DANFONIKA

Live performance and sound level – from cocktails to Coldplay

Live sound engineering is a real time engineering event horizon. Not only do you have to deal with an ever-changeable acoustic space, a highly complex technical set up and an environment in flux - it can also rain, the bathroom is a much longer walk away, and your coffee is always that bit colder by the time you get around to tasting it.

You can't hit STOP and REW. PLAY is your only option. Furthermore, you are the direct link, between the musicians, the stage crew, the tour manager, the concert organizer - and the audience who pays for the tickets that pay your salary.

And yet, no matter how digital the concert experience has become - it remains firmly analog. Your prime audio metering - is you. Furthermore, after millions of years of evolution we still don't have digital ears. Your intelligent and highly experienced flappy bits of flesh on the side of your head are the door to the most expensive stereophonic analog device in the known universe. You don't have to ears like Yoda to have great hearing.

So you need to take care of them. You can't get a software patch for your inner ear when they start crashing. Hearing damage is permanent, irreversible and causes deafness, and sadly hearing aids or surgery cannot reverse this.

It's the same sound soup

The music and entertainment industries are unique in that high noise levels and extremely loud special effects are regarded as essential elements of a live show. High levels of sound are common at a stadium event as well as in bars, nightclubs, orchestras, theatres and TV studio facilities.

High and consistent noise levels exist even in classical music settings. Musicians are routinely exposed to sound pressure levels for even longer than musicians in a rock band. (*Wagners Ring Cycle* is nearly 4 hours long.) A study published in 2006 of hearing protection and hearing symptoms in Danish orchestras suggests more than 27% of musicians suffer hearing loss, with 24% suffering from 'tinnitus' (ringing in the ears), 25% from 'hyperacusis' (increased sensitivity to sound), 12% from distortion and 5% from 'diplacusis' (where the ears hear two distinct tones).

Legislation in many countries around the world has been enacted (normally based upon standard Noise at Work Laws), to give a framework of protection to those who work within these specialized industries. It is interesting to note that governments realized at quite a late stage that personnel involved in the media and entertainment industries were sometimes exposed to noise levels similar to those working in more traditional industries - such as ship building or steel working.

Frameworks now exist in Europe (Control of Noise at Work Regulations 2005, European Directive (2003/10/EC, Health and Safety Executive guidelines HSG260) that focus upon noise barriers and guides, noise dosage, hearing protection, noise measurement, good acoustics, high quality architectural solutions and regular health checks for people in the industry who are routinely exposed to high noise levels regularly.

And so, similar guidelines can be applied in the same way to bar staff mixing vodka martinis (shaken not stirred) - to a sound engineer mixing a rock band in front of 20,000 people. On many occasions they share the same acoustic space.

Getting creative with the big numbers

One has to define the levels that are deemed safe for personnel working in noise sensitive areas. These levels are derived from internationally agreed standard levels that apply in many countries worldwide.

There is a requirement to take specific action at certain action values. These relate to the levels of exposure to noise of employees averaged over a working day or week, and the maximum noise (peak sound pressure) to which employees are exposed in a working day:

Lower exposure action values (LEAV): – daily or weekly exposure of 80 dB; – peak sound pressure of 135 dB

Upper exposure action values (UEAV): – daily or weekly exposure of 85 dB; – peak sound pressure of 137 dB

There are also levels of noise exposure - which must not be exceeded (but take account of any reduction in exposure provided by hearing protection):

Exposure limit values (ELV): – daily or weekly exposure of 87 dB; – peak sound pressure of 140 dB.

To give an idea of noise exposure levels for a concert crew and staff - It is practical to measure the noise levels and dose that are experienced on average during the course of a concert event period.

The average A-weighted sound energy present is measured in the acoustic space near the person – it is expressed normally as a LAeq value in decibels. LAeq takes into consideration the total sound energy over a specific value of time, and is a common expression to state when performing environmental noise calculations. The same measurement can also derive a peak sound level experienced at a specific time – Lp(C).

The LAeq value is further used in the calculation of noise exposure (or dosage) over a longer period of time – such as 8 hours or even 1 week. This dosage is typically then stated as a dB value - $L_{EP,d,}$.

The $L_{EP,d}$ or daily personal noise exposure, and represents a daily noise 'dose' – a combination of 'how loud' and 'how long exposed' for the various noises that a person is exposed to in a working day.

Shown below are typical noise exposure levels for various personnel at a rock and roll concert.

Job	Location	Hearing protection	$L_{EP,d}$ dB
Paramedic	Side of main stage	Muffs	100
First-aider	Tent at side of main stage	Muffs when outside tent	97
Food service	Close by PA delays of main stage	None	100
Gate security	Side of main stage	None	101
Gate security	Wheelchair area for main stage	None	95
Door security	Secondary venue tent – 1	None	99
Stage security	Secondary venue tent – 1	Earplugs	108
Door security	Secondary venue tent – 2	None	103
Drummer	On stage	None	104
Bass guitarist	On stage	None	101
FOH sound engineer	Tower approximately 30 m from stage	Earplugs	99
Monitor engineer	Side of stage, behind PA	None	96

Lets now focus just on one person - the FOH sound engineer. And let us calculate their noise exposure for their entire working day.

Activity	Duration	Noise level (L_{Aeq})
Travel to show	45 minutes	75 dB
Load-in and installation	2.5 hours	72 dB
System check	15 minutes	89 dB
Sound check	30 minutes	92 dB
Show	2.5 hours (inc. support act)	96 dB
Load-out and travel	1.5 hours	73 dB

Exposure calculator

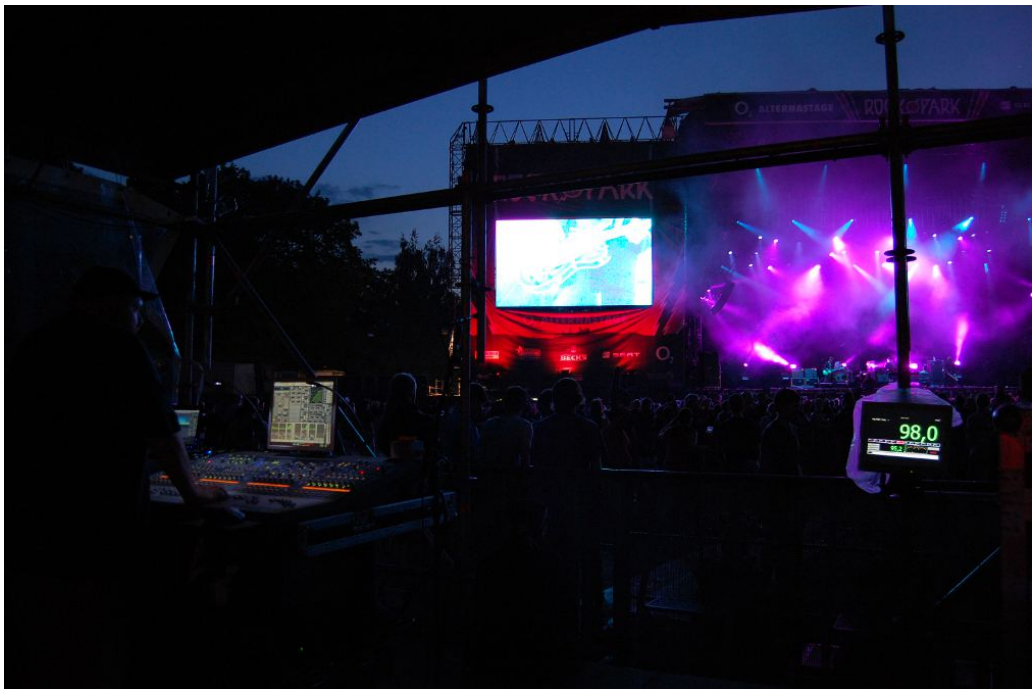
	Noise level (L_{Aeq} dB)	Exposure duration (hours)	Exposure points (job/task)	Exposure points per hour
Job / task 1	75	0.75	1	1
Job / task 2	72	2.5	2	1
Job / task 3	89	0.25	8	31
Job / task 4	92	0.5	31	63
Job / task 5	96	2.5	393	157
Job / task 6	73	1.5	1	1
Job / task 7				
Job / task 8				
	Total duration	8		
Daily noise exposure ($L_{EP,d}$)		**91 dB**	**436 points**	

In this case, one can see would be advisable to recommend hearing protection for the engineer if this occurs every day, as the engineer is working over the recommended daily noise dosage value of 85 dB $L_{EP,d}$. A good solution for this engineer, that would not cause any issues with his critical listening would be attenuated in-ear protection with a linear frequency response. These systems are usually custom made for the client, and a good long term investment for the wearer.

The audience is listening – but for how long?

If you get the sound right for the audience - you see the backs of their heads for two hours. Get it wrong and you see the whites of their eyes. Consistent mix levels sound better as well. So measuring the average sound pressure, LAeq at the mix position throughout the concert is a very clever and smart thing to do. You are measuring what the audience is listening to, and if you can store that data, you can use it for reference later on – even better.

And if you have the right equipment, it will be very easy to set up and get running.



As a guide:

- It is recommended that the A-weighted equivalent continuous sound level over the duration of the event ('The event LAeq') in any part of the audience area should not exceed 107 dB, and the C-weighted peak sound pressure level should not exceed 140 dB(C). These sound-level values are for the *whole* of the audience area.

However, for practical purposes, it is usual for audience sound-level exposure to be monitored close to the front-of-house sound mixing position. For the largest outdoor and indoor venues, this can be up to 75m from the front-of-stage barrier position where the audience sound-level exposure can be significantly higher than at the front-of-house sound mixing position.

For big concerts, make sure that during the sound check the difference in sound level between the front-of-house sound mixing position and the front-of-stage barrier – and, where delay / distribution stacks are in use, at the barrier for each delay / distribution stack – is established. This will then allow a guideline sound pressure level for the front-of- house sound mixing position to be determined that will restrict the whole of the audience sound-level exposure to below an Event LAeq of 107 dB, and C-weighted peak sound pressure levels to below 140 dB. Alternatively - have two measuring systems!

Where practical, the audience should not be allowed within 3m of any loudspeaker. This can be achieved by the use of approved safety barriers and dedicated stewards, wearing appropriate hearing protection. Where this is not practical, the overall music sound levels will have to be modified so that people closer than 3m to the loudspeakers are not exposed to an Event LAeq of more than 107 dB or C-weighted peak sound pressure levels of more than 140 dB.

Under no circumstances should the audience and loudspeaker separation distance be less than 1m.

Where the Event LAeq is likely to exceed 96 dB, advise the audience of the risk to their hearing in advance, e.g. either on tickets, advertising or notices at entry points.

Sources of noise other than music also need to be properly controlled. In particular, the noise from pyrotechnics should be restricted so that at head height in the audience area, noise from pyrotechnics does not exceed a C-weighted peak sound pressure level of 140 dB.

On the level

Reducing noise risks in music and entertainment is not about destroying the art form or the performance. On the contrary, it is about protecting the people – artists, performers and ancillary workers equally.

Furthermore, it is about protecting the creative environment and the people within it for the *long term*. The hearing of performers and other creative and technical personnel is critical and needs to be taken care of as a prime responsibility.

The Live Sound and performance industry has never been is a better economic state. Technology and better training has made touring and live audio performance better and more professional than at any time in its history.

However, without a fair and reasoned Noise at Work framework to accompany this growth, the health of the employees who work in the industry is still at risk. There are many measures that can be taken that are not detailed here – accurate acoustic measurement is only one facet of the issue.

So what can be done?

Your ears are your meal ticket. They have to be protected if a long career in the industry is the goal. Realizing this is only the beginning.

danfonika and 10EaZy believe that these issues should be solved with creativity and common sense – and with the direct input of experienced creative personnel who work in that industry.

Front of House sound engineers are in a unique position to be pro-active about these changes, before legislators enforce a more stringent and over-bearing set of legal rules. If Sound engineers are involved with this – then sensible recommendations can be made, and the art can be protected in the right way. That, in general is what has happened in other countries worldwide.

Having good noise exposure practice also means that you need to have as a fundamental - good data from easy to use tools that are calibrated independently and trusted by the engineers that use them - as well as the legislators and council technicians.

If you are not measuring the acoustic level during your concert then you are missing free information in real time that can only but improve the sound reproduction performance. Your main bus meters are probably nice and colourful and hopefully very well calibrated – but they are only measuring the level of your mix referenced to a standard electrical value. It has no relationship to what you are listening to at all.

Good measurement systems that can measure the concert sound pressure levels in the correct way, also ensures a performance sound level consistency as well as adherence to whatever the local guidelines define

At its best, performance sound level consistency using acoustic measurement of the concert space is a direct and creative way to ensure a quality performance – and provides data that can be used to keep the acoustic levels in the venue safe for all.

And that has got to enhance the live experience even more – right?

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References and further reading

Many of the technical documents referred to are only available in English.

Exposure Criteria. Occupational Exposure Levels. *Dr D.L. Johnson Dr. P. Papadopoulos*, *Dr N. Watfa and Dr J. Takala*

- Health and Safety Executive 11/12 INDG362(rev2) 2012

- Playing safe Control of Noise at Work regulations The Impact on the Concert Industry. *Griffiths Vanguard Consulting FIOA*

- Form G11 Salford City Council, UK. Guidelines for the event manager's controlling sound and noise levels at events that take place on council land.

- The Noise Council Code of Practice on Environmental Noise Control at Concerts 1995

- Sound Advice HSE HSG 260

- The European Directive (2003/10/EC)

- ISO 1999, ISO 7196, ISO 7731, ISO 8201, ISO 9921-1, ISO 11690-1, IEC 60651, IEC 60804, IEC 61012

- Myth buster. Noise in music HSE 2005