WHEN ENTERTAINMENT MEETS LIFE SAFETY

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1 INTRODUCTION

This paper will describe the relationship between Broadcast Sound and Life Safety Audio Systems in Arenas and Stadia. We will investigate how the two systems can be successfully integrated to the benefit of all. Although these are primarily Life Safety systems the majority of use during their lifetime will be for entertainment purposes (we would hope!) and as such they need to perform to the highest levels in terms of frequency range and coverage.

2 BROADCAST AND VOICE ALARM SYSTEMS IN HARMONY

2.1 System Design

The design of these systems, by their very nature, need to be robustly secure and of the highest audio quality. For reference, the standards BS7827 and BS 5839-8 as well as the Green Guide go into some detail in setting the goals that need to be achieved when designing these systems.

In the past these two systems have sometimes been independently installed in venues, primarily due to budget allocations. The VA system is normally within the Fire Detection system package, acting as Fire Alarm sounder circuit - with frills. Whereas the Broadcast system usually has a budget of its own either within the contract or as a fit-out, post contract.

More recently life safety and entertainment systems have been integrated to provide one common system. The protocols and requirements of each being given due regard. The obvious advantages to this for the venue owner are reduced supply, installation and maintenance costs, reduced operator resource costs and the flexibility to use part or all of the system depending on the venue usage and events.

Looking at this from a Voice Alarm perspective the system needs to be automatically and continuously, monitored along its critical signal path. The critical signal path is generally recognized as the capsule of the emergency microphone, router/DSP unit, emergency message unit, amplifiers, loudspeakers, end of line units, primary and secondary power sources and all interconnecting cables between these devices. Monitoring can be low or high frequency signals generated and passed through the critical signal path which are monitored at key points along the path. It can also be a mixture of signals. For instance 20KHz may be used from the emergency microphone capsule through to the amplifiers, with the loudspeaker circuit using a DC signal for monitoring. In fact loudspeaker circuits generally have a separate monitoring signal, be it ultra-sonic or sub-sonic (20KHz/30Hz) frequency, DC with capacitor isolation on the actual loudspeakers or impedance monitoring where the actual load of the loudspeaker circuit is continually evaluated. It should be noted that BS5839-8 only requires the loudspeaker circuit to be monitored, not the actual loudspeaker unit itself. This is fine so long as the loudspeaker is within close proximity to the monitored circuit. Most loudspeakers will have the monitored circuit directly glanded into them. However, there are some loudspeakers that have a pre-fixed lead or no glanding facilities. In these instances a junction box containing ceramic terminals and thermal fuse should be mounted directly adjacent to and within the same fire compartment as the loudspeaker.

Just as important as the dynamic range of the system components is the location and use of the emergency microphone. Where this microphone is installed in a busy control room, which in an emergency situation is liable to increased ambient noise levels, it should ideally be of the close speaking fist type with a lip guard. This will improve the direct signal from the talker whilst reducing the heightened noise levels elsewhere in the room. It is also extremely important that the announcer has had adequate training in the use of microphones so that a clear, unambiguous message can be delivered. This may be from a pre-arranged script that is familiar to all stewards and emergency staff on duty for the event. Broadcasts should also be practiced, outside events, and assessed by other members of the venue and emergency staff to gauge it's suitability and effectiveness.

Broadcasts from the voice alarm element of the system should be intelligible and cover all areas of the venue to enable the safe evacuation of people. In evacuation mode the system should have sufficient gain to ensure announcements are clearly received and understood, but not be too loud so as to cause panic and confusion. The various standards give guidance on the minimum, maximum and ambient noise levels to be considered for these systems.

Broadcasts from the production sound element of the system should also be intelligible and cover all areas of the venue to enhance the experience of the people attending the event. Announcements should be pleasantly clear and intelligible, but not be so loud as to cause discomfort to the spectators. Loudspeakers should be of adequate range to provide high quality music at sufficiently high levels to be entertaining, without being offensive (I know, sometimes this depends on the music content!).

To achieve the high standards expected of a broadcast system for entertainment use, components of the highest quality should be used. Wide frequency loudspeakers and amplifiers should be provided to cover the main audience areas such as the stadium or arena bowl, executive suites and concourses. Coverage should be evenly distributed so as to be pleasing to the listener wherever they may be within these areas. In back of house or other areas, where speech only is required, it may be acceptable to use loudspeakers and/or amplifiers of a lesser frequency range.

In most instances, whether the system is being used for emergency or entertainment, there must be sufficient headroom available throughout the signal path. Having said that, some loudspeakers are better at withstanding transients than others. Transient peaks can also respond better to certain types of circuit topology.

It is highly recommended that any systems used in these venues are designed with the assistance of an electro-acoustic modeling program. There are several suitable computer modeling packages available, some allow the surface areas of the space with absorption co-efficients to be inputted thereby producing more realistic results. However, in all cases, care must be taken with the interpretation of the predictive results of this process. The results of these can also be useful in the verification process of the completed system.

2.1.1 Multi-Rack Networks

In large Arena or Stadium venues it is good engineering practice to distribute the amplifier and control racks around the site. This enables loudspeaker cabling to be kept to reasonable sizes and affords a certain degree of system redundancy in the event of a local failure.

Historically, voice alarm networks have been multi-core, fire rated copper cables whereas broadcast system networks have utilized standard grade fibre optic cables.
With the advent of fire rated fibre optic cable and fibre optic voice alarm interfaces, the two systems can now be more easily integrated.

System networks generally carry audio signals, monitoring and control data. In multi-core copper networks these are carried over separate pairs, whereas over fibre they can be carried on one channel.

There are several transmission methods available, from manufacturer's custom networks to appropriately designed computer networks. Whichever method is used should be standard throughout the system.

All networks should be robust enough so that any recovery from failure or system transmission latency is kept to an absolute minimum. Any network or transmission failures should recover within 30 seconds. All failures should be reported to the fault monitoring system, including any outstanding faults that haven't cleared.

During the set up and commissioning of the networks it is good practice to initiate a variety of fault situations to establish that the network is as robust as possible. This exercise could also highlight any weak points in the system that may need addressing.

When the system is designed for life safety as well as entertainment broadcasts, dual networks should be employed. These may be in the form of two diversely routed fire rated, fibre networks carrying the A or B audio feeds. Alternatively, it may be a single fire rated, fibre network with a separate, diversely routed, copper network carrying the emergency microphone audio.

In either situation it would also be desirable to have local fire alarm interfaces at selected remote rack locations, so that in the event of a catastrophic network failure at least a pre-recorded evacuate message could be broadcast. Care must be taken when doing this though, to avoid intelligibility issues caused by the latency of the message start signals from the fire alarm system.

Ideally the distributed racks in each area should be configured so that one houses the A routers and amplifiers whilst the other houses the B equipment. So that in the event of a local failure, 50% coverage is still maintained in the area. Providing the loudspeaker circuits are truly interlaced this would mean that a loss of around 3dB in level could be expected in the area.

In all situations the voice alarm elements of the system must take precedence in terms of priority and functionality. Diverse routing of the network cables, monitoring the network and adequate bandwidth are all essential to achieving this.

By distributing and networking the racks, cabling to the loudspeakers can be correctly sized to avoid power losses, particularly in the arena or stadium bowl, when installing low impedance or high powered loudspeakers with in line transformers. This also has the commercial advantage of keeping the cables to reasonable sizes.

2.1.2 Loudspeaker selection

The requirements for sound reinforcement systems in large stadia and arenas are becoming increasingly sophisticated. Intelligible emergency announcements remain, without doubt, the most essential criteria though. After all there is still no better means to efficiently communicate safety and evacuation instructions to the large numbers of public likely to be present. In combination with the police, other emergency services and stadium security staff an appropriately trained PA announcer can take instant control of an incident to give clear direction to localized groups of people, moving them away from any potential danger whilst maintaining order and preventing panic. However, for the venue to operate successfully several other factors often play a significant part in the overall design.

Revenues are generated by the events the stadium can stage, many venues capitalise on this by hosting a wide variety of different events, not just the sport for which the stadium might be more traditionally accustomed. This implies that the sound reinforcement system will also need to deliver a performance level acceptable to the event organisers. To achieve this the sound reinforcement system, particularly in the main bowl, needs to operate over a much wider frequency range than is traditional for a dedicated voice evacuation system. A frequency range with -3dB points between 70Hz and 16kHz is not uncommon and on first inspection may not appear too onerous for a typical pro-audio loudspeaker. A two-way passive loudspeaker with direct radiating 15" woofer and small compression driver or tweeter may well meet this specification and provide a reasonably flat frequency response over its operating range to deliver a pleasing tonal character. These types of loudspeaker quickly become very inappropriate however when you consider that a larger stadium may have a capacity for anywhere between 40,000 to 100,000 people. The very scale of the building means the loudspeakers have to be installed at considerable distance from the listener. Obviously this will vary depending on the stadium design but distances of 30 to 40 metres or more are not uncommon. Additionally such large numbers of people can make quite a lot of noise! The authors have recorded average L_{Aeq} levels of between 90 to 100dB(A) at premier league football matches with short term levels occasionally rising to in excess of 110dB(A) when a goal is scored. To stand any chance delivering an intelligible announcement a sound reinforcement system will need to produce at least 6dB higher output at the listener position.

There is considerable research, much of which has been carried out by members of the IOA, which concludes that very high sound pressure levels can have a negative effect and actually reduce intelligibility at the listener. Delivering an announcement at 116dB(A) to overcome crowd noise in the excitement of a goal would actually achieve very little in delivering a message that can be fully understood by the listener and equally such high noise levels are relatively short lived generally lasting 10 to 20 seconds at most. It is far better to wait until the excess noise levels have subsided before commencing an announcement in these circumstances. In an emergency situation an excessively loud announcement could also have a detrimental effect on managing the situation, possibly enticing some degree of panic when the primary objective is to maintain an air of calm and order.

However performance specifications do often stipulate target sound pressure levels at the listener of between 96 to 106dB(A). Simple loss over distance calculations can determine that the loudspeaker array will need to produce sound pressure levels in the order of 134 to 140dB at 1 metre from the array which suggests a sensitivity in the order of 106 to 112dB. This immediately precludes almost all direct radiator loudspeaker designs where typical sensitivity and power handling are in the region of 100dB/1W/1m and generally no more than 1000W RMS respectively. Again simple calculation can show the loudspeaker capable of producing around 130dB, some 6 to 10dB short on the target output and this is generally only when on axis to the loudspeaker as a direct radiator design offers very little pattern control much below 3kHz. The performance specification will frequently demand that direct sound levels on public seating should not vary by more than 6dB over at least 90% of the seating area. Without good pattern control this would be exceptionally challenging to achieve. It should also be noted that the roof of the stadium, where the loudspeakers are usually installed from, may not be symmetrical all the way around the bowl or its height may vary from point to point, spectator seating is usually racked as well. This means the distance from loudspeaker to listener can vary considerably between seating locations. It is generally not sufficient to have just one loudspeaker dispersion pattern and several different patterns may need to be incorporated into each loudspeaker array.

The situation is further compounded by the fact that a large stadium bowl is generally a very reverberant space and maintaining a good direct to reverberant sound ratio can be hard but without it intelligibility will be very poor. It will also be quite off-putting to the listener if a clear localization of the source cannot be determined. Because of its size, due consideration must also be given to potential echoes which should be avoided at all cost. A distinct echo caused by sound emanating from a loudspeaker, reflecting off a large solid surface and directly onto the spectators at the opposite side of the bowl will typically arrive some 700 to 1000ms behind that of the loudspeaker covering that area, resulting in what otherwise might be an acceptable intelligibility level being totally incomprehensible. Great care must be taken by both the designer, when determining loudspeaker locations and aiming, and the installer, when physically trimming the aiming angles of the loudspeaker, to ensure any direct sound is not reflected onto the opposite side of the bowl.

Thus far our loudspeaker arrays need to offer an extended and essentially flat (+/- 3dB from 80Hz to 16kHz) frequency response, high sensitivity and power handling and provide good pattern control at least down to 500Hz to help maintain a reasonable direct to reverberant ratio over the speech frequency range. Most stadia are also exposed to the external elements, even if a roof is employed it will generally not enclose the entire bowl, which means the loudspeakers will also need to be of suitable construction and specially treated for outdoor use. This, for example, precludes the use of non-treated paper cone woofers and exposed metallic parts must be appropriately painted, galvanised or be manufactured from stainless steel. By now the choice of suitable products has been significantly eroded but fortunately a small number of manufacturers do produce ranges of loudspeakers that address each of these requirements in a single loudspeaker package.

Computer simulation software has improved considerably over recent years in terms of its ease of use and level of accuracy compared to the resulting physical installation. Simulations will almost always be carried out to determine loudspeaker array placements, individual loudspeaker dispersion angles and the expected sound pressure levels and intelligibility scores prior to the system being constructed. This has the obvious advantage of proving the design and offering a degree of confidence to both the designer and the client that the selected system will meet the requirements set out in the performance specification.

One aspect not yet considered, but which must frequently be taken into account, is the effect of sound emissions from the stadium to the neighbouring area particularly if this is within a residential area. The architects responsible for the design and construction of the stadium will influence sound leakage more so than the sound reinforcement system designer but appropriate loudspeaker selection can also help in this regard.

A full range multi-box large format line array can offer advantages over a more traditional point source system due to its tightly controlled vertical dispersion characteristics. If the roof of the stadium is suspended over the tiered seating below, the architects design may lead to an ‘acoustic hole’ if there is a gap between the upper seating tier and the roof. Direct sound from a point source loudspeaker which is aimed to give better coverage to the upper seating tiers will also increase the sound emissions from the stadium as it unavoidably escapes through the gap. A properly aligned line array system can offer quite rapid reduction in direct SPL outside of its designed vertical coverage requirement which can result in up to 6dB better attenuation of mid and high frequencies being emitted from the gap. A line array design can also fulfil the other requirements of a suitable bowl loudspeaker system quite admirably although it is typically more expensive to implement than its point source alternative. However, some of its advantages such as evenness of coverage can quickly be negated if careful consideration isn’t also given to the digital signal processing (DSP) control system employed to distributed networked audio signals and provide the necessary filters for the loudspeakers in the arrays.

When a broadcast quality sound reinforcement system is integrated in to a life safety evacuation system aspects such as equipment redundancy to prevent single point of failure need to be considered. In a larger stadium a single line array cluster may be providing audio coverage for several thousand spectators. If all of the separate loudspeaker elements in that array are controlled from a single DSP unit that represents quite a significant single point of failure as a problem with the DSP device or the network system feeding it could result in complete loss of audio for the area of the bowl the array serves. Of course the obvious answer is to use two DSP units connected to a redundantly configured network and interleave the DSP outputs, as you would do with interleaved amplifier circuits, such that no two adjacent band pass elements are fed from the same DSP. This concept provides the requisite redundancy, failure of a single DSP may significantly impede the optimum performance of the line array but there would not be a total loss of audio resulting in announcements that can still be heard, albeit at a reduced level if intelligibility. Using multiple DSP units on the same array can present an unintended problem though. If the latency introduced by the digital audio routing protocol and the DSP processing latency is even just slightly different, typically more than about 10us, between the audio outputs of the two DSP units, or indeed between outputs of the same DSP then this can have considerable detrimental effect on controlling the dispersion characteristics of the array. Networked audio protocols such as CobraNet and Dante, although introducing some latency, do guarantee that audio delivery between a transmitter device and subscribing receivers will be received, buffered and routed on to the DSP processor at the exact same time. Some manufacturers DSP products do not have a fixed latency however, the processing latency introduced may vary between input and output if the DSP processing employed between those inputs and outputs differs. This could well be the case if the DSP is user programmable and the system designer decides that different processing blocks are required between, for example, the HF elements and the mid band elements. Wherever possible DSP with fixed latency between any input and any output should be chosen. The designer can then be confident that any latency induced will at least be consistent across the interleaved DSP units and any advantages gained from line array pattern control are not compromised.

2.1.3 PC Control Equipment

Not only has the audio design and performance requirement become more complex but so too has the operational control. The PA operators and engineers require access to certain system parameters to enable flexible routing and adjustment of entertainment sources and tie line inputs but the integrity of the emergency evacuation aspect of the system must not be compromised by unauthorised access. In this regard the control requirement of the average stadium is significantly more complex than that of a voice alarm system in a more conventional office or commercial building to the point where the type of voice alarm controller typically utilised in such applications may not be able to provide the facilities or flexibility required. PC control software allows the flexibility to provide access to some parameters while effectively locking away any that should not be changed. Earlier analogue based control systems could generally not deliver this level of flexibility.

The system may well need to perform a dual function providing automated evacuation messages triggered from the fire detection system during non event days where the stadium is largely unoccupied with the exception of staff but conversely during an event day where large numbers of the public may be present an automated evacuation message may be totally inappropriate so the system must bypass the fire detection system and enable a manual only evacuation control scenario.

Providing a responsive user interface which is also capable of processing the logic operations for the various states of the system would be much more difficult to manage without the use of computers but equally any computer system must also not represent a single point of failure. The computers themselves can be made more reliable by simple measures such as replacing less reliable rotating discs with solid-state hard drives configured as RAID 1 mirrored arrays where data is simultaneously written to two hard drives to provide redundancy of the data storage. Other measures might include dual power supplied and if computers are deployed as paging stations to route emergency evacuation announcements then at least two consoles should be provided for redundancy. It is recommended that they are also installed at different locations within the stadium, typically the event control room and main security office. In this way location redundancy is also provided. If one location cannot be used, not necessarily due to equipment failure but perhaps due to the location itself becoming inaccessible, control can be reverted to the alternate site. Computer systems also allow topographical user interfaces to be created, this is especially useful where a large number of paging zones need to be accommodated. A stadium may have 70 or more discrete paging zones and providing such a large number of zones on a conventional paging console with physical buttons and switches may not be as intuitive as a computer interface can be made to be, although this may require some custom software to be written.

Fault reporting can also benefit from a computerised user interface. Faults can be displayed on the screen by directly indicating the zone(s) affected, with more detailed textual descriptions of the faults available for the operator to query as required.

The general reliability of PC's has improved greatly over the past few years. The latest operating systems are now quite stable provided the PC's are used only for the intended purpose, all superfluous software is removed and access to operating system functions such as installing new software is disabled for all users except the administrator. The operator should not be able to start up a game or Internet session for example. Wireless networking, although convenient for system setup during commissioning, can be disrupted through interference and may be more susceptible to being hacked. Wired network connections should always be utilised for any mission critical control PC's.

Despite the high reliability computer control systems are often viewed with some scepticism by safety officials and the standards. Often backup systems are put in place to enable some degree of operation should both the main and backup computers fail simultaneously or if the computer network should develop a complete failure. We've already discussed the use of interleaved DSP units for bowl loudspeakers, this technique can be applied equally to other paging zones within the stadium such as the concourses, hospitality and staff areas. The convention for interleaving loudspeaker circuits between at least two independent amplifier channels should also be followed.

Bypassing the control computers can be accomplished in a number of ways but one of the most common is to install an analogue link between the main paging microphone, or a dedicated fireman's microphone, and each DSP processor in the system. In the event of a major PC or network failure paging calls can still be made to a pre-programmed fixed selection of paging zones.

Other techniques the authors have implemented include enabling the DSP units in each equipment rack to continuously monitor the state of the digital audio signal and control data on the network. If these data streams stop unexpectedly the DSP can be pre-programmed with suitable logic to put it into a standalone mode. In the event of an emergency incident the PAVA rack can still be instructed to broadcast a pre-recorded message through the fire detection system interface without any need for the control computer to be online and available.

2.1.4 Primary and Secondary Power Supplies

The primary and secondary supplies to these life safety systems must be secure and monitored.

The primary supply must be in compliance with BS7671 and ideally be fed directly from the incoming supply to the building. In large complex venues this is not always possible and where the supply has to pass through one or more Electrical Distribution Boards a risk assessment should take place to highlight any issues that may compromise the supply. These intermediate Distribution Boards should only carry other services that require infrequent isolation and they must be clearly labeled 'WARNING. THIS SWITCH ALSO CONTROLS THE SUPPLY TO THE VOICE ALARM SYSTEM' at each location to advise Venue owners and Maintenance staff.

There should be a double pole isolator provided adjacent to the equipment rack, preferably lockable in both positions, to allow local isolation of the primary supply during the course of routine maintenance or breakdown works being carried out on the system. This isolator should be clearly labeled 'VOICE ALARM. DO NOT SWITCH OFF.' Occasionally, this isolator may also feed the Fire Alarm system if it is local to the Voice Alarm rack. In this instance the isolator should be clearly labeled 'FIRE ALARM/VOICE ALARM. DO NOT SWITCH OFF.'

All labeling must be clear, fade resistant and durable.

A 'Mains Healthy' and 'Mains Fault' indicator should always be displayed on the Voice Alarm rack to advise of primary supply status. In the event of a primary supply failure, as well as indicating this on the Voice Alarm rack, a fault signal must be transmitted to the Fire Alarm system to notify staff of this event.

Any faults with the primary supply to the Voice Alarm system must not affect the operation of the secondary supply to the rack. The change over from primary to secondary should be smooth and not interrupt any broadcasts being made by the system.

Secondary supplies are available in different forms. The most common are rechargeable batteries with automatic charger, uninterruptable power supply unit and back up generator supply.

All batteries must be of the rechargeable type and should have a minimum expected life span of four years under normal usage conditions for the voice alarm system.
It should be clearly visible on the batteries, without having to move them, their date of installation.
Battery capacity should be that, once they have been discharged to their minimum voltage, they can recover to full voltage within a charging period of 24 hours.
Automotive batteries, typically used for starting car engines, should not be used in life safety voice alarm systems.

Standby and full usage times for batteries vary depending on which standard or risk assessment is applied to the project. For instance, BS5839-8 requires 24 hours in standby mode followed by 30 minutes of full system use. Whereas the Green Guide doesn't specify a standby time, but does require 3 hours of full system use from loss of the primary supply. Other life safety standards have different standby and full load parameters.

In certain circumstances a risk assessment can be carried out to determine the level of standby and full usage requirements of a particular venue. This is normally based on the expected evacuation time for all members of the public from the venue and is usually carried out by the venue owners, system supplier, building control officers and venue insurance representatives.

Rechargeable batteries and automatic chargers are typically integral to the voice alarm rack whose components have dual supply features (AC and DC) and would support all the units in the critical signal path.

Uninterruptable power supply units would normally be in separate enclosures adjacent to the voice alarm rack and would be used to support system components having only a single AC supply input.

Standby generators ideally should be running continuously during an event. This may even be used as the primary supply, providing the system has the capability to fall back to normal mains supply in the event of generator failure.

When using generators for the secondary supply it may be necessary to also have a UPS whilst the generator gets up to normal running speed.

There are several things to consider when calculating the size of a secondary supply for a system, current required in both standby and full use, length of time secondary supply is required, allowance for battery de-rating and aging. Probably one of the most overlooked considerations is the temperature of the room in which the batteries are housed. These need to be kept at an ambient of less than 22° to avoid premature aging of the batteries. When you look at battery manufacturers datasheets, it’s surprising how much of a detrimental effect temperature can have on batteries. However, some manufacturers now produce batteries that will withstand higher temperatures than those previously available.

Finally, in systems that are used wholly or partly for life safety purposes, it is only necessary to provide secondary supplies to those elements that form part of the critical signal path. In essence this means things like general paging microphones, music sources and even low frequency loudspeakers do not need to be supported. However, in the case of the low frequency loudspeakers, you must ensure that the system intelligibility is not adversely affected.

2.1.5 System Calibration

System acoustic calibration should follow the normal steps for any sound reinforcement system. The impedance of loudspeaker circuits should be measured prior to terminating at the amplifier to ensure the circuit is within the expected range and is not shorted. Once line checks are complete EQ, delay and limiter settings should be applied before any acoustic measurements are carried out. Usually three separate sets of measurements are required to confirm each loudspeaker circuit meets with the performance specification.

- Maximum sound pressure level, A-weighted broadband level using a speech shaped spectrum of white noise
- Evenness of coverage in the 4kHz octave band
- Speech intelligibility

These are standard measurements for which a range of test equipment exists.

There is a general requirement for each amplifier circuit to provide at least 6dB of electrical headroom. It is the authors' belief that this headroom should also apply to the loudspeakers as well. After all, when testing the performance of a loudspeaker circuit the loudspeakers connected are an integral part of the test, as is the loudspeaker cabling connecting the elements together. Calculations will be made at the design stage to select appropriate loudspeakers, rate the cable cross-sectional area to provide an acceptable electrical loss and size the amplifier to deliver enough power to drive the loudspeakers at the required sound pressure levels after any inherent system losses have been factored. Confirming these steps have been applied appropriately simply becomes a matter of measuring the broadband sound pressure level in the space with an appropriate test signal. The complete circuit should be able to deliver at least 6dB above the target levels specified in the performance specification at a combination of locations agreed between the system designer, the client and other interested parties. During the test it should be verified that the amplifier is not limiting the output signal significantly.

This may appear to be a rather simplistic approach, and in many respects it is, but almost all good quality professional power amplifiers manufactured in the past few years will incorporate some form of output clip sensing and limiter circuit to prevent the output from clipping even with excessive input signals. The designer can have confidence that the amplifier output will remain linear even with excessive input drive. Therefore, if the signal reproduced over the loudspeakers is free from audible distortion and the DSP and/or amplifier limiters are not being applied to excess it is generally acceptable to the interested parties that the entire circuit has passed this specific test as it confirms the sound pressure level can be delivered as modelled with the compounded effects of line losses, transformer insertion losses and the acoustic environment being taken fully into account.

Older amplifiers may not offer such protective circuits and as such an excessive input signal may well lead to a heavily distorted output signal. Under these circumstances it may well be necessary to verify that the amplifier output is still linear at the target SPL by following the methodology given in BS7827.

3 CONCLUSIONS

Large scale broadcast sound systems can successfully be deployed to provide high quality full range music and speech reproduction and if correctly implemented provide a secure networked audio system which fulfils the requirements of the British Standards for emergency evacuation systems.

The stadium client can save money by installing just one combined system, instead of two separate systems for entertainment and evacuation.

The evacuation element is likely to be better maintained than might otherwise be the case because equipment failures leading to poor audio performance are more likely to result in complaints from paying customers.

4 REFERENCES

1. BS5839-8:2008 Code of practice for the design, installation, commissioning and maintenance of voice alarm systems.
2. BS7827:2011 Code of practice for designing, specifying, maintaining and operating emergency sound systems at sports venues.
3. The Green Guide – 5th Edition