in the pit. As always, compromise is necessary all round." – *Sally Mitchell, ROH*

PROVISION OF REST FACILITIES

Noise reduction potential: 1-2dB over a day, but giving rests out of the noise can provide a considerable intangible benefit.

- Busy canteens, cafés and pubs can be noisy places. Encourage musicians to seek out quieter places to spend their breaks – which includes asking the managements to turn background music down (or off) so they don't have to compete to make themselves heard in their breaks.
- If there is no canteen, try to schedule longer breaks so that there's only not a mad rush to get coffee, deal with telephone calls and so on. There is time for the musicians to rest their ears too.
- Facilitating discussions about what is acceptable in the green room, especially with respect to TV use, could help to create a consensus and may find their way into agreed protocols.

■ "It's often away from the stage that the highest noise levels are experienced. At Symphony Hall Birmingham we have a relatively small artists' bar – and the musicians suggested spending less time in the artists' bar because of it." – *Simon Webb, CBO*

CHOIRS AND CHORUSES, AMATEUR AND CHILDREN'S CHOIRS

In the case of amateur and children's choirs, this relates to a duty of care under the Health & Safety at Work Act, rather than a duty under the Noise Regulations.

- Choral works can be very loud, the stage can be cramped and the singers can be very close to the horns and percussion. Depending on the stage layout and whether the choir is on the same level as the orchestra, screens may be an option – but bear in mind a horn player can suffer more from a screen than a singer will suffer from the horns (the singer can put earplugs in when not singing).
- Once layout options have been explored, and the schedule arranged so that singers are not on stage for longer than necessary, remind the singers that earplugs are advisable and available (reduction: >20dB with disposable earplugs): make announcements, talk to the choir's committee and chorus director. In the short term, it may be easier to persuade singers to use them in rehearsal and during movements where they are not singing. See also the sections on screens and hearing protection.

AMPLIFIED PROJECTS

Actual reductions have been recorded of 9dB when PA and on-stage amplification is reduced. Build-up of temporary threshold shift (TTS) is more likely with amplified music because sound levels are higher and less varied.

SET-DESIGN CHECKLIST FOR AMPLIFIED PROJECTS

This checklist can be further developed and/or shared with third parties. It draws on the expertise of Ben Ranner at the Round House, Camden and Phil Wright of Sound by Design, and elsewhere in the BBC and the sector. It was originally used by the set designers for Strictly Come Dancing in 2010.

WHAT SCENARIOS DOES THIS COVER?

- This covers live events where there is an orchestra or band with a large amplified section (which may also include amplified singers). Typically there are 10-15 musicians or more, up to a full-sized orchestra.

WHY IS THIS IMPORTANT?

- The Control of Noise at Work Regulations require employers to limit the noise exposure of workers, and to protect their hearing.
- We must do all we can to reduce the noise levels on stage to an acceptable level.

WHAT DO ACOUSTIC MUSICIANS NEED?

- Musicians don't need to hear the amplified section: just some of the drum kit, plus guitar and bass. They hardly need to hear the singers / vocalists.

- They don't need to hear any of the mix that goes out to the audience (PA).
- However they do need to hear their own instrument and the other members of the acoustic ensemble. They also need clear sightlines to the conductor/MD.
- It is stressful and fatiguing to play an instrument in competition with over-amplified music.

HOW SET DESIGN CAN HELP

Liaison

- The set designer, sound engineer and lighting designer should meet at an early stage in the planning process to specify their requirements and to ensure that noise control is factored in from the start (eg, if monitors introduced at a later stage and there is nowhere to put them, they may end up too close to the musicians).
- Liaise with the orchestra / band's manager or fixer to find out what instruments are involved in different shows during a run.

Layout and construction

- Getting the layout right can reduce the need for acoustic screens (which take up floor space and create reflections for cameras).
- *Vertical separation (risers)*: This is the best way of controlling noise on a stage. Risers help with sight lines and they create a clear path for the sound to travel from the player, over the heads of the players in front, to the audience (it is also less tiring for the player). Minimum riser height should be 20cm from the floor for woodwinds, and 36cm is ideal for brass, where the ceiling is high enough. Ensure Work at Height Regulations are considered, with handrails, kickboards and/or battens or taped edges for the risers.
- *Horizontal separation*: Acoustic sections should be physically separated from the amplified sections. Build separate platforms if there is enough space. If sections of the stage have to be closer together, clamp them together so there is no chance they will rattle.
- *Space required*: Orchestra players need 1.7-2 m² each, in general (see also the section relating to purely acoustic projects – p.20 – which quotes the standard space requirements devised by AC Gade). They need at least 80cm space from side to side (more for violins and violas, and 110cm for a double bass). Woodwind players in Big Bands and Entertainment shows have up to five instruments to accommodate, and need space for these, as well as leg room. Trombones need at least 180cm in front to accommodate the slides and c. 30cm behind (trumpets a little less).
- *Leaving the stage*: If players are not needed they should be able to leave the stage safely and discreetly. Think about access and egress as part of the design process.
- *Material*: Build staging and risers out of dense solid material such as plywood. Make the frame solid so that vibrations do not travel along the surface. Clamp units together and separate them acoustically using rubber or neoprene stoppers. Surfaces can also be covered with absorbent material such as thick carpet. However, absorbent material on the walls may adversely affect sound quality.
- *Monitors and PA*: In-ear monitors should be used by amplified musicians, ideally. They don't take up any floor space and the mix delivered to each artist can be tailored to their own needs without affecting others. Position any on-stage wedges and other monitors at a distance from the players who don't need them, but up close and angled towards the head of the players who do. This **must** be factored into the stage design. Build a separate dedicated platform for PA stacks if they cannot be flown.

ACOUSTIC SCREENS

- Put the drum kit inside a ‘goldfish bowl’, isolated from the rest of the band. The structure should be placed on the floor and resiliently mounted so it does not transmit low-frequency vibrations
- Other noisy instruments should be separated from the acoustic sections by clear Perspex screens, high enough to come above the head of the players and placed on a solid surface.
- Any individual screens require an extra 20-30cm of floor space behind the player and they should not be too close in front of the brass.

■ The BBC Electric Proms is a case where a considerable amount of sound leakage has been eliminated thanks to good planning and collaboration with third parties. The BBC Concert Orchestra plays acoustically with amplified bands. Over the years stage design has evolved to create physical separation between the two ensembles. PA has been used judiciously so that it sends the sound out into the audience rather than back on to the stage. The solo artists’ contracts now have a requirement to use in-ear monitors rather than on-stage foldback.

■ “An issue for us is using headphones for click tracks. It’s impossible to give everyone in an orchestra individual levels for the click, so it’s a ‘like-it-or-lump-it’ scenario. A solution our management team came up with at the Royal Albert Hall when we were playing to click was headphones with individual volume controls (to be worn over earplugs) so we had control, not the monitor engineer. This isn’t what you find in recording studios, unfortunately.” – Sarah Freestone, BBC Concert Orchestra

LOOKING TO THE FUTURE AND WORKING IN PARTNERSHIP

Not necessarily a noise reduction in the short term, but there are benefits for the long term and it is an important investment nonetheless.

These solutions don’t necessarily reduce noise exposure, but by sharing the load you can save money in the search for creative solutions. Working in partnership also means the messages about noise control reach a wider audience. There are some examples and case studies below as well as many elsewhere in this guide.

- Ensemble managers are in constant liaison with venue managers, and can lobby for improvements to the acoustic of the hall for the musicians, for example, flexible acoustic treatments, hydraulically powered risers, and so on.
 - Ensemble managers can also encourage the venues to share information about the acoustic properties of a venue; this might be added to the ‘information for promoters’ on the venue’s web site.
 - The search for the ideal acoustic screen is still going on. Feeding back experiences to manufacturers will help them develop solutions that work in particular contexts.
 - Partnering up with a university department for research is mutually beneficial.
-

- If touring to places where the legislation is not as comprehensive as the UK, you may have to explain your requirements. If you have to take along your own supply of screens and other portable acoustic solutions it adds to your touring costs. You will need to strike a balance between what you should carry and what the venue might have.

Case study: orchestra and university partnership

■ Knowledge Connect brought together the expertise of London South Bank University with the experience of the London Philharmonic Orchestra's musicians through a London Development Agency-financed scheme. A Knowledge Connect grant was awarded to the Acoustics Group of London South Bank University in January 2009 to undertake a noise compliance investigation for the LPO. The driver for the involvement of the Acoustics Group was the introduction of the Control of Noise at Work Regulation 2005. The collaboration included dosimetry of musicians during rehearsals and performances at different venues; audiometry for musicians in accordance with Health and Safety guidance; room acoustics measurements; and education seminars and information.

The project was assisted by the full cooperation of the management, administrators, musicians and conductor. The LPO purchased equipment vital to the investigation and which will enable a sustained approach to the issues raised.

Audiometric results showed that the musicians had excellent hearing. Dosimetry results identified the noisiest repertoire and the pieces in which musicians have the greatest noise exposure. Educational seminars informed the orchestra as to the risks associated with noise exposure, and when and where to use ear plugs of various types. Room acoustics techniques were used to improve the natural acoustic of one of the LPO's regular rehearsal halls, which may not reduce the noise exposure of the musicians but could enhance their rehearsal time and the quality of performance.

Future work recommendations following this project were as follows:

- To continue the dosimetry measurements using the LPO equipment to establish a profile for each instrument section for a range of musical pieces and venues.
 - To continue the audiometric study to monitor the musicians' long-term hearing acuity.
 - To improve the acoustics of the orchestra pit using computer modelling techniques to assess the various practical noise control solutions.
 - To investigate the acoustics of other venues used for performance and rehearsals.
 - Test the viability of various types of earplugs for practice/rehearsal/performance/gigs.
 - Test various types of acoustic screens as a practical solution for brass and timpani for both stage and orchestra pit. – *Roanna Chandler*
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Case study: conservatoire and university partnership

■ The Royal Academy of Music (RAM) entered into a partnership with London South Bank University (LSBU) Acoustics Department in 2007 to address issues raised by the Noise Regulations. A mutually beneficial approach was agreed upon, allowing a PhD student and a number of MSc students from the university to gather data from a wide range of musical

activities across a range of venues at the Academy whilst allowing the RAM to benefit from the scientific data collected and the results and conclusions of experiments carried out.

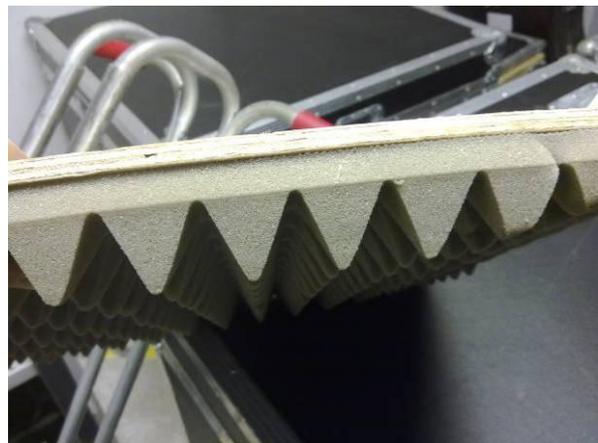
The Royal Academy's noise group was formed as a result of the collaboration and, to this day, representatives from the RAM and LSBU and industry specialists form part of the committee. The results of all experiments (noise exposure, room assessments, layout arrangements, audiometry, and noise control solutions) are reported to the noise group.

In addition, yearly educational noise seminars for all new undergraduate and postgraduate students, given by LSBU, were introduced to the Fresher's week programme. Furthermore, all new students are given an audiometric test at the beginning of their studentship, carried out at the facilities at LSBU. Repeat audiometric tests are given to students undertaking a course of 24 months or more during their last term at the Academy.

The two institutions have also worked together to research, develop and test new means of sound absorption and monitoring equipment such as sound-absorbing mirrors (patented in 2009), acoustic shields and noise screens, personal sound exposure badge and zero footprint absorptive screens. – *Nicola Mutton*

Case study: orchestra and university

■ Bournemouth Symphony Orchestra's brass section carried out an experiment to find out what kind of acoustic screen would best protect the string players whilst not adding unduly to their own exposure (see in the Musician section of the guide). The screens used for the experiment were home-made by one of the players but the 'winning' screen was taken to Bournemouth University where a design project was commissioned with a view to making a screen available commercially.



The winning BSO screen (photo: Andy Cresci)

HEARING PROTECTION (CNAW REGULATION 7)

- The Noise Regulations state that hearing protection should not be used as an *alternative* to organisational means of reducing noise exposure, so you should first ensure that all other noise-control options have been explored.
- Regulation 8 of the Noise Regulations requires managers to ensure so far as is practicable that hearing protectors are used. This can be done by *encouraging* musicians to use them as much as possible, through instruction in their use, having a supply on site and also through education and training.
- While some musicians will take to earplugs straight away, others will take time to get used to them. Offer a range of options and keep reinforcing messages; if musicians get used to them in situations where less precision and subtlety are required, they can build on that.
- Encourage musicians to carry their own earplugs with them at all times, rather than relying on the disposable ones.
- When sourcing disposable earplugs check that the attenuation is adequate and not too much, otherwise they will not be used.
- Note that the 2002 Personal Protective Equipment Regulations require the earplug (or the box it came in) to carry the CE mark.
- The musicians' section of this guide covers the options available to musicians. Bear in mind that it is important to keep abreast of developments as technology is improving very rapidly.

Hearing protection at the Royal Opera House

■ “We have found that one way to encourage the use of ear plugs is to offer our players a range of options. As a number of sections move around the pit, the players can experiment and make their best choice depending on the sound levels where they are sitting for any particular production. We offer individually moulded soft silicone plugs with flat attenuation, ER20 Xmas tree plugs and soft foam throwaways with a cord. We are experimenting with the new vented PRO plugs that have been designed particularly with brass players in mind. We have also tried ear defenders but they block out too much sound to be practical in the pit. We encourage our players to use ear plugs away from work when engaged in noisy activities – travelling on public transport, DIY, mowing the lawn, the cinema, football matches etc – to save their ears for performing.” – *Sally Mitchell*

PROVISION OF HEARING HEALTH SURVEILLANCE

(CNAW REGULATION 9)

INTRODUCING HEARING HEALTH SURVEILLANCE

If you employ musicians on full-time contracts you are obliged to provide hearing health surveillance to those who are identified as being 'at risk'. In practice many employers offer this to all musicians, and it seems to be an effective way of raising the profile of hearing conservation across the board. *Sound Advice* recommends that if you regularly employ the same freelancers you should provide health surveillance. In practice managements will make a judgment based on the amount of work undertaken by the musicians, to determine whether they should be treated as employees for health-surveillance purposes. If employers don't provide hearing tests it is good practice to provide information about how to access appropriate services. Below is a list of considerations when setting up in-house provision:

- *Arrangements*: ensure tests are held at a time and a location that fits in with the musicians' schedules; they should be conducted in a soundproof booth or quiet studio, and at times when the musicians are least likely to have a temporary threshold shift after exposure to noise. Appointment-booking systems need to be agreed and costing arrangements need to be clear.
- *Process*: ensure the quality-control standards are clear. The British Audiology Society www.thebsa.org.uk has published guidelines on this and on the competences required of the tester. Consistency of approach is vital, as the testing process can seem quite subjective to the patient.
- *Information, advice and referrals for individuals with hearing problems*: again, consistency of approach is vital, in terms of information passed on to patients. The pre-test questionnaire should be in line with standard practice and contain questions that are musician-specific. Clear procedures for referring patients to ENT should be established.
- *Management reporting*: ensure that the information provided enables the management to identify trends as well as enabling them to provide for individual musicians' needs. Managers need to maintain a (confidential) spreadsheet or database with dates of tests, hearing category and any referrals made as a result.
- *Re-test schedules*: find out how these are defined and ensure the policy relating to this is communicated to musicians.
- *Data management*: ensure that confidential medical records are stored appropriately and establish procedures for accessing them as necessary. It is standard practice for the patient to be given a paper copy of the audiogram after the test.
- *Managing the relationship*: offer opportunities for the provider to be involved in the life of the orchestra (attending concerts or rehearsals, for example). It is essential for them to understand what the musicians' working lives are like.

COMMUNICATION WITH MUSICIANS

Many musicians express concerns about the implications of having hearing health surveillance. They need reassuring that having a hearing test has nothing to do with their

musical ability; it is simply a way of identifying early signs of a problem. Indeed the techniques commonly used in occupational health surveillance are often criticised as being insufficiently sophisticated for musicians. Clarify that the requirements of occupational health surveillance are not the same as a medical intervention.

Musicians will need reassurances about confidentiality of records. Though they are often prepared to divulge information informally about their health, they may be reticent about this once it becomes 'official'. Hence the need for the reassurances as set out above. Common practice is for musicians to sign a consent form, but note that under the Regulations employees have an absolute right to withhold their consent to the release of information obtained about their hearing ability obtained from health surveillance. Note also that the only information that can be released without their consent is a judgment on whether the musician is fit or not fit to work.

Health surveillance in partnership at a full-time orchestra, the City of Birmingham Symphony Orchestra

■ Setting up a cycle of hearing tests for CBSO musicians was a priority that we addressed in 2008 by working in partnership with Aston University. The team at Aston fully understand the potential sensitivities around testing musicians' hearing and provide briefing notes and letters of agreement between themselves and the individual musicians.

Within the CBSO, whilst the need for hearing surveillance is accepted by both musicians and management, and enthusiastically supported by the board, the process is carefully managed to ensure that there is trust between musicians and those conducting the tests and real understanding towards any sensitivity regarding the musicians' responses to the tests. Before anything was confirmed we discussed in detail with the player representatives the content of the tests, access to the data and also the management and schedule for the process. We agreed that the test results would be stored at Aston University and not at the CBSO, that CBSO staff would have no access to the individual test results and that any requests for medical support would only come from the musician directly and not via the testers or orchestral management. In addition, we set up for several staff members to be available at the hearing unit to ensure that the musicians are always aware of the level of support being offered.

The tests are scheduled in contract time, with the time spent counting towards each musician's annual working days. The testing is therefore obligatory; very few musicians have questioned this, and the couple that have done were reassured by the answers they were given and willingly agreed to take part in the testing. The testing is understood and accepted as one of our ways of expressing our duty or care to our musicians.

In return for an exceptional level of service, we offered the audiology department at Aston University access to CBSO for post graduate research. Apart from the valuable research opportunity for the students, this also gives reassurance to the musicians that all the work around noise exposure and hearing is part of a bigger picture. The research continues to inform our approach to issues of noise exposure in the workplace. – *Simon Webb*

TRAINING, INSTRUCTION AND INFORMATION (CNAW REGULATION 10)

Under the Noise Regulations managers [of musicians] are required to provide the following information:

- Likely noise exposure and the risk this creates
- What is being done to eliminate or reduce the risks
- Where to obtain hearing protection
- What hearing health surveillance will be provided, and how it will be provided
- What musicians can do for themselves (eg, marking up the score, wearing hearing protection)
- Warning signs of hearing problems and how to report them
- What to do if a problems develops during the course of the day.

The list above is adapted from Para 115 of the Guidance to the Noise Regulations. Information provision may take many forms in practice:

- Noise seminars or input from experts
- Regular agenda items at meetings of the managers and musicians
- Ad-hoc reminders at the beginning of a project
- Notices on noticeboards, etc.
- And, of course, the musicians' guide to noise and hearing: *Music, noise and hearing: how to play your part*: www.bbc.co.uk/safety/ and follow the links to the guides and supporting materials.

■ "The Royal Opera House is in the process of typesetting its own copies of its core repertoire, such as the ballet version of *Manon* by Massenet. Loud stage effects, such as gunshots, have been indicated in the new scores so that the players are more thoroughly aware of the noise problems in the production and can prepare themselves accordingly." – Matt Downes, ROH



In addition, managers should be trained in noise-management techniques. As well as key publications (including this one), the vendors of noise measuring equipment and other (industrial) noise consultants can provide training. Consider joining forces with other ensembles to source training that is tailored to the specific needs of the sector.

Universities, patient charities and bodies such as the Royal Society of Medicine or Wellcome Trust occasionally put on seminars on current research. These can be pitched at

a non-specialist audience and are invariably very interesting (and often free).

Massenet, orch/arr Leighton/Lucas *Manon*. Extract used with kind permission of the Royal Opera House

TEMPLATES: SIGNS AND POSTERS FOR STUDIOS AND NOTICEBOARDS

You may use any of the material in this guide (including the pictures) as a basis for your own posters and in-house factsheets. Please acknowledge the source and date.

LINKS, REFERENCES AND DEFINITIONS

ORGANISATIONS AND KEY PUBLICATIONS

<p>The <i>Health and Safety Executive</i> (HSE) provides its own guidance on Noise in the Music and Entertainment Sector, <i>The Control of Noise at Work Regulations 2005</i>, and supports subsequent industry-led guidance, <i>Sound Advice</i>. This is the recognised source of guidance for compliance with the law, and can be found on its website at www.hse.gov.uk</p>	<p><i>Musicians' Union</i>: www.musiciansunion.org MU members' handbook contains a section on health and safety. Regular features on noise and hearing in the quarterly journal <i>The Musician</i>.</p>	<p><i>Incorporated Society of Musicians</i>: www.ism.org <i>Equity</i>: www.equity.org.uk <i>BECTU</i>: www.bectu.org.uk Members of all of these, plus MU, are entitled to discounts on hearing tests.</p>
<p><i>Association of British Orchestras</i>: www.abo.org.uk <i>Sound Ear II</i> (2008) downloadable from the site. The Healthy Orchestra Charter is a joint initiative with the Musicians' Benevolent Fund www.mbf.org.uk on health and wellbeing in orchestras.</p>	<p><i>British Association for Performing Arts Medicine</i>: www.bapam.org.uk Clinics and information on all aspects of performers' health. Association of Medical Advisers to British Orchestras (AMABO).</p>	<p><i>British Association of Concert Halls (BACH)</i>. Forum for managers of concert halls and theatres. Secretariat provided by Sue King s.king2@cardiff.gov.uk</p>
<p><i>RNID: Action on Hearing Loss</i>: www.rnid.org.uk Activities include information, awareness-raising campaigns and funding research.</p>	<p><i>Deafness Research UK</i>: www.deafnessresearch.org.uk Information, research. Provides the Bionic Ear Show, a fun, interactive guide to how the ear works.</p>	<p><i>British Tinnitus Association</i>: www.tinnitus.org.uk Advice line and information on all aspects of tinnitus.</p>

SELECTED FURTHER READING AND LISTENING ON SOUND AND MUSICIANS' HEARING

<p>Text of the EU Directive 2003/10/EC can be found at http://eur-lex.europa.eu (search by CELEX number: 32003L0010). ISO 7029 (age-related hearing loss). ISO 1999 (noise-induced hearing impairment).</p>	<p>During 2008/09 a literature review was carried out of the peer-reviewed literature on noise, acoustics, hearing and music. The Q&As that prompted them are here and the literature review is here. <i>Music Matters</i> extract (10') on musicians and tinnitus. <i>Twenty Minutes: The Pleasure of Noise</i>.</p>	<p>The standard textbook on the subject is Meyer, J <i>Acoustics and the Performance of Music</i> (1972 – now in its fifth edition pub Springer).</p>
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LINKS QUOTED IN PART I – IN FULL

<p>To locate video clips on YouTube: <i>Tinnitus</i>: “RNID Buzz off”, “RNID Tune out tinnitus” <i>Cochlea</i>: “cochlear animation”, “dancing hair cell”.</p>	<p>Noise calculators: www.hse.gov.uk/noise/calculator.htm (needs Excel) www.xpglobe.com/bbc/noise/calc/</p>	<p>Audio clips: all © BBC: Brahms Symphony No 4 in E minor, BBC SO, rec Maida Vale Studios, 20/04/11. <i>Music Matters</i> extract, broadcast 02/04/11. <i>Twenty Minutes</i> broadcast 18/02/11.</p>
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YOUR OWN CONTACTS: SUPPLIERS OF AUDIOMETRY AND ACOUSTIC SOLUTIONS, ETC

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ACRONYMS AND SELECTED DEFINITIONS

‘A’ weighting	Used for $L_{eq}(qv)$, it gives additional weight to the frequencies the human ear is most sensitive to
‘C’ weighting	Used for peaks, it treats all frequencies equally
AGC	Automatic Gain Control (your ear’s volume knob)
dB	Decibel – measurement of sound intensity
High frequencies	Usually means above 5kHz
Hz	Hertz – cycles per second
$L_{EP,d}$	Daily personal noise dose
$L_{EP,w}$	Weekly personal noise dose
L_{EQ}	Equivalent continuous sound level (=average)
Low frequencies	Usually means frequencies up to 300Hz (D_4)
Mid frequencies	Usually means between 300Hz and 5kHz
NIHL	Noise Induced Hearing Loss – characterised by a notch in the audiogram at 4-6kHz
OAEs	Otoacoustic emissions – vibrations in the ear canal
PTA	Pure-tone audiometry
PTS	Permanent threshold Shift
Reasonably practicable	Reducing noise to as low a level as reasonably practicable involves weighing a risk against the trouble, time and money needed to control it
SNR	Single number rating (for hearing protection)
The 3dB rule	Reduction or increase of 3dB is a halving or doubling of sound intensity
TMJ	Temporomandibular – jaw joint.
TTS	Temporary Threshold Shift

ACKNOWLEDGMENTS

This guide is the result of many years' work in the BBC and around the sector, and dozens if not hundreds of people have contributed along the way.

When the Noise Regulations came into force for the music and entertainment sector in 2008 the six BBC Performing Groups (PG6), together with the Controller of Radio 3 Roger Wright and Radio 3's Head of Station Management Ben Woolland, agreed to fund a one-year project to investigate what more could be done in the BBC's five orchestras and the BBC Singers. That year involved a great deal of measurement and many conversations with musicians, managers, acousticians, engineers and doctors, and two main conclusions emerged: one, solutions have to be found for individual musicians as well as for workplaces and ensembles, and two, controlling noise requires sustained management over a long period to make a lasting difference. It was also clear that sharing solutions would bring wider benefits.

Paul Greeves, head of BBC Safety and Chris Burns, Audio & Music, agreed to take the work forward, as the BBC was an early signatory to the HSE's 'pledge' to 'be part of the Health and Safety solution'. Steve Gregory, BBC's Head of Production Safety, saw the scope for cross-sector working and a seminar was organised in July 2010 bringing together musicians, ensemble managers, acousticians, occupational health colleagues and safety practitioners and others. Out of that came a working group which acted as an editorial group for this guide.

Working group membership was as follows: Leo Beirne, Colin Chatten and Anne Wright (Noise & Vibration Unit, HSE), Phil Boughton (Welsh National Opera), Roanna Chandler (London Philharmonic Orchestra), Sally Mitchell (Royal Opera House), Keith Moston (ABO), Nicola Mutton (Royal Academy of Music), Simon Webb (CBSO), Helen Wilson (Opera North), Euan Turner (Federation of Scottish Theatres) and Bill Kerr, Morris Stemp and Diane Widdison (Musicians' Union). From the BBC Performing Groups: Susanna Simmons (BBC Symphony Orchestra) and Richard Wigley (BBC Philharmonic). From BBC Safety: Laura Baker, Louise Bisdee and Wendy Pelaez.

Many others have had a hand in this guide and their ideas and contributions have been incorporated in some form or another: acousticians Steve Dance and Georgia Zepidou (London South Bank University) and Richard Cole (BBC) and many engineers including Ian Astbury, Andy Leslie and Dougal Proudlock (BBC), Brad Backus (UCL Ear Institute). Medical colleagues whose contribution is in here include Paul Checkley (Musicians' Hearing Services), audiologist and epidemiologist Dr Christian Meyer-Bisch, Chris Rhodes (Capita Health Solutions), the late Dr Martin Rosenberg and Dr Colin Thomas (BBC's Chief Medical Officer). Dom Stiles of the RNID Library provided access to the literature. Countless musicians have helped to influence what has gone into the guide (and what's been left out) and particular thanks go to Andy Cresci and Jamie Pullman (Bournemouth SO), Sarah Freestone and David McCallum (BBC Concert Orchestra) and Chris Bowen (BBC Singers). Jayne Bailey, Chris McNally and Nick Walker are among the many BBC Safety colleagues who have provided help. Philip Burwell of BBC Radio 3 prepared the Brahms sound clips. Photos are mostly by Euan Turner; percussionist Alasdair Malloy (BBC CO) took the photo of Sir Henry Wood. Violinist Julian Gregory of the BBC Philharmonic has captured in his cartoons of the kind of scenarios we hope will become a thing of the past.

THE 2005 NOISE REGULATIONS: PLAYING YOUR PART

Time-line	Musicians	Managers (coloured text refers to a duty / responsibility under the Noise Regs)	Venues
General activity	<ul style="list-style-type: none"> Minimise extra-curricular noise exposure. Get used to wearing earplugs. Have hearing tests. 	<ul style="list-style-type: none"> Provide audiometry to in-scope musicians. Go on noise awareness training to understand duties under CNAW. Information provision Provide hearing protection. 	<ul style="list-style-type: none"> Put documentation together and make it available.
Artistic planning	<ul style="list-style-type: none"> Contribute to Risk Assessment. 	<ul style="list-style-type: none"> What are the noise implications of this project? (rep+venue). Risk assessment. Measuring if no figures exist. 	<ul style="list-style-type: none"> Can the venue accommodate this project? (stage? acoustic treatments?)
Sched-uling	<ul style="list-style-type: none"> Inform management of potential noise risks. 	<ul style="list-style-type: none"> Ensure there are adequate rest periods in the schedule 	
Rehearsal	<ul style="list-style-type: none"> Mark up score. Ask for screen if necessary. Discuss noise problems with colleagues. Wear hearing protection Rest ears during breaks. 	<ul style="list-style-type: none"> Adjust staging Provide screens and check they are positioned correctly Encourage musicians to leave the stage when not required Remind re: hearing protection 	<ul style="list-style-type: none"> Adjust staging and acoustic (treatments) of room if possible.
Before the show	<ul style="list-style-type: none"> Ask again: do I need this screen? Give your ears a rest. 	<ul style="list-style-type: none"> Check position of screens. Reminder re: hearing protection. Dynamic risk assessment. 	
Show	<ul style="list-style-type: none"> Earplugs. 	<ul style="list-style-type: none"> Stage mgt to add or remove screens according to the repertoire. 	
After the event	<ul style="list-style-type: none"> Feed back to management and each other. Don't add to your noise exposure. 	<ul style="list-style-type: none"> Feed back to venues. Revisit risk assessment: what can we learn? 	<ul style="list-style-type: none"> Listen to the feedback; use it for business case for improvements.