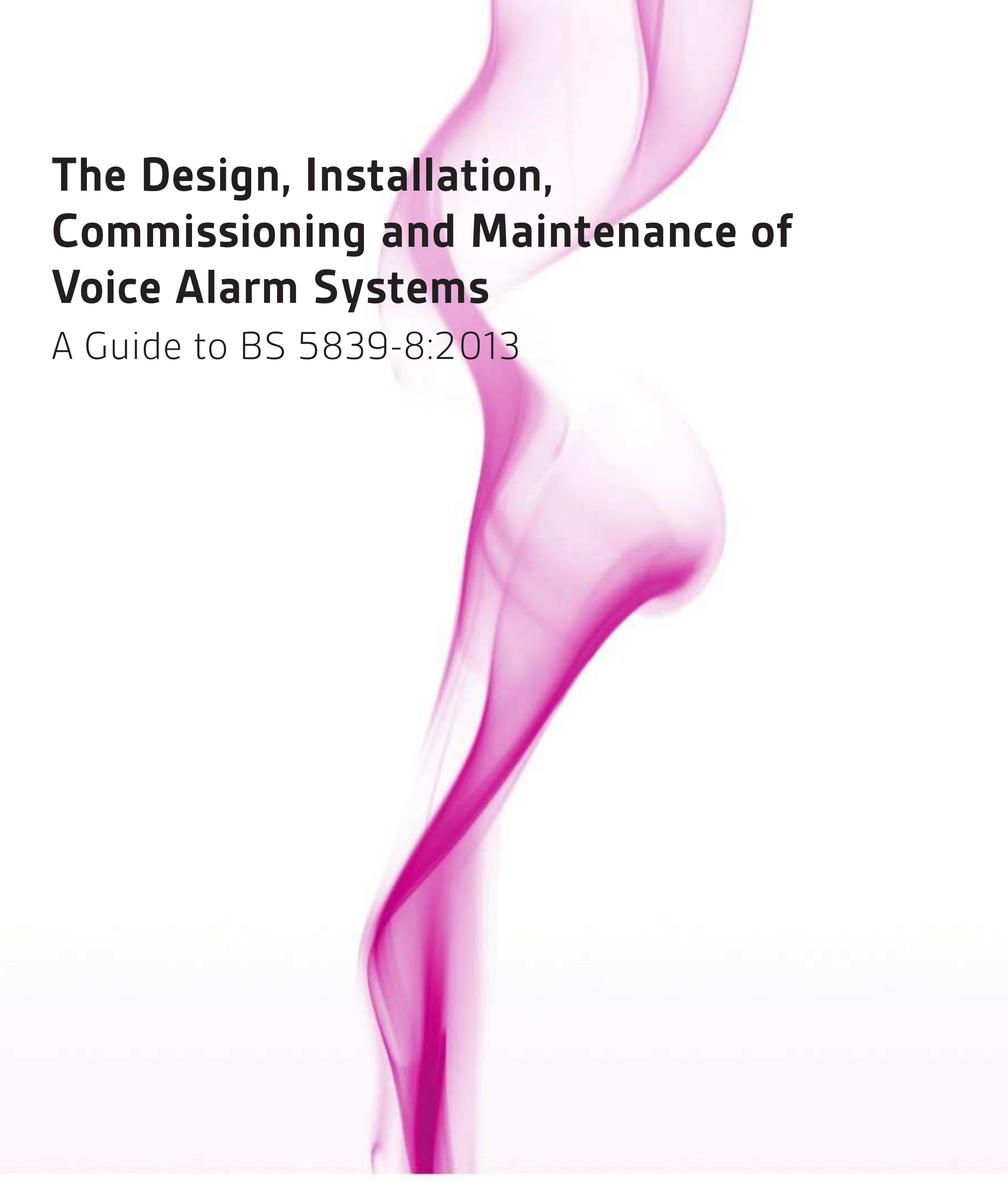
The Design, Installation, Commissioning and Maintenance of Voice Alarm Systems

A Guide to BS 5839-8:2013



Douglas F. Mason and Colin S. Todd

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To my dear wife, Elizabeth.

Douglas F. Mason

To my three loving children, Keith, Jayne and Fiona (Little Boo), because of whom I am blessed. And to Karen for her everlasting love and support. And to the cats of Hutton Roof (past and present), for their loyal company as I write in the dead of night.

Colin S. Todd

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About the authors

Colin Todd graduated from Edinburgh University in 1974 with an honours degree in physics. He then became one of the first four students in the United Kingdom to undertake a postgraduate Masters degree in fire safety engineering, thereby shaping his future career in fire protection.

After fire protection experience in industry, the Fire Offices' Committee (which was later incorporated into the Loss Prevention Council) and a leading insurance broker, he founded the leading fire consultancy practice, C.S. Todd & Associates, in 1982. The practice, of which Colin is managing director, provides consultancy services in all aspects of fire safety and fire engineering, but has always been able to offer specialist advice on fire detection and fire alarm matters, an area in which Colin specialized during his time with the Fire Offices' Committee (FOC).

Colin served for two years as a member of the Board of the Institution of Fire Engineers (IFE), and was the director responsible for technical matters. He also served on the Board of the Engineering Council Division of the Institution, and, for many years chaired the Division's Membership Committee. He is, at the time of writing, Chairman of the Fire Risk Assessment Council of the Fire Industry Association.

Colin Todd is a chartered engineer, a Fellow of the Institution of Electrical Engineers, a Fellow of the Association of Building Engineers, a Fellow of the Institution of Engineering and Technology, a Fellow of the Institute of Physics, and a corporate member of the Society of Fire Protection Engineers and the Institute of Risk Management. He is also a standards associate of the British Standards Society.

For many years, Colin has served on national standards making committees, particularly those of BSI. He is a member of the BSI Technical Committee that was responsible for the production of BS 5839-8, and he served on the BSI working group that prepared the final draft of the 1998 version of the standard.

Douglas Mason graduated from Glasgow University with a degree in mathematics and physics. His career spanned industrial electronics, defence electronics and research before he entered the field of fire protection in 1983 as Engineering Manager of Planned Equipment Ltd, a fire detection system manufacturer and installer. He became technical director of the company, and designed a new generation of conventional (but microprocessor-based) fire alarm panels.

The company also majored in sound systems, and Douglas led the company into the voice alarm field. He was responsible for the introduction of a range of sophisticated, electronic voice alarm control equipment.

Recognizing the need for standardization, Douglas lobbied the British Fire Protection Systems Association (BFPSA) (now the Fire Industry Association) to develop a voice alarm standard. He subsequently chaired the BFPSA working group that generated the first UK standard for voice alarms in 1994. He then served as a member of the BSI working group that, in effect, converted the BFPSA Code into BS 5839-8.

He joined C.S. Todd & Associates in 1998 as a senior consultant specialising in fire detection and voice alarm consultancy work, and until 2008 designed many fire detection and fire alarm systems and voice alarm systems.

Also, since 1998, he has drafted a number of British Standards, including BS 5839-9, and most recently has served on the BSI working group that created the revised version of BS 5839-8.

Douglas is a chartered engineer and a corporate member of the Institution of Engineering and Technology. He retired from full-time employment with the practice in 2008, but continues to work as a part-time consultant in this field.

1. Introduction

This is the third edition of *The design and installation of voice alarm systems*. The book remains a guide to BS 5839-8,[1] the first code of practice in the UK for the design, installation and maintenance of voice alarm (VA) systems, but has been brought up to date to reflect the changes to that document. The Code is one part of the BS 5839 suite of codes, all of which now bear the generic title *Fire detection and fire alarm systems for buildings*.

Since the publication of the original version of BS 5839-8 in 1998, VA systems have become more prevalent, particularly in buildings in which substantial numbers of members of the public assemble, but also in medium and large multi-storey office buildings. Accordingly, there is an even greater need for the Code, and for it to be as appropriate and up to date as possible. This book refers to the latest (2013) version of the Code but covers all the extensions of the scope introduced in BS 5839-8:2008, as well as those now included in BS 5839-8:2013, such as allowance for an increasing need for fire-resistant data cable. New concepts, such as types of VA systems, have been introduced to help those specifying VA systems.

In the first edition of this Guide, the question 'Why is there a need for a "guide to the guide"?' was asked. The answer is probably still 'interpretation'. As in its first published form, this book gives further guidance on issues that were previously contentious or surrounded by ambiguity. However, the Code has now been in force for 15 years and a number of changes have been found to be needed; few, if any, of these changes were made to the Code (in 2008, and now in 2013) because the Code, in its original form, was 'wrong'. However, as well as the extension to the scope,

[1] BS 5839-8:2013 *Fire detection and fire alarm systems for buildings. Code of practice for the design, installation, commissioning and maintenance of voice alarm systems.*

account has had to be taken of newly published standards and codes of practice, particularly BS EN 54-16,[2] which obviates the need for many of the previously included detailed recommendations relating to control and indicating equipment for VA systems and BS EN 54-25,[3] which refers to radio-linked VA systems.

Codes of practice do not give detailed guidance on implementation, nor is it possible, in a code of practice, to explain in any detail the reason behind the various recommendations made. The main purpose of this Guide is, therefore, to increase understanding of the Code by, for example:

- explaining the reasons for the recommendations in the Code;
- outlining the consequences of failures to satisfy the recommendations;
- providing more detailed guidance on the manner in which the recommendations may be satisfied;

using numerous examples to aid interpretation. Also, the Guide is not as formal a document as the Code, permitting it to include background and other associated information. For example, the opportunity is taken to consider the use of VA systems for purposes other than emergency warning. The authors hope that this approach will make the Guide interesting to read, as, they hope, was the case with previous editions.

Although the Code has been used primarily for VA systems associated with fire detection systems in buildings, these systems have sometimes included facilities for broadcasting messages relevant to other emergency situations such as bomb or other security alerts. To take this into account, 'fire microphones' are now referred to as 'emergency microphones'. It is important that the Code deals with emergencies other than fire emergencies, because BS EN 60849,[4] another VA system standard dealing with such emergencies, has been withdrawn. It should, however, be noted that there are also other relevant codes or standards that may be specified in particular circumstances, for example BS 7827[5] if the voice alarm is intended for use in a sports ground or stadium.

It is strange how long it has taken for voice messages to become established as credible alarms of fire – or, indeed, any other emergency. In the

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[2] BS EN 54-16:2008 *Voice alarm control and indicating equipment.*

[3] BS EN 54-25:2008 *Fire detection and fire alarm systems — Components using radio links.*

[4] BS EN 60849:1998 (edition 2) *Sound systems for emergency purposes.*

[5] BS 7827:1996 *Code of practice for designing, specifying, maintaining and operating emergency sound systems at sports venues.*

17th century, a handbell was used to draw people's attention, but the warning was usually supplemented by a voice message, if only comprising the word 'Fire'! Even in those early days, the use of voice messages must have assisted in evacuation.

In recent times, however, bells or electronic sounders, without any voice messages, have been established as fire alarm warning signals. The very word 'alarm' conjures up loud bells or sirens and, to those of us in the fire safety profession, it seems obvious that these warnings should be taken seriously. We all know, however, that the sound of ringing bells is really useful only to those who have been trained to recognize them as warnings of fire and to respond appropriately.

Those unfamiliar with a building may not recognize the warning from an audible alarm device as a fire warning. Moreover, there is a tendency for members of the public to disbelieve the warning, even if they do recognize it, on the assumption that it might be a test or a false alarm. (Unfortunately, statistically, this assumption is correct!) This means that there is often reluctance on the part of occupants to evacuate a building when the fire alarm system is operated, resulting in a 'pre-movement time', between the initial sounding of the alarm and the initiation of evacuation, that can greatly exceed the evacuation time itself.

Research has shown that the reluctance arises, in part, because of a desire for further information. This information can be provided by broadcasting an appropriately worded speech message, thereby resulting in a much more appropriate response; practical research and anecdotal information both confirm this.

There is now, however, some evidence that emergency voice messages, although in themselves giving clear information on action to be taken in the event of fire, can sometimes be ignored in a real fire condition, if occupants of a building have been exposed excessively to repetitive broadcasts of the actual emergency messages for test purposes (despite messages before and after the tests, advising listeners to take no emergency action). To counter this, emphasis is put, in the latest version of the Code, on minimizing this exposure to the actual emergency message during weekly test periods, by broadcasting the message out of normal working hours.

That aside, the replacement of bells or electronic sounders by voice messages dramatically reduces the occupants' pre-movement time and, therefore, the overall evacuation time. There are not yet enough statistics to determine whether lives have been saved by the use of voice messages, but there can be no doubt that, in many types of building, life safety is enhanced by the use of these systems. The voice alarm is here to stay and its use will grow.

BS 5839-1[6] refers its readers to BS 5839-8 for systems 'where audible alarms comprise speech messages generated by a VA system', and the design of VA systems is therefore established as a separate discipline in its own right. Although the design principles can, and should, be based on the principles developed for fire alarm systems, there are many special considerations in the design of VA systems. They involve audio technology and acoustics, and the system must be able to broadcast emergency messages that can be easily understood. Thus, there is a major difference between a conventional alarm sounder system and a VA system. For example, an alarm sounder system requires only adequate audibility for optimum perception of the warning, whereas a VA system requires intelligibility, of which audibility is only one component.

As discussed in more detail in the next chapter, the absence, for a considerable time, of specific codes of practice or standards for VA systems resulted in many design shortcomings, bad practices and, ultimately, installations that did not even meet the basic principles of fire alarm design as embodied in, for example, BS 5839-1. Inadequately intelligible and not easily understood broadcasts were one of the common shortcomings. Without the discipline now applied by the recommendations of BS 5839-8, many VA systems would still exhibit problems such as:

- unsuitable and non-fire rated cabling for loudspeaker circuits;
- unsuitable loudspeakers;
- ineffective fault monitoring arrangements for loudspeaker circuits;
- totally unmonitored sections of the alarm path, including the crucial link between the fire detection system and the VA system.

These shortcomings arose not merely through ignorance of system requirements (although the sound systems industry was initially slow to appreciate the principles of fire alarm design), but in order to reduce costs and win orders – a very unsatisfactory state of affairs! Accordingly, the publication of BS 5839-8 was an important step in rationalizing, standardizing and providing a tool for the control of design standards. These important factors have now been enhanced by the publication of this revised version of the Code. Nevertheless, the authors of the

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[6] BS 5839-1:2013 *Fire detection and fire alarm systems for buildings — Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises.*

Code have once again been conscious of the need to avoid ‘going over the top’ in making recommendations or placing onerous requirements upon system designers that would inevitably lead to excessively high costs and drive purchasers back to conventional alarm sounder systems. In the original version of the Code, particular care was taken to avoid recommendations for VA systems that went beyond the analogous recommendations for conventional alarm sounder systems. The revised Code further emphasizes this need by introducing the concept of VA system types, which assists in providing a ‘horses for courses’ approach to VA system design.

Attempts have also been made to ensure that the Code is flexible where appropriate. For example, with the advent of BS EN 54-16, which *inter alia* gives performance requirements for power amplifiers, it may now not be necessary to include automatically switched standby amplifiers because of the inherent reliability of power amplifiers conforming to that British Standard.

Even after the great care taken in the original version of the Code to consider the views of all parties, and to develop recommendations that were logical and justifiable, there has was still some misunderstanding on certain issues, such as the use of ‘dual’ loudspeaker circuits. Particular attention is therefore given to these issues in this Guide.

In BS 5839-8:2008, a significant number of alterations and additions to the content were made, because of changes in technology, custom and practice. The principal changes (taken from the text of the revised Code) were as follows:

a) ‘Types’ of VA systems have been introduced to recognize and identify the different configurations of systems that can be used and their specific operational needs;
b) the need is clearly identified for the building evacuation plan to be based on a risk assessment by a competent person;
c) recommendations in the use of voice sounders have been included as a clause in the main part of the Code as opposed to an annex, thus recognizing their increased acceptability in simpler VA systems where manual control is not required;
d) recommendations for VA control and indicating equipment and power supply equipment have been rewritten taking into account that the new harmonized European standards, BS EN 54-16 and BS EN 54-4, give the applicable product requirements;
e) the information on standby battery calculation has been consolidated into one informative annex;

f) two different levels of fire resistance of cables are recognized, and recommendations given for application of each type;
g) recommendations for networked systems, for example in respect of cable types, are included;
h) the use of radio to link parts of the VA system is recognized and recommendations for the implementation of such radio links included;
i) recommendations for the maintenance of systems, including the periods at which routine servicing should be carried out, have been revised;
j) the single ‘commissioning and installation’ certificate has been replaced by a modular certification scheme separately covering: design, installation, commissioning, acceptance, verification, inspection and servicing, and modification;
k) the code of practice has been simplified by the use of practice specification format, in which commentary on relevant principles is followed by short, succinct recommendations. This is intended to make the code of practice less ambiguous and simpler for the non-specialist to apply and compliance of installations more straightforward to audit;
l) the term ‘deviation’ has been replaced with the term ‘variation’, to avoid any negative connotation associated with the term used to describe an aspect of system design that, for good reasons, does not conform to this standard.

Since then, at least the following alterations and additions have been made in BS 5839-8:2013:

a) the text on radio-linked systems has been modified to remove conflicts with BS EN 54-25:2008;
b) new recommendations for measurement of audibility of background noise have been added;
c) the text on cables and wiring has been updated;
d) Annex C has been modified to allow for alternative amplifier efficiencies;
e) practical guidance is now included on placement of loudspeakers in simple acoustic environments;
f) the term ‘responsible person’ has been removed and replaced with references to ‘premises management’ to avoid confusion with the term defined in legislation;
g) changes have been made to recommended regular system test procedures.

VA systems must be properly designed if they are to operate continuously and reliably. However, the philosophy behind the recommendations of BS 5839-8 does not involve the creation of systems that cannot fail. (Indeed, not only is 100 per cent reliability impossible, but it would be unaffordable even if it did exist.) The Code does stress the need for measures that will minimize failures and downtime, but also stresses the need for comprehensive monitoring of all critical system elements. This need for comprehensive fault monitoring is one of the main features that distinguish a VA system from a traditional public address system.

As in the case of any code of practice, BS 5839-8 provides recommendations, rather than requirements. In practice, of course, the Code forms the basis for purchase specifications and requirements by enforcing authorities. Nevertheless, variations from the recommendations may be acceptable in particular circumstances. Such variations should be subject to agreement between all interested parties, including the purchaser, any relevant enforcing authority and, possibly, the fire insurer.

VA systems are particularly appropriate for medium- and large-sized buildings that house significant numbers of members of the public. The ability of these systems to broadcast specific messages for particular areas of the building and real time speech make them very suitable for buildings in which phased evacuation is used. However, the principle of using voice messages to give fire warning is appropriate for virtually any size of building, and, as the cost of systems decreases and there is greater integration of VA systems and fire detection systems, the size of buildings for which VA systems are used will continue to decrease. The enhanced guidance contained in the revised version of BS 5839-8 should assist this growth in VA systems, while ensuring that the systems installed meet the needs of fire safety.

Even though the revised Code addresses the few ambiguities and imperfections found in the original version, further such issues may arise, as experience in the use of the Code continues to grow. Users should note that BSI technical committees always welcome feedback. The technical committee responsible for BS 5839-8 would, no doubt, be prepared to consider further comments from users and would, obviously, continue to be in a position to respond to enquiries in the event of serious problems of interpretation.

2. Voice alarm systems and standards – a short history

Before the discovery of electricity, the spoken word was the first form of local warning by someone who had seen something recognizable as an emergency or warning whether it be smoke, fire, remote signals transmitted via semaphore, bonfires, etc. However, communication of the message across even a limited area involved dispatching a messenger, even over very short distances.

The ancient Greeks had found that, in order to transmit a really clear voice message across an assembled group of people simultaneously, there were benefits if the auditorium were a rounded hollow in the side of a hill and the speaker was located at a 'focal point'. This was, effectively, early acoustic design and no doubt of a very approximate nature. Nevertheless, it demonstrated an understanding that consistent intelligibility throughout a listening area is essential if the message is to be understood by everyone.

Voice alarms, as we know them today, have become possible because of:

- the discovery of electricity;
- inventions such as microphones, amplifiers and loudspeakers;
- the development of communications techniques.

Early public address systems were used first for indoor and outdoor meetings, etc., but their use grew for paging and background music.

During the Second World War, there was plenty of opportunity for installation and regular use of emergency sound systems. For example, they were used to scramble air force crew and give specific orders. However, large loud sirens were widely used for air raid warning, so as to warn large numbers of people quickly and simultaneously. Air raid sirens are, of course, an example of the exceptional case where the meaning of the alarm signal was known to everybody, with very little training!

By the 1950s, every respectable large office block had ‘the Tannoy’, as public address systems were often known. ‘Music while you work’ in factories brought a large increase in the use of sound systems in industry. Because public address systems were installed and available, consideration began to be given to their use in the event of fire and other emergencies. Thus, it is the case that, in the UK, public address systems have been used for giving fire warnings for several decades. In some cases, the public address system was the primary means of giving fire warnings (as well as serving as a conventional public address system), although, in other cases, public address systems were used only to provide supplementary information when fire alarm sounders operated. The level of integration of a fire detection system with a public address system tended to be either non-existent or very crude.

The term ‘voice alarm system’ or ‘voice evacuation system’ was sometimes used by certain organizations to describe these systems. However, in engineering terms, these early systems were simply relatively standard public address systems that happened to be used for fire warning.

These early systems often relied upon either taped messages or real time speech, often by operators who were ill-suited to the task! Moreover, the systems themselves fell far short of the level of integrity expected of a fire alarm system, even a fire alarm system that met the less stringent standards of the time in question. Circuits were neither monitored nor wired in fire-resisting cable, while standby power supplies were either non-existent or, often, of a relatively short duration. Until the 1960s, valve amplifiers were used, making the systems prone to failure, while elementary design of microphones and, particularly, loudspeakers, resulted in inefficiency of systems, necessitating large loudspeakers that did not produce a particularly high output.

The intelligibility of the systems was often quite poor. Indeed, in some cases, the paucity of loudspeakers was such that the messages were completely unintelligible within, for example, cellular office accommodation. Sometimes, the system was intended to do no more than attract attention with an alarm tone, so causing people to vacate their offices and proceed to a location, such as the corridor, where the broadcast information might be intelligible.

Thus, for the vast majority of applications, bells and electronic sounders were the norm. These devices are, after all, loud and attention-drawing. Bells and sounders are still in popular use today and are perfectly adequate as fire alarms for many applications, provided listeners are trained to recognize them and understand the action they must take on hearing them.

In the UK, recognition of what became known as 'use of public address equipment in lieu of conventional sounders', and the need for special consideration of particular aspects of engineering design, can be traced back at least as far as 1972, when British Standard Code of Practice CP 1019 was published, to provide recommendations on fire alarm system design. This code contained eight recommendations for public address systems that were to be used for giving fire warnings. Most of these recommendations remain relevant, and indeed are an inherent part of good design today, although some are still overlooked from time to time by designers! The recommendations were carried over into BS 5839-1:1980 and BS 5839-1:1988, but expanded by a later amendment to the latter code. Since then, versions of BS 5839-1, published after the first version of BS 5839-8, have been able to refer to the latter code of practice for recommendations in respect of VA systems.

In the USA, the first National Fire Protection Association (NFPA) 'Voice/Alarm Signalling Service Sub-Committee' was formed in 1975 and immediately began work on the development of NFPA Standard 72F.[6] As in the case of BS 5839-8, the intention was to standardize design practices.

The approach in both of the early UK and American codes was simply to ensure that the principles of fire alarm design were adopted in the design of VA systems. There was little or no attention to acoustic issues, or to aspects of design for which there was not a strictly analogous aspect in fire alarm system design.

Major growth in the use of VA systems in the UK probably emanated from two sources, both of which are discussed in more detail in the next chapter. The first source was the increased use of phased evacuation principles for tall buildings, the construction of which went through a boom, particularly in London, during the 1980s. Secondly, a considerable amount of important and quite elegant research into human behaviour in fire revealed that response of people to alarm signals could be greatly improved by provision of additional information via voice messages. It is interesting to note that, in the first case, the intention is to ensure that those who need not evacuate are reassured and remain in their own areas of the building, while the intention in the second case is to promote rapid evacuation!

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[6] NFPA 72F *Standard for the Installation, Maintenance and Use of Emergency Voice/ Alarm Communication Systems*.

The coming together of fire detection systems and sound systems in a widespread manner has, therefore, taken place primarily within more recent years. However, during the initial years of the growth in the use of VA systems, it rapidly became clear that there was inadequate guidance on design issues. Part of the problem has been that, even in the 1990s, the provision of VA systems tended to be achieved by taking an off-the-shelf fire detection and fire alarm system and connecting it, often by relatively crude means, to a public address system of enhanced design, to form a single system that often fell short of the spirit, and sometimes even the letter, of even the simple guidance traditionally contained in fire alarm design codes.

The link between the fire detection system and the VA system was, for many years, a particularly ‘grey’ area. Clearly, this is an essential part of the alarm path that must be robust and fully monitored. However, it was quite common for the supplier of the fire detection system to give very little attention to this matter, as the VA system was treated as an auxiliary system, connection to which justified, sometimes, nothing more than an unmonitored piece of telephone cable. Basically, the organization providing the fire detection system considered that this was an input to the VA system and nothing to do with a fire alarm supplier, while the supplier of the VA system treated it as an output from the fire alarm system and nothing to do with the voice alarm supplier!

Loudspeaker circuit monitoring also presented particular problems and was not always properly considered or implemented. In the inevitable competitive commercial world, purchasers often selected the lowest cost system, which, unsurprisingly, did not always have comprehensive fault monitoring of the type generally required for fire warning systems.

Equally, after certain fire disasters, an increase in attention to fire safety standards sometimes led to some consultants’ requirements being considered as over-specification. In some aspects of design, the requirements specified went beyond those that would traditionally apply to a fire warning system.

There was, therefore, an urgent need for suitable standardization. Many hoped that, when BS 7443[7] was published in 1991, it would resolve some of the contentious issues. This British Standard was actually the British version of an IEC standard, IEC 849:1989.[8]

Unfortunately, the standard, which had been produced without any real reference to those involved in fire alarm standards, provided little

[7] BS 7443:1991 *Specification for sound systems for emergency purposes.*
[8] IEC 849:1989 *Sound systems for emergency purposes.*

practical assistance. It did, however, introduce the concept of speech intelligibility, and made a definitive recommendation in respect of the manner in which intelligibility should be measured and the result that should be achieved.

On the negative side, the standard introduced widespread confusion as to whether conformance necessitated two independent (and usually 'interleaved') loudspeaker circuits on all floors of a building, a practice that was not required at the time to satisfy the recommendations of BS 5839-1 for sounder circuits (although this is now recommended for a limited number of situations in the current version of BS 5839-1).

However, VA standards moved forward with a quantum leap when, in 1994, the British Fire Protection Systems Association (BFPSA) published its *Code of practice for the design, installation and servicing of voice alarm systems associated with fire detection systems*. In contrast with BS 7443, this code of practice contained a significant amount of 'meat'. Moreover, it adopted many of the principles contained in BS 5839-1, so ensuring at least a degree of consistency of design principles between fire alarm systems using conventional sounders and those incorporating VA systems.

The BFPSA (now known as the FIA) code lacked, however, some of the rigour of a British Standard, and remained somewhat ambiguous in respect of a number of matters. In the meantime, voice alarms with design deficiencies were being installed into complex buildings, in which the safety of large numbers of people would depend on adequate fire warning. Such was the concern over this issue by the Loss Prevention Certification Board (LPCB) that the LPCB issued a Technical Bulletin, reminding interested parties, particularly fire alarm contractors certificated by the LPCB, of commonly experienced pitfalls and a number of design features required for conformance to BS 5839-1.

BSI simply adopted the BFPSA code, verbatim and in its entirety, as the first draft of BS 5839-8, which was then offered for public comment. The public comments were not extensive in number, but were very significant in respect of the technical matters and fundamental design principles that they addressed. Accordingly, the BSI Technical Committee responsible for the new code formed a small working group, which, over a prolonged period of time that was commensurate with the significance of the public comment, undertook major redrafting of the document. The working group added new material on issues that commentators indicated should be addressed, in some cases completely rethinking the philosophy that underlay a number of design principles, and providing a more definitive code of practice, against which quite rigorous and unambiguous verification could be undertaken. About eight years after publication of the Code, the same BSI Technical Committee re-formed a working group to revise the Code, following a considerable number of comments received. Once again, drafting required a prolonged period of work, but all the issues referred to in the Introduction of this Guide were addressed in detail, resulting in an updated Code that is easier to digest than its predecessor.

Although it is still the case that the revised BS 5839-8 is only a code of practice, it will continue to form the basis of contracts and enforcing authority requirements. The authors of the revised version have therefore striven to ensure that the Code is as definitive and as unambiguous as possible, without stifling innovation.

When drafting the original version of BS 5839-8, in the absence of appropriate product standards, it was decided to include recommendations for equipment, such as control and indicating equipment, despite the fact that the Code was a systems-related document. With the publication, for example, of BS EN 54-16 for voice alarm control and indicating equipment and BS EN 54-4[9] for power supply equipment, it has been possible for the revised Code to concentrate more upon the systems aspects of voice alarm.

In our opinion, an excellent job was done in updating BS 5839-8. It is now set out in 'practice specification' format, with separate commentary and recommendations, making it easier to read than in its previous version. The Code should be an even more valuable document in the promotion of greater use of VA systems as a result of increased user and specifier confidence, as well as clearer, standardized objectives for the product designer.

[9] BS EN 54-4:1998 *Fire detection and fire alarm systems. Power supply equipment.*

3. The role of voice alarm systems in fire warning

In principle, a VA system can be used as the means of broadcasting fire alarm signals in any building, regardless of size, occupancy or function (provided, of course, the nature of the building is not such that reasonable intelligibility would be impossible to achieve – the issue of alarm intelligibility is discussed in Chapter 19). It is unlikely that, engineering and economic issues aside, there would ever be a significant fire safety or managerial basis for rejecting a VA system in favour of a system that used conventional alarm sounders.

In practice, there is little, if any, advantage in using a VA system in buildings of limited size, with occupants who are familiar with the building and trained in evacuation procedures. Voice alarms are still not being used in such buildings to any great extent, simply because of the greater cost normally associated with the VA system. However, there is a continuation of the trend towards the use of VA systems in more straightforward buildings than has traditionally been the case, provided any cost penalty associated with a VA system can be kept to a minimum. Even in straightforward buildings, a VA system can be designed to provide additional information (such as the location of the fire) if this information is of value to occupants.

Equally, there are buildings for which the use of a VA system may be regarded as essential or, at the very least, recognized good practice. Such cases arise when there is a recognized need for:

- optimum control of large numbers of the public;
- sophisticated evacuation procedures;
- an enhanced motivation to evacuate.

Three common examples of buildings in which one (or more) of these factors is relevant are buildings in which:

- phased evacuation procedures are used;
- the public assemble within a single large compartment;
- pre-movement time must be minimized.

The concept of phased evacuation has been used for many years in buildings in which it is unnecessary, and even undesirable, to evacuate the entire building when fire is first detected. In a large industrial site with an extensive range of buildings, even though the buildings may be interconnected, there may be no need to evacuate areas remote from the fire. A VA system can provide information as to the location of the fire, so that, for example, a fire team may be assembled, other key staff may be aware of the situation and occupants may be advised to keep out of the affected area.

However, perhaps the most common phased evacuation application in which the use of a VA system is particularly important involves tall office buildings. In these buildings, subject to certain safeguards that need not be discussed here, the number and/or widths of staircases may be reduced if a phased evacuation system, rather than any form of single stage evacuation, is adopted. The philosophy is that the staircase capacities need not be designed to cater for the simultaneous evacuation of all occupants. Instead, occupants are evacuated in a controlled and phased manner, usually two floors at a time, normally starting with the floor of fire origin and the floor immediately above. Since the occupants of two floors only are likely to be using the staircases at any one time, the permitted reduction in staircase capacity can be significant, providing greater usable and lettable floor space. Phased evacuation is mainly used in the case of office buildings, particularly those over around 30 m in height, although it is, occasionally, used in other occupancies.

In the case of a tall office building with a phased evacuation arrangement, there must be an unambiguous method of giving instructions to evacuate and, of course, giving instructions not to evacuate. This can be achieved with bells or electronic sounders (e.g. by the use of an intermittent signal for the 'alert' condition and a continuous signal for the 'evacuate' instruction).

The use of a VA system, however, adds a further dimension to the management of the evacuation. Firstly, voice messages are much less ambiguous than intermittent or continuous tones. (Although to those of us conversant with two-stage alarm arrangements, the intermittent or continuous ringing of bells, and the meanings associated therewith, appear relatively straightforward to understand, the confusion that can exist in the minds of occupants who have been inadequately trained is astonishing!) Moreover, the VA system can, and should, provide reassurance to occupants on floors not yet to be evacuated that they are safe and need not attempt to evacuate, notwithstanding that, looking from their windows, they may see a host of fire appliances and, possibly, even evidence of a fire! It is important that occupants are reassured in this way since, if they were to decide to attempt, in effect, to evacuate from all areas of the building simultaneously, there would be serious overcrowding on the staircases.

Such is the recognition of the role of VA systems in phased evacuation that, for example, the London District Surveyors Association (LDSA) guidance document on phased evacuation[10] specifically recommends the use of VA systems, although there is the potential to relax this in the case of office buildings of six storeys or fewer. Similarly, BS 9999[11] makes reference to VA systems and their benefits in supporting means of escape.

The reason for the use of VA systems becoming standard practice in large public assembly buildings is somewhat different. In this case, the majority of occupants will be unfamiliar with the fire alarm signals and the evacuation procedures.

Use of a VA system ensures that an unambiguous warning is given to all occupants. The VA system is also used to provide additional information regarding the procedures to be followed. In this respect, there can be vastly more flexibility than in the case of a system using conventional alarm sounders; pre-recorded messages can be overridden by real time messages broadcast from a control room, where information on the fire is available, or by the fire and rescue service when they take charge. This can permit direction of occupants regarding escape routes that should be used (or not used), etc.

Response to fire alarm warnings and motivation to evacuate have been the subject of considerable research on the subject of human behaviour in fire, particularly during the 1980s. The results of much of this research were widely disseminated, even reaching the general public by means of some of the popular science programmes on television.

The research indicated quite unambiguously, as everyone in the world of fire safety knew only too well, that people tend to react inappropriately to conventional fire warning signals. They might even be unsure as to whether the warning signal was intended to indicate fire or some other emergency. However, even if they were to recognize the sound as that of

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[10] LDSA Fire Safety Guide No. 3. 1990 *Phased Evacuation from Office Buildings*.
[11] BS 9999:2008 *Code of practice for fire safety in the design, management and use of buildings*.

a fire warning, there would be a tendency to disbelieve the warning signal, on the assumption that it might be a test or false alarm. As a result of this uncertainty, there is often a reluctance on the part of building occupants to evacuate when the fire alarm system is operated, resulting in a ‘response time’ that can greatly exceed the evacuation time, so constituting the major element of the time interval between outbreak of fire and total evacuation of a building.

Research also showed that part of that delay resulted from a desire for further information, which could be satisfied only by conferring with others, or even telephoning others, to obtain appropriate information that was perceived to be reliable in nature. There is, however, a remarkable contrast in behaviour when the fire warning comprises an appropriately worded speech message, giving clear and unambiguous information along with appropriate instructions. In this case, the response is much more immediate, so resulting in a significant reduction in the time between outbreak of fire and occupants’ arrival at a place of safety outside the building.

In the fire engineering design of buildings, involving a holistic approach to fire safety design, account may be taken of the shorter evacuation time that will pertain if a VA system is used instead of conventional alarm sounders. In fire engineering design, the time between ignition and evacuation may be divided into a number of components, one of which is ‘pre-movement time’, defined as the time between the giving of an alarm signal to occupants of the building and the point at which occupants begin to evacuate. Pre-movement time is, itself, divided into two components, namely, ‘recognition time’ and ‘response time’. Recognition time is the period for which the alarm signal is evident but occupants are not yet responding to it. During this period, occupants continue with their normal activities. Response time is the period after occupants recognize that they are being given an instruction to evacuate, but before they begin to move directly to an exit.

In the fire engineering approach, a reduction in response time may be assumed if a VA system is used. (However, care should be taken to ensure that, in situations with rapid fire development, the assumed benefit of a VA system is not overstated; ultimately, there must come a point in fire growth when evacuation will begin, regardless of whether an audible alarm has even been given.) Equally, with increasing use of VA systems, there are suggestions that this benefit may not now be as great. This may be the result of exposure of the public to false alarms from automatic fire detection systems in which warning is given by a VA system. Even so, BS 9999, for example, permits travel distances to exits to be increased by 15 per cent and door widths to be reduced by 15 per cent if there is automatic fire detection (primarily smoke detection) *and* a VA system, provided these show a clear benefit.

It is clear, therefore, that a VA system employing speech messages is not simply a new-fangled form of fire alarm signal. The specific use of a VA system, rather than conventional sounders, may form an integral part of the fire safety strategy for the building. In performing this role, it may, therefore, not simply act as an alternative form of fire warning, but a necessary form of fire warning, given the nature of the strategy proposed.

4. Scope of BS 5839-8

The Code has been written to guide all interested parties involved in any stage of a VA installation project, both technically and in terms of project management. Coverage extends therefore from microphones to loudspeakers via amplifiers, but also from initial planning to system maintenance via design and handover.

The recommendations of BS 5839-8 basically apply to any VA system that is automatically triggered by, and therefore effectively forms an integral part of, a fire alarm system. Normally, VA systems are used in buildings in which there is a significant amount of automatic fire detection, but the recommendations of the Code would apply even if the fire alarm system were purely a manual (break glass call point) system. In this respect, the Code interfaces perfectly with BS 5839-1, advising on the connections between the fire detection and fire alarm system and the VA system, as well as on the information that must be fed back from the VA system to the fire detection and fire alarm system. (The previous sentence presupposes that the two systems are entirely separate; this need not, of course, be the case, and the availability of fully integrated fire detection/voice alarm systems has grown, as predicted, since the first edition of this book was published.)

VA systems other than those of Type V1 (see Chapter 7) incorporate a facility for live speech broadcast. VA systems within the scope of the Code must, however, always have a facility for automatic transmission of pre-recorded messages. A system that requires manual intervention by an operator in order to transmit either pre-recorded or live messages would not come within the scope of the Code, nor would such a system generally be regarded as acceptable for fire warning purposes. Thus, the simplest VA system to which the Code would apply would be one in which, for example, there was only a single message (and thus a single stage alarm arrangement) that was automatically triggered by an associated fire detection and fire alarm system (whether incorporating automatic fire detectors or not). Systems used in large complexes will, of course, be much more sophisticated, typically involving tens of loudspeaker zones, several emergency microphones, multiple evacuate/alert and test messages, several different types of loudspeaker and often various manual controls to start and stop messages.

The Code applies equally to centralized systems, in which all power amplifiers are installed at a single location, and distributed systems, where power amplifiers, etc., are located in groups at strategic points around a building. The choice between the two types of system is basically a matter of economics and engineering 'taste', but exactly the same recommendations apply to both types of systems. Some recommendations of the Code may appear quite onerous for small systems but the view taken was that system format was an engineering issue to which absolutely consistent recommendations should apply.

Fire telephones are specifically excluded since they make up an entirely separate form of communication system, now referred to as an emergency voice communication system. A VA system is intended to inform the occupants of a building collectively of the existence of a fire. Fire telephones, on the other hand, are provided for operational use by the fire and rescue service during the fire, and for use by fire wardens in an emergency or, much more commonly, disabled persons requiring assistance with evacuation. A code of practice covering such systems, BS 5839-9,[12] was published in 2003.

Voice alarms used for fire warning, and conforming to BS 5839-8, may be used for warning of other types of emergency, such as bomb warnings, etc. The potential use of VA systems for this purpose is fully acknowledged in BS 5839-8, which provides relevant recommendations in respect of, for example, prioritization. This continues to represent a distinct difference from recognized practice in the USA, where use of a VA system for purposes other than fire warning would need special approval. The acceptance of VA systems for multiple emergency situations and for non-emergency broadcasts, such as paging, background music, etc., is extremely important, as it often makes the VA system economically viable in situations in which a public address system is required for other purposes. This is considered further in Chapter 14. If one were designing a VA system for purposes other than fire warning, although this would not lie within the scope of the Code, its

[12] BS 5839-9:2003 *Fire detection and fire alarm systems for buildings — Code of practice for the design, installation, commissioning and maintenance of emergency voice communication systems.*

recommendations would nevertheless be appropriate if there were a need for high reliability and integrity of the warning system.

Originally, BS 5839-8 did not apply to VA systems used in sports stadia because of the existence of the code of practice, BS 7827, which provides recommendations for the installation, maintenance and operation of permanently installed sound systems used for emergency purposes at sports venues. However, most of the recommendations of the Code apply to such systems and this was recognized in an Amendment to the Code, introduced in 2005. The revised version of BS 5839-8 now includes more information relevant to sports venues, but, in the Scope, still refers the reader also to BS 7827.

The first version of the Code, although an installation code of practice, contained a number of recommendations for the design of hardware. This arose because of the absence of product standards for components of VA systems. With the advent of BS EN 54-16, a product standard for control and indicating equipment for VA systems (including microphones), it has been possible to remove much of that information. Recommendations for appropriate loudspeakers, however, have had to be retained in the revised Code because the new standard BS EN 54-24[13] for VA system loudspeakers does not (at the time of this edition going to press) include requirements for fire-related mechanical and electrical integrity of loudspeakers and their connections.

The Code continues to apply only to VA systems that are used in a temperate climate such as that of the UK.

In the original Code, recommendations for the use of voice sounders (stand-alone devices connected to fire alarm systems, containing the components necessary to generate and broadcast their own digitally recorded messages) were included in an annex. In recognition of their increasing use, voice sounders are now dealt with in a separate clause of the revised Code.

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[13] BS EN 54-24:2008 *Fire detection and fire alarm systems. Components of voice alarm systems. Loudspeakers.*

5. Contents of the Code

The presentation of the revised Code has been totally altered to follow a practice specification format. This makes for concise recommendations, with separate commentaries (in italics). Those checking what recommendations apply to a particular feature of a VA system should therefore be able to do so quickly, whilst those who wish to check on the reasoning behind them can do so in the commentary. The original Code was quite intentionally drafted to follow and parallel the format of BS 5839-1:1988 and the revised version retains that approach, but now emulating BS 5839-1:2013. The title of each of the six sections of the Code corresponds to a title in Part 1. These titles are:

- General.
- Design considerations.
- Installation.
- Commissioning and handover.
- Maintenance.
- User responsibilities.

Four annexes provide further information on a number of issues.

These six sections are subdivided into a total of 44 clauses, which are briefly reviewed, along with the four annexes, below, highlighting important aspects that will be discussed in subsequent chapters of this Guide.

Section 1 – General

1. Scope

The scope of the Code has been discussed in the previous chapter. The important point is that the VA systems covered by the Code are those which automatically transmit messages in response to signals from associated fire detection and fire alarm systems; systems that necessitate manual intervention are outside the scope of the Code.

2 Normative references

In accordance with current BSI practice (different from that applying at the time of publication of the original version of the Code), only 'Normative' references appear in Section 2. 'Normative' references are basically other standards and codes (or European Directives), providing requirements or recommendations that should be followed. Most, but not all, of these are, in this case, BSI publications.

If, in the Code, a normative reference includes a date, the edition of that date, only, applies (together with any amendments to the reference that have been made prior to the publication of BS 5839-8). If the reference is undated in the Code, the latest edition of the document applies, together with any amendments.

Many normative references in the Code are dated, since they are references to sections or clauses of a standard published on a particular date. However, in the case of normative references that are undated, over a period of time the recommendations of BS 5839-8 could change subtly, because of changes to the recommendations or requirements contained in normative references. It is, therefore, important that users of the Code ensure that they refer to the latest version of undated normative references.

3 Terms and definitions

Clause 3 now defines 26 terms used in BS 5839-8 *as they are to be understood for the purpose of interpreting the Code*. These include a definition of 'voice alarm system' itself.

Some of the terms defined may be unfamiliar to those in the fire industry, as opposed to the sound systems industry. One important term is 'intelligibility', a particularly important parameter in VA system performance. Intelligibility is discussed in Chapter 19 of this Guide. The terms 'emergency loudspeaker zone' and 'PA zone' are also defined here; it is important to distinguish these from fire detection zones.

4 Need for a voice alarm system

This short clause is there as a guide to those trying to establish whether a VA system is actually required for a particular premises. It basically refers the reader to appropriate guidance documents, standards and enforcing authorities.

5 Types of systems

VA systems can have varying degrees of manual control of broadcast of emergency messages, whether live or recorded. The revised version of the Code therefore groups VA systems into types, each of which defines a particular combination of automatic and manual control. More information about types of system, and their selection is given in Chapter 7.

6 Exchange of information and responsibilities

In the commentary, the Code makes it clear that the purpose of the VA system is to support the building's fire safety strategy (an obvious point, made in the previous version of the Code, but emphasized more in the revised version). To achieve that objective, particularly in complex premises, there needs to be liaison between the system designer, the user or purchaser, the enforcing authority and, possibly, specialist consultants.

The recommendations clarify the responsibilities for liaison of the user or purchaser, the designer and the installer to ensure that the VA system is appropriate in all respects. They include a recommendation to ensure that one organization is responsible for the overall fire detection and fire alarm system/voice alarm system package. The importance of this cannot be overemphasized, since many of the shortcomings that exist in installed systems have arisen from an approach in which a fire alarm company has been responsible for the design of the fire detection system while a sound systems company has been responsible for the design of the VA system. The result, in such cases, has sometimes been a package that, in various respects, has failed to provide the integrity and reliability required for a fire warning system.

Clause 6 also discusses issues such as the need to determine whether the VA system is to be used for other purposes.

7 Variations from the recommendations of this standard

This clause includes recommendations for the recording of variations at design, installation and commissioning stages. It has been introduced here to keep the order of sections similar to those in BS 5839-1.

Section 2 – Design considerations

8 Relationship between system type and evacuation plan

The purpose of this clause is to give some guidance on the types of VA systems that would be appropriate for different buildings, with differing evacuation strategies. Since the Code does not set out to define the exact system needed for any specific building, most of the clause consists of commentary. Recommendations include the need for a risk assessment to determine the appropriate type.

9 Interface with the fire detection and fire alarm system

This clause formed part of a 'General' clause in the original version of the Code. However, it is an essential and critical part of a VA system and has now rightly been written as a separate clause. Recommendations for the link included in the 'old' Code are retained but there is a new recommendation for greater protection against complete failure of the link.

10 Systems in explosive gas or dust atmospheres

Originally introduced under Amendment No. 1 as a subclause of 'General' in Section 2 of the original Code, this individual clause now follows the pattern in BS 5839-1.

11 System components

This new clause lists the standards to which components of a VA system should conform. None of these standards were published at the time of publication of the previous edition of this Code. Their existence has now enabled many of the product-related recommendations in the original version of the Code to be replaced by simple references to them.

12 Monitoring, integrity and reliability of circuits external to the voice alarm control and indicating equipment (VACIE)

The recommendations in this clause are now divided into two subclauses, 'Fault monitoring' and 'System integrity', for clarification. All aspects of fault monitoring are addressed, including the monitoring of the critical link between the fire detection and fire alarm system and the VA system. Advice is also given on the location at which fault indications should be given.

The clause gives very detailed advice on the nature of the failures within the system that should be indicated, as well as describing the form of indication that should be provided.

The 'System integrity' section covers such aspects as the need or otherwise for duplication of loudspeaker circuits.

13 Loudspeaker zones

This clause effectively introduces the concept of 'emergency loudspeaker zones'. Particular attention is given to the need for acoustic separation between different loudspeaker zones and the relationship between boundaries of emergency loudspeaker and fire detection zones.

14 Loudspeakers

Factors to consider in selection of the type, number, location and orientation of loudspeakers are contained within the commentary. Also, in this version of the Code, more recommendations are made regarding, for example, loudspeaker mounting arrangements. With regard to types of loudspeaker, the annex included in the previous version of the Code has not been retained because it was not considered to be of much benefit to those who would normally design VA systems.

Consideration is given to the protection of loudspeakers against fire. In this respect, the Code offers advice beyond that offered in respect of conventional alarm sounders in BS 5839-1, and additional to the requirements of BS EN 54-24.

15 Voice sounders

In recognition of their increased usage, voice sounders are now covered by this main clause in the new version of the Code. Guidance, including some caveats, is given on the appropriateness of voice sounders for certain applications, and recommendations are made for attention-drawing signals, voice recording, etc.

16 Power amplifiers

This clause is particularly important for the system designer since it defines the extent of resilience that should be provided to cater for the failure of a power amplifier. Reference is now made to the need for a risk assessment to determine whether standby amplification is required. This is because the Code now recommends that power amplifiers used in VA systems should conform to the requirements of BS EN 54-16, possibly precluding the need for standby amplifiers.

17 Ambient noise sensing and compensation controller (ANS)

This clause describes the facility that can be provided to adjust VA broadcast levels as background noise levels vary. Potential applications for the facility are described, along with safeguards to ensure that the provision of this facility cannot detract from system performance in the event of unforeseen circumstances.

18 Emergency microphones

The Code now recommends that emergency microphones (referred to as ‘fire microphones’ in the original version) should conform to the requirements of BS EN 54-16 (in which emergency microphones are deemed to be part of the voice alarm control and indicating equipment (VACIE)). However, an increased number of recommendations are included in the new Code, particularly relating to microphone location and environment.

19 Emergency message generators

This short clause contains very important recommendations, which have major implications for equipment design. Fault monitoring of message generators is now covered in BS EN 54-16.

20 Emergency messages

Clause 20 makes recommendations for the format of the messages that should be used, whether pre-recorded or live. Specific formats, timings and examples of wording are offered for evacuate, alert and coded alert broadcasts, as well as test messages.

21 Audibility of non-speech broadcast

This new clause reflects the extension of the scope of the Code to include non-speech emergency 'broadcasts'. The recommendations also apply to the attention-drawing tones that precede emergency voice messages. Recommendations are similar to those set out for attention-drawing tones in the previous version of the Code. However, various explanatory notes, derived largely from BS 5839-1, are included.

22 Intelligibility of speech messages

Since audibility of non-speech broadcasts is dealt with separately in the new version of the Code, this section now relates purely to voice messages. The concept of 'intelligibility', which is, of course, unique to warning systems that broadcast speech messages, is introduced. Recommendations related to clarity and audibility, as components of intelligibility, are given. Guidance is also given on factors that can assist in the measurement and optimization of intelligibility. The Code recognizes that, where acoustic surroundings are difficult, objective measurement of intelligibility is likely to be needed.

This clause is, therefore, the foundation for VA system performance; many other clauses within the Code are concerned with engineering issues, with a view to optimizing integrity and reliability, but, from the point of view of the user, it is the recommendations within this clause that will ensure that the system performs well as a warning system.

23 Priorities

This is a short clause that makes recommendations in respect of the priorities that should be attached to different event messages.

24 Voice alarm control and indicating equipment (VACIE)

With the advent of BS EN 54-16, it has been possible to remove much of the detail that was in the Control equipment clause of the previous version of the Code. However, there is a need to address the 'options with requirements' in that standard; recommendations for their use in VA systems in the UK are therefore included in the new version of the Code.

This clause includes a number of recommendations for siting of VACIE.

25 Networked systems

Following the introduction of a similar clause in BS 5839-1:2002 and retained in BS 5839-1:2013, the increasing prevalence of networked systems in large buildings is recognized in this new clause. Recommendations for network cable and system response times are included.

26 Power supplies

Here again, the clause is analogous to the corresponding clause of BS 5839-1. It is therefore now divided into three parts, covering mains supply, VA system power supply units and standby power supplies. In addition to the referred need for the power supplies to conform to the recommendations of BS EN 54-4, there are numerous systems-related recommendations.

Calculation of standby battery capacity is more complex in the case of a VA system than for a fire detection and fire alarm system. Accordingly, Clause 26 supplements the advice contained in BS 5839-1, particularly in respect of standby battery calculations. An entire informative annex is dedicated to the calculation of standby battery capacities.

27 Cables, wiring and other interconnections

Again, this clause relies substantially on the recommendations of Clause 26 of BS 5839-1. The text now reflects this section of BS 5839-1 including, for example, recommendations for the use of standard and enhanced fire resisting cable. Newly modified recommendations relating to conductor diameters, etc. allow the use of Cat 5 fire-resisting data cables in modern networked systems.

28 Radio-linked systems

This is a clause that was not included in the previous version of the Code. It recognizes that components such as microphones and loudspeakers may be radio-linked to VACIE and that sections of VACIE may be interlinked by radio signals. Recommendations are given *inter alia* for power supplies, associated cables, communication, fault monitoring and radio surveys. Modifications to recommendations now avoid conflicts with BS EN 54-25.

29 Climatic and environmental conditions

This short clause deals with such matters as siting, safe mounting and robustness of VA equipment.

30 Radio and electrical interference

Now much expanded in the current version of the Code, this clause contains similar information to that in Clause 28 (Electromagnetic compatibility) of BS 5839-1. Recommendations are given for cable screening and earthing.

31 Electrical safety

Again derived from BS 5839-1, the short list of recommendations is clear-cut and simple. There is a detailed commentary, supported by two diagrams, that provides guidance on protective and functional earths.

Section 3 – Installation

32 Responsibility of installer

The recommendations in this clause comprise a list of practical points regarding actual installation of components and wiring. The particular drawing and documentation needs are also highlighted. (Clauses 32, 33 and 34 of this version of the Code mirror Clauses 36, 37 and 39, respectively, of BS 5839-1.)

33 Installation practices and workmanship

Installation techniques are covered here, with the accent on cabling.

34 Inspection and testing of wiring

Recommendations of this clause are almost entirely given over to testing of wiring and the need for test records.

Section 4 – Commissioning and handover

35 Commissioning

Within the recommendations of this clause, there is a long and useful list of commissioning, inspection and tests that should be carried out on a typical VA system.

36 Documentation

The recommendations of this clause include the provision of certificates, operation and maintenance manual, and as-fitted drawings.

37 Certification

This short clause gives guidance on the types of certificate that would be applicable to particular works.

38 Acceptance

The recommendations of this clause spell out, as guidance to the user or purchaser, the criteria for acceptance of a VA system.

39 Verification

Guidance is given here as to when verification of a system is necessary or desirable and how such a process should be carried out.

Section 5 – Maintenance

40 Routine testing

Recommendations of this clause include minimum routine tests needed to check operation of the various types of system, appropriate test broadcasts and test records.

41 Inspection and servicing

Following the format of the equivalent clause in BS 5839-1, this clause contains a comprehensive list of recommendations for routine maintenance. There are three lists of checks needed to be made at intervals of: three months, six months and one year, respectively.

42 Non-routine attention

This is a long and detailed clause that sets out recommendations for servicing/maintenance actions to be taken:

- after a change of maintenance organization;
- in the event of repair of faults or damage;
- in the event of modification work;
- after a fire; or
- after a long period of disconnection.

Section 6 – User responsibilities

43 Premises management

There is a need for the appointment of a responsible person to oversee all aspects of a VA system. The recommendations form a list of the duties of such a person. (In the previous edition of BS 5839-8, this person was described as the ‘responsible person’. However, this person, is not the ‘Responsible person’ on whom duties are imposed under the Regulatory Reform (Fire Safety) Order. That Responsible Person is usually a body corporate, whereas, in the case of BS 5839-8, the person would generally may be a premises manager, building services engineer or similar.) To avoid confusion of terminology, the term ‘Responsible person’ is no longer used in the Code, reference being made instead, where required, to 'premises management'.

44 Logbook

This clause identifies the need for a logbook to be available and includes details of the records to be kept in it.

Annexes

Annex A (Informative) – Typical ambient noise levels and their effect on system design

This annex contains useful information on how ambient noise should be measured and includes two tables. The first table gives an example of design data for a sound system in a hotel. The second table lists typical ambient noise levels in various environments, from very quiet to very loud.

Annex B (Informative) – Voice alarm control and indicating equipment

A useful description of the functioning and make-up of a VA system starts this annex. There is also a list of relevant 'options with requirements' appearing in BS EN 54-16. These are all cross-referenced to the relevant subclauses of that standard.

Annex C (Informative) – Standby battery calculations

In the previous version of the Code, the information in this annex was split into two sections: one in the main body of the Code and the other as an annex. Now, all the information is contained in one place. However, as before, detailed guidance is given, with a worked example, on calculation of the battery load current. The calculation is much more complicated than in the case of a fire alarm system using conventional sounders, because a typical emergency message is actually a composite of periods of silence, attention drawing signals and voice. Calculation formulae now include a variable for amplifier efficiency, to allow for, for example, Class D power amplifiers.

Annex D (Informative) – Model certificates

This annex includes suggested formats for certificates covering separate design, installation, commissioning, acceptance, verification, inspection and servicing, and modification.

6. Defining the terms

Because a VA system is an audio system, the Code contains audio terms that may be unfamiliar to some in the fire industry. A number of definitions therefore appear in Clause 3 of Section 1. Although most of the definitions are of audio terms, others are included to prevent ambiguity.

The following list gives the definitions set out in the Code, but with explanatory comments in each case, where considered necessary.

acoustically distinguishable area (a.d.a) subdivision of an emergency loudspeaker zone characterized by an individual reverberation time and ambient noise level

NOTE This may be an enclosed or otherwise physically defined space.

This is a useful term when considering types of loudspeaker to be used in a system.

ambient noise ambient sound pressure, expressed in dB, normally present in an a.d.a., measured using the equivalent sound pressure level, $\mathbf{L_{Aeq,T}}$ or $\mathbf{L_{A10,T}}$, depending on the nature of the noise.

This is a new definition, added for clarification.

area of coverage area, inside and/or outside a building, where the voice alarm system meets the recommendations of this standard

It is necessary that the area of coverage be clearly defined, for two reasons:

1. The designer needs to know where to allow for loudspeakers, making sure that the VA system is neither under- nor over-specified.
2. When the system is commissioned, intelligibility needs to be assessed over the specified listening area.

attention-drawing signal	tone which precedes either an alert or evacuate message when the system is automatic and put in emergency broadcast mode by the detection system

This is the tone that precedes a recorded emergency message, rather than the ‘pre-announcement tone’ that precedes a live voice broadcast.

audibility	property of sound which allows it to be heard among other sounds

Audibility is not the same as intelligibility. In fact, audibility is a necessary component of intelligibility; in other words, if a speech message is intelligible, it must be sufficiently audible. See also the definition of intelligibility.

automatic mode	mode of operation of a voice alarm system which does not require manual intervention
clarity	property of a sound which allows its information-bearing components to be distinguished by the listener

NOTE 1 It is related to the freedom of the sound from distortion of all kinds.

NOTE 2 There are three kinds of distortion that can reduce the clarity of a speech signal in an electroacoustic system:

a) amplitude distortion, due to non-linearity in electronic equipment and transducers;
b) frequency distortion, due to non-uniform frequency response of transducers and selective absorption of high frequencies in acoustic transmission;
c) time domain distortion, due to reflection and reverberation in the acoustic domain.

This, together with audibility, is a component of intelligibility.

critical signal path all components and interconnections between every fire alarm broadcast initiation point and the input terminals on, or within, each loudspeaker enclosure or other alarm warning device

In a conventional fire detection and fire alarm system, there is, of course, a critical path for the signals from detectors or manual call points through the fire panel and out to the bells or sounders. Now also defined in BS 5839-1 (in relation to fire detection and alarm systems), the term ‘critical path’ is convenient for a VA system because the path of the audio signal passes through many stages from microphone or message generator to the loudspeakers. It is an amplified version of the low-level input audio signal itself that must reach the loudspeakers to provide the broadcast message.

emergency loudspeaker zone part of the area of coverage to which emergency information can be given separately

The important type of loudspeaker zone for a VA system is an emergency loudspeaker zone, as opposed to a non-emergency loudspeaker (or PA (see later definition)) zone. As explained later, in Chapter 15 of this Guide, emergency loudspeaker zones should not be confused with fire detection zones; emergency loudspeaker zones are, in fact, similar to the areas covered by sounder circuits in conventional fire detection and fire alarm systems. A large building will probably be divided into many loudspeaker zones.

emergency microphone microphone dedicated for use by the fire and rescue service or other responsible persons as part of a voice alarm system

This microphone will normally be the highest priority input to the VA system, overriding any automatically triggered emergency messages, as well as all non-emergency messages. It is to be distinguished from any microphones used merely for paging or other non-emergency broadcasts.

There may be more than one such microphone in a system and, if so, the emergency microphones can have equal or different priority levels, taken as a group.

emergency mode status of a system whereby emergency messages (either live or pre-recorded) are broadcast

NOTE 1 If the system is in manual mode, all emergency messages would be preceded by a pre-announcement tone. If the system is in automatic mode, all messages would have intervening tones between the messages.

NOTE 2 If the system is used for broadcasting sounds other than emergency messages and tones, the sources of such non-emergency broadcast are to be disabled for the whole period of the state of emergency.

equivalent continuous sound pressure level $L_{eq,T}$ twenty-fold decimal logarithm of the ratio of the root mean square (RMS) sound pressure level for a given time interval to the reference sound pressure, where the RMS sound pressure is determined with a standardized frequency weighting.

NOTE 1 The A-weighted time-average sound pressure level is notated $L_{Aeq,T}$, where T is the time interval.

NOTE 2 BS EN 61672 gives further information regarding the requirements for sound pressure measurements.

This new definition is to assist in the measurement of audibility.

intelligibility	measure of the proportion of the content of a speech message that can be correctly understood. *NOTE Satisfactory intelligibility requires adequate audibility and adequate clarity.*

This is perhaps the most important factor in a VA system. The whole of the broadcast emergency message must be understood for the system to be effective. Assessment of intelligibility can involve merely a listening test or, particularly in cases where there is doubt as to its adequacy, objective measurements. Those measurements are in units such as STI, Alcons, PB word scores, etc. (See Chapter 19 of this Guide.)

listener	person of normal hearing within the area of coverage and able to understand the speech message broadcast

This is included for clarification should there be a dispute as to who should be able to understand the broadcast messages in the listening area.

loudspeaker circuit	transmission path to an assembly of loudspeakers supplied from the same control equipment and protected against over-current by the same protective device(s) or current limitation arrangements

This definition has been added to clarify the difference between loudspeaker zones and loudspeaker circuits.

manual mode	operator-controlled broadcast of live or pre-recorded sounds
maximum alarm load	load imposed on the power supply of a voice alarm system under emergency conditions

NOTE This will normally comprise the power required for simultaneous operation of all voice alarm loudspeakers, all VACIE, all emergency microphones and any external alarm devices, such as visual warning beacons, driven from the voice alarm system.

Account must be taken of the maximum alarm load in, for example, determining the capacity of standby batteries.

noise measurement ($L_{A10,t}$) noise level exceeded for 10% of the measurement period with 'A' frequency weighting calculated by statistical analysis over a representative period, *t*.

Measurement of ambient noise is often required to help determine the sound pressure levels needed for alarm audibility.

non-emergency mode status of a system whereby non-emergency sounds are broadcast

NOTE Typically the non-emergency broadcast would be background music, paging or operational messages.

PA zone sub-division of an emergency loudspeaker zone also used for non-emergency broadcasts

NOTE In this context, a PA zone might be used for any kind of non-emergency broadcast, such as music.

pre-announcement tone short tone or series of tones broadcast before each live message

Although the terms 'attention-drawing tone' and 'pre-announcement tone' are nearly synonymous, in the Code, the former is used for a tone preceding a recorded message and the latter for a tone preceding a live message.

premises management — persons having day-to-day control of the premises, the fire and voice alarm systems and implementation of the fire procedures

NOTE In large premises, a single person with specialist knowledge is often delegated the responsibility for the fire alarm system and associated matters. In small premises, a person with specialist knowledge is unlikely to be present, but responsibility for the fire alarm system can still be delegated to a specific 'delegated person'.

This definition is in place of the no longer used term 'responsible person'.

reverberation time RT — time in seconds required for the average sound-energy at a given frequency to decay by 60 dB after the sound source has been stopped

This additional definition is included because RT is referred to in clause 14 on loudspeakers.

transmission path — physical connection between sound system components (external to the cabinet of the component) used for the transmission of information

NOTE This could include audio and/or power.

voice alarm control and indicating equipment VACIE — component or components of a voice alarm system through which other components may be supplied with power

NOTE 1 VACIE is used:

- *to receive signals from the fire detection and fire alarm control and indicating equipment (CIE),*
- *to manage priority and signal routing from emergency microphone(s) and message generator(s);*
- *to transmit messages to loudspeaker circuits;*

and to provide:

- *if required, manual controls for the selection of loudspeaker circuits;*
- *if required, indicators for identifying which loudspeaker circuit is selected;*
- *message generators and power amplifiers;*
- *if required, emergency microphone(s) for broadcasting live emergency messages.*

NOTE 2 VACIE is also used to monitor the correct functioning of the system and give audible and visible warning of any faults, e.g. short circuit, open circuit, or a fault in the power supply or power amplifiers.

voice alarm system VAS	sound distribution system that broadcasts speech messages and/or warning signals in an emergency

It should be clear from this definition that a VA system is not necessarily used solely for fire emergencies, nor is it essential for the system to include an emergency microphone. Although every VA system must have a facility for the automatic broadcast of pre-recorded emergency messages or tones, its definition in this second edition of the Code no longer includes a reference to automatic messages. However, it must be remembered that, as set out in the Scope, 'Systems that depend solely upon manual intervention are not covered by this standard.'

7. Types of systems and the evacuation plan

On considering the need for a revision of BS 5839-8, information from the marketplace indicated that, although the Code has been available for years, VA system specifications are still sometimes not reflecting the customer's needs. In particular, systems are often over-specified, with unrequired facilities. This factor tends to inflate the prices of VA systems and can result in potential users reverting to the purchase of fire alarm systems using alarm bells or sounders, and thereby losing the advantage of having a speech message capability.

It was decided that categorizing systems would help designers and purchasers to identify the appropriate degree of system complexity for a particular application. There are many variables in a VA system, e.g., number of emergency loudspeaker zones, number of automatically broadcast emergency messages, number of manually triggered emergency messages, number of emergency microphones, whether microphones are 'all call' type or capable of use for broadcasting messages in manually selected areas, sources of non-emergency broadcast, etc. The form of categorization chosen, however, was based upon the degree of manual control needed; the more complex the building, the more likelihood there is that some manual control of the emergency warning system will be required.

Five so-called 'types' of system are described in Clause 5 of the revised Code. (This clause is largely in the form of commentary.) Also, Clause 8 provides a useful correlation of the possible types to buildings' evacuation plans, although it is emphasized that the standard does not recommend which type of system should be installed in any given premises. The following list is an extract of the main content of Clause 5, supplemented by guidance contained in Clause 8.

Type V1: Automatic evacuation

> The objective of the Type V1 system is to offer automatic operation of the voice alarm system against a pre-programmed set of evacuation rules. The system may also have facilities for the manual selection and initiation of non-fire emergency messages, provided that these are automatically overridden by messages initiated from the fire detection and fire alarm system. For example, pre-recorded messages giving warning that a fire alarm test is about to commence and that the test has been completed will be needed unless the building has other means of giving occupants these warnings.

However, no emergency microphones are provided for live voice broadcasts.

This is the type of VA system with the simplest mode of operation in emergencies. However, that does not mean that it will be appropriate only for very small buildings. The evacuation strategy may be two-stage or even, theoretically, multi-stage, where there could be phased evacuation with several different broadcast messages. There could be many emergency loudspeaker zones. In practice, however, it is unlikely that a larger building with a complex structure would not require some form of manual control of voice alarm messages. Clause 8 gives as examples of buildings that might be adequately served by a V1 system: public houses, shop units, factories, schools, hotels, office blocks, cinemas, bus stations and night clubs.

The local VA system in a shop unit forming part of a shopping centre could automatically broadcast emergency messages within the unit in the event of a fire on those premises. This would be considered a V1 system, but landlord's messages, live or pre-recorded, could also be broadcast using the shop unit system.

Of course, many of those buildings on the list of examples might require a more complex VA system (see below).

Type V2: Live emergency messages

> In addition to the automatic facilities provided by the Type V1 system, the Type V2 system provides the facility to broadcast live emergency messages by means of an all-call emergency microphone situated at a strategic control point.

> The objective of the Type V2 system is to allow supplementary live announcements to be made.
>
> NOTE V2 systems may incorporate supplementary all-call emergency microphones at fire and rescue service access points.

Clause 8 gives five different examples of buildings for which a Type V2 system might be appropriate. These comprise a leisure centre, an office building, a multi-screen cinema, a hotel and a shop, school or other building. The examples vary in evacuation strategy and include multi-stage evacuation and staff alarm arrangements. In every case, of course, an emergency microphone is provided for use by a delegated person to override the automatic broadcast messages if necessary.

To avoid the premature cancellation of broadcast messages during a fire emergency, the VA system should latch after being triggered from the fire detection system (see Chapter 9). It is thus necessary for there to be a separate reset signal from the fire detection system to cancel the message broadcast.

Type V3: Zonal live emergency messages

> Type V3 provides, in addition to the functions of the Type V2 system, the facility to broadcast live emergency messages in pre-determined emergency zones or groups of zones.
>
> The objective of the Type V3 system is to permit evacuation control in specific areas of the building where a pre-determined evacuation plan might not cover all eventualities.

To quote Clause 8:

> In buildings which require an emergency microphone and have several emergency loudspeaker zones, such as those with phased evacuation plans, it may be inadvisable to have an all-call emergency microphone facility. In these cases, a V3 system, in which the emergency microphone(s) provides a facility to broadcast to individual zones or groups of zones, is appropriate.

It is assumed, in a building with a V3 system, that there will be a manned control room, e.g. a security room, and that the emergency microphone will be sited there, but it is also pointed out that there may be further emergency microphones at strategic locations, e.g. fire and rescue service access points, if these are considered necessary.

In this case, six examples of buildings for which V3 systems are likely to be appropriate are listed. These comprise a shopping centre, an office building, a large multi-screen cinema, a hotel, a transport terminal and a sports centre. In essence, these are, typically, more complex versions of the buildings listed as examples for a V2 system; in these buildings with V3 systems it is considered likely that there will be a need for live voice emergency messages to be broadcast to some emergency loudspeaker zones but not to others.

Type V4: Manual controls

> In addition to automatic operation and live emergency messaging provided by the Type V3 system, the Type V4 system has the facility to manually select and direct stored emergency messages to individual zones. V4 systems also have the ability to disable or enable emergency broadcast messages and display their status.
>
> The objective of the Type V4 system is to allow well trained and disciplined staff to follow a pre-planned evacuation strategy when the automatic mode needs to be overridden.

V4 systems could be appropriate for buildings with phased evacuation where manual triggering of emergency messages is needed in, for example, successive floors of a multi-storey building. Three examples are given of buildings in which V4 systems would be likely to be appropriate: a high rise office building, a large industrial complex and a large transport terminal such as an airport terminal building. In each case, the building would have a manned dedicated control room that enabled authorized and trained personnel to broadcast any pre-recorded message to any combination of zones.

Type V5: Engineered systems

> Type V5 applies where the application falls outside the scope of Types V1–V4, or wherever a prescriptive solution is either unsatisfactory or where the designers believe that an alternative approach

> is more suitable. It covers tailored solutions based on the assessment of special or mutable risks.

(The reader familiar with the contents of BS 5839-1 may compare a Type V5 VA system with a Category L5 fire detection and fire alarm system, since the *raisons d'être* of the two are similar. However, it is inadvisable to try to stretch the 'V/L' comparison too far since the other 'L's and 'V's do not compare. In fact, an L1 system will be much more complex than an L4 system, whereas a V1 system will be much simpler than a V4 system.)

The comments on V5 in Clause 8 are self-explanatory and are as follows:

> The complexity of certain buildings, combined with the dramatic change of occupancy levels and operational requirements, is likely to require a solution to the evacuation strategy not covered by systems V1 to V4. In such cases, a V5 system would be appropriate.
>
> V5 systems, unlike the other categories, might include a facility to isolate the voice alarm system from the fire detection system. This may be particularly appropriate during periods where crowd control is a prime concern.
>
> A V5 system may include sub-systems of other categories that are normally autonomous but may be controlled to some extent by the V5 system.

The single example of a building for which a V5 system would be appropriate is of a building that would accommodate thousands of people, e.g. an exhibition centre or sports centre 'where the result of an "all call" broadcast is likely to cause fatalities rather than avert them.'

Clause 8 does contain four recommendations.

Probably the most important of these is that an assessment is required to determine the 'risk rating'. From this, the most appropriate evacuation plan can be derived. Guidance is given on what should be taken into account in assessing the risk, namely occupancy factors, the nature of the building and the extent of the life safety risk involved. The evacuation plan and the results of the risk assessment, after being agreed by all interested parties, are to be included in the system documentation. This is an important new recommendation since, up until now, such very useful information has not necessarily been included in, say, a typical VA system's operation and maintenance manual. It is also recommended that the system specification should include the objective of the evacuation plan and how this is to be achieved by the VA system. The final recommendation relates to the need for a shop unit in a shopping centre to have a facility to allow emergency messages from the landlord's fire alarm/voice alarm system to override locally generated messages, but this is really just an example of the need for adherence to a comprehensive agreed evacuation plan.

8. System planning considerations, including exchange of information and responsibilities and variations

Many of the stages in the design and specification of a VA system will simply mirror the stages that would be encountered in the case of a fire alarm system that incorporated sounders; after all, the VA system is simply one, albeit major, component of the overall fire warning system. Accordingly, Clause 6 of the Code, which deals with exchange of information and responsibilities, is quite similar to the equivalent clause in BS 5839-1. Thus, for example, in both codes, recommendations are spelt out for the initial discussions needed amongst the interested parties to ensure that the project runs smoothly. The responsibilities, in this respect, of the purchaser or user, the system designer and any consultants involved are set out, as are those of the parties responsible for commissioning, verification and acceptance of the system. Also, the need for the VA system to follow the evacuation plan is highlighted in the recommendations.

Both BS 5839-1 and BS 5839-8 advise on the need for consultations with interested parties at the design stage. Most of these parties are identical, regardless of whether the fire warning signal is to be given by voice or sounder. However, in the case of VA systems, the Code recognizes that there may be two designers who need to consult, one designing the fire detection and fire alarm system while the other designs the VA system. The Code also recommends that, where appropriate, acoustics engineers or consultants should be involved in the design of a VA system.

The Code advises that it is desirable that one organization should be given overall responsibility for the performance of the total system, formed by the integration of the fire detection and fire alarm system with the VA system. In particular, the responsibilities of the main contractor and all subcontractors should be clearly defined in all relevant documentation relating to the installation. This is a very important piece of advice, which, if it had been followed in the past, would probably have obviated some of the shortcomings in, for example, monitoring of the interconnection between the VA system and the fire detection and fire alarm system.

In the revised Code, the need for the VA system to reflect the evacuation strategy is recommended in Clause 6 but this is now covered in more detail in Clause 8 (see Chapter 7). Similar advice is, of course, given in BS 5839-1, as the same considerations will apply to evacuate and alert messages in a conventional sounder system.

Both BS 5839-1 and BS 5839-8 refer to the potential problem of different alarm signals, relating to different hazards within the same building, and the scope for confusion between fire warnings and warnings of other hazards. In the case of BS 5839-1, it is simply envisaged that these other hazard warnings will be given by totally independent alarm systems. In the case of VA systems, however, the Code acknowledges that the single VA system may be used to broadcast all of the warning signals in question, including those not associated with fire. Therefore, prioritization of alarm signals, which is addressed in BS 5839-1, becomes much more significant in the case of a building in which all alarm signals are broadcast by the VA system. Both codes do also acknowledge that fire may not be the highest priority, although it normally will be so; a possible example is a warning of radiation hazard, which could conceivably be regarded as an even higher priority than fire in certain circumstances.

A further special consideration in the case of a VA system is the issue of whether the VA system is to be used to provide other audio services, such as general paging and background music; the Code recommends that the system should be designed so that these services cannot prevent or delay any fire alarm broadcasts. The use of a VA system for purposes other than fire warning is discussed in Chapter 14 of this Guide.

The Code does not gather together in one subclause all the special considerations that apply in the design, planning and installation of a VA system that would not apply if conventional sounders were used; this is unnecessary, since the Code stands alone in respect of the advice given on these issues, having no reliance on references to BS 5839-1, albeit that some of the material has been reproduced from Part 1. However, in this guide, we set out below a list of such special considerations, based on the recommendations of Part 8, which we hope will be helpful, in particular to those whose experience lies primarily in the design, specification and planning of systems incorporating conventional alarm sounders.

It is considered that the particular factors that the designer must address at an early stage comprise the following (where appropriate, the relevant chapters of this guide are shown in parentheses):

- overall responsibility for the combined system;
- interconnections with the automatic fire detection system: type of interface and engineering requirements;
- whether or not the system is to be used to broadcast other hazard warnings (Chapter 14);
- whether or not the system is to be used for paging and/or background music, etc. (Chapter 14);
- prioritization of applications;
- the possible need for the assistance of acoustics consultants or engineers;
- acoustic information on the building, such as reverberation time and background noise;
- the possible need for additional loudspeaker circuits (Chapter 15);
- the method of loudspeaker circuit monitoring (Chapters 10 and 15);
- the resilience required for power amplifiers (Chapter 16);
- the possible need for ambient noise sensing and compensation (Chapter 17);
- the required level of intelligibility (Chapter 19);
- the need for, and number of, emergency microphones (Chapter 21);
- the possible need for interfaces with other sound systems (which can, of course, occur in the case of conventional alarm sounders).

There are, of course, other more minor considerations that are unique to VA systems, but, in general, although these should be given brief consideration at the design stage, their final specification may not be critical at the very initial stages of the project. Examples include the format and text of the voice messages, the types of loudspeaker used, etc.

Despite all the above being taken into account during design, installation and commissioning of a VA system, variations may be needed for various reasons. As is now the case in BS 5839-1, variations have been allocated a separate clause heading. Clause 7 makes it clear in its recommendations that all variations whether at design, installation or commissioning stages should be clearly identified, agreed by all interested parties and recorded, particularly on appropriate modular certificates.

The commentary to Clause 7 gives guidance on what is meant by the term ‘variation’. Sometimes, recommendations may be unsuitable for a particular system’s application and there are valid reasons for variations. Examples are given of variations that might arise relating to numerical values recommended in the Code, e.g. minimum sound pressure and intelligibility levels, the maximum size of areas in public buildings above which the installation of duplicated emergency loudspeaker circuits is normally recommended, etc. It is also emphasized that the facility of variations is not intended to provide a means for errors, e.g. in design or installation, to become acceptable.

9. Interface between the voice alarm system and the fire detection and fire alarm system

Recent history

The commentary to Clause 9 of the revised BS 5839-8 commences with the statement: ‘The link between the fire detection and fire alarm system and the voice alarm system is of vital importance to maintain the integrity of overall operation.’ This is obviously because the link forms part of the critical path of the combined system. However, there are many other elements in the critical path and the reader may wonder why the link is singled out for special treatment.

The reason for the emphasis is that there was, for a long time (and even now there may occasionally be), a misconception amongst some fire detection and fire alarm system suppliers and installers. They appeared to consider a VA system as a sort of ancillary item not warranting special consideration (with regard to, for example, monitoring for faults). Unmonitored outputs at the fire alarm panel were often provided for the link and not much attention was paid to the type of cable to be used to run to the voice alarm control equipment. Instead, the fire detection company often used to ignore the issue, considering the link as an input to the system provided by the (often separate) voice alarm installer; equally, the voice alarm installer considered it as an output from the fire alarm system and, hence, the responsibility of the fire alarm installer. Fortunately, the original Code addressed this problem, and the revised version has now considered it worthy enough to justify coverage by a complete clause (Clause 9).

Functions of the link

The main purpose of the link is to transmit the alarm signal(s) from the fire detection and fire alarm system to the VA system, thereby triggering one or more automatic emergency messages. In a simple system with single stage evacuation, only one control signal is required for the link to trigger the one evacuate message to be broadcast throughout the building. In large buildings with complex evacuation procedures, however, many control signals might be needed to cope with the initiation of broadcasts in different areas (emergency loudspeaker zones).

Not only is a unique signal required for each loudspeaker zone, but also a different trigger signal for each type of message. If all the signalling emanates from, or terminates at, the central VACIE, this can lead to the link becoming a large multi-core cable. For example, in multi-storey buildings where phased evacuation is employed, there may be many different types of emergency message (e.g. alert and evacuation) and there would certainly be many loudspeaker zones.

There is also a recommendation in the Code that the VA system, once triggered into an emergency broadcast condition, needs to have a positive signal from the fire detection and fire alarm system to silence or reset it. This means that the VA system is effectively latched on when triggered (see below). The consequent separate 'message silence/reset' signal(s) may add to the number of signal channels needed to form the link between the systems.

It is worth commenting here that, although it is possible for the VA system to perform logical operations based upon combinations of signals from the fire detection and fire alarm system, this arrangement is, in practice, used only in large, complex systems. In such systems, the combination of numerous output signals and the 'cause and effect' logic needed is sometimes beyond the capability of readily available fire detection systems' CIE; it is then necessary for the VA system to be specially designed to include the required logic. In such cases, great care needs to be taken to ensure that there can be no conflict between commands from fire detection and VA system for broadcast of different emergency messages (see Chapter 18). However, in most VA systems, there is a separate input signal for every required message/zone combination, e.g. an 'evacuate message to Zone 3'.

The link, however, is not there purely to carry one-way information from the fire detection and fire alarm system to the VA system. There should be an indication at the fire alarm CIE of any fault in the VA system; BS 5839-8 recommends at least a common fault indication. Fault information is therefore passed via the link, from VA system to fire detection and fire alarm system. Sometimes, more comprehensive voice alarm fault information at the fire alarm CIE is specified in large systems, but generally a common indication is quite adequate, because it will lead the investigator of the fault to the VACIE, where comprehensive fault indications are a recommendation of the Code.

It follows that the simplest link conforming to the Code should be able to carry three signals:

- single emergency message trigger;
- 'message silence/reset';
- common VA fault.

In Type V4 systems, however, e.g. where the VACIE is remote from the fire control panel, there is a requirement for manual initiation of emergency broadcasts at that remote VA equipment. Dependent upon the evacuation strategy for the building, the arrangement could lead to confusion if a responsible person (e.g. a fire officer) were at the fire control panel and unaware that emergency broadcast(s) had already been manually initiated remotely. In such cases, it might be desirable for there to be indications at the fire control panel that these manually initiated messages were being broadcast. The revised Code does not appear to address this issue but it would appear to be something to be considered. At least, to avoid confusion, Subclause 24.4.2 recommends that messages initiated from the fire detection and fire alarm system should be capable of being cancelled only at the fire detection and fire alarm system.

System response time

The link forms the interface between the fire detection and fire alarm system and the VA system, thereby creating a combined system. For a conventional 'bells or sounders' fire alarm system, BS 5839-1 calls for a maximum delay of 3 s from the time of operation of a manual call point to the initiation of the audible alarm. However, BS EN 54-2[14] allows this delay to be extended to 10 s. It is now necessary for VACIE to conform to

[14] BS EN 54-2:1998 *Fire detection and fire alarm systems — Control and indicating equipment.*

the requirements of BS EN 54-16, and Subclause 7.1.1 of that standard requires a maximum delay of 3 s for a voice alarm system to respond to a signal from its associated fire detection and fire alarm system. This effectively means that there could be a maximum delay of 6 s from operating a manual call point to the appropriate emergency broadcast, in a combined system to BS 5839-1 and BS 5839-8. If the '3 s delay' recommendation of BS 5839-1 is ignored, and is extended to 10 s to conform to the BS EN 54-2 requirements, then the total delay could be as much as 13 s. The UK reader may feel that this is an excessively long delay and the authors would agree! Likewise, after operation of an automatic fire detector, the broadcast could be delayed by 13 s after activation of the detector but this would be less significant, since the activation time of detectors is difficult to predict.

Type of link

The revised Code now covers radio-linked VA systems and Clause 28 is intended to include the link with the fire detection and fire alarm system. A fibre-optic link could also be used as an alternative.

Nevertheless, in most systems the link still comprises electric cable(s). The simplest arrangement is a number of wire pairs, each driven separately from the fire alarm control panel. This is a so-called 'parallel' connection. Where the fire detection and fire alarm system is of the analogue addressable type (as is increasingly the case), the link can be connected to the VA system via loop-driven 'sounder driver' interface units rather than directly to the fire alarm control panel.

Where a considerable amount of information has to be transmitted via the link, normally in large systems, the use of serial data transmission can make a saving in the cost of cable (and possibly electronic circuitry). Nevertheless, although referred to in the original version of the Code, use of this type of link is still not particularly common. There are at least two reasons for this.

Firstly, if the VA system has a facility for a serial data link, its protocol is not likely to be the same as that required by the fire alarm control panel. This might not apply if there had been, for example, a previous joint design agreement between the two companies involved (or the same company manufactured both types of system). Secondly, many commercially available fire alarm control panels have one serial port only, and it is usually dedicated to a printer.

The link need not be one entity (and in any case normally has to be duplicated – see below). A large installation often has its VA system distributed, i.e. composed of discrete sections of control equipment distributed throughout the building or building complex, and the fire detection and fire alarm system may also be of the distributed type. It may be prudent, in such a case, to link each distributed VA unit locally to each distributed unit of the fire detection and fire alarm system. The 'link' is then a number of links, with a possible consequential reduced risk of total system failure, compared with the use of, for example, just one multi-core link to a central fire alarm control panel.

Integrity and monitoring of the link

Six aspects of this integrity are covered in Clause 9 of the Code. These are: fault monitoring of the link, means by redundancy to prevent a single fault in the link from disabling the interface, preserving the integrity of a detection circuit used for interfacing the link, 'latching' of the VA system, fire protection of the interlinking cable, and conflicting signals in networked systems.

Fault monitoring of the link

As well as being able to transmit the common voice alarm fault referred to above, the link itself (with regard to the triggering of emergency messages) needs to be monitored for short- or open-circuit faults. Since a fault indication is very much more likely to be noticed at the fire alarm control panel (normally near a manned position) than at the main VA control equipment (often located in a more remote position), the monitoring should be undertaken by the fire detection and fire alarm system. Also, the VA system effectively takes the place of sounders connected to the fire detection and fire alarm system; a link failure is therefore equivalent to the failure of a sounder line and would be expected to give a fault indication at the fire alarm control panel.

In practice, for parallel-connected links, monitored outputs from loop-driven interface units are commonly used, or sometimes monitored 'sounder' outputs directly from the fire alarm control panel. The latter, although a normal interface in the case of a conventional fire alarm system, are not used so much for the following reasons:

- Fire detection and fire alarm systems using conventional control panels tend to be installed only in small buildings, where voice alarm is not used, mainly for reasons of cost.
- Fire control panels, whether conventional or analogue addressable, do not always have numerous parallel 'sounder' outputs to drive the links.
- It is normally much more convenient and cost-effective in terms of wiring to install interfaces near to the appropriate VACIE.

Thus, the link is usually DC monitored (see Chapter 10), with end-of-line components at the input to the VA system.

When serial data transmission is employed, there is intrinsic monitoring for transmission integrity. A fault indication will be given if that is impaired and therefore if there is a short- or open-circuit fault in the link.

Redundant links

Although not a clear recommendation in the original version of the Code, it has now been recognized that it is insufficient to have only a single, say a wire-pair, link to trigger an emergency message broadcast. Although an indication at the VACIE (and a common VA fault indication at the CIE) would be given in the event of such a fault, the link is so critical that it is considered unacceptable for it to be out of action until repaired. A means of preventing a single fault in a link from disabling that interface is therefore needed.

This safety feature is normally achieved by running two physical links to provide the same trigger function, i.e. duplication of links. However, alternative arrangements are not precluded, provided that they produce the same result.

This redundancy is not recommended as needed if the VACIE and fire detection and fire alarm system CIE are separated by less than 10 m.

Integrity of detection circuit

Where the link uses an interface unit connected to a detection circuit, removal of a detector from the circuit or any other single fault on that circuit should not affect operation of the link. This is included to prevent link interface units from being isolated by a fault on the fire detection circuit. In practice, this will necessitate installation of short-circuit isolators on each side of the interface unit, immediately adjacent to the unit.

System 'latching'

If the VA system required the continuous presence of a message-triggering signal via the link, the message would cease if the link were cut. Particularly where there is some distance between the VACIE and the fire alarm control panel, there is the possibility that the link's cabling could be open-circuited or short-circuited as a result of fire attacking the cable. The Code therefore recommends that the VA system, once triggered, should continue to broadcast emergency messages even if there is a subsequent fault in the link cabling (much in the same way as the fire alarm control panel latches on receipt of an indication from a fire alarm trigger device).

The above arrangement requires a separate 'silence/reset' signal to cancel the message broadcast.

In practice, the 'latching' and silencing (or 'de-latching') is usually achieved in hardware by the use of relays with electronic latching, bistable (latching) relays or opto-isolators with electronic latching. (It should be noted that all of these methods involve isolation; that is because the power supplies for the VA system and the fire detection and fire alarm system are separate and problems could arise if they were galvanically joined.) Where there is software control within the VA control equipment, 'soft' latching and de-latching can, of course, be used.

An associated point is that higher priority broadcasts should still be available even if the link's cable is faulty. This is to allow, for example, for the use of an emergency microphone.

Cabling

Although the latching arrangement referred to above should allow a message already being broadcast to continue if the link's cabling is damaged by fire, such damage could nevertheless prevent further emergency messages from being triggered, even with the duplication of links also referred to above. The Code therefore recommends that the link should be protected against fire and mechanical damage and should, where practicable, pass through areas of low fire risk. The relevant types of fire-resisting cable are described in Chapter 22.

These comments about the protection of the link's cabling refer to a link between physically separate voice alarm and fire detection and fire alarm control equipment. If, for example, the system were small and both sets of control equipment were contained in the same enclosure, there would not normally be a need to use fire-resisting and/or mechanically protected cable; it could be argued that the interlinking cables were, effectively, internal panel wiring.

Conflicting commands in networked systems

The list of recommendations includes a warning that great care should be taken to avoid the potential for conflicting commands in the design of a networked VA system with multiple links. This is particularly important where there are numerous possibilities for manual or automatic triggering of the broadcast of emergency messages.

10. Fault monitoring, integrity and reliability of circuits external to the VACIE

As the purpose of a VA system is to protect life, it is obviously necessary that all reasonable precautions be taken to ensure correct operation of the system when required in an emergency. To conform to the recommendations of BS 5839-1, a fire alarm system should be tested every week and should undergo a thorough maintenance check at intervals not exceeding six months. This also applies to a VA system, which is, after all, a part of the overall fire warning system. Such tests, whilst very useful, are, however, only periodic. The intent of the Code is that there should be continuous automatic monitoring for the presence of any faults that would directly or indirectly affect the broadcast of emergency messages.

Fault monitoring

The question, 'What does "continuous" mean in respect of fault monitoring?' is often asked. This is because it is fairly common for a monitoring signal in a VA system to be generated periodically, rather than be literally continuous. The answer is that BS 5839-8 recommends, as does BS 5839-1, that any fault condition be indicated at the control equipment within a specified time (see below) of its occurrence. Provided that this response is achieved, the monitoring is deemed to be continuous, even if the monitoring signal(s) involved consist of one or more short-lived pulses within each specified time.

VA equipment, of course, includes many components (such as microphones and loudspeakers) not found in conventional fire detection and fire alarm systems. Hence, the types of faults to be monitored in a VA system are more numerous.

The advent of BS EN 54-16 has resulted in changes to the way in which fault monitoring recommendations are set out in the revised Code. It is assumed that VACIE to BS EN 54-16 will be reliable and of high integrity and will incorporate monitoring of its own constituent parts. Also, the VACIE will include monitoring facilities for external circuitry such as loudspeaker and microphone circuits and interconnections with additional VACIE, if applicable.

For clarity, aspects of system integrity and reliability have now been consolidated with fault monitoring into the single Clause 12. Although described individually in that clause, the recommendations tend to fall into groups, which form headings throughout most of the remainder of this section.

The fault monitoring condition

Presumably to clear any misunderstanding that may have arisen in the past, there is now a recommendation that all fault monitoring, except that for the secondary supply, should continue under conditions of failure of the primary power supply.

Power supply faults

In the original version of the Code, failures of normal power supply, standby power supply and battery-charging equipment were all to be indicated, but only a single common indication was necessary. In the revised Code, following, where appropriate, the recommendations and requirements in BS 5839-1 and BS EN 54-16 respectively, the response times for indication of power supply faults differ; the result of this is generally a relaxation in the response times but the need for several different indicators. This is summarized below.

An indication should be given at the VACIE of the following:

- failure of the main power supply to any part of the system (within 30 min of occurrence);
- failure of the standby power supply (within 15 min of occurrence);
- failure of the battery charger (within 30 min of occurrence);
- reduction of the battery voltage to less than the voltage specified in BS EN 54-4 at which a fault warning should be given (within 30 min of occurrence).

Furthermore, in the case of the standby power supply, the code of practice recommends that there should be means to indicate a fault if one battery in a paralleled combination of batteries is disconnected (or if one cell within a battery becomes short-circuited) within 15 min of occurrence. This is in keeping with the equivalent recommendation in BS 5839-1 and is particularly important in VA systems where batteries are often parallel-connected to cope with the large currents arising mainly from power amplifiers and their load circuits. Disconnection of one battery of the paralleled combination would otherwise almost certainly not be detected, and the duration of the standby supply would have been reduced unacceptably.

The Code makes it clear that the above recommendations apply whether or not the VA system is being used for emergency or non-emergency purposes.

There is also a reference in a note to an optional facility for indication of failure of both normal and standby power supplies (i.e. both being inoperative simultaneously). The idea here is that an audible and visual warning indication would be given for a reasonable period after full discharge of the standby batteries, and in the absence of power from the normal (usually mains) supply. This would draw attention after, say, a weekend break, to the complete failure of the VA system because of local interruption of the normal mains supply. (The green 'supply healthy' indicator would, of course, be extinguished, but its absence would not, in itself, tend to attract attention.) This arrangement, sometimes called a 'tertiary power supply', would require a small battery, normally kept charged.

Fuse failures

Fuses, the rupture of which would prevent emergency broadcast, need to be monitored, such that a fault indication is given at the VACIE within 100 s of occurrence of the fault. For example, if a fuse conducts current to a background music facility and to nothing else, it does not need to be monitored. It has to be said, however, that most fuses in a VA system are in the critical signal path.

Despite that, many fuses do not have to be directly monitored; this is the case if their rupture would cause failure of a component or section of wiring that is already monitored. An example would be a fuse in an output circuit to a loudspeaker line; rupture of the fuse would create an open-circuit condition, which would be detected. On the other hand, rupture of a mains fuse in a power amplifier might still allow the amplifier to operate from the standby supply; in this case, a fault indication would be needed.

Links between components of a distributed VA system

Distributed VA systems, as opposed to centralized VA systems, have their control equipment split into units distributed throughout a building or throughout a site containing several buildings. There might, for example, be one distributed unit per floor of a building. Distributed VA systems may have one or more 'master' units with 'slave' units, or all the interconnected units may be of 'master' status. Either way, secure communication between units is essential for the correct distribution of emergency messages and such links therefore need to be monitored.

Both the audio message signals and associated switching signals passing between units should be monitored, so that the required messages can be broadcast in the required areas. Increasingly, serial data is used for routing of emergency messages (often as well as digitized audio signals); monitoring of such serial data links is then straightforward, since two-way information is being constantly checked as part of the normal signal handling.

The Code recommends that failure of a transmission path between components of a distributed VA system should be indicated at the VACIE within 100 s of occurrence of the failure.

The critical signal path

The critical signal path in a typical VA system is composed of a number of sections, which are not all connected together in the normal non-emergency state of the system. If a critical path were completed from input to output, a message source, i.e. emergency microphone or emergency message generator, would be connected through to the loudspeakers; in other words, the system would effectively be in the 'emergency' mode. (Completion of the critical signal path is, of course, what happens when the appropriate electronic or electromechanical switch(es) operate(s) within the VA system control equipment in response, for example, to the detection of a fire by the fire detection and fire alarm system.) Under revised recommendations, this complete functioning of the VA system (along with the associated fire detection and alarm system) is tested manually on a weekly basis, out of normal working hours, and no less frequently than every three months within normal working hours.

For the above reasons, the critical signal path is normally monitored in sections, and the switches themselves are not operated during the automatic monitoring. Ideally, however, the switches should be constantly tested (because, when operated, each forms a part of the final critical signal path) but to do so adds to the design complexity. (However, there is no recommendation in the Code for this form of automatic testing.)

Generally, to perform the monitoring, an inaudible signal (subsonic or ultrasonic) is fed into a system input at, for example, the emergency microphone, and its presence or absence is then detected somewhere 'downstream'. (Strictly speaking, the signal could be in the audible range, unless monitoring a section of the critical path that includes loudspeakers, but an inaudible signal is generally used for consistency throughout the monitoring process.) Provided that there are at least two switches between the sound source and the loudspeaker lines, these switches could each be closed individually at different times, and two overlapping sections of the critical path tested, each including an operated switch. Because of the design complexity involved, monitoring of the switches in the 'operated' condition is, however, not called for in the Code.

When considering monitoring of the critical path, all attention is often devoted to the audio signal path. It should also, however, be borne in mind that the integrity of the routing control signals, i.e. zone selection, etc., is actually equally important. (This philosophy also applies to the integrity of the 'press to talk' switch at the emergency microphone, and is now recognized by the inclusion of an appropriate recommendation in the revised Code.) In other words, there is not much point in having a perfect audio path for the emergency messages, if you cannot switch them to the correct, or possibly even any, loudspeakers!

Power amplifiers

These days, power amplifiers are designed to be very reliable and generally they are. Of course, they still handle considerable amounts of power and consequently, if one fails, it can prevent emergency broadcast to many, if not all, loudspeakers. In the revised Code, it is recommended that amplifiers conforming to BS EN 54-16 are used. Although, therefore, in the original version of the Code, they were treated as particularly vulnerable to failure and continuous availability of standby amplifier power was recommended, this standby facility is no longer a 'must'. It may nevertheless be needed on the basis of a risk assessment; this is covered in Clause 16 (see Chapter 16).

As should be the case for other components in the critical signal paths, monitoring of a power amplifier for faults is normally achieved by sending the inaudible surveillance signal (previously described) through it and detecting its presence or absence at the output. To facilitate replacement of a faulty amplifier, in the view of the writers, each amplifier should have a unique fault indication. In practice, such indications are often found on the amplifier itself, rather than on a separate monitoring panel. However, the revised Code now reflects the requirements of BS EN 54-16: Subclause 8.2.4e of the standard gives a requirement for indication of amplifier faults only as at least a common general fault, within 100 s of occurrence.

Emergency microphone

The best theoretical way to monitor a microphone is to feed into it an acoustic signal (from an adjacent loudspeaker or other type of transducer) and check that the resultant audio signal is correctly outputted from it. In practice, however, this is awkward to achieve because of difficulties in physically accommodating suitable transducers and in obtaining a consistent sound pressure level at the microphone. Also, in the original version of the Code, monitoring of the microphone capsule for faulty condition was included in the recommendation; however, this is actually very difficult, if not impossible, to achieve with certain kinds of microphones. For these reasons, recommended microphone monitoring in the revised Code is now restricted to an indication of 'failure of an emergency microphone including associated control signal paths and the wiring up to the microphone capsule' to be given within 100 s of occurrence of the fault.

A dedicated 'emergency microphone' fault indication was called for in the original version of the Code. However, this is no longer clearly the case; Subclause 12.1.2 of BS EN 54-16 merely asks for a fault indication to be given after 100 s for a number of different fault conditions, including an emergency microphone fault. Clarification of whether these indications should or should not be dedicated could be usefully given consideration at a future review of the Code.

Emergency message generators

As well as monitoring the integrity of the signal path through a message generator, it is also necessary to check that an actual message can be transmitted. Ideally, because automatic surveillance is envisaged and the message cannot be listened to, it should be continually analysed for exact amplitude and frequency content. This approach, however, is technically elaborate, difficult and, presumably, expensive.

With regard to the revised Code, it appears to be assumed in BS EN 54-16 that the message will be stored digitally in non-volatile memory (which is, in fact, the case). The revised Code now refers to BS EN 54-16 in relation to monitoring of message generators (stores); BS EN 54-16 does not single out message stores for monitoring but, in Subclause 14.6 Monitoring of memory contents, it requires that 'The contents of memory devices containing the site specific data shall be automatically checked at intervals not exceeding 1 h. The checking device shall signal a system fault if a corruption of the memory contents is detected.' This is presumed to apply to the message store.

In the previous edition of this book, methods of checking transmission paths for emergency messages provided by the generators (stores) were described. The authors still consider this to be desirable; however, there appears to be no requirement for it in BS EN 54-16, nor now any reference to it in the revised Code. It is assumed that there was a lack of agreement among the European countries involved to include the comprehensive monitoring of the audio path throughout the various parts of the VACIE, including the path for the automatically generated messages.

There appears no longer to be a recommendation for a dedicated indication of internal message generator faults. That indication will merely be given as a common 'system fault', which is the BS EN 54-16 requirement.

Loudspeaker circuits

To meet the recommendations of the Code, loudspeaker lines should be monitored for short-circuits, open-circuits and earth faults. Contrary to a misbelief that sometimes still exists, there is not a requirement to detect the removal of a certain percentage of loudspeakers from a loudspeaker circuit. Equally, it is essential to detect a fault in the external wiring to any single loudspeaker.

There are many methods of monitoring loudspeaker circuits, but to enter into detail about all of them is really outside the scope of this book. However, it may be worth citing examples of the commonest methods. These are as follows:

- *DC monitoring*. Here, a small DC current is fed through the loudspeaker line, via an end-of-line resistor, in much the same way as a fire detection zone line is typically monitored. It is a simple and reliable method but has the disadvantage that a capacitor has to be fitted in series with every loudspeaker to stop the DC from reaching the low resistance loudspeaker transformer windings.
- *AC monitoring*. There are three common forms of this type of monitoring:
  – *'End of loop' or 'return loop' monitoring*. In this arrangement, the loudspeaker line continues from the last loudspeaker back to the control equipment, forming a wiring loop. An inaudible AC signal is injected into the driving end of the line and detected at the returned end. A high frequency surveillance signal of about 20 kHz is often used.

    This is a simple monitoring method that is suitable for fairly short loudspeaker lines. At 20 kHz, however, the capacitive line impedance is significant for longer lines; this increases the monitoring current, loading the power amplifiers and requiring an increased standby battery capacity.

    At least two further problems can be encountered with 20 kHz monitoring:
    - The transmission line effect, i.e. the presence along the lines of node points at or near which any fault will go undetected. It is dangerous to use this method for line lengths over 500 m.
    - Capacitive coupling effects. Because of the relatively high capacitive reactance involved at 20 kHz, an open-circuit condition in one line conductor may not be detected. This occurs because the monitoring signal is able to bridge the cable conductor break via capacitances to and from an adjacent conductor, e.g. the cable screen. The effect is even more likely to occur if there are adjacent conductors within the same cable sheath. This is a good reason for not using 4-core cables to carry two different loudspeaker lines.

    It should be mentioned that low frequency surveillance signalling is also used for fault monitoring. Frequencies between 20 Hz and 40 Hz are often employed. Whilst the use of this frequency dramatically reduces the line loading problem, the signals' harmonics, or even the fundamental, are sometimes audible where loudspeakers with good low frequency response are used.

- *Impedance monitoring*. This method effectively measures the impedance of the loudspeaker line and interprets a minimum change in impedance as a fault condition. For certain types of system, e.g. those where the number of loudspeakers is not great, is not likely ever to change and where loudspeaker ambient temperatures are very constant, the arrangement may be satisfactory. Where ambient temperatures vary considerably and where changes in the number of loudspeakers, wiring, etc. are likely, such a method can have troublesome side effects because of the associated variation in line impedances. Bearing in mind also the above disadvantages of working with 20 kHz signals, impedance monitoring using high frequency surveillance signalling is very unlikely to be satisfactory for many VA systems. Moreover, it is unlikely to be sensitive enough to detect a fault in the wiring close to a single loudspeaker.
- *'Active' end-of-line monitoring*. Here, an inaudible AC signal is sent along the loudspeaker line and received at an end-of-line device. The receiving device then responds by returning an 'OK' signal to the control equipment. The returned signal can be DC or AC; various commercially available schemes exist. Once again, this arrangement will suffer from line loading effects if 20 kHz is used.

A less common method of monitoring loudspeaker lines involves 'addressable loudspeakers'. Serial data is superimposed on the loudspeaker line and two-way communication occurs between the control equipment and the loudspeakers. The line and, in this case, the loudspeakers themselves can then be monitored in much the same way as detection zone lines and detection devices are monitored in an addressable fire detection system. Such addressable loudspeaker systems, however, tend to be expensive and are mainly used in specialist applications.

The revised Code recommends that open-circuit, short-circuit or earth faults on any loudspeaker circuit, including any spur circuit, should be given at VACIE within 100 s of the occurrence of a fault, regardless of whether the VA system is being used for a non-emergency purpose (e.g. the broadcast of background music) or not. The latter comments reflect the fact that the system is a VA system and should always be ready to broadcast emergency messages if required to.

Other circuits external to the VACIE

The need for fault monitoring of two further types of circuits external to the VACIE is highlighted in the revised Code. These are:

- the transmission paths between components of a distributed system;
- the ambient noise sensing (ANS) control system, if fitted, including ANS microphones and their associated cables (see Chapter 17).

These may not always strictly form parts of the critical path, since, in the case of the former, individual parts of the distributed system may stand alone in the event of a fault in the transmission path, and in the latter case, the ANS may default to a preset gain in the event of a fault. However, it is a good idea always to monitor these functions. The Code therefore recommends that a fault indication be given at the VACIE within 100 s of the occurrence of either type of fault, regardless (as in the case of loudspeaker line faults) of whether the VA system is being used for a non-emergency purpose (e.g. the broadcast of background music) or not.

Microprocessors and software

These form part of the VACIE and monitoring of their integrity and correct functioning is now included in BS EN 54-16.

Fault indication and detection during emergency broadcast

In Subclause 12.1.2 of the Code, there is a note which states, ‘The indication of faults that exist prior to initiation of an emergency broadcast may be suppressed during the emergency broadcast, except where these pre-existing faults might adversely affect any emergency broadcast.’

This is a clearer statement than in the original Code and effectively means that the only faults occurring during an emergency broadcast that need be indicated during that broadcast are short- or open-circuit faults appearing on any loudspeaker circuits (except any fault that cannot be sensed because it is associated with a loudspeaker circuit in use for emergency broadcast at the time).

The link to the fire detection and fire alarm system

This is mentioned here since it is a very important part of the critical path and must be monitored. Because of its unique nature, however, this link, including its fault monitoring, is dealt with in Chapter 9.

Fault warning indications and panel controls

The detail of these controls and indicators is now covered in BS EN 54-16.

System integrity

These subclauses group together recommendations that appeared in different clauses in the original version of the Code. This is definitely a clearer arrangement.

First of all, there is the recommendation that a fault on one circuit should not affect any other circuits. This could apply particularly to emergency loudspeaker circuits.

For those readers conversant with BS 5839-1, there is a familiar ring about the recommendation,

> In the event of a single open-circuit or short-circuit fault in any loudspeaker circuit, at least one loudspeaker, normally located in the vicinity of the control and indicating equipment, should be able to broadcast the emergency message if a fire alarm condition occurs anywhere within the building.

This strictly means that there need to be two emergency loudspeaker circuits in the vicinity of the VACIE, each of which circuits could have a minimum of one loudspeaker connected to it. The purpose of this recommendation is to ensure as far as is reasonable that the emergency message will continue to be heard near the VACIE. There is an assumption that this VACIE is located near a building exit to open air and that anyone trying to enter or re-enter the building would be dissuaded from doing so by the broadcast message.

Subclauses 12.2.3 and 12.2.4 cover recommendations for loudspeaker circuits in buildings designed to accommodate the general public in large numbers. This is covered in Chapter 15 of this book, which deals with loudspeakers, loudspeaker zones and loudspeaker circuits.

New recommendations are included to increase the integrity of power supplies powering the VACIE, where such supplies are in enclosures separate from the VACIE. Connections between the enclosures should be duplicated so that, 'a single open or short-circuit in the connections does not completely remove power from the voice alarm control and indicating equipment. The duplicated cables should be separated by at least 300 mm where practicable.' Another recommendation calls for over-current protection to BS 7671[15] for any cable connecting VACIE to a separate associated power supply unit or standby battery. It is, however, made clear in a note that these recommendations do not apply where the VACIE and power supply/battery enclosures are in contact with one another.

[15] BS 7671 *Requirements for electrical installations — IEE wiring regulations.*

11. Typical arrangements of voice alarm systems

So far, we have looked at various aspects of VA systems, with some limited comments upon their functioning. Before going into more details about components such as microphones, amplifiers and loudspeakers, this therefore seems a good point at which to describe some common arrangements of VA systems.

Basic VA systems

In its simplest form, a basic version of a Type V1 system, a VA system has no emergency microphone and only a single emergency message generator, automatically triggered via a link from the associated fire detection and fire alarm system. Theoretically, the minimum number of loudspeakers is two. In practice, however, it would be unusual for a VA system with only two loudspeakers to be installed. Despite its simplicity, such a VA system would still have to be fully monitored for faults (see Chapter 10) and its normal power supply battery-backed, with all the associated costs.

Figure 11.1a shows a basic VA system. As can be seen, a signal (often a simple contact closure) from the fire detection and fire alarm system causes the emergency message generator to broadcast its message via the power amplifier(s) to the loudspeakers. The 'fault monitoring point' symbols are shown at indicative strategic locations along the critical signal path; dependent upon, for example, the type of power amplifier, there might be more monitoring points in an actual system.

Usually, there will be a requirement for a mains-driven power supply to provide DC to operate, e.g., the emergency message generator/store. Sometimes, moreover, the power amplifiers themselves will operate from the same or a separate DC supply. Whatever the mix of 'mains-fed' or 'DC-fed' system components under normal power supply conditions, they will all need to be arranged to operate from batteries (usually 24 V DC) should the mains supply fail. Hence, the two types of power supply are shown in the figure. It is assumed that the battery charger includes automatic switching from normal to standby supply.

Figure 11.1a also illustrates a simple way of automatically switching in a standby amplifier via relay contacts, although this would not normally be needed except on the basis of a risk assessment.

Another interesting point is that three power amplifiers are shown. BS 5839-8 recommends that there should be a means of ensuring that at least one loudspeaker at or near the control equipment continues to broadcast under emergency conditions, even if there is a short circuit on one loudspeaker circuit. In Figure 11.1a, an independent amplifier drives that loudspeaker, thereby conforming to the Code. The alternative arrangement shown in Figure 11.1b uses one amplifier only to drive both the main and the single loudspeaker circuit. However, to meet the BS 5839-8 recommendation in this case, as well as being monitored independently for open-circuit line faults, each of the two loudspeaker circuits must be automatically isolated from the other (and from the power amplifier) in the event of a line short-circuit. A common method of achieving this is to isolate the faulty line by opening relay contacts in response to detection of the short circuit; this method is illustrated in Figure 11.1b.

Theoretically, one loudspeaker 'loop' could be used to serve the same purpose, with short-circuit isolators detecting a short-circuit condition on a section of the circuit and then isolating it, but allowing the remaining loudspeaker(s) to be driven from both ends of the loop. This technique, similar to the short-circuit isolation found in fire detection and fire alarm system addressable detection loops, may be used in the future, when the technology needed is available at reasonable cost. (More details of loudspeaker circuits and, incidentally, types of loudspeaker, are given in Chapter 15.)

Details of controls, indicators and other aspects of voice alarm control equipment form the subject of Chapter 12. Nevertheless, it is worth commenting here that the control equipment for such a simple VA system would be expected to be contained in one compact enclosure, almost certainly including the standby battery and its charger. Also, there would be no 'operator controls', since the broadcast of emergency messages would be triggered and cancelled from the associated fire detection and fire alarm system.

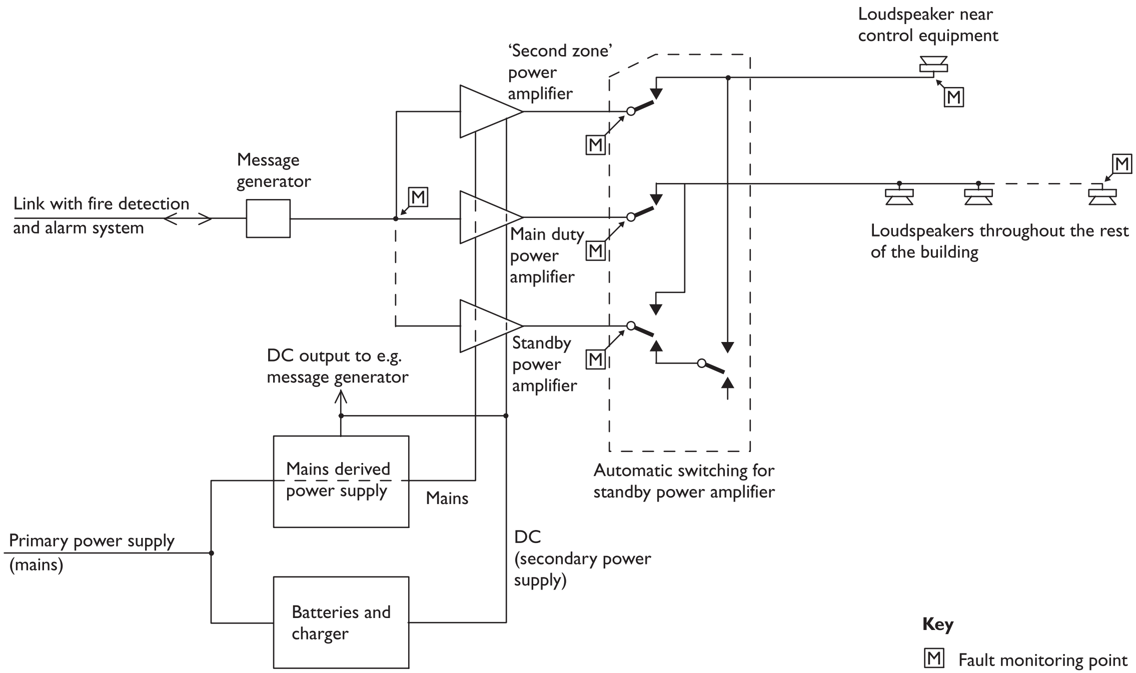


Figure 11.la — Basic voice alarm system (using three power amplifiers)

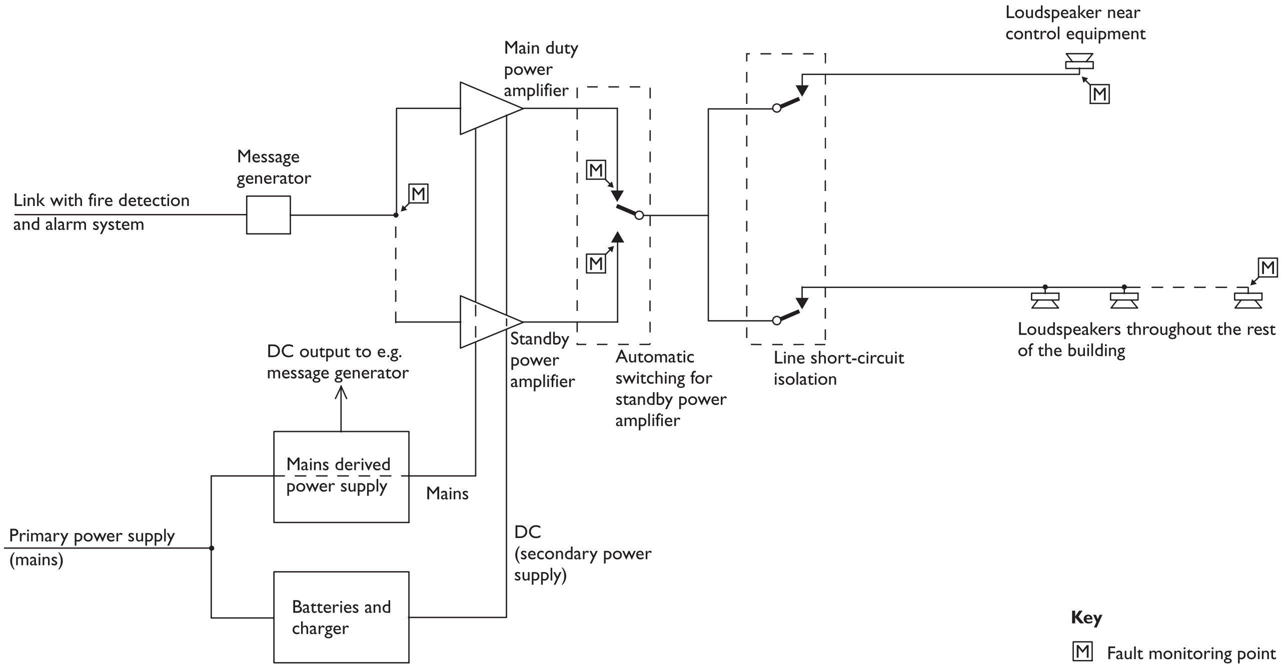


Figure 11.1b — Basic voice alarm system (using two power amplifiers)

Likewise, wiring is covered in a later chapter (Chapter 22). Because of the small number of external cables required for this 'minimum system', loudspeaker cables would generally be terminated directly at the control equipment, without the need for an intermediate junction or marshalling box.

Typical medium-sized VA systems

The VA systems illustrated in Figures 11.2a, 11.2b and 11.2c are more typical. Here, there are several 'secure sound sources', viz. emergency microphone, 'evacuate' message generator, 'alert' message generator, etc. Simultaneous broadcasts from more than one of these sources will often be required during an emergency condition, for example, an 'evacuate' message in one area and an 'alert' message in several other areas. These areas are referred to as emergency loudspeaker zones and are dealt with in Chapter 15. The signal routing required to allow any emergency message input to be broadcast to any number of zones, simultaneously with a number of other messages, can become quite complex when the number of inputs (sources) and outputs (loudspeaker zones) is large. One method of achieving this routing is to use a switching matrix, which may consist of relay contacts or, increasingly, of electronic solid-state switches. When solid-state switching is used, control of the matrix is normally digital and often microprocessor-controlled.

Figure 11.2a illustrates a system that uses a switching matrix. The switching controller responds to alarm signals from the linked fire detection and fire alarm system, causing pre-programmed combinations of zones to receive appropriate emergency broadcasts.

It also responds to manual zone selections from the emergency microphone unit/console. There is an in-built priority structure for the broadcasts, normally such that the emergency microphone is highest, then 'evacuate', then 'alert', and so on down to, for example, a 'test' or other non-emergency broadcast as lowest priority (see Chapter 14). As can be seen, there are many fault-monitoring points in the system. In fact, dependent upon the actual design, there may be even more monitoring points than shown in the diagram.

The structure of the VA system shown in Figure 11.2a is usually referred to as an 'input switching' arrangement, since the power amplifiers are fixed, i.e. each dedicated to a particular loudspeaker zone. Incidentally, to simplify the diagram, one power amplifier is shown connected to one loudspeaker circuit for each zone; in practice, however,

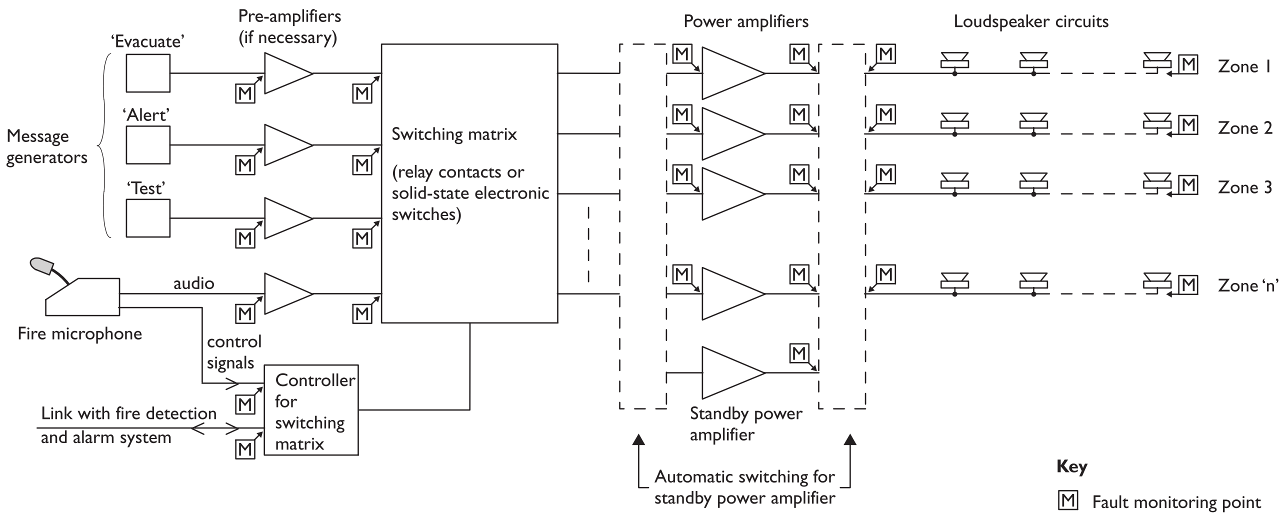


Figure 11.2a – Typical voice alarm system (using zonally dedicated power amplifiers and input switching)

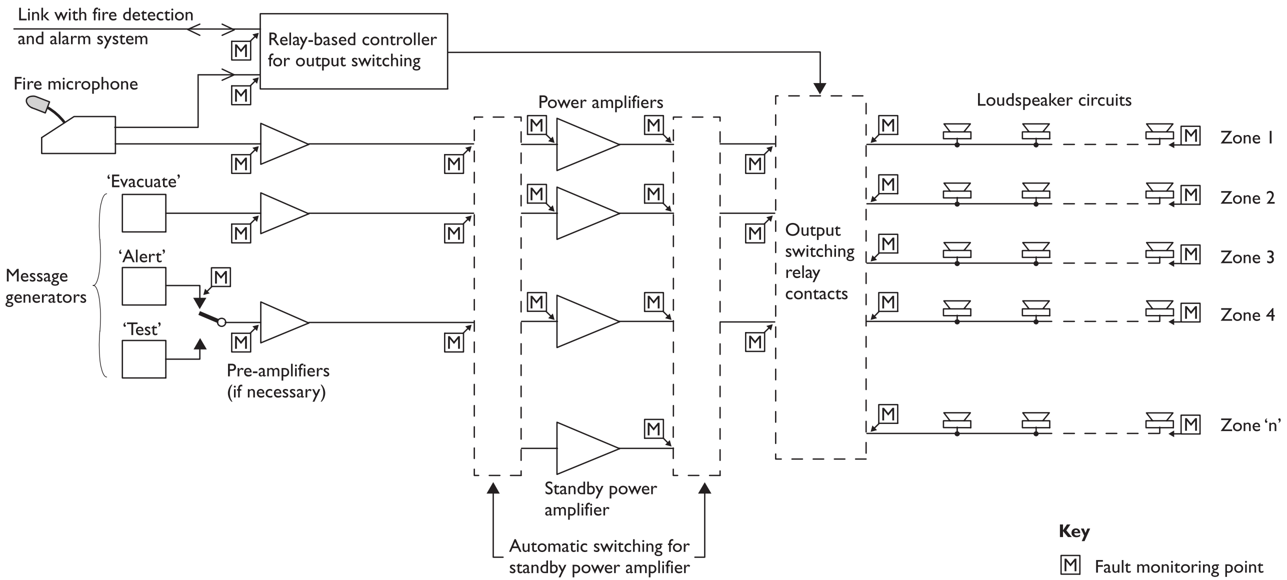


Figure 11.2b – Typical voice alarm system (using input channel dedicated power amplifiers and output switching)

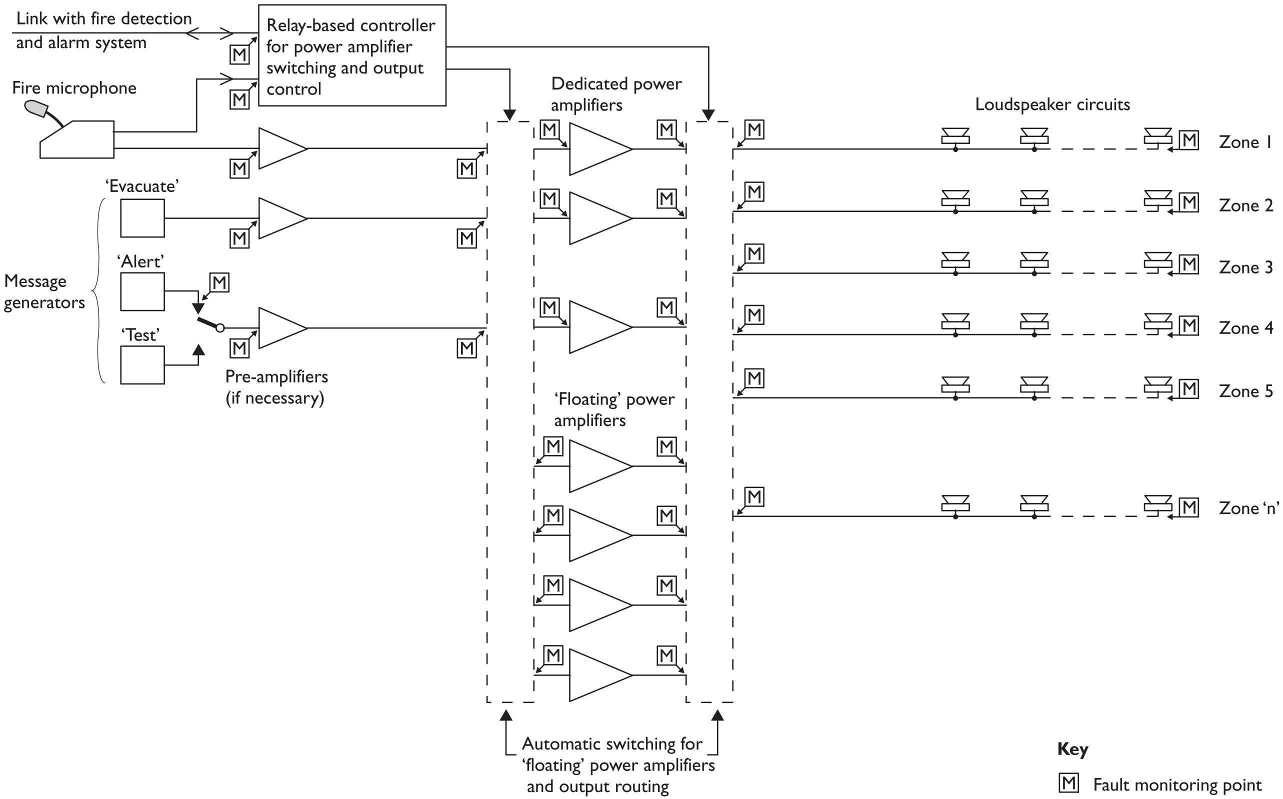


Figure 11.2c — Typical voice alarm system (using 'floating' power amplifiers and output switching)

two or more amplifiers could be paralleled to meet a larger power requirement for any particular zone and/or the zone could have more than one loudspeaker circuit connected to the amplifier(s). In the latter case, also, each loudspeaker circuit could be connected to an individual amplifier of a paralleled combination, each amplifier being driven from the same audio source. This ‘multiple loudspeaker circuits’ concept offers advantages in certain circumstances and is covered in more detail in Chapter 15. Power supplies, normal and standby, are not shown here or in Figures 11.2b or 11.2c but are of course required; their arrangement would be similar to that shown in Figures 11.1a and 11.1b.

An alternative approach to the design of a typical VA system is shown in Figure 11.2b. In this case, there are dedicated input channels, very often emergency microphone, ‘evacuate’ and ‘alert’; often the ‘alert’ channel is used also for non-emergency broadcasts such as the ‘test’ function illustrated. Zone selections for broadcast are all made after the power amplifiers and the arrangement is therefore referred to as ‘output switching’. This output routing is traditionally implemented using relay switching, as shown, with the relays controlled both from the fire detection and fire alarm system and from the zone selection switches at the emergency microphone. The priority structure referred to above must also apply with this arrangement and it is normally implemented within the output relay switching. Standby power amplifier switching, if required, is carried out in the same way as for the system shown in Figure 11.2a.

Figure 11.2c illustrates a third design approach. In this case, there is at least one power amplifier dedicated to each input channel; often, there are two parallel-connected power amplifiers per channel. A number of so-called ‘floating amplifiers’ are kept in a powered-up state and continuously monitored for faults. They are switched into use for broadcasting purposes by sets of relay contacts or appropriate electronic switching, the switches or relays being controlled from the link with the fire detection system and from the emergency microphone zone selection switches. Floating amplifiers are switched into use only when the power outputs of the dedicated amplifiers are insufficient for the loudspeaker loads they have to drive. This concept is probably best understood by the use of an example, as follows. Let us assume that the dedicated power amplifier for the emergency microphone channel is rated at 200 W, loudspeaker circuit no. 1 has a loudspeaker load of 142 W and loudspeaker circuit no. 2 has a loudspeaker load of 136 W. Then, if the emergency microphone is called upon to broadcast to loudspeaker zone 1 only, the dedicated 200 W amplifier will easily meet that load requirement of 142 W and it will not be necessary for a floating amplifier to be switched in to boost the loudspeaker drive capability. If, on the other hand, the emergency microphone is required to broadcast to both loudspeaker zones 1 and 2, the loudspeaker load of 142 + 136 W, i.e. 278 W, would overload a single 200 W amplifier and therefore a 200 W floating amplifier needs to be switched in parallel with the dedicated amplifier to give an output drive capability of 400 W.

The system of switching in the floating amplifiers is known as ‘parallel banking’. With this arrangement, instead of having a dedicated standby power amplifier, where required, an ‘extra’ floating power amplifier can be provided so that there is always available one power amplifier more than that required to meet the overall system’s maximum loudspeaker power requirement.

Which arrangement should then be chosen, from Figures 11.2a, 11.2b and 11.2c? They all meet the recommendations of BS 5839-8. In general terms, the system using the fewest power amplifiers would probably be that shown in Figure 11.2c. The main disadvantage, however, of amplifier parallel-banking, with an array of ‘hot’ floating amplifiers, is the number of relays (and their contacts) involved; relay contacts are not ideal for switching low-level signals, as found at the inputs to the power amplifiers, because they can create audible switching noise. Also, the large number of relay contacts, effectively in series, represents a large number of unmonitored switches that must make properly to allow emergency broadcasts to take place. Although the use of a large number of relay contacts does not breach the recommendations of BS 5839-8, it could be argued that the fewer present the better. The input-switching arrangement of Figure 11.2a allows noiseless electronic switching to take place, without the need for simultaneous output switching. Another factor to bear in mind is that the complexity of the switching increases greatly, in the case of the floating amplifier switching arrangement, as the number of inputs increases. The use of parallel banking appears to be less prevalent than at the time of publication of the original edition of this book.

To summarize, for systems with large numbers of inputs and not many outputs, input switching is preferable. Conversely, where there are few inputs and many outputs, output switching is appropriate. Parallel-banked amplifier systems can be used with a cost advantage, particularly where there are many outputs, but account should be taken of the number of relay contacts involved. (If a VA system is specified to exceed the recommendations of BS 5839-8 in respect of critical signal path monitoring, such that switches in the path are exercised under normal non-emergency conditions, then any relay-based output-switched system, including a parallel-banked amplifier system with floating amplifiers, is unsuitable, because the relays would have to be energized and de-energized continually, causing audible clicking noises and reducing the life of the relay contacts unacceptably; a solid-state input-switched VA system should be used instead.)

Voice alarm/public address systems

The VA systems described above have included emergency (or 'test') inputs only. VA systems, however, can also be used for non-emergency broadcasts such as paging and background music. This subject is covered in Chapter 14.

Networked VA systems

So far, every VA system referred to above has been a so-called centralized system (also known as a 'central rack system'). Such a system has all of its VACIE, except any emergency microphone console(s), located in one place in the building concerned, normally fairly centrally in the building in order to minimize the total amount of loudspeaker cable required. For large buildings and even more so for sites containing many buildings, networked systems, also referred to as distributed systems, are often used.

Figure 11.3 shows a networked VA system in block diagram form. In a networked system, the VACIE is divided into a number of individual units, sometimes referred to as outstations. The outstations are often physically identical but they need not be; sometimes they are sized to suit differing loudspeaker loads and zone requirements, in areas throughout the building or complex. Generally there will be a central display and control unit, which will indicate fire and fault conditions site-wide. In large systems a printer may be included, to record events such as fire and fault conditions. There may also be a visual display unit (VDU), which can be used both for display, for example, of exact locations of triggered fire detection devices, and for control purposes, e.g. manual initiation of emergency message broadcasts.

A critical element of a networked/distributed VA system is the site-wide communication link interconnecting all the outstations and the central control and display unit, i.e. all the VACIE. The link is required to handle both control and audio information. Some systems use two or more wire pairs for simultaneous audio transmission, together with

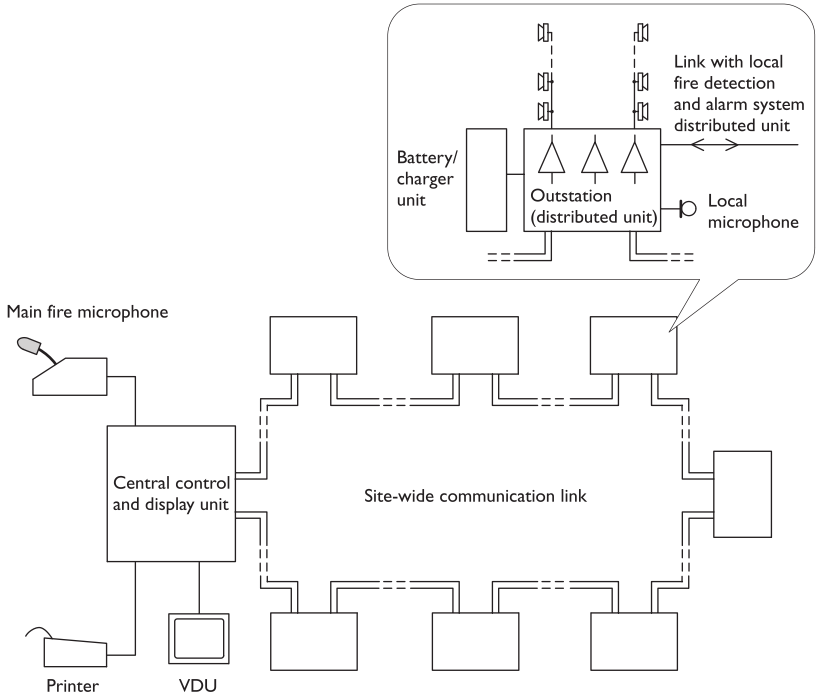


Figure 11.3 — Distributed voice alarm system

another wire-pair for control data. Many large systems employ digital audio techniques, and are thereby able to combine audio and control information via common wiring or, in some cases, via fibre optics. The site-wide communication link generally forms a closed loop and/or has each communication wire-pair duplicated; moreover, short-circuit isolation is often provided, so that, even if one outstation fails, communication will continue amongst all other parts of the system. The link should be monitored for faults to conform to 25.1 of BS 5839-8. (That subclause refers back to Subclause 12.1 for wired networks and Clause 28 for radio networks.)

Many different versions of distributed VA systems are available commercially. There are 'master/slave' systems, where, for example, emergency messages are stored centrally and broadcast via the site-wide link, or, alternatively, messages locally stored in the outstations are triggered by control signals from the central 'master'. On the other hand, 'peer to peer' systems are commonly installed. In these cases, all distributed units are identical but, usually, any one can control any or all of the other units. In practice, one of the units will almost always be programmed to act as a main control unit, possibly with associated printer and VDU.

Although not strictly necessary, provided that there is sufficient integrity built into the site-wide link itself, the recommendations of BS 5839: Parts 1 and 8, regarding integrity of the system, are often met by arranging for each outstation to be a ‘stand-alone’ fire detection and fire alarm system. Thus, should there be a complete failure of the site-wide communication link, all outstations will still operate as individual fire detection and fire alarm systems, albeit without a centrally based emergency microphone facility (although local microphones are often provided, as shown in Figure 11.3). With this arrangement, a minimum of one ‘evacuate’ message generator would be required within each outstation. For practical reasons, each outstation normally has its own standby battery/charger.

Whilst it is possible for the VA system to include the logic associated with distribution of emergency broadcasts in response to differing ‘fire’ inputs, this is normally only the case in larger systems. In practice, the fire detection and fire alarm system is normally itself distributed, and each of its distributed units arranged to provide simple ‘message initiation’ signals to the neighbouring VA system outstation.

Finally, on the subject of distributed VA systems, if a risk assessment determines that failure of any one power amplifier in the VA system should produce no loss of coverage, this would be costly to achieve, particularly where the outstations are small, i.e. they include, say, only two ‘duty’ power amplifiers, each driving a separate loudspeaker circuit. In such a case, the only obvious ways of achieving this are either to provide a ‘hot standby’ power amplifier in every outstation (i.e. three amplifiers per outstation) or to ensure that each of the two power amplifiers has sufficient power to drive both loudspeaker circuits, should one amplifier fail.

Much more attention to recommendations for distributed systems is given in the revised Code than was the case in the original version. Clause 25 of the Code contains the following further recommendations – these are repeated verbatim with comments where appropriate.

> 25.1 The normal operating parameters of the network should be defined and agreed at the design specification stage.
>
> *Note These parameters may include bit error rate (BER), signal latency and jitter.*

This newly introduced recommendation is intended to remind designers that these parameters need to be established at the design outset.

> 25.2 The communications link between subsystems should be monitored in accordance with 12.1 for wired networks and Clause 28 for radio networks.

This newly introduced recommendation makes it clear that both wired and radio networks need to be monitored for possible faults.

> 25.3 A fault on the communications link between sub-systems should not affect the stand-alone capability of any sub-system.

Normally, the subsystem (outstation) would be expected to continue to operate locally in the event of a catastrophic failure of the network.

> 25.3 In networked systems in which the communications link forms a critical signal path and comprises one or more cables, the cable installation should conform to Clause 27, except that, as a minimum, standard fire-resisting cables should be used in all circumstances in which:
>
> a) the network is configured as a loop;
> b) there is diverse routing of incoming and outgoing circuits, except in the immediate vicinity of a VACIE;
> c) there will be no loss of communication to any sub-system in the event of a single open or short circuit on the loop;
> d) the loop is monitored for loop continuity.

As suggested in the previous edition of this book, the words ‘as a minimum’ before ‘standard fire-resisting cable" have now been deleted, clarifying the meaning of the subclause. This is that standard, instead of enhanced, cable would be acceptable for the network cabling provided that the network conformed to 25.4a), b), c), and d), although enhanced cable could be used, if preferred.

> 25.5 Once the message initiation command is received by any sub-system, the message should be broadcast by all required sub-systems within 1 s.

Without this recommendation there could be excessive delays in the start of emergency broadcasts between subsystems on the ‘beginning’ and the ‘end’ of a network loop.

> 25.6 Equipment of a networked system not required for indication purposes should be readily accessible for maintenance purposes.

This statement reinforces the recommendations made elsewhere for the accessibility of VACIE for maintenance purposes.

12. Voice alarm control and indicating equipment (VACIE)

Introduction

The control equipment of a VA system is probably most simply described as all the equipment excluding interconnecting cables and loudspeakers. In the previous version of the Code, microphones were not considered to be part of the VACIE, but microphones have now been included to conform to the definition of VACIE used in BS EN 54-16.

Although not intended as a comprehensive list, control equipment generally comprises pre-amplifiers, power amplifiers, switching/routing circuitry, emergency message generators/stores, emergency microphones, broadcast priority control, other signal processing, monitoring circuitry, displays and controls, and power supplies (often including standby battery supplies, in small systems). As previously mentioned, it is generally no longer necessary for BS 5839-8 to cover VA equipment characteristics or performance since these aspects are covered by BS EN 54-16; some exceptions occur, where ‘options with requirements’ taken from BS EN 54-16 apply in the UK. Also, there are specific ‘system’ recommendations applying to many of the VACIE components, and these are covered in the revised Code in dedicated clauses. The main components of the control equipment, i.e. power supplies, power amplifiers, message generators/stores and microphones, are dealt with separately in the Code. Following that pattern, these subjects are covered later in this book as Chapters 13, 16, 20 and 21, respectively. This chapter concentrates upon the ‘system’ aspects of VACIE and the recommendations in Clause 24 of the revised Code.

General

It is worth commenting that the VACIE is, in fact, very often split into at least two physically separate parts, excluding microphones. In the case of simple systems, e.g. a small Type V1 system, where an emergency microphone is not included, all items can often be accommodated in one cabinet. However, it is much more common for there to be an equipment 'rack', containing power amplifiers, etc., in a non-public area, such as a security room, and one or more 'microphone consoles' located, for example, at a reception point. A microphone console will incorporate controls and indicators associated with message broadcasts to an extent dependent upon the 'V' type of system required.

Recommended controls

The first Subclause, 24.4.1, is a reminder that control facilities need to accord with the agreed evacuation strategy and should be agreed by all interested parties (rather than relying on the capabilities of any particular piece of control equipment that might be available, for example).

Subclauses 24.4.3, 24.4.4, and 24.4.5 clarify what controls are needed for the various V types of system. The need for these can already be deduced from descriptions of the V types in Clauses 5 and 8 of the Code. However, it is useful that this slightly more detailed information is given under the VACIE heading. For example, Note 2 to 24.4.4 explains that it is allowable for loudspeaker zone selection and message activation controls to be combined (which is a common practice).

When a VA system has means for starting and stopping emergency messages from different locations in a building, there could be a risk that broadcast messages are stopped incorrectly because, for example, of misunderstanding of the details of the emergency. The same risk could apply to the 'downgrading' of messages, say from 'evacuate' to 'alert' status. It is therefore necessary that the design of a VA system precludes these dangerous situations from arising. Subclauses 24.4.2 and 24.4.6 are intended to achieve this. The recommendation in the former subclause prohibits the silencing or resetting from the VACIE of automatic emergency messages initiated by the fire detection and alarm system CIE. For example, in a Type V4 VA system with manual controls for starting and stopping emergency broadcast on a microphone console not located close to a fire alarm control panel (CIE), this would prevent someone from silencing an automatic emergency broadcast without going to check the indications on the CIE. Subclause 24.4.6 allows that an emergency broadcast initiated automatically from the fire detection and alarm system can, however, be ‘upgraded’ at the VACIE to a message of higher priority, e.g. from an ‘alert’ to an ‘evacuate’ message, or overridden by a live voice message, but not ‘downgraded’ from, say, ‘evacuate’ to ‘alert’ status.

In a Type V5 system where the system can be switched into a fully manual mode, e.g. in a stadium during a match or performance, 24.4.6 also recommends that competent trained staff should be on duty to manage any fire emergency. A switch is recommended to ‘disconnect the triggers’ under these conditions but, in the authors’ opinions, a visual indication that this disconnection applies should also be provided at the VACIE. The latter is not called for in the Code; this could be a point to consider when the Code is next amended.

It is a commonplace alarm strategy in a building for an ‘evacuate’ alarm to be given in the zone of origin of an automatically detected fire, while all other zones in the building receive an ‘alert’ signal. Note 2 to 24.4.6 allows the same strategy to apply when an ‘evacuate’ emergency broadcast is manually initiated from the VACIE, i.e. all other emergency loudspeaker zones would receive an ‘alert’ broadcast.

Subclause 24.4.7 relates to buildings subject to phased evacuation. It is equivalent to Subclause 19.2.1b) of BS 5839-1, recommending that there should be no ‘all out’ manual evacuation control for such a building. This is to avoid overcrowding of escape routes in a fire emergency. However, the BS 5839-8 recommendation recognizes that a building might be occupied during the working day and unoccupied or substantially unoccupied during the night; in such cases, it would be allowable for simultaneous evacuation to apply during the night only.

Recommended indications

The first recommendation mirrors that for controls (see above). VACIE indications need to be as required by the alarm/evacuation strategy for the building and must be pre-agreed with relevant interested parties.

Subclause 24.3.2 reflects the need in a Type V4 system for there to be an indication of which emergency loudspeaker zones have been manually selected for emergency broadcast. The absence of such indications would otherwise leave a situation where, for example, a new person arriving at a microphone console with manual stop-start message controls in a control room would not be sure which zones were receiving manually initiated emergency broadcast or which types of broadcast were being transmitted. (The broadcast giving rise to the 'zone receiving an emergency broadcast' indication would probably not be audible at the microphone console.) The recommendation does not preclude the inclusion of indications of which emergency loudspeaker zones are receiving emergency broadcasts automatically triggered from the associated fire detection and alarm system. Although not discussed in Subclause 24.3, if both manually and automatically triggered emergency messages were being broadcast in several different zones, there would need to be some method of distinguishing, on the display, between the 'automatic' and 'manual' messages, to avoid confusion.

The remaining three subclauses of recommendations relate to the format and operation of the displays. It is spelt out that all zones receiving emergency broadcasts need to be displayed simultaneously. Similarly to the displays of the CIE of a fire detection and alarm system, separate light-emitting diodes (LEDs) can be used or a composite display, e.g. VDU or liquid crystal display (LCD), or geographic illuminated mimic diagram to achieve this. Since such displays in very large premises might otherwise include an excessive number of indicators or excessively cluttered 'screens', a note allows a hierarchical arrangement of displays to be used in such situations, with, say, the 'master' display indicating only sectors (groups) of emergency loudspeaker zones. Where a VDU is used, it is recognized that this is not sufficiently reliable in itself as the primary display for the system. In such a case, duplication of the VDU or provision of a printer is recommended (see 24.3.4). In a note, it is made clear that a printer on its own is not suitable as a primary indicator; this is because it relies on mechanical moving parts, regular replacement of printing ribbon, paper, etc.

Rather similarly to the recommendation in BS 5839-1 for zone plans to be installed, 24.3.5 calls for 'a diagrammatic representation of the building, showing at least the building entrances, the main circulation areas and the division into emergency loudspeaker zones. Where the division into zones is not provided by the display recommended in 24.3.3 or 24.3.4, a correctly orientated plan of the premises should be displayed.'

Further controls and indications

Other than in large buildings and complexes, the above controls and indications are often located on an emergency microphone console at, for example, the reception area or in a security room in a building. The following indications and controls are also useful, although they may not be necessary to meet the recommendations of the Code:

- A test message switch would provide a consistent pre-recorded message without the need for someone to use the microphone and read from a script before every routine test. (Such switches would probably be necessary for pre- and post- fire alarm test warnings in a type V1 system.)
- Controls and indications for broadcast of non-fire related messages, including bomb alert (security) messages.

Construction

Aspects of construction of VACIE were covered in this chapter in the previous edition of this book. These no longer appear in BS 5839-8 and are all covered in BS EN 54-16.

Siting

In a typical situation where voice alarm controls and indications are needed in a reception area adjacent to the main access to the building, these, although often located on a microphone console (or voice alarm control point), could be combined with the fire alarm control panel (which would also normally be located in that area). Such integrated fire alarm/voice alarm control points have become more prevalent than at the time when the first edition of this book was published.

Careful consideration needs to be given to the location of the VACIE, i.e. the equipment rack (which may be in a security room), the microphone console (or voice alarm control point) and any other control units; the VA system could, for example, be distributed. The advice in 24.1.1, 24.1.3 and 24.1.4 on protection from fire, ambient light level and background sound level, respectively, should be taken at an appropriate early stage in the design of the VA system and should apply to all locations of voice alarm control equipment in the building. Also, all VACIE likely to need routine attention for maintenance should be sited in readily accessible locations that facilitate safe maintenance work. Voice alarm equipment racks have been known to be crammed into riser cupboards, with no means of accessing, say, their backs for maintenance.

With regard to background sound levels in the region of the control equipment, a common problem encountered is that of sound from the nearest VA loudspeaker. Where this sound level is too high, i.e. exceeding about 40 dBA, if it is not possible acoustically to screen the control equipment, either the loudspeaker will need to be moved further away or its sound output volume reduced so that an acceptable background level can be achieved. This problem could, of course, be avoided through careful planning.

13. Power supplies

Introduction

A VA system requires a thoroughly reliable power supply, but in the words of BS 5839-1, 'It is, nevertheless, likely that the mains supply will fail at some time during the lifetime of the fire alarm system.' Furthermore, we cannot assume that there will not be any emergencies during a mains failure. There has, therefore, to be a standby (often referred to as 'secondary' or 'back-up') supply that will switch into circuit automatically and without any interruption that could prevent an emergency alarm from being given.

Although BS 5839-1 is referring to conventional 'bells and sounders' fire alarm systems in particular, this need for a back-up supply applies equally to VA systems. Both BS 5839-1 and BS 5839-8 now recommend that power supplies conform to the requirements of BS EN 54-4. This allows BS 5839-8 to concentrate on the 'system' aspects of power supplies. With regard to standby supplies, the main difference between what is envisaged in BS 5839:1 and what is required for a typical VA system is the size of a typical standby power supply. A voice alarm equipment rack full of power amplifiers can consume many watts in its quiescent state and kilowatts when the system is in alarm mode!

In the revised version of the Code, Clause 26 mirrors many of the recommendations of Clause 25 of BS 5839-1. Consequently, detailed recommendations are now given for the normal supply as well as for the standby supply.

Categories of power supply

There must be at least two categories of power supply in a VA system: normal and standby supplies. Sometimes, a building will have a generator operating continuously together with the mains supply. Should the mains fail but not the generator, the normal supply is effectively extended, at least until the generator also fails; a standby supply is, however, still required, but of reduced duration. Occasionally, there is a third level of supply, sometimes called a 'tertiary supply', but this is not necessary to satisfy BS 5839-8.

Normal supply

The normal supply is almost invariably the public mains electricity supply system. Although there is nothing the system designer can do about that source of power, it is important to ensure that it is connected properly.

It is recommended in the Code that a specific isolating device or circuit breaker should be used for the VA system and labelled accordingly, and that power to it should be taken from the 'dead' side of the main isolating device for the building. Usefully, it is now made clear that the VA system mains supply can be common to the fire detection and alarm system mains supply. However, in a note to 26.1.1, there are cautionary words about ensuring that the rating of any fuse or other circuit protective device needs to be high enough to cope with the combined maximum currents taken by the voice alarm and fire detection systems.

The larger the number of intermediate isolators between the 'dedicated' voice alarm mains supply and the mains intake into the building, the greater the chance of the supply being inadvertently commoned to serve other equipment or systems. This is why 26.1.2 calls for the dedicated isolator to be close to the main isolating device for the building. It is sometimes unreasonable or impractical to run long lengths of cable from all parts of the VACIE of a VA system in a very large building to achieve the above recommendation. A note to 26.1.2 allows local distribution boards to be used for such mains power supplies by agreement with all interested parties. Common sense should prevail; however, the number of series isolators should be kept to a minimum and a local distribution board used only if it is expected to have infrequent use, thus minimizing the likelihood of someone inadvertently switching off power to the VA system.

Details of the recommended labelling of the mains isolators are now given. Unsurprisingly, these follow the pattern of BS 5839-1 recommendations for fire detection and alarm systems, 'Voice Alarm' replacing 'Fire Alarm'. However, since it is allowable to combine the CIE and VACIE mains power supplies, in that case labelling should be 'Fire Alarm/Voice Alarm'.

Again following the lead of BS 5839-1, for safety reasons, there is a recommendation for the inclusion of a double pole secure isolator close to the relevant VACIE. An engineer working on the VACIE should be able to see clearly from the isolator that the power has been turned off; this means that it is strongly preferable for the isolator to have 'on' and 'off' clearly marked, e.g. engraved, against the appropriate switch position. A neon indicator of the presence of mains voltage at the isolator output is not so secure, as the indicator could fail. The isolator needs to be secure; i.e. to operate it, it should be necessary to use a tool such as a 'secret' key (as used for testing of emergency lighting) or a conventional key (see 26.1.3). This level of security of operation is naturally extended to all isolators that could switch off the VA system, so all these isolators must either be in locations accessible only to authorized persons or protected in a similar way by, say, a key (see 26.1.8).

A mains switch on the voice alarm equipment rack itself is sometimes provided, with access at 'access level 2', i.e. usually behind a locked cabinet door. It is very debatable as to whether this practice is allowable, but the Code does not appear to specifically prohibit it.

It might be necessary for the mains supply to a VA system to be protected by a residual current device. If so, the device should serve only the VA system (and possibly the associated fire detection and alarm system); otherwise, the normal supply to the VA system could be disconnected by some other circuit in the building tripping the residual current device. However, the Code makes it clear in a note that this does not imply that all VA system mains supplies should be protected by residual current devices; these might, however, be required by BS 7671 (see 26.1.9).

It is very important that the mains power supply should be capable of supplying the maximum alarm load (see definition in 3.17) while at the same time charging a flat standby power supply battery. In the past, VA equipment is understood to have been sold that would support the maximum alarm load from mains supply provided the standby battery was fully charged. This is considered unacceptable because, for example, if a fire occurred shortly after a period of mains failure, alarms might not operate such as to provide the recommended sound level (see 26.2.10). Whereas the standby supply requirement (see below) is usually for a minimum of 30 min, the normal supply has to be capable of powering the maximum alarm load continuously. BS EN 54-4, however, allows the charging to be temporarily reduced or even stopped '…when the power supply equipment is delivering a short duration maximum output load'.

The revised Code now contains a subclause covering ‘voice alarm system power supply units’. Such a power supply unit is not defined in the Code but appears to be intended to mean any power supply serving the VA system; this would include the primary and secondary supplies and all the equipment needed to modify the basic power sources to provide power of appropriate voltage, etc. for the remainder of the VACIE.

VA system power supply units

The recommendations in this Subclause (26.2) relate primarily to the degree of autonomy needed for the main and standby power supplies. Basically, the two supplies should not be in any way interactive. Both supplies should be able to drive the maximum alarm load independently; this means, for example, that it should not be necessary for some load current to be supplied from the standby battery to supplement the mains-derived current in order to cope with maximum load, a ‘dodge’ that was sometimes used in the past in some systems, presumably to reduce equipment cost (see 26.2.5). Also, a fault in one supply should not affect the other. Subclause 26.2.3 adds that ‘The operation of a single protective device should not result in failure of both the main and the standby supply.’ Thus, a single fuse in a common supply path from the main and standby power supplies is disallowed since its rupture would disable the VA system completely even if one of the two supplies were still functional.

Another important recommendation is that there should be no ‘hiccups’ in the emergency broadcast during a changeover from normal to standby supply (see 26.2.2).

Standby supply

The recommendations for standby power supplies are now taken directly from those of BS 5839-1 and there is little point in repeating all of them here. However, there are two points relating specifically to VA systems that do not appear in BS 5839-1, and some other material is reproduced from the first edition of this book, with references modified to apply to the revised Code. These are:

- Tertiary supply. Occasionally, a specifier may call for the inclusion in a VA system of a facility for giving an audible and visual warning on failure or disconnection of both normal and standby supplies. This is referred to in a Note to 12.1.3b) in the Code. Provision of such a warning would obviously entail the inclusion of a small rechargeable battery supply to allow for, say, 72 h' duration of a repetitive 'all power failed' indication.

- Duration and loading of standby supply. The VA system must be capable of operating in the full emergency alarm mode for at least 30 min to allow for evacuation from a building (see 26.3.5a)). Under mains failure conditions, the standby supply has therefore to cope with that requirement as well as providing power for the system to remain operational under 'non-alarm' conditions for 24 h.

The longer evacuation time that is incurred in a high-rise building, for example, requires an extended evacuate broadcast period. That period should be agreed at the early stages of VA system planning and will then place greater demands upon the standby power supply. The Code recommends an extension of the minimum evacuate broadcast period of 30 min, when the total evacuation time for the building exceeds 20 min (see 26.3.5b)).

Where a standby generator is automatically switched into circuit on failure of the normal supply, the duration of the battery supply can be reduced to a minimum of 6 h (plus an allowance for 30 min under full alarm conditions). See 26.3.5c). This time is to allow for obtaining and connecting another source of power should the generator, for example, fail to start. A note is now added for clarification that, if a system is distributed, there may be some power supplies that are not powered by the standby generator. In such cases, it should be ensured that the 'full' standby supply duration applies to these power supplies, i.e. they meet the recommendations of 26.3.5a) or 26.3.5b), as appropriate.

When a building is re-occupied after an extended period of failure of the normal supply, there should be provision for ensuring that the VA system will broadcast an evacuate message for the required period (normally 30 min).This may be achieved by connecting a charged battery temporarily in place of the presumed fully discharged battery. In practice, however, this facility is rarely if ever provided.

Reference is made to the possible need for the VA system to retain the ability to broadcast some non-emergency but important messages, in the event of mains failure. (Such messages would exclude routine paging or background music.) This might apply, for example, to railway stations, where essential passenger information could continue to be given during a power failure. A formula for calculating the required extra standby battery capacity to cover such needs is not given in the Code. This is because the needs will vary from system to system. The Code merely recommends, in 26.3.8, that

> …it is agreed with all interested parties that the voice alarm system needs to remain capable of broadcasting non-emergency but important messages during a period of mains failure. The capacity of the standby batteries should be such as to allow for this usage.

Load currents drawn during these announcements will be much higher than system quiescent currents. The capacity of the standby power supply has to be sufficient to cope with these, and will typically be much larger than that required for a VA system without such facilities.

All of the recommended methods of calculating standby battery capacities are now provided in an annex (Annex C). This annex covers VA systems that broadcast tones only and reference is also made to the possible need for 'essential' but non-emergency broadcast to continue to be available under mains failure conditions (see above). The calculation formula now allows for differing power amplifier efficiencies.

Non-emergency functions such as background music should be automatically disconnected on mains failure so as to conserve battery capacity.

Battery back-up systems

Standby battery type. Valve regulated lead acid (VRLA) batteries remain the commonest types used in VA systems, although this is no longer referred to in the revised Code. Previously known as sealed lead acid (SLA) batteries, they are maintenance-free, not subject to leakage and reasonably priced. Car batteries are unsuitable as they are designed for quite different charge/discharge conditions.

Large capacities are often needed for voice alarm use. VRLA batteries with capacities up to about 160 Ah can readily be obtained; since the most common DC operating voltage is 24 V, a typical 100 Ah supply consists of 4 × 100 Ah, 6 V batteries connected in series.

It is, of course, possible to use other types of battery – nickel cadmium, for example. Because of the charge/discharge characteristics of the voice alarm application, however, care will have to be taken that the battery retains its full capacity over its projected life.

Whatever the type of battery chosen, its minimum life should be four years. Environmental conditions are important and are referred to later.

Battery charging. The battery charger needs to be appropriate for the type of battery chosen; for VRLA batteries, constant voltage charging is required, a typical float voltage being 27.1–27.6 V for a 24 V nominal battery combination. Where necessary, temperature compensation should be incorporated to keep that voltage in range, in order to preserve battery life.

The charging rate must be sufficient to recharge to at least 80 per cent of its rated capacity, within 24 h, a battery that has been discharged to its final voltage. To protect the battery, many chargers include an 'anti-deep discharge circuit' which disconnects the battery when a preset minimum voltage is reached (usually 20 V to 22 V in a 24 V system); in this case, a 'fully discharged' battery will still contain a small charge.

Location of standby supply and environmental factors. The current from the batteries under mains failure conditions will primarily be drawn by the power amplifiers in the equipment rack. Because of this, the standby supply should be close to or in that rack. Cable length implications are dealt with in Chapter 22.

Wherever the supply is located, great care should be taken to ensure that the batteries do not overheat. A VRLA battery operating in a continuous ambient temperature of 35 °C has an expected life of only 60 per cent of its specified life at 20 °C. Ventilation must be provided, both to keep down operating temperature and to allow for any possible gassing.

If the supply is very large, it will probably be located in a separate cubicle from the rest of the central equipment; for reasons of cost and minimizing cable length, however, it is preferable to mount the supply in the same rack as the rest of the equipment. In this event, because the batteries are heavy, they should obviously be mounted at the bottom, with the charger immediately above them. In any case, power amplifiers can run hot (particularly if Class AB type), even when quiescent, and tend to heat up any equipment above them in the rack.

Fault monitoring. This subject is covered in Chapter 10 under 'Power supply faults'.

Changeover. Automatic changeover from normal to standby supply, or vice versa, should occur without loss of supply (and therefore potential loss of emergency broadcast). Usually, in the case of a battery supply, the design is such that on mains failure the mains-derived DC voltage drops slightly to a level at which the battery takes over the current feed via a diode. If there is the possibility of a break in supply occurring during the changeover, it may be necessary to add a small uninterruptible power supply (UPS).

The changeover to standby supply should not cause the performance of the VA system to be degraded so as to be unable to produce the required sound pressure levels and intelligibility. In practice, this usually means that each power amplifier must still be able to deliver sufficient power albeit with a slightly reduced internal voltage rail.

Cabling. The wiring of standby power supplies is discussed in Chapter 22.

Standby battery calculations

At first glance, the way to calculate battery capacity for a VA system is to divide the maximum power output required by the DC voltage and multiply the resulting amperage figure by the duration of the standby supply in hours. This would work but would be unlikely to help a supplier to win any orders, as the resultant power supply could well be larger than the rest of the VA equipment (and maybe even more expensive)! Even taking this 'maximum load' approach for just the 30-min alarm period and correctly using system quiescent current for the remaining 24 h would result in an unnecessarily large and expensive supply. Costs of both batteries and charger have to be taken into account.

Annex C therefore recommends the formula:

$$C_{min} = 1.25\{(D_1 \times T_1 \times I_1) + (D_2 \times T_2 \times I_2)\}$$

where:

C_{min} is the minimum capacity of the battery (Ah) – if VRLA type, at the 20-hour rate.

D_1 and D_2 are, respectively, de-rating factors from the 20-hour rate to the rates appropriate to quiescent current conditions and full alarm load.

T_1 and T_2 are, respectively, specified duration under quiescent and full alarm conditions (hours).

I_1 and I_2 are, respectively, quiescent and average full alarm load currents (amperes). (I_1 may be an averaged current, reflecting certain 'essential' non-emergency use of the system.

Figure 13.1 shows how the contributions from the periods T_1 and T_2 are calculated, particularly I_2, which has to take account of the mixed content of one message cycle. In Figure 13.1, an amplifier efficiency of 50% (Class AB) is assumed in the calculation for I_2.

Annex C of the Code also gives full details of the calculation for I_2, including a worked example.

a) For a system that broadcasts speech messages and tones

Taking L (watts) as the output power requirement for all loudspeakers and V as the standby supply voltage (volts), the formula derived is:

$$I_2 = \frac{50L(2X + Y) / \eta}{MV}$$

where

M (seconds) is the total duration of one message cycle, including periods of silence.

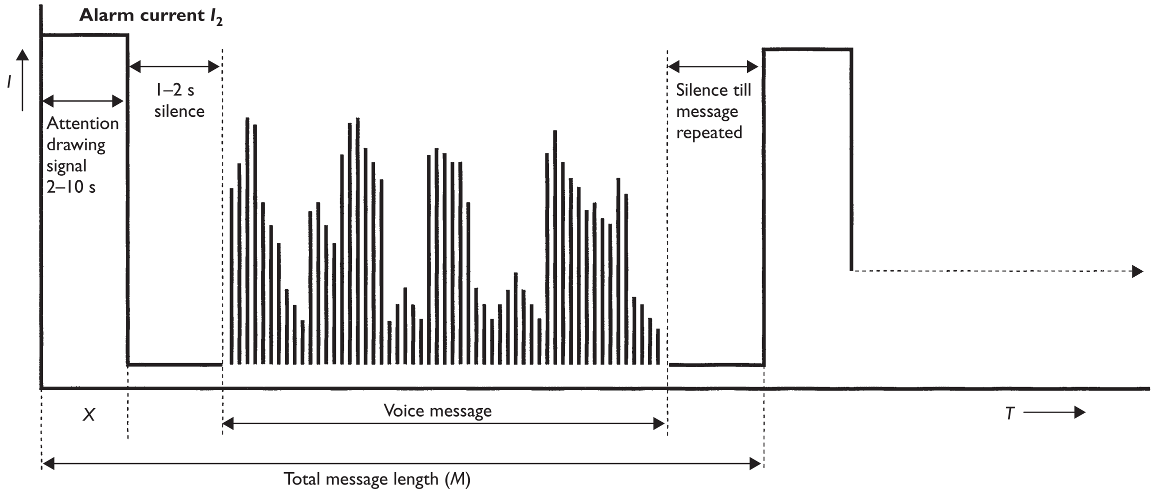
X (seconds) is the total duration of the attention-drawing signal within one message cycle.

Y (seconds) is $(M - X)$, the total duration, within one message cycle, of the speech section of the message, together with all periods of silence, including the subsequent period of silence preceding the start of the next message cycle.

η is the power amplifier efficiency as a percentage (100 × output power/input power).

b) For a system that broadcasts tones only

The calculation is much simpler. There is a steady tone (evacuate or alert signal) and the alarm current (I_2) is merely the assumed output power required divided by the standby battery voltage (V), but taking account of the amplifier efficiency. i.e. $I_2 = 100L/\eta V$.



$Y = M - X$

where L (watts) = output to loudspeaker, $2L$ (watts) = input power, V (volts) = system voltage.
Assume current I_2 drawn for the complete alarm period (usually 30 min).

1. Current contribution from attention-drawing signal = $\frac{X}{M} \times \frac{2L}{V}$ (quasi-sinusoidal).
2. Average power of voice message section = half that of sinusoidal signal. Therefore, current contribution from voice message = $\frac{Y}{M} \times \frac{2L}{2V}$

I_2 = sum of 1 and 2 above = $\frac{2LX}{MV} + \frac{2LV}{2MV} = L\frac{2X + Y}{MV}$

Note: Y includes silences as well as voice; this allows for possible use of a fire microphone.

Figure 13.1 — Calculation of standby battery currents during mains failure

Designing to minimize battery and charger size

Because of the potential large size, weight and cost of battery back-up facilities for some VA systems, it is important to achieve an efficient design for the VA equipment. Examples of measures to be considered are:

- Using efficient power amplifiers. The higher the efficiency, the lower the quiescent current; the 24-hour period of quiescent current drain in non-emergency conditions is usually the major contributor to the total drain from the battery.

  It is sometimes possible to alleviate this by switching the amplifiers into a reduced current 'sleep' mode on failure of the normal supply.
- Ensuring that, during an emergency, all current drains associated with facilities for non-emergency use of the system are disconnected.
- Paying careful attention to the design of the critical path fault monitoring system. Substantial power can be drawn by the ultrasonic or subsonic monitoring signals and the system design should therefore ensure that such current drains are minimized.

14. Use of voice alarm systems for purposes other than warning of fire

Introduction

There are those who say that a VA system should be used only for emergency (or test) broadcasts. This is probably because either they feel that a non-emergency broadcast could possibly mask an emergency broadcast, or they want to minimize the use of the sound system. In North America, public address systems designed to assist in the evacuation of people from buildings are normally restricted to use only for emergency purposes.

In the UK, a different approach is taken. A VA system can be used for non-emergency broadcasts, but only provided that a reliable broadcast priority system is in force, such that any emergency broadcast will automatically override all non-emergency broadcasts. Although BS 5839-8 does not contain a section specifically concerned with non-emergency system use, the priority system is explained in Chapter 23 (and discussed further below).

Advantages of including non-emergency messages in a VA system

Fire alarm systems tend to be 'grudge purchases' and users will therefore often look for the least expensive systems that just meet the requirements and recommendations of the relevant standards and codes of practice. Despite the accepted fact that VA systems have been proved to be more effective in evacuating people quickly than conventional 'bells or sounders' systems, the latter are generally considerably less expensive, particularly when they are for small buildings. Sadly, therefore, the advantages of VA systems are all too often outweighed by their perceived excessive costs.

Where, however, a building requires a fire alarm system and a sound system for non-emergency uses, it may well be economical to install a VA system that incorporates the non-emergency facilities. The sound system will then be a 'public address/voice alarm' (PA/VA) system, normally using the same amplifiers, wiring and loudspeakers for both PA and VA. All components of the combined system that are used during an emergency situation will, of course, need to be monitored for faults as described in Chapter 10, cabling will need to be fire-rated, etc. Only those components or sections of the system that are never used in an emergency need not be fault-monitored. For example, a CD player itself does not require to be monitored, but later sections of the audio path through the system must be monitored, if they also carry emergency signals. There is, of course, no harm done if sections dedicated to non-emergency use are, in fact, monitored for faults; quite often in practice, because of, for example, the complexity of switching and routing arrangements, it is actually simpler for the designer to retain fault monitoring over such sections.

When multi-zone selection features are included in a VA system, they can be used to advantage for non-emergency broadcasts. Emergency loudspeaker zones (see Chapter 15) can be subdivided into paging/music zones, if required.

Some types of non-emergency message are more important than others; for example, announcements to passengers at transport terminals are in a different category from background music. Where important, but not necessarily emergency, messages are regularly broadcast, the reliability and fault monitoring of a VA system would normally be seen as an advantage over the installation of a separate (from the fire alarm system) PA system.

Types of non-emergency broadcast

The most common types are:

- music (background or, sometimes, foreground) and advertisement injection;
- paging (from one or more microphones);
- other customer or passenger information.

Detailed discussions about these facilities are more appropriate to a book on the subject of public address and background music systems, rather than a guide to BS 5839-8. Nevertheless, non-emergency broadcasts are commonly associated with VA systems and perhaps merit the following brief comments.

Music (background or foreground) and advertisement injection

A music/voice source such as a CD player, iPod MP3 player, radio tuner or satellite receiver is usually mounted in or close to the VA system equipment rack. Often, a selection panel is associated with the audio source, so that music, for example, can be channelled to selected loudspeaker zones. Since music may be playing for long periods, the amplifiers and loudspeaker circuits need to be continuously monitored for faults. The monitoring circuitry has to operate correctly in the presence of the music audio, and modern VA systems are quite capable of achieving that. With regard to the loudspeaker circuits, DC monitoring is totally unaffected by the presence of audio signals (including music) within the specified output voltage range. Along the amplification chain prior to the outputs, subsonic or ultrasonic monitoring (see Chapter 10) can be used, provided that the fault detection circuitry is designed so as not to be swamped by the higher level music audio signals.

Where background music only is required, normal VA system loudspeakers can generally be used quite successfully, since their frequency range has to meet the Code's recommendations for audibility and intelligibility. If higher quality music is required, then better loudspeakers will be needed; this may present some problems, because such 'pro-sound' loudspeakers are not usually designed to voice alarm standards. Another problem with the use of 'pro-sound' equipment in a VA system is that the extended bandwidths of the components will inevitably increase the chance of the ultrasonic or (particularly) subsonic monitoring signals being heard at the loudspeakers.

A further problem area is that local zonal volume control of background music is often specified. In a VA system, the volume is preset in the control equipment and is rightly adjustable only at access level 2 (see BS EN 54-16). To achieve volume control for music (and possibly also paging), but not for emergency broadcast, it is usually necessary to include a switching arrangement known as 'restoration'. That often takes the form of a separately wired control relay, at each volume control, which allows the adjustable volume to apply to background music but instantly causes the volume to revert to the preset 'VA' level when any emergency broadcast is to be made. If such a facility is used in a VA system, it should be ensured that all loudspeaker circuits are correctly monitored for faults 'through' the volume controls, whether receiving attenuated music or full volume emergency broadcast.

Paging

One or more dedicated paging microphones can be included in a VA system and their wiring up to the input switching arrangement (see Chapter 10) need not be fault-monitored. An emergency microphone may also be used for non-emergency paging but only if that non-emergency use is automatically inhibited as soon as any emergency situation arises and a clearly separate (and secure) means of using the microphone in emergency is provided (see Chapter 21).

Other customer or passenger information

Sometimes, in addition to emergency and test messages, other important pre-recorded messages are included in the VA system's message 'menu'. Examples are security-related or 'building closing' messages. Such messages may well be given a higher priority (see below) than, for example, background music.

In railway stations and airports, passenger information announcements may require to be made on a continuing basis. Both live voice and pre-recorded messages are often broadcast. Once again, these are important messages and will override any background music, for example, but will themselves be overridden by any emergency broadcast. Although non-essential system operation, such as broadcast of background music, should be automatically disconnected on failure of the normal power supply (see note to 26.3.8 in the Code), passenger information, for example, may well need to continue and not be suppressed. (26.3.8 also covers the implications relating to standby power supplies for such systems.)

Priorities

It is hardly necessary to explain what a priority system means in a VA system since there have already been copious references to priorities earlier in this book. Clause 23 gives some general guidance on the classification of priorities, but it must be remembered, in the design of a VA system, that the actual priorities have to be agreed beforehand by all interested parties, including the enforcing authority concerned. This clause is, of course, concerned with non-emergency use of VA systems, but, as was seen above, there is often a hierarchy of such messages, just as there is for emergency messages.

In a large VA system including non-emergency usage for, say, a transport terminal building, a typical comprehensive list of broadcast priorities could be as follows, increasing number representing decreasing priority:

1. emergency microphone(s);
2. automatic fire evacuate message;
3. automatic fire alert message(s);
4. security (e.g. bomb) alert message;
5. passenger information announcements from a control centre;
6. lower level announcements (e.g. paging);
7. test messages;
8. background music/advertisement injection.

Of these, 1, 2, 3 and 4 are of emergency status and broadcast of any of them would normally inhibit 5, 6, 7 and 8 throughout the building. 5 (and possibly 6) would be considered essential information and would override lower priority broadcasts in the loudspeaker zones to which they were directed.

15. Loudspeakers, loudspeaker zones and loudspeaker circuits

Introduction

The above three subjects are grouped together here in the Guide because they are obviously related. In BS 5839-8, the first two appear as different clauses, namely:

Loudspeakers	14
Loudspeaker zones	13

Loudspeaker circuits, in the revised Code, is no longer treated as a sub-clause heading. Such circuits are, however, referred to in, for example, the chapter on fault monitoring (Chapter 10).

Loudspeakers

In the first version of the Code, types of loudspeaker appropriate for VA systems were described and the particular application for each type was listed. Later, however, it was considered that this treatment of the types of loudspeaker was too simplistic, particularly for ‘difficult’ environments such as large halls, railway stations and sports stadia. The information was therefore removed from the Code and replaced by the following recommendation in 14.1, ‘The selection of the types, quantities and locations of loudspeakers should be based on relevant information regarding the acoustically distinguishable area(s) and should be carried out by a competent person.’

Clause 14.2 is a new addition, giving basic guidance on appropriate location of VA system loudspeakers in simple acoustic spaces. It is recognized that such simple spaces do not necessarily need the involvement of specialist acoustic engineers or consultants. However, the ranges of the acoustic parameters: reverberation time, ambient noise level and predicted broadcast voice sound level over which these techniques may be safely used are clearly set out in 14.2 a), b) and c). Placement of VA loudspeakers in this way should be appropriate for most office areas. Also, it is likely that the inclusion of the acoustic 'caveats' will help to prevent the design of inadequate VA systems for such areas.

It is recognized that VA system performance is sometimes jeopardized by the choosing of loudspeakers based mainly upon appearance (e.g. blending with existing décor). Clause 14.3 therefore recommends that loudspeakers be chosen primarily for their ability to produce an intelligible result rather than for aesthetic considerations such as size or appearance.

The type, location and mounting of loudspeakers used in a VA system should be appropriate for the acoustic environment and mounting surfaces in the areas requiring broadcast coverage. In particular, 14.4 in the revised Code recommends that the response of loudspeakers should not be compromised by their immediate surroundings, for example:

a) rear enclosures of insufficient volume or absorption;
b) grilles with insufficient open air holes;
c) coves or dropped ceilings such that they cannot directly radiate to the listening space.

With regard to a) above, some metal ‘fire domes’ fitted to ceiling-mounted loudspeakers are un-vented and fairly small, and the result is a very ‘tinny’ broadcast sound.

Factors to consider in selection of types of loudspeaker are discussed below, although this level of detail is not now incorporated within the Code.

Acoustic environment. Different environments within a building can have very different acoustics. In a building comprising cellular offices, for example, typically with absorbent ceiling tiles and carpeted floors, there would be little ‘reverberation’ (a pattern of decaying repetitive sound reflections from room surfaces). Basic cone-type flush-mounted ceiling loudspeakers, evenly spaced in sufficient numbers to provide the required audibility (see above), would generally also provide the required intelligibility (see Chapter 19). However, in a large atrium with marble flooring and great expanses of glass, reverberation would be a problem and loudspeakers would need to be carefully chosen and located to maximize intelligibility. Sometimes, in extremely reverberant areas, e.g. indoor swimming pools, it is very difficult if not impossible to achieve that intelligibility. Specialist acoustic consultants will usually need to be involved in such difficult cases.

Ambient noise level. As ambient noise levels increase, intelligibility of broadcast messages decreases (see Chapter 19), assuming a steady average sound pressure level from the loudspeaker. Where there are high ambient noise levels, therefore, sound pressure levels from a loudspeaker will need to be correspondingly high. In 21.1b) of the Code, it is recommended that the sound pressure level of the attention-drawing signal preceding the spoken message, and of a non-speech alarm broadcast, should be at least 5 dB above the background noise, where the sound pressure of the background noise is greater than 60 dBA. This should be throughout all accessible areas of the building, and is simply so that the signal is audible above background noise. (The first version of the Code recommended a figure of 6 dB, but the figure of 5 dB brings the recommendation into line with those of other standards, e.g. BS 5839-1.) However, the average sound pressure level of the speech section of the message should be higher than that of the background noise by about 10 dB (see 22.1.1).

Therefore, as an example, if the ambient noise level is measured as 70 dBA at a listener's ears, the message sound pressure level at that point will need to be about 80 dBA. The sound pressure level produced by a loudspeaker is usually specified as that achieved at a distance of 1 metre from the loudspeaker, with an input power to the loudspeaker of 1 W. Of course, to achieve 80 dBA at some distance from the loudspeaker, a much higher level will be needed at 1 metre from the loudspeaker, because sound pressure level reduces markedly as the distance from the source of sound increases. The sound pressure level requirements can then be calculated for a suitable loudspeaker (taking into account the contributions made from any other loudspeakers in the same listening area).

Climatic environment. Where VA loudspeakers are to be sited in very humid environments, such as laundries or swimming pool buildings, care needs to be taken that loudspeaker materials are suitable. For example, the material used for the cones in ceiling or cabinet cone loudspeakers should be water-resistant. Horn loudspeakers are generally of robust construction and do not have cones; they are therefore normally used for outdoor voice alarm applications.

Area coverage requirement. In a listening area, the number, location and acoustic power output of the loudspeakers required must be calculated. To do so correctly, of course, further expertise in audio engineering will be needed (and details are not included here, since this book is not intended as a textbook on acoustic design).

Mounting arrangements, for example ceiling tiles, wall, pole, etc. In corridors with suspended tiled ceilings, ceiling mounted loudspeakers are normally used. Where the ceilings are solid, that arrangement is not practical and cabinet or projection loudspeakers are normally instead mounted on the walls close to the ceiling.

Architectural design and relevance of the appearance of the loudspeaker. Loudspeaker cabinets can be painted in special colours, although normally at extra cost. If a perforated ceiling is used, it is sometimes possible to mount loudspeakers above it, and therefore totally out of sight.

Type of broadcast, i.e. if used for purposes other than voice alarm, *such as background music*. If music of good quality is required, loudspeakers with a wide bandwidth, e.g. 100 Hz to 15 kHz, need to be used.

Interrelationship between loudspeaker zones and fire compartments. This really relates to the need to connect the loudspeakers to the correct circuits so that they will broadcast the correct messages in the correct loudspeaker zones.

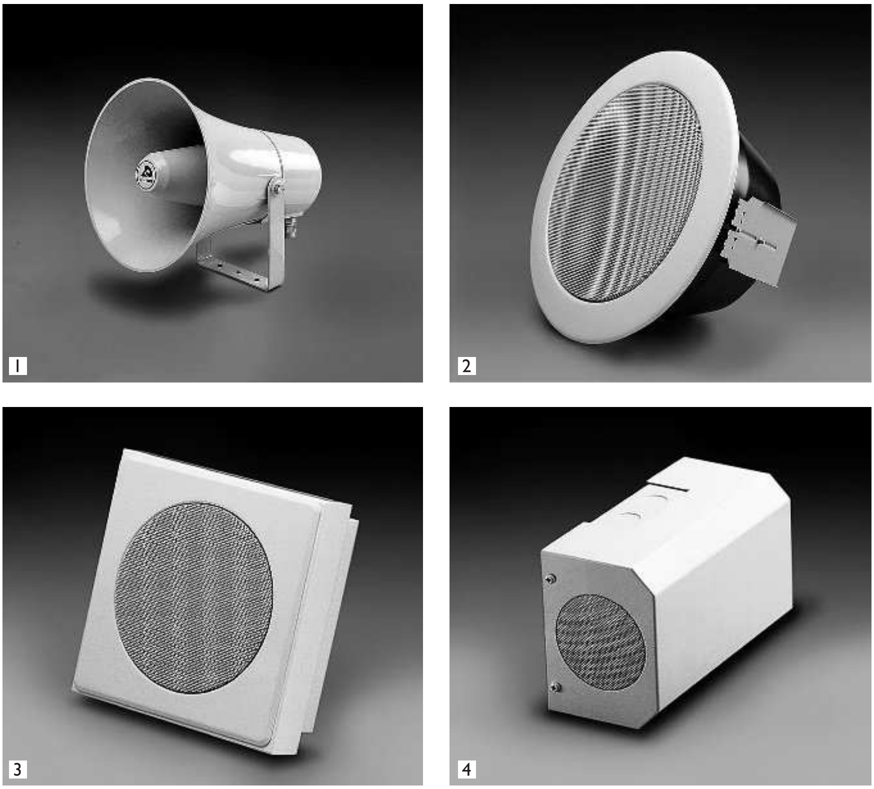
The requirements for potentially explosive atmospheres. Special explosion-protected loudspeakers are available for such areas, but not in a wide range of types. Generally, they are horn loudspeakers and the sound quality is not very high.

The directional characteristics, sensitivity and frequency response of the chosen loudspeaker. The higher the sensitivity of a loudspeaker the lower the loading it imposes upon the driving power amplifier for a given power output; this means that the use of loudspeakers with higher sensitivities will minimize standby battery size. With regard to frequency response, this should normally be at least the minimum recommended for an emergency message generator or emergency microphone, so as not to limit further the overall frequency response of the system.

For general information, Figures 15.1 to 15.7 illustrate, respectively, examples of the following loudspeaker types:

- horn;
- flush-mounted (ceiling);
- wall-mounted;
- bidirectional;
- column having a wide horizontal and narrow vertical coverage angle;
- projector;
- explosion-protected type.

All the above details refer to general sound distribution systems, such as public address or music systems. There are also, however, specific requirements for loudspeakers intended for use in VA systems. These relate primarily to the integrity of the loudspeakers' construction and connections in fire situations. Clause 14 of the Code now covers these aspects.



Figures 15.1–15.4 — Types of loudspeaker (see text). Photographs 1–4 courtesy of Penton UK Ltd

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Figures 15.5–15.7 — Types of loudspeaker (see text). Photograph 6 courtesy of Penton UK Ltd. Photographs 5 and 7 courtesy of ADS Worldwide

Since publication of the first version of the Code, BS EN 54-3, *Fire detection and fire alarm systems — Part 3: Fire alarm devices — Sounders* and BS EN 54-24, *Fire detection and fire alarm systems — Part 24: Components of voice alarm systems — Loudspeakers* have both been published. In its present form, however, BS EN 54-24 does not include requirements relating to the fire-resisting properties of voice alarm loudspeakers. In practice, of course, if there were sufficient heat to cause a loudspeaker to fail, the fire condition would probably have become obvious beforehand to any person directly in that area. However, as is made clear in the Code, it is necessary to take all reasonable steps to ensure that the failure, as a result of fire, of a loudspeaker, or its local connections, does not short-circuit or break the main loudspeaker circuit lines. Continuity of these lines needs to be maintained so that emergency messages can still reach other areas of the building not yet affected by the fire.

Because loudspeaker zones of a VA system can cover large areas, long lengths of loudspeaker circuit cable are often involved and considerable power can be drawn by a loudspeaker circuit. If, as in domestic sound systems, low voltage audio signals were fed directly from a power amplifier to the loudspeaker coils, loudspeaker circuit currents would be very high, and consequently large, expensive cables would be required, in order to avoid excessive voltage drop. Normally, therefore, VA (and public address) systems have power amplifiers supplying audio signals at high voltage (usually 100 V nominal in the UK but 70.7 V in North America). This arrangement is referred to as '100 V line working' and requires a step-down transformer to be mounted in every loudspeaker (except for large loudspeakers drawing hundreds of watts, e.g. for central clusters in large concourses).

With regard to the integrity of the loudspeaker circuit, the Code suggests some methods for reducing the likelihood of the occurrence, under fire conditions, of a short-circuit condition at or near the terminals in or on the loudspeaker. (An open-circuit condition would be unlikely because the connecting conductors are normally screw- or spring-clamped into the loudspeaker terminals.) In 14.8, three alternative design measures are cited, as examples, for the terminal blocks:

a) using terminal blocks capable of withstanding a similar temperature for a similar duration to that of the interconnecting cable used;
   NOTE For example, terminal blocks constructed from ceramic materials are normally suitable.
b) using terminal blocks with a lower temperature resistance but protected with thermal insulation to achieve the same level of protection as a);
c) designing terminal blocks such that, on melting, an open circuit or a short circuit does not occur

Of the alternative methods a), b), and c), method a), the use of ceramic-insulated terminal blocks, is by far the most popular.

In 14.9 d), a recommendation is now given for the use of a thermal fuse to isolate the short circuit from the external loudspeaker circuit under local fire conditions. This has become a standard component of voice alarm loudspeakers. Also, if a short circuit of the transformer primary winding results from the fire, this will cause an excessively high current to be drawn through the fuse, which will then either rupture, becoming open circuit, or rapidly become high resistance. In the latter case, the thermal fuse may be self-resetting if the temperature falls. In practice, of course, the loudspeaker will almost certainly be destroyed in entirety by a local fire.

Although the revised Code no longer specifically mentions the need for the design and layout of internal wiring to minimize the potential for the occurrence of a short circuit, this is still a relevant factor. It is therefore worth giving two examples as follows:

1. The connecting wire leads from the loudspeaker transformer primary winding to the terminal block should not be twisted together and should be of stiff wire.
2. Loudspeaker transformers normally have three or four tappings to allow for local adjustment of volume, usually set at commissioning stage. For VA systems, these tappings should preferably be on the secondary winding. Otherwise, with primary winding tappings, it would be difficult to keep separate the connecting leads from primary winding to terminal block, with a risk of a short circuit occurring under fire conditions. (This difficulty of separation will, of course, apply also to the secondary winding tapping leads. In practice, however, because of transformer and line losses, a short circuit associated with the transformer secondary winding of one loudspeaker will not normally have a major effect upon the quality of broadcast from other loudspeakers on the same circuit.) However, it has been observed that, in practice, voice alarm loudspeaker transformers generally have their primary windings tapped; short-circuit protection thus relies upon the layout of the wires and the presence of thermal fuses.

Figure 15.8 shows a typical loudspeaker/transformer arrangement, with connecting leads conforming to the above recommendations.

The cones of flush-mounted ceiling loudspeakers are fragile and the Code recommends (see 14.7) that, for voice alarm use, each loudspeaker should be fitted with a protective rear enclosure. There is a common misconception that the enclosure is intended to protect the loudspeaker against fire, but its main purpose is actually to protect the loudspeaker from damage caused by objects falling from above it and also to prevent inadvertent contact with live parts (bearing in mind that the loudspeaker lines operate at 100 volts AC). In the unusual situation where a ceiling is fire-resisting, it will minimize any loss of integrity of the fire resistance of the ceiling, providing that it is unvented.

Subclause 14.8 of the Code recommends that the melting point of the material used for the enclosure should be at least 850°C. In the past,

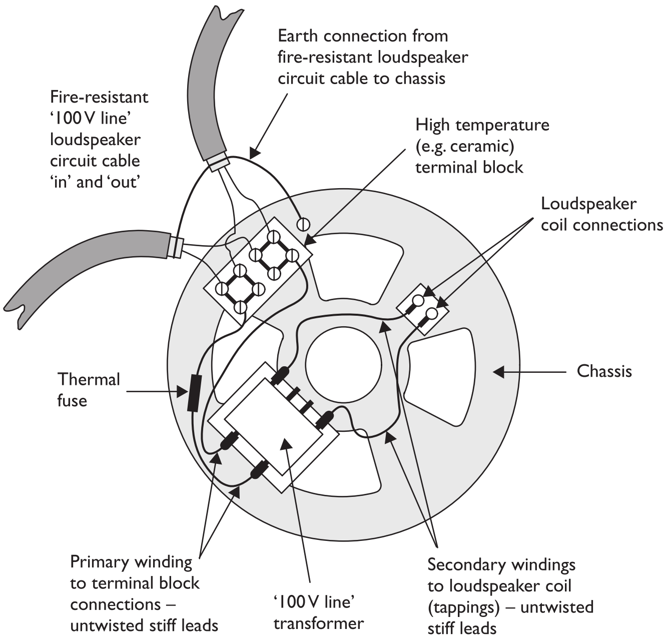

Figure 15.8 — Rear view of chassis of cone-type VA loudspeaker

aluminium alloy was often used, but that material could melt in intense heat and possibly drip down, causing a short circuit at the loudspeaker line connections; such enclosures do not therefore conform to the Code. Steel is now normally used, because of its much higher melting point. The 'downside' of steel enclosures as opposed to those of aluminium alloy is that the manufacturing process is generally more expensive and the weight is higher. Care should be taken that heavy steel enclosures are not used with ceiling loudspeakers designed for lightweight (or no) 'fire domes' (as they are often referred to); otherwise, the weight of the steel can overcome the retaining force of the loudspeaker mounting springs, causing the loudspeaker to 'droop' below the ceiling.

From the point of view of mechanical protection, the enclosure need not be completely unperforated (a fact perhaps not appreciated by all voice alarm loudspeaker manufacturers). In fact, as mentioned previously, a totally unvented metal enclosure normally has acoustic resonances that make the loudspeaker broadcast sound 'tinny'. Ironically, therefore, intelligibility is usually better from a 'non-VA' unenclosed ceiling loudspeaker. Nevertheless, readily available voice alarm ceiling loudspeakers (with rear enclosures) can achieve the intelligibility recommendations of the Code. Where the relevant ceiling is a fire-resisting barrier, the steel loudspeaker rear enclosures will need to be unperforated and such as to form a sufficiently effective seal. Where there is any doubt as to the effect on the integrity of the ceiling as a fire-resisting barrier, specialist advice should be sought.

Loudspeaker circuits

As explained previously in this book, the revised Code no longer includes 'loudspeaker circuits' under a separate heading. However, the recommendations relating to the provision of loudspeakers in areas frequented by large numbers of members of the public, for example, are given in 12.2.3. The following information is still considered to be relevant and is therefore retained from the first version of this book.

The subject of configuration of loudspeaker circuits has been, and perhaps still is, the most contentious and least well understood aspect of VA system design. Much of the confusion has arisen from wholly analogous, but less wide-scale, confusion that exists in respect of fire alarm sounder circuits. Past confusion, has, in the case of loudspeaker circuits, been exacerbated by the inexperience of voice alarm designers and specialists, such as those with a background in sound systems rather than fire alarm systems, in respect of fire alarm system design.

Basically, the major question is whether to 'duplicate' or not duplicate. The original trade association code of practice for VA systems, on which the first draft of BS 5839-8 was based, certainly favoured 'dual' and 'interleaved' circuits. In this arrangement, two independent loudspeaker circuits are provided in each loudspeaker zone (see below), with interleaving such that each adjacent loudspeaker is on a different circuit. Equally, the original trade association code accepted that this might not always be necessary. Indeed, it listed some 20 factors to consider in determining whether dual circuits were necessary. The intention was that, in the event of failure of one of the circuits, there should still be adequate intelligibility, albeit of a reduced level. This is an onerous requirement, which, in general, requires that, in any room in which the provision of a loudspeaker is necessary, a minimum of two loudspeakers, each on a separate circuit, are necessary.

The provision of dual circuits had, at the time of final drafting of the original version of BS 5839-8, become almost custom and practice. Since any British Standard is intended simply to reflect good custom and practice in the industry at the time of drafting, the BSI Technical Committee could easily have incorporated a blanket recommendation for dual circuits within BS 5839-8. Certainly, such a recommendation would have received the support of a number of influential bodies who commented on the draft.

On the other hand, the committee were concerned about three particular issues, namely:

1. The additional cost involved, which could act as an obstacle to the wider use of VA systems and so limit the enhancement in the safety of buildings that can be achieved thereby; put bluntly, would public safety, in a case where provision of a VA system might not be strictly necessary under legislation, be best served by a conventional fire warning system (which need not have dual circuits) or a VA system that does not have dual circuits?
2. The compelling logic for comparable recommendations in respect of conventional fire alarm systems and VA systems. Conformance to BS 5839-1 does not necessitate that dual circuits be provided throughout a building; while it may be argued that power amplifiers are more likely to fail than conventional sounder modules, this is totally irrelevant to the subject of dual loudspeaker circuits, and is addressed separately in the Code in relation to redundancy in the provision of power amplifiers (where this is considered necessary by a risk assessment). The copper conductors carrying the audio signal to a loudspeaker are no more or less likely to fail than the copper conductors carrying the current to a conventional alarm sounder.
3. The committee were aware that many exponents of dual circuits erroneously believed that this was necessary to satisfy BS 5839-1; simple adoption of the practice within BS 5839-8 might, therefore, be nothing more than promulgating an error of understanding.

In order to understand the philosophy adopted in BS 5839-8, it is necessary to understand the philosophy contained in BS 5839-1, since the intention of the committee was to ensure, as far as possible, consistency between the two codes and the two forms of fire alarm warning system that they address.

The purpose of the second circuit that is normally provided in conventional fire alarm systems to satisfy BS 5839-1 is to address a particular concern, which is as follows. A situation might arise in which the fire alarm system in a building operates, people evacuate the building, but suddenly the fire alarm sounders stop. Given the simple statistical fact that most fire alarm signals are false alarms, people might then re-enter the building on the assumption that it is safe to do so. However, even though fire alarm circuits are wired in fire-resisting cable, if the entire building were served by a single fire alarm sounder circuit, the bells might have stopped because the fire caused a short circuit of this single circuit, perhaps at a vulnerable point, such as a termination.

It is quite specifically to address this concern that BS 5839-1 recommends that, if fire damages a sounder circuit, a minimum of one fire alarm sounder should continue to sound; this ensures that the alarm will be maintained at at least one point in the building, usually near the control equipment. The control equipment is normally sited in the vicinity of the main entrance to the building, or at least at a supervised location, so there is likely to be a constant reminder at the entry point to the building, or at a location supervised by a responsible person, that the building should remain evacuated.

Strictly, BS 5839-1 does not even specifically recommend that two independent sounder circuits should be provided. A single ring circuit, with short-circuit isolators, could satisfy the recommendations of that code of practice. However, the simplest arrangement that would satisfy the recommendations of BS 5839-1 would be one in which a single circuit served the entire building, while just one sounder located immediately adjacent to the main control panel was served by a second circuit. While this practice is sometimes deprecated as a 'cheap' or somewhat substandard design, in actual fact not only does it fully address the scenario about which the authors of BS 5839-1 were concerned, but it may do so more effectively than a much more expensive dual circuit arrangement. In the case of dual circuits, if fire development is sufficiently great to cause a short circuit of one sounder circuit, it may well also have developed sufficiently to cause a short circuit of the adjacent sounder circuit, resulting in a form of common mode failure of both; this cannot occur in the very simple arrangement that is the minimum required to satisfy BS 5839-1.

Nevertheless, in order to be objective and, if really necessary, rectify any shortcoming in BS 5839-1 when applying its principles to VA systems, the committee considered afresh whether there was any justification for dual circuits. It was considered that there might be several reasons behind the practice of duplication of circuits in VA systems. It could be that users and specifiers were concerned that:

- Mechanical damage might occur to a loudspeaker circuit, and the occupants would then be vulnerable in the event of a subsequent fire.

- The fire itself might damage a single loudspeaker circuit, resulting in total loss of the fire alarm signal within the area in question.
- A single circuit might be disabled for maintenance purposes at the very time there was a fire.

Considering each of these scenarios in turn, the committee first noted that BS 5839-8 already recommended that cables be protected against mechanical damage in accordance with the recommendations of BS 5839-1. It was further noted that any such damage would, in systems conforming to the Code, affect only that circuit, but not other circuits or loudspeaker zones. Moreover, any such fault would result in a fault warning at the fire detection and fire alarm control and indicating equipment within 100 s of its occurrence.

Accordingly, if the damage occurred when the building was occupied and people were vulnerable to fire, a responsible person would be aware of the fault almost immediately and should take suitable action to facilitate a repair. (If repair could not be effected in a reasonable period, consideration could, of course, be given to evacuation of the affected area or building.) Happily, fire is a relatively rare event, and the simultaneous occurrence of damage to a circuit (which should also be a rare event) and a fire, within what should be the relatively short timescale between occurrence of the damage and repair, was considered to be an event of extremely low probability. Certainly, the likelihood of this event does not seem to warrant considerable expenditure in duplication of circuits.

With regard to failure of a circuit as a result of fire, as already noted, the provision of two circuits in the same area actually provides the potential for common mode failure. By the time fire is sufficiently developed to cause a short-circuit of what should be a fire-resisting cable system, people should be aware of the need to evacuate; the need, thereafter, is for a ‘reminder’ signal so that the warning continues at a suitable location in the building.

With regard to the potential for a circuit being disabled by maintenance operations, such circumstances should not be prolonged, and, once again, the probability of fire at the very time that the circuit is disabled should be very small. Moreover, anyone working on the equipment would be aware of an incoming signal and could possibly even be in a position to reinstate the circuit.

Given the considerations outlined above, the committee took the view that since, in simple terms, a loudspeaker may be thought of as a sophisticated fire alarm sounder, the recommendations that have been deemed to be adequate for fire alarm sounder circuits should be adequate for voice alarm circuits. Accordingly, BS 5839-8 recommends that, in the event of a single open-circuit or short-circuit fault on a loudspeaker circuit, the emergency broadcast should be intelligible at one point, at least, in the building, preferably at a supervised location, such as a reception area, security control room or main entrance foyer. As in the case of BS 5839-1, however, the Code does advise that if there is a desire (presumably on the part of the user or specifier) to maintain audibility or intelligibility over a greater area of the building, in excess of the minimum recommendations of the Code, additional loudspeaker circuits should be provided. In practice, other than in small buildings, multiple loudspeaker circuits will be provided as a result of engineering considerations, such as circuit load, volts drop, etc. However, as far as BS 5839-8 is concerned, there is not generally a need to duplicate circuits in any area.

There is, nevertheless, an exception in BS 5839-8, which also applies in the latest version of BS 5839-1. The committee were cognisant of the fact that a VA system is now considered critical to the safety of large numbers of people in major public buildings, and recognized the genuine concern on the part of the 'dual circuits lobby' to ensure that VA systems are of the highest reliability that is reasonably practicable in such buildings.

Typical examples of such buildings, given in BS 5839-8, are:

- transport terminal concourses;
- mall areas of covered shopping complexes;
- public areas of:
  - large department stores;
  - leisure centres.

The Code recommends that 'additional' interleaved circuits (presumably a minimum of one 'additional' circuit to make two in total) be provided in uncompartmented public spaces of such buildings if the open space is either:

- greater than 4000 m^2 in area; or
- designed to accommodate more than 500 members of the public.

In many cases, the second of these situations may be the more onerous, unless the density of population is greater than 8 m^2 per person. Presumably, in determining the likely number of occupants, it would be reasonable to count the seats in an area of fixed seating, such as an auditorium, or use the 'floor space factors' for determining the number of persons likely to occupy a space, in means of escape codes of practice.

Even if dual circuits are provided in certain areas of large public buildings, BS 5839-8 advises that it is not generally necessary to provide them in small cellular spaces and non-public areas of these types of building.

Where dual loudspeaker circuits have been provided to enhance reliability in these situations, the duplicate circuits should not be enclosed within the same multi-core cable. This is because, if a multi-core cable is affected by fire or mechanical damage, it must be assumed that all conductors are open- or short-circuited.

The dual circuit philosophy appears in 12.2.2k) of BS 5839-1:2013.

Loudspeaker zones

A loudspeaker zone, although no longer defined in the Code, is any part of the area of coverage to which information can be given separately. Two types of loudspeaker zone are referred to in the Code:

Subclause 3.9 defines an *emergency loudspeaker zone* as 'part of the area of coverage to which emergency information can be given separately'.

Subclause 3.20 defines a *PA zone* as a 'sub-division of an emergency loudspeaker zone also used for non-emergency broadcasts', and the following note applies:

> NOTE In this context, a PA zone might be used for any kind of non-emergency broadcast, such as music.

The latter is often referred to as a paging zone.

In a small building, only one loudspeaker emergency broadcast zone might be needed for satisfactory evacuation under fire conditions. (A minimum of two loudspeaker circuits would be needed, however, as discussed in 'Loudspeaker circuits', above.) Most VA systems, in fact, have a number of loudspeaker emergency broadcast zones, so that, for example, an alert message can be broadcast to certain areas whilst an evacuate message is being broadcast to other areas.

Emergency loudspeaker zones may be subdivided into (non-emergency) PA zones. A large open-plan office, for example, comprising one emergency loudspeaker zone, could contain several PA zones, to allow for broadcast of non-emergency information to sections of the office; this would mean that several loudspeaker circuits would be contained within the office. If a broadcast were made to one PA zone only, there would almost certainly be acoustic overspill into adjacent office sections. Although that would probably have no great significance, since the message would be likely to be addressed appropriately, it would clearly be an inappropriate method of broadcasting an emergency message. Therefore, to comform to the Code, an emergency message applying to the office should only be broadcast to all of the PA zones in the office plus any remaining office areas not covered by PA zones (i.e. the emergency loudspeaker zone) simultaneously. Conversely, emergency loudspeaker zones can, of course, be grouped for emergency broadcast or for non-emergency paging purposes.

Clause 13 describes clearly the need for acoustic separation between loudspeaker zones. This is, of course, difficult if not impossible to achieve at any 'virtual' boundary between loudspeaker zones, where there is no physical partition between them. Experiments are believed to have been carried out to try to create a 'wall of noise' at such boundaries, i.e. a corridor between the loudspeaker zones where the sound broadcast from both adjacent loudspeaker zones would be masked by white or pink noise. There is, however, no evidence that this has been successfully achieved or, indeed, that such a system would actually satisfactorily address the problem. A person standing in the 'dead area' would obviously have to move into one loudspeaker zone or the other to hear a message, and would not necessarily know to do so. Presumably, in the absence of the sound masking, someone hearing the two messages would be more likely to move into one area or the other in order to understand at least one message. What is clear from this is that every effort should be made to provide physical acoustic separation between loudspeaker zones. Arrangements in which one part of an open area receives one message, while another receives a different message, are unlikely to be very successful.

The Code also recommends that there should be no conflict between the zone boundaries of the fire detection and fire alarm system and the emergency loudspeaker zone boundaries. The aim of that statement is to avoid the possibility of an emergency loudspeaker zone boundary crossing one or more fire detection and fire alarm system zones. Were that to be allowed to happen, there would be a possibility that two different emergency messages could be broadcast to the same fire detection and fire alarm system zone, causing confusion. For the same reason, a fire detection and fire alarm system zone should not contain more than one emergency loudspeaker zone. However, there is, obviously, no difficulty in a situation in which several (or all) fire detection zones in their entirety are included within a single loudspeaker zone.

16. Power amplifiers

Introduction

Power amplifiers of good quality are readily available today. Almost any such amplifier will have a bandwidth of from <100 Hz to >20 kHz, more than adequate for a VA system. The bandwidth of the overall VA system for audio broadcasts will normally be limited at the top end by the frequency response of the emergency microphone or message generator, and at the bottom end by the frequency response of the loudspeakers. The subsonic or ultrasonic fault monitoring signal will require an extended frequency response from the amplifier but typical amplifier bandwidths will be adequate for this use also. Distortion figures for these readily available amplifiers are also adequately low for voice alarm use, e.g. 0.1 per cent total harmonic distortion at 1 kHz. The revised Code, as previously mentioned, no longer needs to contain the product-related recommendations for power amplifiers that were in the original version, because those amplifiers now need to comform to the appropriate requirements of BS EN 54-16. Nevertheless, the opportunity is taken here to retain a short discussion on some of the particular characteristics needed for VA use.

Features of power amplifiers for VA systems

Not just any amplifier will be suitable for VA system use. The following features are desirable:

- ability to operate from normal and from battery back-up power supplies;
- low amplifier quiescent current;

- 100 V line drive facility for loudspeakers (see Chapter 15);
- fault monitoring of (at least) fuses;
- cooling to be by natural convection;
- rack mounting.

These aspects are dealt with below.

Ability to operate from normal and from battery back-up power supplies

The Code recommends that VA systems continue to operate, usually from standby batteries, under failure of the normal (mains) power supply (see Chapter 13). There are two common methods by which power amplifiers meet these recommendations:

1. By always operating from a DC power source (equal to that of the standby power supply, i.e. often 24 V DC). In this case, one or more separate mains-derived DC power supply(ies) are required, together with an automatic changeover arrangement to allow operation from the standby battery under mains failure conditions.
2. By using so-called 'dual voltage' power amplifiers, which have both DC and AC (mains) power inputs. Such amplifiers have an internal automatic facility to allow the mains input to be used normally, with a default to the DC power input under mains failure conditions. A disadvantage of this method is that every amplifier has to contain a mains transformer and associated power supply components.

Low amplifier quiescent current

As described in Chapter 13, the quiescent current drawn by the VA system (in practice mainly by the power amplifiers) is very significant in determining the capacity of the standby battery. Some amplifiers are designed to consume quite high quiescent currents but, other than the heat that they thereby generate, this is not a particular problem for amplifiers intended to operate always from the mains power supply. Amplifiers available in the marketplace differ greatly in their quiescent currents, and this is therefore an area where 'careful shopping' is needed. So-called 'Class D' amplifiers, which 'chop up' the audio signals and then process them at a higher frequency, tend to have the lowest quiescent currents but some early versions had electromagnetic compatibility (EMC) problems and difficulties in handling fault monitoring signals.

100 V line drive facility for loudspeakers

Power amplifiers intended for public address use normally have this facility (see Chapter 15).

Fault monitoring of (at least) fuses

Many power amplifiers intended for VA system use have built-in facilities for monitoring the path of audio through them. Typically, they will have integral fault indicator LEDs and/or outputs to send fault status information to separate fault display panels. It is not necessary that the amplifiers themselves contain such facilities (because the relevant critical audio path can be monitored before and after them) but it is common practice for VA equipment suppliers to sell 'monitored power amplifiers'. Fuses, however, need to be monitored, where their rupture could cause loss of emergency broadcast (see Chapter 10) and will require local, and/or facilities for remote, fault indication.

Cooling by natural convection

The equipment used in the VA system should be capable of performing all its functions in the environmental conditions expected in buildings. Some power amplifiers include cooling by forced ventilation, usually under thermostatic control, so that a cooling fan is switched on under heavy current load conditions or in high ambient temperatures. Such amplifiers are usually smaller and lighter for a given rated power than those cooled by natural convection only.

The problem with forced ventilation is that, should a cooling fan or temperature detection arrangement fail, the amplifier could overheat and fail. Although, eventually, the amplifier failure would be detected by the fault monitoring system, the excessive heat could perhaps have damaged adjacent components before the fault was indicated. To prevent that situation from arising, it is sensible that the fan/temperature detection circuit be fault-monitored; a fault of this nature would then be detected and indicated, and a standby amplifier would possibly be switched into circuit (see below).

Rack mounting

Because of the number of different components needed in a typical VA system (see Chapter 11), these are usually contained in an equipment rack. Power amplifiers are heavy and, where there are several of them in a set of VA system control equipment, rack mounting allows them to be readily withdrawn for servicing and maintenance.

Standby power amplifiers

For many years, up to and including the time of preparation of the original version of BS 5839-8, it was felt that, because of the powers handled by them and the potential for overheating, power amplifiers should be considered particularly vulnerable to failure. Consequently, it was decided not to rely entirely upon monitoring of amplifier faults, but to recommend that facilities be provided for rapid substitution of a good for a failed amplifier. Prior to publication of the Code, it had become common practice for VA system specifications to call for a number of standby amplifiers in proportion to the number of duty amplifiers, for example one in ten. Consideration was given to that philosophy when BS 5839-8 was drafted, but it was felt that, provided repairs were put in hand without undue delay after the indicated failure of a power amplifier, the chance of a failure of a further amplifier within that time, and the simultaneous occurrence of a fire, would be remote. The original Code therefore recommended that facilities be provided to prevent any loss of system performance through the failure of any one power amplifier (but only one, regardless of the number of power amplifiers in the system).

Because power amplifiers for use in VA systems now have to conform to the requirements of BS EN 54-16, it is considered that their reliability is considerably higher than previously was the case. The revised Code therefore now calls (in 16.1) for standby power amplifiers to be provided on the basis of a risk assessment. This is a very vague concept particularly as the Code offers no guidance on how the risk assessment should be carried out, how the relevant factors should be determined or who is expected to carry this out. The designer of the system may not be a fire safety specialist and so may not be in a position to make the assessment in the overall context of fire risk. Equally, the fire safety specialist is unlikely to have the specialist electronics knowledge required to determine the likelihood and consequences of an amplifier failure. The

Technical Committee responsible for the Code has, in effect, abdicated responsibility for a decision as to whether redundancy is, or is not, appropriate (perhaps because of conflicting views within the technical committee), so leaving it open for disputes to arise, possibly at a stage when the system is already installed; this emphasizes the need for early agreement on design parameters amongst all interested parties. In practice, economic considerations are likely to dictate the decision on this matter.

Assuming that, in a particular system, standby amplifiers are deemed to be needed, the following comments (which have been retained, almost in entirety, from the original version of the Code) still apply.

Typical VA system arrangements have already been described (see Chapter 11), including the alternative philosophies of parallel-banked amplifiers and amplifiers dedicated to loudspeaker zones. To cover the standby requirement, the former arrangement contains sufficient reserve power (from one or more amplifiers), while the latter has one separate standby amplifier of at least the same power rating as the faulty amplifier.

Both of the above arrangements are fully automatic and the latter is now much the more common method. Although the Code allows for manual arrangements for failed power amplifier substitution, subject to the agreement of interested parties any substitution would have to be carried out within 5 min of the failure occurring (see the note to 16.1 of the Code). This would obviously be difficult to plan for reliably at the design stage but the method is said to be quite commonly used, leading one to question whether 'lip service' is being paid to the Code. In any case, an automatic arrangement is better in the sense that substitution is immediate, with minimal, if any, loss of broadcast during the changeover.

Standby power amplifiers in a VA system are usually referred to as 'hot standby' amplifiers; that is because the Code recommends that all power amplifiers, including standby amplifiers, are kept in a powered up state and continuously monitored for faults. This applies even if a standby amplifier is intended for manual substitution.

17. Ambient noise sensing and compensation

Introduction

Clauses 21 and 22 of the Code recommend that, for an emergency message to be sufficiently audible and intelligible:

- The sound pressure level of the attention-drawing signal should be at least 60 dBA in smaller areas, 65 dBA in larger areas, or 5 dB above background noise, whichever is the greater (see Clause 21).
- The speech signal to background noise ratio should be at least 10 dB (see Clause 22).

This is normally achieved by measuring or estimating the average, or expected average, background noise level and, at system commissioning, setting the volume of the broadcast announcements accordingly. For listening areas where the background noise stays reasonably constant (i.e. in most cases), this 'fixed volume' arrangement is generally perfectly satisfactory. However, where there can be dramatic changes in background noise level, for example in railway stations, airports and auditoria, Clause 17 recognizes that it may be advantageous to use an automatic system to adjust the volume of the broadcast, keeping it, as far as possible, audible and intelligible above background noise. Such a system is referred to in the Code as an ambient noise sensing and compensation controller, and the concept is commonly known as 'ANS'.

ANS operation

ANS operates by continuously 'listening to' the background noise in a loudspeaker zone, via ambient noise sensing microphones (or transducers, as they are sometimes called). The level of noise detected is then processed and used to control the gain of the amplifier(s) supplying that loudspeaker zone, increasing the gain when background noise increases, thus increasing the volume of broadcast sound, and vice versa. Generally, the background noise is sampled in this way only in the absence of broadcasts and the gain reached immediately before a broadcast is 'frozen' for the duration of the message. That arrangement is satisfactory, if dramatic changes in background noise are reasonably predictable or if messages are kept short. Obviously, however, if background noise were to change significantly during a longer message, the broadcast volume would continue unadjusted and possibly then be unintelligible.

Some ANS arrangements do continue to sample background noise during broadcasts. Their electronic design has to be sophisticated, however, because a simple system that monitored all noise reaching the ANS microphones would 'hear' the broadcast as well as the background noise and would almost certainly be unstable. (Such a simple system would not be able to distinguish between background noise and broadcast and, during a broadcast, would tend to keep on increasing volume to compensate for the increased volume, eventually reaching maximum volume!) It is sometimes possible to site the ANS microphones so that they will detect primarily the (loud) background noise and to a much lesser extent the broadcast sound, but this is not usually the case. There are also other techniques for avoiding that 'positive feedback', such as the sampling by the ANS microphones of only a very small selected frequency range, and the corresponding 'notching out' of that frequency range from the broadcasts. Such techniques, however, are only partially successful.

Another factor in the design of an ANS system is its rate of response to changes in background noise level. If the response were immediate, fluctuating background noise would cause the broadcast to fluctuate, and might make it more, rather than less, difficult to understand; if there were a sudden loud noise, for example from a screaming child, an instant response would be totally unsuitable. On the other hand, if the response were very slow, too much of the broadcast might be unintelligible before the volume settled at a suitable level. Usually, the response rate is adjustable and will be optimized at commissioning, by carrying out tests. The aim, of course, is to achieve the specified intelligibility of broadcast messages under any expected background noise conditions – not always an easy task.

Recommendations for the duration of noise sampling and the type of noise measurement to be used are now included in 22.1.3 (under *Audibility*) as follows:

> Where ambient noise sensing systems are included in the VAS (see Clause 17) these should be set to measure the equivalent continuous sound pressure level (LAeq,T) for a period of 1 second of ambient noise immediately prior to the start of an announcement. The broadcast level should then be set to have an equivalent continuous sound pressure level over 10 seconds ($L_{\mathrm{Aeq,10}}$), 10 dB higher than the ambient noise.
>
> *NOTE For messages of duration shorter than 10 seconds, a pro rata broadcast level may be used.*

The main purpose of including this discussion on ANS operation is to make it clear that, whatever system is used, the final result will always be a compromise. There is no perfect ANS system. Nevertheless, as Clause 17 of the Code indicates, such a facility can be used with advantage in spaces that can be subject to significant variation in background noise levels.

Fault monitoring

It should be remembered that the element controlled by an ANS is usually an amplifier in a critical path of the VA system. Therefore, if an ANS system that was unmonitored for faults failed, the relevant amplifier gain could swing to a maximum or a minimum, rendering broadcasts to the appropriate loudspeaker zone unintelligible. This is why the Code recommends that the ANS should fail-safe by reverting to the 'commissioned or operating maximum level'. The inference, therefore, has to be that the level should be agreed by all interested parties, after listening tests have been undertaken.

No specific recommendations for fault monitoring of ANS systems are given in Clause 17 of the Code. This appears to the writers of this book to be an omission. The original version of the Code cited three conditions as needing monitoring: failure of any noise-sensing transducer, short circuit or disconnection of any noise-sensing microphone circuit, and failure of the associated control circuit. Perhaps the need for fault monitoring of ANS systems can be readdressed at the next amendment or revision of the Code.

A matter also not addressed at all in the Code is the difficulty of monitoring the critical path of the audio signals through an amplifier that is having its gain constantly adjusted automatically by an ANS system. The subsonic or ultrasonic monitoring signal (referred to in Chapter 10), once set at commissioning, is generally assumed to remain reasonably constant in level at any point in the audio amplifier ‘chain’. With the continual gain adjustment, however, the level of that monitoring signal will change with the audio itself, unless special circuitry is included to stabilize its level. Because of this difficulty, many VA systems are designed to monitor the critical path for faults only before and after the amplifier that is ANS-controlled. However, the Code offers no relaxation of monitoring of systems that incorporate ANS.

18. Emergency and non-emergency messages

Introduction

Firstly, emergency messages need to be intelligible. The intelligibility of a message, however, does not purely depend upon the performance of the voice alarm control equipment or even the acoustics in the listening area (although both of these are significant factors). If the message fed into the VA system is not clear to start with, there is not much chance of its being intelligible when it emerges from the loudspeakers!

Secondly, emergency messages need to be fit for purpose. They should make their point clearly and concisely, with appropriate wording, and be delivered in a calm but firm manner, to avoid inducing undue fear on the part of the occupants.

Thirdly, a pre-message warning signal is needed to draw people's attention to the emergency broadcast.

All three above matters, and other aspects of broadcast messages, are covered in Clause 20 of the Code.

Attention-drawing signal

20.1 of the Code calls for the attention-drawing signal to be in the frequency range 500 Hz to 1 kHz; this is in accordance with the recommendations of BS 5839-1 for alarm sounders. The sound of this warning signal in a VA system should be the same as would be expected in a conventional fire detection and fire alarm system using conventional sounders or bells.

Subclause 19.2.3a) of BS 5839-1 calls for an alert signal to be pulsing at a rate of 1 ± 0.5 s on and 1 ± 0.5 s off, as opposed to a steady evacuate signal. In the case of a VA system, however, the difference between an evacuate and an alert message is in the content of the voice message itself (see below); it is not therefore necessary to use different attention-drawing signals before the two kinds of message. It is common practice, and acceptable under BS 5839-8, for the same signal to precede both types of message.

Message quality

Guidance is given in 20.2 and 20.3 on the way to 'put the message across'. In deciding upon a particular emergency message, for example an evacuate message, the wording needs to be short and to the point, but delivered in a calm and yet commanding voice. Examples of messages that are in use in real systems are given in Note 1 to 20.7 (and they do not start with 'Don't panic! Don't panic!').

In difficult acoustic conditions, a higher pitched (female) voice may be more easily understood than a lower pitched (male) voice. For example, in a reverberant listening area, such as a large hall or cathedral, where the lower frequencies generally reverberate for longer than higher frequencies, the greater clarity of the female voice would be expected to give improved intelligibility. A female voice could also be used to advantage in an area with high background noise at lower frequencies, e.g. from electric motors and machines driven by them. Although these points are no longer included as recommendations in the revised Code, the writers consider that they are still relevant. The point is, however, made in the commentary to Clause 20 that it might be appropriate to use a male voice in one area and a female voice in an adjacent area, where overspill of sound could occur between the two areas.

The message should not be delivered too fast, particularly when the broadcast is to be delivered to reverberant areas. A slow delivery is desirable as an aid to understanding. In this connection, it should be borne in mind that, although 20.2 and 20.3 imply that the message is live, this recommendation applies equally to the recording of a pre-recorded voice message. Therefore, when a message is being recorded, the speaker should be instructed as to the exact speed of delivery required.

Language

One of the obvious advantages of voice messages is that they can be in different languages. This possibility is referred to in recommendation 20.4. Possible examples where broadcasts in multiple languages would be desirable are airports and main railway stations. In fact, the idea does not appear to have 'caught on' to any extent, partly, perhaps, because it is sometimes difficult to select a (small) number of languages to use for emergency messages, where a huge variety of languages is spoken by the public in the area concerned. There is also a tendency in the UK to assume that everyone should be able to speak English! Of course, if any occupants do not speak English, they will still hear the attention-drawing signal, and will, thus, be no worse off than they would have been in a building with conventional alarm sounders.

Live voice and pre-recorded messages

It is soul-destroying for the designer of a VA system of proven good performance to hear some of the broadcasts made by untrained operators. We have all heard (but not understood!) such announcements, particularly at railway stations. The frightening fact is that, while it is bad enough to miss a train, unintelligible emergency broadcasts could hazard life safety. This is why 20.5 stresses that persons making such broadcasts should be trained in the use of the microphone.

Emergency microphones are primarily intended for use by fire officers or trained persons in authority. The Code makes it clear (also in 20.5) that anyone else using the microphone in an emergency should read from a prepared script. Otherwise, 'ad lib-ing' by an untrained person, who might be nervous or anxious in the emergency situation, could lead to confusion because of poor message content or poor intelligibility.

With regard to the recording of emergency messages, the persons speaking should be trained in the proper use of the microphone. This is crucial, because the message will never sound better than it does at the recording microphone, only worse. The recording, signal processing, amplification, loudspeaker characteristics, and acoustics of the listening area will all contribute to a degradation of the original sound quality. To help achieve satisfactory broadcasts, 20.6 recommends that recordings be carried out in a controlled acoustic environment. Such an environment might have an ambient noise level no greater than 30 dBA and a reverberation time no greater than 0.5 s, over the range from 150 Hz to 10 kHz. Obviously, any recorded noise or reverberation would just add to whatever applied in the listening area receiving an emergency broadcast.

Emergency broadcasts

General

To aid understanding, there should be short periods of silence between the attention-drawing signal and the emergency speech message, and after the speech section of the message but before a repeat of the whole message. Figures 3 and 4 in 20.7 a) and 20.7 b), respectively, show the same pattern for evacuate and alert messages, the main difference between the two types of message being the content of the speech section. (As discussed above, the attention-drawing signal can be the same for both types of message.)

In defining the format of an emergency message broadcast, as for many other aspects of the Code, the committee writing BS 5839-8 liaised with another group writing a code of practice that was to become BS EN 60849, *Sound systems for emergency purposes*. The lengths of periods of silence within a message, for example, were 'harmonized' between the groups but, because of the common experiences of group members, there was very little difference between the original suggested times. In the revised Code, the periods of silence, tones and voice message have been retained without change from the amended version of the original Code (which themselves changed slightly on publication of that amendment).That does not mean that these times are 'cast in stone'; the Code notes that there may be circumstances where the periods of silence should be longer. In a very resonant listening space such as a large domed area, messages should be as short as possible, delivered very slowly and with longer periods of silence than those recommended in the Code for normal use. Of course, the messages are still broadcast for life safety reasons and must be repeated at reasonably short intervals (see below).

For all pre-recorded emergency messages, the 'attention-drawing signal – silence – speech message – silence' format should be repeated continuously until manually silenced, superseded manually or automatically by a message of higher priority, or, if it is a '1st sequence' alert message (see below), replaced by a '2nd sequence' alert message (see below).

Evacuate messages

The typical evacuate message given as an example in the Code is:

> Attention, please. Attention, please.
> Fire has been reported in the building.
> Please leave the building immediately, by the nearest exit.
> Do not use a lift.

Although it refers to ranges of periods of silence for such messages, the Code does not explicitly recommend any lengths of time for the speech sections themselves. However, at a slow delivery, the above message has a length of about 15 s. In certain circumstances, a message may need to be a little longer, referring perhaps to the need not to use one or more exits. If, however, the message length were excessive, it would tend to delay the start of the evacuation. Subclause 20.7 a) recommends a maximum time between the start of each repeated evacuate message of less than 30 s. Working back from that figure, and allowing the minimum periods of silence recommended, a maximum length of speech message of 23 s can be deduced. A maximum message length of about 20 s, therefore, is probably desirable for an evacuate message.

The assumption made up to now has been that one evacuate message only would be broadcast throughout a building, and this is normally the case. However, Note 2 to 20.7 a) also refers to situations where it may be desirable to have more than one type of evacuate message. Examples are given as a building with many different means of escape and a building using phased evacuation. Although it is not mentioned at this point in the Code, it is of course necessary for each different type of evacuate message to be broadcast to a separate loudspeaker zone that is therefore acoustically isolated from its neighbouring zones (see Chapter 15).

Alert messages

The format of an alert emergency message is the same as that of an evacuate emergency message. However, an average alert message lasts longer than an average evacuate message, say for 20 s rather than 15 s, and also the emergency situation is not as critical in the alerted area as in the area being evacuated. For these reasons, 20.7 b) allows for a maximum time between the start of each repeated message of 45 s (but see below in connection with second stage alert messages). Working back from that figure, using the minimum recommended periods of silence, a maximum length for the speech section of an alert message can be deduced as 30 s. A practicable maximum length for this speech section should therefore be about 25 s.

There are four commonly used forms of alert message:

1. normal (not sequenced),
2. 1st sequence;
3. 2nd sequence;
4. coded

Normal (not sequenced) alert messages. These are standard single alert messages. Such a broadcast will be repeated continuously until manually silenced or superseded, manually or automatically, by an evacuate broadcast. The typical example of such a message given in Note 3 to 20.7 b) is:

> May I have your attention, please.
> May I have your attention, please.
> Fire has been reported in the building.
> Please listen for further instructions.

Sequenced alert messages. Particularly in large, multi-storey, buildings, the Code advises that there may be a need for two stages of alert message. Generally, such an arrangement is appropriate for areas where the occupants would be expected to continue their work, staying at their normal workplaces while there was an emergency in another part of the building. The first stage would be to broadcast a '1st sequence' message; the example given in the Code is:

> May I have your attention, please.
> May I have your attention, please.
> Fire has been reported in the building.
> This report is being investigated.
> Please remain at your workplace whilst the fire alert exists.

This message would be repeated until silenced, superseded by a 2nd sequence alert message, or superseded by an evacuate message. The 2nd sequence alert message would be intended to remind occupants of the area, after they could be presumed to have heard sufficient repeats of the 1st sequence message, that there was still an existing fire emergency situation elsewhere in the building. The example given in Note 4 to 20.7 b) of a 2nd sequence alert message is:

May I have your attention, please.
May I have your attention, please.
You are reminded to remain at your workplace whilst the fire alert exists.

No guidance is given in the Code as to the length of time for which the broadcast of a 1st sequence alert message should be continuously (automatically) repeated before being replaced by a 2nd sequence message. Allowing for about ten repeats of the 1st sequence message, a reasonable length of time might be 6 to 8 min, but such a figure should be agreed by all interested parties before setting the time within the control equipment.

Although subclause 20.7 b) calls for a maximum of 45 s between the start of each repeated alert message, it is assumed that this does not apply to 2nd sequence alert messages. The reason for that assumption is that 2nd sequence alert messages are reminders, after a period of continuous broadcast of 1st sequence alert messages. Another point is that continuous broadcast of a message, with very short gaps between repeats, can be increasingly annoying to those in the listening area. It is therefore assumed that the format of 2nd sequence alert messages will be as previously indicated, but that the times between the starts of each repeated 2nd sequence message may be longer than 45 s. The periods of silence between repeats might be, say, 1½ to 2 min, but, once again, that time should be agreed by all interested parties before setting it within the control equipment.

Coded alert messages. This type of alert message broadcast is intended to be understood by staff, rather than by the general public in the area in question (and it is therefore often referred to as a ‘staff alarm’). Its use may be appropriate for certain public assembly buildings. Typically, in a building with such an arrangement, security staff would respond to the broadcast by rapidly investigating the presumed emergency, before the public became aware of the situation. Normally, the broadcast would not continue for very long, because either the source of a nuisance alarm would be found, or, in the event of it being a real fire situation, the message would be manually overridden by an evacuate broadcast. Moreover, the start of the coded alert message would generally coincide with the start of a ‘time out’ delay, such that, if no action were taken, for example the silencing of alarm messages, within a preset time (of, say, 4 or 5 min), an evacuate broadcast would automatically commence, overriding the coded alert message.

Coded alert messages are normally disguised as routine staff announcements, to avoid alarming the public in the area. The example given in Note 5 to 20.7 is:

> Attention please! Will Mr Frost ring 123.

The use of coded alert broadcasts is controversial since there may be a delay in broadcasting an evacuate message in a real fire situation. It cannot be assumed that such an arrangement will be safe and acceptable in all (or perhaps even many) buildings in which a VA system is installed. BS 5839-8 makes it clear, therefore, that coded alert broadcasts, and associated delays in evacuation, should be discussed and agreed to by all interested parties before implementation.

In this connection, there is a common belief that it is dangerous to make the public aware that an instruction to evacuate a building has resulted from a fire or suspected fire. In the opinion of the authors, this belief is a misconception and is somewhat out of date. Modern research on human behaviour in fire suggests that, for optimum response by members of the public, they should be given appropriate information about the circumstances of the incident, including the fact that the evacuation has been necessitated by a fire alarm signal.

Test messages

General

Test messages can, of course, be broadcast live via a microphone, but use can also be made of the pre-recorded message facilities in a VA system for test purposes. (40.1c)) of the Code recommends that all microphones be tested on a weekly basis; there is therefore no need for live voice to be used to test other parts of the VA system.)

Note 3 to 20.8 warns that broadcast of a test message is no substitute for the recommended weekly testing of the whole of the fire alarm system, including the fire detection and fire alarm system. BS 5839-1 recommends that, every week, a manual call point is activated and it is checked that the appropriate alarms sound, or, in the case of VA systems, that the appropriate emergency message(s) are broadcast.

The wording of test messages should be carefully considered so as to avoid causing alarm or excessive disturbance to the occupants of the building. There is also no need for the messages to be long-winded. Three types of test message are referred to in the Code; these are as follows:

1. audio system test messages;
2. announcements to precede fire alarm tests;
3. announcements to follow fire alarm tests.

Whilst not specifically referred to in the test messages section of the Code, any such test message could, if desired, be preceded by a chime or other attention-drawing signal, provided that that signal was different from the attention-drawing signal(s) used to precede emergency messages. This arrangement would lessen the chance of any confusion of the test message with an emergency message.

Audio system test messages

These messages are simply to test the operation of the audio system, during routine maintenance (see Chapter 28). They should therefore not refer to 'fire' in their wording, so as to avoid any confusion with fire alarm testing or emergency messages. The straightforward example given in Note 4 to 20.8 is:

> This is a test of the public address system.

Announcements to precede fire alarm tests

As a convenience, a pre-recorded test message can be used to announce a fire alarm test. This facility would obviously be highly desirable in premises where no microphone was available within the VA system. The example given in Note 1 to 20.8 is repeated below:

> May I have your attention, please.
> May I have your attention, please.
> The fire alarm system is about to be tested.
> Please take no further action.

In the original version of the Code, there was a note recommending a minimum of delay between the broadcast of this pre-test message and the actual fire alarm test. If the delay were too long, the fire alarm test could be taken to be a genuine fire alarm by some of the occupants of the building. This note was probably inadvertently omitted from the revised Code and could usefully be re-added at a future amendment or revision.

Announcements to follow fire alarm tests

The example given in Note 2 to 20.8 is repeated below:

> May I have your attention, please.
> May I have your attention, please.
> The fire alarm test is now complete.
> If you have had any difficulty in hearing any part of this message, please advise the main reception.
> Thank you for your co-operation.

Broadcast message priorities

Where there is a very secure but remote fire control centre (e.g. in the case of an underground railway station), automatic evacuate messages initiated at the control centre may be considered to be at a higher priority level than a local emergency microphone (e.g. at one of the underground stations). Usually, however, the emergency microphone(s) is given the highest priority status in a VA system.

Below the emergency microphone in priority come fire evacuate messages, fire alert messages, etc. Reference should be made to the closing section of Chapter 14, which includes a list of priorities for a typical large VA system.

19. Audibility and intelligibility

Introduction

In the revised BS 5839-8, audibility and intelligibility are dealt with primarily in two places: Clause 21 (for recommendations concerning audibility of non-speech broadcast) and Clause 22 (for recommendations concerning intelligibility of speech messages). This chapter covers both of these clauses of the Code.

As has already been stated more than once in the book, the aim of a VA system is to provide intelligible fire warning message broadcasts in buildings. For a message to be intelligible, it has, amongst other factors, to be sufficiently audible and sufficiently clear. This means that, strictly speaking, a measurement of intelligibility takes into account audibility and clarity and that, provided intelligibility is measured, there is no need to measure audibility as well. In practice, however, intelligibility is more complex to measure (objectively) than audibility; special equipment is needed and it can be expensive to purchase or hire. For these reasons, intelligibility, except in large (and often acoustically 'difficult') spaces such as exhibition halls, large auditoria and sports stadia is generally determined subjectively, i.e. by a small team of people, who listen to broadcasts at various points throughout the building, and decide, on a personal basis, whether or not a message is intelligible. Objective measurements are therefore commonly made of audibility, but not necessarily intelligibility (see below).

Simple 'rules of thumb' may sometimes be used for satisfactory acoustic design in acoustically simple buildings such as open plan office areas (see Chapter 15 re loudspeaker design), whereas acoustically difficult buildings, for example railway stations and power stations, will generally require the involvement of a specialist electro-acoustic engineer. Even for some apparently acoustically simpler situations, the 'rules of thumb' might not necessarily apply. Appropriate training would then be required, sufficient to allow an engineer designing a VA system to cope satisfactorily with the acoustic environment when specifying/locating loudspeakers.

The content of this chapter is largely split between audibility and intelligibility, with the emphasis upon the latter.

Audibility

Recommendations covering audibility apply both to speech and non-speech broadcast. First of all, consideration is given to non-speech, i.e. tones. Clause 21 gives the recommendations for audibility of non-speech broadcast; this may be either the tones from a VA system broadcasting tones only, or the attention-drawing tones of a VA system with speech messages. As set out in 21.1, the audibility recommendations in BS 5839-8 are very similar to the recommendations for sounders quoted in 16.2.1 of BS 5839-1:2013. BS 5839-8 recommends a minimum sound level of generally 65 dBA, but 60 dBA in stairways, enclosures of no more than 60 m^2 in area (e.g. cellular offices), and specific points of limited extent. However, where the background noise is greater than 60 dBA, the emergency broadcast should be at a level of 5 dB above that noise. Notes 1 and 2 make it clear that the 'background noise' referred to here does not constitute noise that persists for a period of less than 30 s, or that arises from running water in showers or bathrooms. The 5 dB figure was 6 dB in the previous version of the Code; this change brings the Code into line with BS 5839-1 and other standards.

The recommendation for 75 dBA at the bedhead, to arouse sleeping persons, is a direct quotation from BS 5839-1. Useful Note 3 to 21.1c) now makes it clear that this minimum sound level will normally require the installation of a voice alarm loudspeaker in every such room, and 21.2 recommends that audibility measurements should be made with all relevant room doors shut. The latter may seem an obvious point but it should help to avoid arguments about doors that are supposedly 'always open'.

Four further notes are included in 21.2; these are all imported from BS 5839-1:2002. The fourth handy note relates to the measurement of audibility in the presence of background noise (which of course is the normal case) and advises that

> The sound pressure level of the attention-drawing signal or non-speech alarm broadcast (in isolation) can be deemed to be 5 dB above background noise if, when the background noise is present, a

sound pressure level increase of 6 dB occurs on operation of the fire alarm system.

Note 3 to 21.2 states that the audibility measurements should be made using a sound level meter (exactly as for bells or sounders in a conventional fire detection and fire alarm system). The meter should be an instrument conforming to BS EN 61672-1, set to slow response and A weighting. Before the speech message, there will be a burst of at least 2 s of attention-drawing signal (see Chapter 18), generally allowing the meter reading to steady sufficiently, on slow response setting, and enabling a reasonably accurate reading to be taken.

Although not strictly necessary to conform to the recommendations of the Code (since intelligibility, which includes audibility, will be measured either subjectively or objectively – see below), the audibility of the speech section of the message can be measured, particularly if it is questionable. Unfortunately, an accurate measurement demands the use of complex equipment and, consequently, could be expensive.

A 'rough and ready' method of measurement was given in the original version of the Code. Basically, it is the same method as is used for measurement of the audibility of the attention-drawing signal; a standard sound level meter can be used, set to A weighting and 'slow response'. Provided that the speech message used has very few gaps (periods of silence within the message), the meter will tend to read the average sound level; unfortunately, the average level will, inevitably, itself fluctuate, and it will be necessary to estimate an 'average' of the changing average readings.

The recommendation 22.1.1 in BS 5839-8:2013 has been slightly altered to indicate that the audibility of the speech section of a speech message should generally be at least 10 dB above background noise level. Where RT is particularly high, the sub-clause also recommends that care needs to be taken to ensure a high enough direct to reverberant sound level ratio, involving the creation of a higher signal to noise ratio.

For accurate measurements of background noise, new sub-clause 22.1.2 recommends, in more detail than in the previous version of the Code, the types of noise measurement to be made in environments with differing types of background noise: $L_{\mathrm{Aeq},T}$ for short bursts, and $L_{\mathrm{A10},T}$ for long periods of noise.

Sub-clause 22.1.3 now gives prescriptive recommendations for how and when to measure ambient noise in checking and setting up ambient noise sensing systems. Because it was known that ambient noise sensing systems were not always very effective in practice, the previous version of the Code did not go into this level of detail; time will perhaps tell if the prescriptive approach is successful. (See also Chapter 17, Ambient Noise Sensing and Compensation.)

Subclause 22.1.4 recommends that the assistance of a qualified electro- acoustic designer should be sought in cases where background ambient or occupational noise levels exceed 75 dBA. Many industrial buildings, railway stations and swimming pool buildings, for example, have noise levels of that order or higher.

Intelligibility

Intelligibility includes clarity as well as audibility. In the revised Code, clarity is given a subclause in the recommendations, 22.2. The three recommendations do not appear to relate specifically to clarity only but are useful points. Subclause 22.2.1 is a reference to the need for the frequency response of a VA system to conform to the requirements of BS EN 54-16.

Subclauses 22.2.2 and 22.2.3 recommend, respectively, that the assistance of a qualified electro-acoustic designer is sought in cases where:

- the reverberation time of the listening space is likely to be greater than 1.5 s. (These conditions often apply in large halls, some auditoria, large churches, cathedrals, etc.)
- the loudspeaker to listener distance is likely to exceed 10 m. (This would be most likely to apply in large listening spaces where it may not be practical to mount loudspeakers closer to the listeners. Equally, this recommendation may be interpreted as a warning against the use of a small number of high output loudspeakers, rather than a larger (and hence more costly) number of lower output loudspeakers.)

The latter two recommendations are retained from the previous version of the Code and are perhaps now not particularly necessary since to some extent they duplicate the 'rule of thumb' guidance for simple acoustic spaces given in 14.2.

In the previous version of the Code, quite a bit of information about the behaviour of broadcast sound in an interior environment was included. The panel generating the revised Code considered that some of those details were unnecessarily technical. A similar but shorter version is now included in the commentary on 22.

Since this book is a ‘guide to the guide’, some of the comments upon the previous information have been retained below. Interspersed with them are comments relating to the guidance in the commentary in the revised Code.

Factors affecting intelligibility

Ratio of direct sound received to reflected sound received. The sound that travels directly between the loudspeaker and the listener, together with sound that arrives at the listener from reflections within 35 milliseconds (ms) of the direct sound, the 'early' sound, aids intelligibility. Reflections arriving more than 95 ms after the direct sound, the 'late' sound (i.e. echoes), reduce intelligibility. Therefore, the larger the ratio of 'early' to 'late' sound, the better the intelligibility. The use of directional loudspeakers can 'beam' sound to the listeners, thereby minimizing the amount of sound that is misdirected and reflected from walls, etc. Constant directivity (CD) horn loudspeakers are often used for that purpose.

A certain amount of reflected sound is, therefore, beneficial, provided that the 'reverberation time' (see next paragraph) of the space is quite short. Indeed, sounds generated in a totally 'anechoic' space can appear odd to a listener, as, under normal listening conditions, some reflected sound always exists at the ear of the listener. The human brain 'retains' any sound for a short time and, hence, cannot distinguish between the directly received sound (which follows the shortest path) and reflected sound received within about 35 ms thereafter; the two sound components are effectively additive. (There is something of an analogy here with the performance of the brain in response to visual signals, which are also retained for a short time, making a series of pictures, as occur in films and television, seem continuous.)

In a reverberant space, such as a cathedral, echoes from a single sound continue for some seconds, gradually dying away. The 'reverberation time', i.e. the time taken for that reverberant sound to decay to a negligible sound pressure level, in such spaces, can be up to 11 s! (The version of reverberation time commonly used is RT_{60}, the time taken for the sound pressure level of the reverberations to decay by 60 dB.) Obviously, there will be strong sound reflections continuing well after the 95 ms referred to above, and intelligibility will be greatly affected. The commentary on 22 tells us that the reverberation time of a space is a critical factor in designing a suitable electro-acoustic solution. It is worth reminding the reader that delayed sound can reach the listener from several loudspeakers in the area. Where sound is broadcast in the same direction, as, for example, in auditoria, places of worship, and usually in railway station concourses, loudspeakers are often located at intervals over the distance from front to rear of the area. Listeners at the rear would be likely to find it difficult to understand broadcasts because of the 'late' sound arriving from loudspeakers located towards the front. This problem can, however, usually be overcome by introducing delays electronically, within a chain of amplifiers. These allow audio signals to reach the front loudspeakers first, and the rear loudspeakers after a slight delay (approximately equal to the time taken for the broadcast sound within the listening area to travel from the front to the rear loudspeakers). An original sound broadcast through all the loudspeakers will reach a listener at the rear by several routes (from different loudspeakers). With the introduction of the delay(s), however, each different component of the sound, although coming by a different route (from a different loudspeaker), should reach the listener's ears approximately at the same time, thereby helping intelligibility.

Signal level. Sufficient signal level (audibility) is needed for intelligibility (see above).

Signal to background noise ratio. The lower this ratio, the worse is the intelligibility. As stated in 22.1.1, the speech signal to background noise ratio should be at least 10 dB.

Solid elements. A solid element, such as a door or partition, between listener and loudspeaker, attenuates the sound received by the listener, but not evenly throughout the frequency range of the broadcast sound. The sound is usually 'muffled', i.e. lacking in high frequency content. That modified broadcast is then difficult to understand, particularly in the presence of background noise on the listener's side of the solid element. This is because much of the information needed by the brain to 'decode' the broadcast is carried in the higher frequencies. Therefore, whereas each room might not require a conventional fire alarm sounder, in a traditional fire alarm system, a loudspeaker might be needed in each room to ensure intelligibility, rather than simply audibility.

Optimizing intelligibility. To obtain optimum performance from the VA system in terms of intelligibility, a number of steps need to be taken (some of them to overcome problems referred to in the immediately previous section of this chapter). These are described next.

In order to design for maximum intelligibility, as previously discussed, signal to background noise ratio needs to be sufficiently high. It is therefore necessary to know, as accurately as possible, the actual or expected background noise levels in the listening areas. As a guide, Annex A of the revised Code lists typical expected background noise levels in many common types of building. The annex emphasizes the importance of taking into account background noise in determining the intelligibility of a VA system and replaces Table B.1 in the previous version of the Code. The difficulty of forecasting the background noise in a building not yet constructed, or not yet occupied, is discussed, and it is pointed out that the background noise often changes dramatically dependent upon use and level of occupation. Table A.1 gives actual noise measurements taken in a hotel and usefully lists the design criteria appropriate for the varying public spaces in the building. These examples should give the reader of the Code some insight into the processes needed in designing VA systems for optimum intelligibility.

Some guidance, which was in the form of recommendations in the original version of the Code, is now contained in the commentary on Clause 22. This includes the following two points which advise that intelligibility can be optimized by:

- where necessary (and possible), making use of sound absorption material, for example perforated roof decking, acoustic ceilings, carpets and upholstered seating, to optimize the 'early-to-late' sound ratio. Generally speaking, this type of acoustic treatment can be applied to new buildings; in historic buildings, however, it is usually unacceptable.
- the installation of ambient noise sensing and compensation control in buildings with very variable levels of background noise, such as railway stations (see Chapter 17).

Intelligibility levels and their measurement. Perhaps the most controversial issue in the writing of the revised version of the Code was the question: 'Should intelligibility be measured subjectively or objectively?' On the one hand, it was argued that for acoustically 'simple' buildings, such as office blocks, a small team of listeners could carry out a subjective assessment of intelligibility of emergency messages and this would be quite adequate. For large venues such as sports stadia, exhibition centres or transport terminals, on the other hand, it was generally agreed that intelligibility ought to be measured objectively, using appropriate equipment. It therefore came down to a question of balance between these extremes. In the previous version of the Code, the general recommendation was that subjective assessment should be adequate for most systems, unless the building concerned was particularly 'difficult' acoustically, or there was any dispute as to the intelligibility level.

In the end, a compromise was reached, namely that the intelligibility measurement could be either subjective or objective, provided the method was agreed by all relevant and interested parties. In the revised Code, 22.3.1 recommends that ‘The extent and method of testing and levels of intelligibility to be achieved should be agreed by interested parties and stated in the system specification…’. Notes 2 a), b) and c) to 22.3.1 (referred to at the beginning of this section on intelligibility) give the likely criteria for the use of objective, rather than subjective, measurement. The revised Code, as before, recommends objective assessment in the event of a dispute.

The Code (in 22.3.3) recommends a minimum intelligibility of 0.5 STI (speech transmission index) for a VA system. STI is a measure of intelligibility made objectively, i.e. using electronic equipment to generate appropriate sound signals for testing and further electronic equipment to receive and analyse the resulting signals at the listening position. The test signals are preferably fed into the VA system under test and broadcast, therefore, from the VA system’s loudspeakers into the required listening area. The receiver/analyser is able to compare the received signals (which will have been altered by the effects of reverberation, background noise, etc. in the listening area) with the original signals, and an STI figure can be derived.

STI is measured on a scale from 0 to 1: the closer the number to 1, the better the intelligibility. ‘1’ represents perfect intelligibility. Although the range stretches from 0 to 1, the ear can readily detect a difference of 0.05 STI in the middle of the STI range. For example, at a position with an STI of 0.45, it might be reasonably easy to understand a message, but, if the acoustic conditions were altered so that the STI level decreased to 0.40, it could become very difficult to understand the same message.

The RASTI method of measurement of STI is worthy of mention here, because it has been called up as one possible measurement method for intelligibility in BS EN 60849. RASTI stands for rapid (or room acoustics) speech transmission index and is a simplified method of determining the STI. So-called ‘full’ STI involves complex test measurements at a number of centre frequencies over the main part of the audio range that contributes most to intelligibility, say, 125 Hz to 8 kHz. The RASTI measurement is restricted to two centre frequencies, namely 500 Hz and 2 kHz, and therefore gives a useful though less accurate STI figure than would be derived from a ‘full’ STI test. BS EN 60849 advises that RASTI is suitable for room acoustics with direct sound transmission between speaker and listener. Only in specific conditions (i.e. substantially linear systems, where there is no signal compression), can the method be applied to sound systems. Proprietary equipment has been available to carry out RASTI measurements directly, using a special 'RASTI message' that is designed to simulate, as far as possible, a human voice. There are, however, now a number of more accurate methods of measuring intelligibility and the results can be in, or can be converted into, STI. These are discussed in BS EN 60268-16.[16]

Returning to the recommendations in the Code, the figure of 0.5 STI should be readily achievable in acoustically straightforward listening areas, for example open-plan offices. As mentioned before, however, there are buildings such as swimming pools where it may be difficult or even impossible to achieve that level of intelligibility. In such cases, an acceptable level of intelligibility will need to be agreed by the interested parties.

The Code does not recommend over what percentage of the area of coverage of a VA system the intelligibility should be 0.5 STI. However, as previously mentioned in a note, the audibility of the non-speech signal should meet the recommended levels except in 'small areas of limited extent within the enclosure, for instance the area behind a pillar'. Perhaps the same philosophy can be applied to intelligibility of voice messages. Also, it has been the practice among acoustic specialists to call for, or accept that, this STI level applies to 95 per cent of the listening area. In the absence of a definite recommendation, a strict interpretation might be to demand that the specified intelligibility be achieved over the entire area. However, it may be more reasonable to accept the '95 per cent' rule or the 'except behind a pillar'. It would, however, be advantageous to all concerned if consideration could be given to the inclusion of some guidance of this type at the next review of BS 5839-8.

Although the Code specifically recommends that intelligibility, for the purposes of the Code, be quoted in STI, there are other units of (objective) measurement of speech intelligibility, such as percentage articulation losses of consonants (Alcons), articulation index (AI) and phonetically balanced (PB) word scores. 'PB word scores' is a very accurate method of measuring intelligibility, because, unlike the other methods (which all use measuring instruments) it involves an audience of trained listeners; however, it is a cumbersome and expensive method. Readings of intelligibility taken in these alternative units can generally be converted into STI. For example, 0.5 STI approximates to 11.5 per cent Alcons. The Alcons scale is from 0 per cent to 100 per cent, but, unlike the STI scale, increasing Alcons mean decreasing intelligibility, i.e. 100 per cent Alcons represents complete lack of intelligibility!

[16] BS EN 60268-16:1998 *Sound System Equipment.Objective rating of speech intelligibility by speech transmission index.*

A so-called 'common intelligibility scale' (CIS) was introduced some years ago; it is referred to in BS EN 60849 and BS EN 60268-16. Using the established conversions between existing units, the existing intelligibility unit ranges have been 'mapped' against one another and a linear scale (the common intelligibility scale) derived. (The conversion table is included in BS EN 60849.) The graphical representations of the various intelligibility scales overlaid on the CIS conversion chart demonstrate that these scales are at their most accurate only over differing restricted ranges of intelligibility. The chart is intended to be useful in optimizing the accuracy of a measurement in the following way. With knowledge of the approximate intelligibility expected, e.g. in STI, the conversion chart should indicate the measuring technique/units likely to give the most accurate measurement. It is understood, however, that the CIS scale is no longer considered to be sufficiently accurate and has fallen out of favour.

Know-how and specialized measuring equipment are required for the instrument-based intelligibility measurements. As previously discussed, where there is any doubt or dispute, objective measurements will be needed; in that case, 22.3.2 recommends that intelligibility should be quoted in STI units in accordance with BS EN 60268-16. It has to be said, however, that an STI figure of, say, 0.5, is an indication that intelligibility should be acceptable; it is not a guarantee of intelligibility. A listener in a particular acoustic environment may find broadcast speech easily understandable at a point that has been tested to have an STI of 0.5. The same listener, however, in a different acoustic environment, may find broadcast speech difficult to understand at a point in that area that also has a tested STI of 0.5.

Although the Code recommends in 22.3.3 a minimum intelligibility of 0.5 STI, that may be considered a 'default' level. In fact, the Code now makes it clear in Note 1 that a lower STI figure may be acceptable to the interested parties….'

a) in some very reverberant spaces, and areas with high background noise;
b) where the persons who are required to understand the messages are, or will be, reasonably familiar with them through regular system tests, but to a minimum of 0.45 STI.

This should help prevent slavish adherence to the 0.5 STI figure in circumstances where it is not strictly needed and thereby, for example, keep down system costs.

The revised Code usefully now makes allowance for situations where occupancy regularly varies. Note 3 advises that

> some relaxation in STI recommendation may be given to an exhibition centre to take into account the different operational modes of "empty", "half-build", and use by the public. In this respect, the "empty" condition may be mitigated by the requirement for visitors to be accompanied by venue staff, and the "half build" condition mitigated by venue staff monitoring non-venue workers.

Intelligibility should be assessed under the worst expected conditions. In 22.3.4, an important point is made about the testing environment. Testing should be carried out in the presence of the worst noise levels that would be expected during a real fire condition; such noises would be generated by, for example, pressurization and smoke extract fans. Where these noise sources are not available at the time of testing, the Code recommends that they be simulated. Recordings could, for example, be made of such fans operating elsewhere and the results broadcast into the test area using a test sound system (that could itself be adjusted to bring the injected noise to the desired level). A new note adds further clarification as follows, 'Where objective measurements are being taken, the noise may be replayed at a representative level close to the measurement microphone; however subjective assessment will require the assessor to be immersed in a sound field of the noise.'

Intelligibility is the ultimate aim of a VA system and therefore it is insufficient to test a system merely for audibility. To test whether a broadcast is intelligible, speech messages must be used, and therefore it is obviously important that persons involved have normal hearing.

Although the method is subjective, 22.3.5 of the Code recommends that messages used for the testing should be unknown to the listeners. Prior knowledge of the message content, or repeated broadcasting of the same message, would lessen the effectiveness of the test for intelligibility. (It is noted that repeated pre-recorded messages are of a lesser value as the message can be learned by listeners.) The 'one off' nature of this type of test implies that it should be live rather than recorded; the Code therefore recommends that appropriate text should be read into a system microphone, where fitted. It is reasonable to assume that, where a microphone is not fitted, either pre-recorded test messages could be used, or (as is normally possible) a test microphone could be temporarily wired into the control equipment for the duration of the test.

Subclause 22.3.5 recommends that, where it has been agreed by all interested parties that a subjective assessment would be adequate, the tests should be based on both intelligibility and audibility, conducted by persons with normal hearing (see BS 5330).

A point that was not so well brought out in the previous version of the Code is that pre-recorded emergency message broadcasts need to be checked for intelligibility. It is not sufficient just to broadcast live messages using a microphone. Hence, 22.3.6 – ‘When commissioning a system, the intelligibility of the stored messages should be assessed.’

20. Emergency message generators

Introduction

Emergency and test messages themselves have already been discussed (see Chapter 18). Why, however, use automatic recorded messages rather than broadcast a live message from a microphone? There are at least the following three reasons:

1. Every time the recorded message is broadcast it will be delivered in the same manner, will consist of exactly the same previously agreed message, and should be of good quality (provided the recording was of good quality).
2. Broadcast of the recorded emergency message does not rely upon the immediate availability of a trained person to use the microphone.
3. In Type V1 systems, no microphone will be installed.

A VA system does not normally include a facility for recording emergency messages. The Code recommends that the messages are recorded in a suitable studio or the like, and by a person trained in the use of the microphone (see Chapter 18). Once a message is recorded and appropriately processed, it is electronically stored; the stored message is then included in a 'message generator' unit or module, which contains further electronics to allow the message to be played on demand. Strictly speaking, the person who recorded the message is really the 'message generator' and the above unit or module is a 'message player'. However, because the message audio is outputted from it when required, the unit has become known as a 'message generator' and that is the meaning attached to the expression when used in this book.

Message generator design

Strictly speaking, message generator design should now be covered by BS EN 54-16 (which, of course, was not published at the time of publication of the original version of the Code). Nevertheless, a number of design recommendations are contained in Clause 19 of the revised Code. These are discussed below, and text from the previous Code version has been retained as it should still be relevant/useful.

Because of the importance of the integrity of an emergency message generator in a system for life safety, such generators should use solid-state electronics exclusively. Tape and cassette players, compact discs or any other form of rotating disks (for example, computer hard disks) are all unsuitable for use in VA systems conforming to BS 5839-8. It should be pointed out that this recommendation places no great onus upon the VA system designer, since such solid-state 'data storage and retrieval' techniques have been commonplace for many years. The aim of this design restriction is to avoid the use of continually moving parts (which, sooner or later, will experience wear and eventually fail). Relays, perhaps associated with status or fault detection are, however, permitted.

For additional security in the event of, for example, temporary power supply failure or disconnection, the storage memory for the message should be non-volatile. The new recommendation is for memory with a data retention period of at least ten years. Appropriate non-volatile memory is readily available in various types.

The recorded message(s) should be protected from unauthorized changes. This is rather a vague statement, but it can reasonably be interpreted that there should not be, for example, a recording facility with microphone that would readily allow someone to re-record an emergency message. In practice, as previously mentioned, no such recording facility is normally provided. In fact, to change messages, it is generally necessary for memory microcircuits to be accessed at level 3 or level 4 (see BS EN 54-16) and then physically replaced.

When the recorded message is played, the voice should sound natural. This can be achieved by making a good quality recording of a live voice, and, indeed (to the authors' knowledge), that is still the method used at present. A synthetic voice could be used for emergency messages, but only on condition that the results were indistinguishable from a human voice.

The bandwidth of the audio outputted from the message generator needs to be sufficient to allow the recommended intelligibility of emergency broadcasts to be achieved in the listening areas. In arriving at the bandwidth to be used, it should be borne in mind that there is certain to be some degradation of bandwidth caused by all the other elements in the path of the audio through the VA system. Subclause 19.1a) recommends that, to achieve intelligibility in typical acoustically simple areas, the 0 to 3 dB bandwidth points should be at least 200 Hz to 8 kHz (more exacting than in the previous version of the Code); however, this is not difficult to achieve. Additional aspects of the audio specification for a suitable message generator are covered in the two following subclauses, where a signal to noise ratio of 60 dB is recommended and a total harmonic distortion figure of 0.5 per cent at 1 kHz at –1 dB from maximum level is called for. These minimum recommendations should ensure that the constraints of the message generator performance have only a small effect upon the overall performance of the VA system.

Fault monitoring of both hardware and software is recommended. In this case, reference is merely made to the appropriate requirements in BS EN 54-16.

Other points

Attention-drawing signals that precede messages can be produced in at least the following three ways:

1. by using a signal generator that is completely separate from the message generator(s);
2. by including signal generators (probably software-based) within the message generator(s);
3. by recording the attention-drawing signal, followed by the speech section of each message, into the memory store.

Of the above alternatives, the second is probably the most flexible and convenient. Programming switches, for example, can be included that allow selection of different lengths and types of attention-drawing signal. In practice, however, methods 1 or 3 are more often used. In the case of 3, a typical fire alarm bell or proprietary electronic sounder may be recorded.

Message generators are still usually designed as modules that plug into the control equipment rack. They often include indicators for 'message running' and faults. Generally, each message generator has a 'menu' of selectable messages within it, including evacuate, alert and test messages. The number of single message generators needed in a VA system is equal to the number of different (automatic) messages required to be broadcast simultaneously. Most commonly, either one or two simultaneous message broadcasts are required. Many message generator modules are therefore designed as ‘dual’ units, to allow for transmission of two different but simultaneous message broadcasts to different loudspeaker zones. It is also possible for a wide range of emergency and, indeed, non-emergency messages to be stored and used, provided that a system of prioritization applies. Such a priority system may be pre-programmed within the message generator or may be external to it, but, in either case, it should ensure that all message priorities are preserved. For example the message of highest priority level (usually, but not necessarily, a simple fire evacuation message) must override any lower priority messages. (See also the last part of Chapter 14 for a list of typical priorities of message.)

21. Emergency microphones

Introduction

Emergency microphones are now considered in BS EN 54-16 to be part of the VACIE (see Chapter 12).

One or more emergency (previously referred to as fire or firemen's) microphones may be installed in a VA system to allow the building management or the fire and rescue services to take control of evacuation procedures during a fire emergency. (This applies to Types V2, V3, V4 and most V5 systems – see Chapter 7.) A VA system should always have at least one message generator, allowing the automatic broadcast of an emergency message when called for by the fire detection and fire alarm system. In simple buildings, such as small office blocks or manufacturing premises, an automatic evacuate message broadcast may be quite adequate for safe evacuation. (This arrangement is the voice alarm equivalent of a conventional single-stage fire alarm system, where bells or sounders would operate in evacuate mode, i.e. continuously and steadily throughout the building.)

In more complex buildings, where two-stage fire alarm systems (i.e. those capable of broadcasting an evacuate message in one (or more) area(s) and an alert message simultaneously in other areas) are used, installation of emergency microphones would normally be advantageous. The Code recommends that they should always be part of VA systems in buildings where phased evacuation is used. Such buildings, for example, tall, multi-storey office blocks, require careful control of evacuation in an emergency. Emergency microphone(s) give the building management or fire and rescue service a greater flexibility of control than is available from pre-recorded messages. Even where many different pre-recorded alert messages are available, a fire officer may need to give specific instructions to aid evacuation, or reassurance to those awaiting an evacuation signal, and he would be able to do so using an emergency microphone.

Emergency microphones can be used for communications between members of the fire and rescue service in a fire emergency but are primarily intended to be used for broadcasting specific evacuation or alert instructions to the occupants of the building. Fire telephones (which are not covered by the Code, but are the subject of BS 5839-9) may be provided for communications amongst the members of the fire and rescue service.

Types of emergency microphone

The grade of microphone needs to be sufficient to allow intelligible broadcasts to be achieved throughout the area of coverage. The acoustic characteristics of listening areas within a building often vary greatly. A microphone of poor quality (for example, with a very ‘lumpy’ frequency response causing excessive distortion) may allow intelligible broadcast in a loudspeaker zone with good acoustics, but may contribute to poor broadcast quality in other, perhaps more resonant, listening areas. As outlined below, however, there are aspects of microphone performance other than just frequency response that need to be considered for an emergency microphone. (It should also be remembered that the performance of a microphone is only one of the factors that affect the intelligibility of broadcasts; the performance of loudspeakers and their positioning also play a major role in that (see Chapter 15).)

Subclause 18.1 recommends that the frequency response of an emergency microphone should be 200 Hz to 5 kHz ± 3 dB. Ideally, a larger frequency response range would have been recommended but the writers of the Code agreed that the ‘double standards’ applying to the previous version of the Code should not be retained. (In the previous version of the Code, the frequency range recommended for ‘gooseneck’ microphones was considerably wider than that for hand-held fire microphones. This was because hand-held microphones were not readily available with the wider frequency response (and are still not today)). So the upper end of the frequency response of an emergency microphone is now 5 kHz ± 3 dB, whatever the type of microphone. It is questionable whether such a microphone strictly conforms to the requirements of BS EN 54-16, since that standard includes a diagram showing required overall VACIE performance, but not microphone performance alone.

Along with the frequency response recommendation, there is now a recommendation that there should be means to minimize distortion caused by overloading the microphone. Compression circuitry is suggested in a note as an example of such a means. This is a welcome addition, although it has been normal practice for microphone amplification to include compression. (It is also worth pointing out that such compression would need to be bypassed or disconnected during objective intelligibility measurements, since its presence strongly affects the readings obtained.)

Two other recommended electrical characteristics are listed:

1. 18.1c) 'means to ensure that emergency microphone(s) override all other audio sources (see 23.1a)'
2. 18.1d) 'means to ensure that only one emergency microphone is active at any one time (BS EN 54-16:2008, 12d)'.

Unlike the previous version, the revised Code does not recommend gooseneck microphones for certain applications in preference to hand-held types. This is because, over the last ten years, it has become clear that both types are used in differing locations; also, there is now theoretically no difference in frequency response between the two types.

However, the following recommendations are listed:

'18.2 The emergency microphone should include the following mechanical features:

a) means, such as a pop filter, to prevent plosives causing distortion'. This is a good point because we have all heard the irritating sound from uncovered microphones.

'b) means, such as air vents, to create an acoustic gain in the direction of the mouth'. Such microphones are termed 'directional' and the accompanying note gives examples as cardioid, super-cardioid and noise cancelling types (see below).

'c) shock/vibration isolating mountings to reduce any mechanically borne sound'. This is usually more relevant to microphones mounted on fixed goosenecks or arms rather than to hand-held types. (If the isolation is poor, very slight unintentional rubbing or tapping of the microphone stem or even the case of the microphone console can be heard from the loudspeakers; likewise, operation of switches or push buttons on a microphone console can result in audible clicking noises. A good quality microphone would be expected to have a well-isolated capsule but it might be necessary to isolate the stem of a 'gooseneck style' microphone from its console via, for example, a rubber anti-vibration mounting. Of course, if a proprietary microphone console were being used, it would be reasonable to expect that such problems would have been overcome in its design.)

'd) means to allow the mouth to microphone distance to be as consistent as possible.' This is more important than it might appear since users of microphones should be but are not always properly trained to, or forget to, hold the microphone at the correct distance from their mouth. The note to this recommendation further states that, for hand-held microphones, devices such as lip-guards enable the talker to achieve the optimum microphone to mouth distance whilst speaking and thus ensure uniformity of input signal.

To reinforce 18.2d), recommendation 18.3 asks for a pictogram to be placed immediately adjacent to the microphone showing clearly the optimum speaker to microphone distance. Figures 1 and 2 show the pictograms.

Although there is no actual recommendation for appropriate locations for gooseneck- or arm-mounted as opposed to hand-held types, the following text from the previous version of the Code has been retained in this Guide, since it may be useful.

Emergency microphones are often sited in control rooms, and a gooseneck or arm mounted version is frequently mounted on a panel or box, creating a 'microphone console' (see Chapter 12).

As explained in 18.2b), a microphone with an acoustic gain in the direction of the mouth should be used when ambient noise levels near it are high. Obviously, when designing a VA system, the emergency microphone(s) should be located in a quiet area, if at all possible (see below), but there are situations where there is no alternative but to locate a microphone in a noisy area.

Siting and mounting of emergency microphones

Although the revised version of the Code no longer explicitly states so, one emergency microphone should normally be located beside the indicating equipment intended for use by the fire and rescue service in an emergency situation. This location would normally be close to the main point of entry to the building to be used by the fire and rescue service.

Naturally, the locations of emergency microphones need to be agreed; 18.6 recommends that

> emergency microphones and their associated manual control facilities should be sited at suitable locations where both staff and firefighters can manage an emergency situation... There should be consultation between the user or purchaser (or others acting on their behalf) and the fire and rescue services to agree suitable siting.

In practice, any additional microphones are usually located in security or control rooms, or sometimes at a reception desk.

The chosen position for any emergency microphone should be such that audible noise near the microphone does not affect the intelligibility of broadcasts made using the microphone. Subclause 18.4 refers to the need for minimum background noise, and recommends that ambient noise (both typical and untypical) be assessed in determining a suitable location for an emergency microphone.

Another form of ambient noise can be from loudspeakers nearby. In this case, when a live voice broadcast is made using the microphone, the sound fed back from a neighbouring loudspeaker can reinforce the voice causing coloration of the broadcast sound (i.e. distortion of the sound because of uneven amplification of the various frequencies within it). At its worst, this form of feedback can result in 'howl round', where the amplification chain becomes unstable and oscillates, normally causing a loud howling noise to be broadcast. The two commonest methods of overcoming this are:

1. To move the offending loudspeaker(s) further away from the microphone and/or reduce the volume of the broadcast sound.
2. To arrange the control circuitry such that the loudspeakers in question are switched off automatically when the microphone is used.

Reverberant acoustic conditions at the microphone location would also detrimentally affect the broadcast sound quality. This problem would not be expected in security or control rooms, but might occur in, for example, large reception halls. In the latter case, some relocation and, possibly, use of a noise-cancelling microphone might be necessary.

Accessibility and priorities

Since the use of an emergency microphone for emergency purposes will override other emergency broadcasts, e.g. pre-recorded evacuate or alert messages, the Code recommends that suitable precautions should be taken to minimize the possibility of unauthorized use occurring. However, it is often convenient for a microphone to be used both in emergency situations and for general non-emergency announcements. Subclause 18.5 therefore deals with two possible arrangements: microphones dedicated to emergency use and microphones usable for both emergency and non-emergency purposes.

a) Emergency microphones dedicated to emergency use only

As a protective measure, the Code gives as an example the enclosure of the microphone in a glass-fronted cabinet. If necessary, the cabinet could be locked and the key kept in a known safe place or in an adjacent small break glass enclosure. In practice, emergency microphones are often enclosed in red wall-mounted metal boxes; such boxes are intended to be kept locked, with the key held in a known place.

Where the microphone is located in a relatively restricted area, e.g. a security room, it may not be necessary to locate it in a locked box. It is common practice, in such cases, for the 'press to talk switch' (and, if appropriate, other message or zone selection switches) of the emergency microphone console to be shrouded by a small hinged flap, purely to prevent inadvertent operation of the switch.

b) Emergency microphone for both emergency and non-emergency use

The problem here is in distinguishing between emergency and non-emergency use of the microphone. A microphone with a priority set to 'use for normal paging and routine announcements' cannot be used for emergency announcements because it will, to meet the recommendations of the Code, need to be automatically disabled by any emergency message. Equally, a microphone with a priority set for emergency use (normally overriding any automatic emergency message) must obviously not be used for paging or routine announcements. Therefore, at least one further manual control is required to allow for emergency and non-emergency use of the microphone.

Generally, where the emergency microphone is required to be used for emergency broadcast only to all zones in the building simultaneously, a momentary action shrouded push button or key-operated switch (dependent upon the security of access to the microphone) is provided to act as the ‘press to talk’ switch for emergency use. It should be clearly labelled as such. Where the microphone is required to broadcast to a number of loudspeaker zones, both in ‘non-emergency’ and in ‘emergency’ modes, a large clearly labelled protected mode switch could be provided. In this case, means should be provided to ensure that the mode switch is reset to ‘non-emergency use’ after an emergency is over. This could possibly be achieved automatically by using a momentary action mode switch with electronic latching, so that that the switch would be de-latched on system reset of the fire detection and fire alarm system after the emergency, causing the microphone console to revert to non-emergency mode. Alternatively, if a mechanically latching switch were used, a visual indicator on the microphone console could be fitted, to provide a warning when the microphone console was in ‘emergency mode’.

An emergency microphone should normally have the highest priority of all the possible emergency and non-emergency broadcasts from a VA system. Where more than one emergency microphone is specified for a building, the priority hierarchy among the emergency microphones should be agreed by the interested parties at an early stage in the system design. Generally speaking, if one microphone were at the entry point to the building to be used by the fire and rescue service, that microphone would be given a higher priority than other emergency microphones within the building. These latter microphones could be themselves in an agreed priority chain or they could be of equal priority, i.e. usable on a ‘first come first served’ basis.

22. Wiring

Introduction

As is the case with the bells or sounders circuits of a fire detection and fire alarm system, a VA system has to continue to operate, as far as possible, during and after a fire. Therefore, it is necessary that the wiring interconnecting the control and indicating equipment, including microphones (i.e. the VACIE), and the wiring to loudspeakers is able to withstand the effects of fire for prolonged periods of time. It must also, of course, be suitable for its purpose of carrying audio or data signals.

Transmission requirements of signals, and environmental conditions

Subclause 27.1 recommends that the electrical characteristics of all cables used in VA systems should be 'suitable for the system', and cites a number of example characteristics. Problems which can influence the choice of interconnections that should be used are included in the following paragraphs, with comments upon how they can be overcome. Also included below are further factors to be taken into consideration when choosing cables; some of these relate to observations made in the commentary to 27.

Electrical noise disturbing the audio signal or corrupting the data transmitted. The cables should be routed as far away as possible from the source of electrical noise, particularly where the interference arises from a low frequency AC source. If the noise is high frequency AC, the extent of interference should also be minimized by the cable screening. (Cables recommended in 27.2 of the Code all include an outer screen, which should be earthed.) In cases where equipment is being sourced externally, reference should also be made to the control equipment designer/manufacturer's specified recommendations for cabling, for example to loudspeakers or to link to another component of a distributed VA system. Sometimes, twisted wiring pairs may be recommended.

Incorrect choice of cable for the speed of the data transmission or impedance matching requirements of the equipment connected at both ends. Manufacturer's data should be consulted to ensure that the correct cable is used. Where relevant equipment design is involved, reference could be made to the British Standard relating to matching values in audio systems, BS EN 61938.[17]

Excessive voltage drop in the loudspeaker wiring limiting audio power transmission. As quoted in 27.1 of the Code, the maximum voltage drop in any loudspeaker circuit should not exceed 10 per cent (approximately equivalent to a 1 dB loss of sound pressure level). Once the type of cable to be used has been chosen, the cable manufacturer's published data for voltage drop should be consulted; voltage drop is usually quoted in mV/A/m and, obviously, decreases with increasing conductor size (i.e., cross-sectional area).

The average loudspeaker current (during an emergency message broadcast) flowing along each section of cable – i.e. from the amplifier to the first loudspeaker, then to the second loudspeaker, and so on – can be calculated. Using the length of each cable section, together with its estimated current, the voltage drop, for a particular cable conductor size, can be calculated for that section. Adding together the voltage drops of all the sections will then give the overall voltage drop to the last loudspeaker. If that voltage drop is greater than 10 per cent, a larger conductor size will be needed and the calculations will have to be repeated. In practice, the conductor size of loudspeaker cables is generally either 1.5 mm^2 or 2.5 mm^2, although 4 mm^2 may be used for exceptionally long cable runs. Power amplifiers in VA systems are rarely larger than about 300 W, and a single loudspeaker circuit of 300 W should generally be 'comfortable', with respect to voltage drop, when wired in 2.5 mm^2.

It may not be necessary to use the above 'full' incremental calculations to establish the required conductor size. This would be the case where,

[17] BS EN 61938:1997 *Audio, video and audiovisual systems. Interconnections and matching values. Preferred matching values of analogue signals.*

for example, the total loudspeaker current, taken to be over the full length of the cabling, would give rise to a theoretical voltage drop of less than 10 per cent for 1.5 mm^2 cable.

A high level of vibration, temperature or humidity, any of which may cause degradation of cable properties and eventual failure of the interconnection. Use of the recommended cable types (see later) should generally overcome possible problems associated with temperature or humidity.

Hazardous areas and their specific safety requirements. Each such case will need to be evaluated on its merits. Flameproof loudspeakers are available.

Protection of cables

The clause covering ‘cables, wiring and other interconnections’ in BS 5839-1:2002 (now substantially maintained in BS 5839-1:2013) was considerably rewritten as compared with the equivalent clause in the earlier BS 5839-1:1988. The concept of ‘standard’ and ‘enhanced’ cables was introduced, together with many recommendations relating to cable applications, cable fixing, cable containment, etc. The revised BS 5839-8 has adopted the majority of those recommendations for cables in VA systems, and the appropriate clause (Clause 27) has been expanded accordingly. In the original version of the Code, relevant subclauses of BS 5839-1 were cited and it was necessary for the reader to consult these on each issue of cable protection. Now, the recommendations are set out in full as subclauses of 27. Because BS 5839-1:2002 (and now BS 5839-1:2013) has become well established, it seems unnecessary slavishly to address every subclause here in detail. Instead, most, but not all, of the following paragraphs cover those recommendations relating specifically to aspects of VA systems that are not encountered in fire detection and fire alarm systems.

Recommended cable types

In VA systems, all wiring should be fire resistant, just as is required for sounder circuits in fire detection and fire alarm systems, because the whole VA system, in effect, is analogous to sounder circuits in a traditional fire alarm system. The types of cable recommended are therefore exactly the same as are recommended in BS 5839-1. These cables should be used for all cable external to the VA control equipment, including connections between separate parts of the control equipment.

The recommended cables, as set out in 27, are the fire resistant types listed in BS 5839-1 but an added note states, 'In order to provide flexibility of location and practicality, the final connection between the emergency microphone and the site wiring may use a different cable type.' This is a sensible statement because, for example, standard fire resistant cable with single-stranded 1.5 m^2 conductors would be totally unsuitable for final connection to a microphone. However, to avoid exploitation of this relaxation of the normal recommendation, it is also stated that, 'If a different cable type is used for the final connection between the emergency microphone and the site wiring, it should not exceed 3 m.'

Mineral-insulated copper-sheathed cable is arguably superior to the alternative 'soft-skinned' cables, because its thick copper tubular sheath provides mechanical protection, without the need for additional mechanical protection anywhere in the installation. However, it is more expensive than the more flexible, but less durable, cables conforming to BS 7629, and it is more time-consuming to terminate. The latter cable types are still becoming increasingly popular.

In most cases, voice alarm cables can be of standard fire resistance, as defined in BS 5839-1. Cables of enhanced fire resistance would be needed only where BS 5839-1 recommends cables of enhanced fire resistance for the fire detection and fire alarm system. To deal with a lack of clarity, in the previous version of BS 5839-8, as to when enhanced (instead of standard) wiring is to be used, 'old' subclause 27.4 has been replaced by new subclauses 27.4 and 27.5. It is now made clear that 'at least standard fire-resisting cables … with appropriate means of support and jointing' are recommended for VA systems and that enhanced cables are generally needed only for particular types of buildings and/or evacuation schemes (which are detailed in subclause 27.5).

Subclause 27.3 has been modified to clarify minimum acceptable cable core sizes and, in particular, to allow for the use of fire-resisting CAT 5 cable. A minimum core cross-sectional area of 1 mm^2 is generally still recommended but this figure is reduced to 0.5 mm^2, provided the cable is multicore, with a minimum of eight cores (often four wire pairs). This change means that appropriately sized and mechanically robust fire-resisting cabling can be used for VA system wiring where serial data communications are used.

Fibre optics can be used instead of copper cable. BS 5839-1 refers to this only in the commentary (26.1), namely 'Where fibre optic connections are used, they need to provide at least equivalent integrity and reliability to other cables that are recommended for the same purpose.' In the revised version of BS 5839-8, however, an actual recommendation is given in 27.8, which states,

> Optical fibre cables used for a critical signal path should conform to 27.6 or 27.7 depending on the application. The maximum increase in attenuation under the fire test condition in 27.6 or 27.7 should not exceed that specified by the designer of the system and should be given in the specifier's cable standard. In any case, satisfactory operation of the transmission path should continue for 30 min (standard cable) or 120 min (enhanced cable).

This more detailed treatment should help to remove some of the conflicting opinions on the suitability of fibre optics for use under fire conditions.

Regarding joints in system wiring, as recommended in BS 5839-1, these should be in junction boxes but, as one would expect, labelled 'VOICE ALARM' rather than 'FIRE ALARM'.

Although no longer specifically referred to in the revised Code, it is considered worth retaining the remarks about connections within control equipment racks and to standby battery supplies. These are included below.

As was explained earlier, because VA control equipment is normally located in an area of low fire risk, it is not normally considered necessary for the internal wiring in control equipment racks to be fire resistant. It is just as well that this approach is taken since a typical rack is full of electronics and it would be totally impractical to make all its interconnections fire resistant!

Unlike the normal alarm current of, say, 2A to 5A, taken by bells or sounders from a conventional fire panel, the broadcast of an 'evacuate' message, containing steady attention-drawing signal and speech, can draw 30 A to 150 A at the usual voltage of 24 V. The battery size and the size of its connecting cables have therefore to be correspondingly larger than those of a conventional fire alarm system's standby power supply.

With the high currents involved, a relatively short increase in the length of the cable connecting a standby power supply to the control equipment can result in the need for excessively large and cumbersome cables. It is clearly paramount that the standby power supply (i.e., in particular, the batteries) is installed as close to the control equipment as possible. In practice, the equipment rack(s) and standby power supply enclosure for a typical VA system are generally installed side by side in, for example, a security room, and the problem does not arise.

When the standby power supply is in the same area of low fire risk as, and adjacent to, the control equipment rack, it may be considered unnecessary for the battery connection cable to be fire resistant (as is also the case with the internal wiring of the control equipment rack). Certainly, in the vicinity of the equipment rack, it would seem pointless to use fire resistant cable, since neither the rack (or battery charger) components nor the batteries themselves will withstand high temperatures. Nevertheless, the use of a non-fire resisting cable in these circumstances would constitute a variation that would need to be agreed with the interested parties and documented in the design certificate.

23. Radio-linked systems

The advantages and disadvantages of radio-based fire alarm systems are no doubt now well established. However, as a reminder, the major points are summarized as follows.

Advantages

- The absence of wiring often makes radio-based systems particularly suitable for historic buildings or buildings with historic surfaces, where cables could not be disguised sufficiently without, for example, damaging such surfaces. Stately homes and university colleges come to mind as appropriate examples.
- In certain buildings where cabling would be extensive and/or difficult to install, radio-based systems might be less costly than their wired counterparts.
- Installation time for radio-based systems is always less than for wired systems, making the radio option attractive where time is at a premium.
- Because of the lack of fixed wiring, radio-based systems are often used as temporary systems. Applications would include areas that were to be occupied only temporarily and areas that were due for major refurbishment or due for incorporation into larger fire alarm systems in the short term.

Disadvantages

- Radio-based systems rely upon the spaces between devices such as detectors and sounders and control and indicating equipment being suitable for the transmission of radio signals. This means that they are not appropriate for buildings with, for example, significant amounts of metal in walls, ceilings, panels, etc. Radio field strengths at radio sounders must always be a comfortable margin above the threshold for their satisfactory operation. For the same reason, radio-based systems are not ideal for buildings where there are large quantities of metal objects such as shelving and cabinets that are likely to be moved around frequently; for safety reasons, it would be necessary to carry out field strength checks after any major shifting of such metal objects.

- A major disadvantage of radio-based systems is that the device batteries need to be replaced or recharged periodically. Particularly for a medium or large system, a well-managed rigorously applied maintenance regime is required; otherwise, the number of 'low battery' faults indicated at the VACIE could become excessive, possibly leading to complacency among those checking VACIE indications. The costs involved in such maintenance can be significant.
- Radio devices have tended to be larger than wired alternatives. However, with modern components, the size difference is only slight.

Radio-based fire detection and fire alarm systems have been available for many years now; Clause 27 of BS 5839-1:2013 contains many recommendations for such systems. Since the publication of the original version of the Code, radio-linked voice sounders have become available and radio-linked loudspeakers (including amplifiers) have been used, e.g. in offshore applications. Where, in a radio-based fire alarm system, there is a need or preference for emergency voice broadcasts rather than signals from bells or sounders, it seems reasonable that radio-linked components such as loudspeakers and visual warning beacons should be usable while still allowing the system to comform to BS 5839-8. The relevant working group at BSI therefore decided to include radio-linked systems in the revised version of the Code.

Most of the material in Clause 28 of the Code is, as would be expected, taken from Clause 27 of BS 5839-1. The commentary makes it clear that not all of the recommendations for wired systems are appropriate and, in some cases, may be impossible to achieve with radio-linked systems, just as is the case in radio-based fire detection and fire alarm systems. These 'anomalies' generally relate to methods of fault monitoring and to power supplies. For example, open and short circuits do not occur over the radio waves. However, instead, recommendations are given for checking that radio signals are being transmitted and are receivable. In terms of power supplies, because there is (obviously) no external wiring to provide power to loudspeakers, these have to contain their own amplifiers and power supplies, which are usually batteries. Hence, recommendations are given for means of regularly checking the batteries' state of charge.

The commentary describes various forms of radio-linked systems. It is emphasized that such systems do not need to be fully radio-based; radio relay units could be included to extend a wired system to a detached area which would otherwise be difficult to access via cables. In other words, both fully radio-linked and wired/radio hybrid systems are covered by the Code.

The Code covers the use of radio-linked emergency microphones. It is worth commenting that these require transmission of speech information, as opposed to control data to trigger the start of speech messages in radio-linked voice sounders. At present, radio-linked systems tend to use radio-based fire alarm system technology and do not include emergency microphones.

BS EN 54-25, *Fire detection and fire alarm systems. Components using radio links*, a European standard adopted in the UK in 2008, contains require- ments relating to such factors as radio communications protocols, means to ensure that the radio signals will be unique to the relevant system and battery life. These aspects therefore do not need to be included as indi- vidual recommendations in the Code. Partly because of the publication of BS EN 54-25, Clause 28 of the Code has been completely revised, there now being no need to refer to the recommendations of BS 5839-1 for radio-linked fire detection and alarm systems (which are almost identical to those now in the Code). Subclause 28.1 recommends that the components of a radio-linked VA system should conform to BS EN 54-25. However, there are now eight further subclauses which relate specifically to VA systems. These are as follows.

First of all, 28.2, which gives recommended power supplies for radio-linked VA systems, is necessary because BS EN 54-25 allows the use of a single primary battery power sources in components. Here, following the pattern of BS 5839-1's recommendations, BS 5839-8 recommends that two separate power sources be used, namely mains plus a reserve battery (primary or secondary), primary battery plus primary battery, or primary battery plus secondary battery. To take account of technical developments that are taking place, a Note allows capacitors to be used instead of secondary batteries. 28.2 b) makes it clear that batteries can be used as a normal supply only for components other than VACIE; this matches BS 5839-1, which contains similar recommendations to preserve the integrity of CIE. 28.2 c), recommends that, where a primary battery is used, a fault warning be given at the VACIE when normal operation can be maintained for no longer than 30 days (plus 30 minutes, where the component concerned is a voice sounder or amplifier/loudspeaker). A Note makes it clear that it is allowable for an earlier warning of impending battery failure to be given, if preferred.

As now recommended in 28.3, open and short circuits in external cables connecting to radio-linked system antennae need cause a fault indication at the VACIE within 300 s of occurrence. This relaxation from 100 s brings the recommendation into line with the BS 5839-1 equivalent.

Subclause 28.4 has been retained from the previous revision of the Code (where it was 28.3). This recommends the use of standard or enhanced fire-resisting cable for external connections to antennae (unless the cables are run through areas of low fire risk and buried appropriately or separated from any fire risk by appropriate insulating material).

For clarity, recommendations relating to radio surveys are now reworded and grouped in a dedicated subclause, 28.5. It is recommended that a radio survey ensures that:

a) 'there are no other sources of radio transmission that might interfere with or block radio communication between the VACIE and other components of the system;' These could include local radio paging systems.
b) 'there is adequate signal strength for communication both to and from components as appropriate in all areas of the building(s) in which radio-linked components are to be located. This should take into account the minimum acceptable signal level defined by the manufacturer in respect of the level of background radio "noise" at the time of the survey;' In practice, an appropriate 'headroom' allowance is often subtracted from that defined minimum signal level and the resultant lower level signal used as the acceptance criterion.
c) 'where the system is networked, the communication conditions described in b) are achieved throughout the network;' This would cover both VACIE-to-VACIE radio communications and acts as a reminder that it is not sufficient to check only part of a network.
d) 'records of signal strength readings for each radio device taken at the time of the survey, and of the background noise level, are kept for future reference.'

Subclause 28.6 recommends that radio survey test gear should be calibrated and as recommended by the manufacturer. This is included to try to prevent the use of inferior test equipment, which might lead to a radio-linked VA system being unintentionally left in an unsafe condition.

Subclause 28.7 details the radio data records to be kept. Subclause 28.7a) introduces a need for a record to be kept of the system coding (or address). This should preferably be unique, to avoid the possibility of interference from other sources on the same frequency. Otherwise, correct operation of the system could be jeopardised. Subclause 28.7b) recommends detailed record-keeping of signal and background noise figures, and that these should be updated annually.

Subclauses 28.8 and 28.9 call for signal levels to be recorded in the system log book and for remedial action to be taken if these levels are not within the specified range,

Subclause 28.1f) states that ‘any fault giving rise to loss of communication with a radio-linked component should be indicated at the VACIE within 400 s of occurrence of the fault’. This differs from BS 5839-1, which allows 2 h before indication. The reason for this is that BS EN 54-25 requires a response to this type of fault within 300 s and an indication after a further 100 s.

Subclause 27.2e) of BS 5839-1 states, ‘Facilities for automatic silencing of radio-linked fire alarm sounders should conform to the recommendations of 16.2.1h).’ There appears to be no counterpart in BS 5839-8. This would seem to be an oversight, since radio-linked voice sounders or loudspeakers would be likely to be powered by batteries, and long-term operation of such components could run down those batteries. BS 5839-1, subclause 16.2.1h), recommends that

> where a radio-linked Category L or P system incorporates battery powered fire alarm sounders, subject to agreement of the authority responsible for fire safety legislation, the sounders should silence automatically after 30 min, unless the premises are continuously occupied so enabling manual silencing by occupants. The sounders should restart if, before the system is reset, a further alarm condition occurs. Where a period longer than 30 min is required, e.g. for phased evacuation, the 30 minute period may be extended to meet the requirements of the system specification.

It would appear that automatic silencing of radio-linked voice sounders or emergency loudspeaker broadcast could be implemented in conformity with (certainly in conformity with the spirit of) BS 5839-1. It is, however, suggested that this point could usefully be clarified at an amendment or revision of BS 5839-8.

24. Voice sounders

Voice sounders, as described in the Code, are audible fire alarm devices that contain all the necessary components, except normally power supplies, to generate and broadcast recorded voice messages. These components were excluded from coverage by the original version of BS 5839-8, although guidance about their use was given in an annex. The revised Code, however, now includes voice sounders, within its scope, in Clause 15.

Voice sounders are generally a lower cost option than VA systems using VACIE and wired or radio-linked loudspeakers. This has made them increasingly popular. The commentary on 15 gives useful information about the applications of voice sounders, including their benefits and their limitations. Some comments on those follow.

The comment, 'Voice sounders cannot normally be used to broadcast non-life-safety material, limiting their use to dedicated voice alarm systems' is not strictly correct since readily available voice sounders are equipped with the facility to broadcast some non-emergency messages, e.g. test messages or 'store closing' announcements. These can be started and stopped from switches on associated control equipment. On the other hand, it is true that voice sounders cannot normally be used to broadcast live speech. Such a facility would require running an audio wire pair from a microphone to some or all of the voice sounders. As stated, the application of voice sounders is therefore normally limited to Type V1 systems.

The comment

> Voice sounders are generally suitable for use in small rooms with low background noise and little reverberation such as offices and hotel bedrooms. They are unlikely to be suitable for applications with significant background noise or reverberation such as shopping malls, gymnasiums, airport concourses or railway stations

is no doubt true in many cases. However, the larger voice sounders available, i.e. those that use conventional loudspeakers rather than modified electronic sounders based on piezoelectric resonators, have a better frequency response and can sometimes be used satisfactorily in large listening spaces.

> It is common to install voice sounders on walls in a similar manner and at a similar spacing to normal fire alarm sounders but this often affects intelligibility, especially in larger rooms. In spaces such as open-plan offices, the intelligibility achieved from wall-mounted voice sounders might not be acceptable and it might be necessary to install voice sounders on the ceilings in order to achieve even coverage.

This comment presumably relates to the commonly used small voice sounders that are variants of electronic sounders; intelligibility of broadcasts from these is bound to be somewhat lower than from loudspeakers outputting the same 'speech power'.

The recommendations in Clause 15 major on the need for an attention-drawing tone to precede the speech section of the message and call for the same tone characteristics as recommended for the attention-drawing tone used in VA systems. Recording of the speech messages used in voice sounders also needs to meet the same recommendations as does the recording of voice alarm messages.

It is not explicitly stated in Clause 15 that voice sounder broadcasts should meet exactly the same criteria for intelligibility as do voice alarm emergency broadcasts. In fact, there are technical difficulties in trying to measure intelligibility objectively from voice sounders. A reasonable assumption is that intelligibility should be assessed subjectively, and that this should be satisfactory since voice sounders should not be used in acoustically difficult environments.

Because there is a separate message generator in each voice sounder, broadcasts from different voice sounders could gradually become out of phase with each other, reducing intelligibility. To ensure that this does not happen, the Code recommends that voice sounders within the same listening area should be synchronized such that their broadcasts do not drift out of synchronization by more than 0.05 s over a 30 minute period. The provision of this feature could, as is indicated in a note, involve additional wiring. The additional wiring might not be necessary if some form of encoded signal could be, for example, superimposed on the wires supplying power/message start signal to the devices. However, at the time of writing this Code revision, a separate ‘sync’ wire is normally employed.

25. Climatic and environmental conditions, radio and electrical interference and electrical safety

The heading really represents three subjects, covered in the Code as Clauses 29, 30 and 31, respectively. Since the clauses are short, they have been combined as a single chapter of this book.

Climatic conditions

The recommendations in Clause 29 contain useful practical advice on the local environment that should apply to, for example, VACIE. In the past, it was quite common for voice alarm equipment racks to be installed in riser cupboards only just larger than the racks themselves. This caused two main problems:

1. The equipment could overheat because there was no satisfactory ventilation.
2. Access to the equipment for servicing was difficult and sometimes virtually impossible without disconnecting the whole system.

Recommendations now include identification and recording of the predicted VACIE environmental conditions in documentation. Where VACIE is cooled by forced ventilation, a note warns that 'electronic equipment can fail due to dust-clogged heat sinks or fans'.

Although an obvious point, there is a recommendation that any voice alarm equipment or loudspeakers to be mounted outdoors need to be fit for purpose, i.e. chosen to withstand the expected environmental conditions. Loudspeakers can be ‘tropicalized’ to cope with conditions of high temperature and high humidity.

Since loudspeakers, for example, are heavy and often mounted overhead, recommendations are also given that attention should be given to their mounting, for safety reasons.

Radio and electrical interference

Clause 30, entitled ‘Radio and electrical interference’ is very similar to Clause 28 of BS 5839-1:2002 (which is entitled ‘Electromagnetic compatibility’). No comments are therefore needed here.

Electrical safety

Again, this Clause (31) is largely taken from Clause 29 of BS 5839-1. However, a VA system has loudspeakers that normally operate at LV (100 or 70.7 V AC) rather than extra low voltage (ELV). The safety precautions recommended are therefore important at the loudspeakers and at their connections to loudspeaker wiring as well as at VACIE.

The two diagrams in BS 5839-1 showing examples of protective earthing and functional earthing arrangements have been replaced in the Code by ‘voice alarm versions’. These are very helpful, since they indicate how earth loops are avoided (in the case of functional earths) and emphasize the need to connect all exposed metal surfaces to protective earth (including loudspeakers in metal enclosures).

Recommendation 31.1 is very important. The whole system should conform to BS 7671 (the current IET Regulations). Sometimes, it has wrongly been assumed that, if a safety feature of a VA system is not explicitly recommended in the Code, it need not be provided. Although the revised Code appears to contain all necessary safety recommendations elsewhere, this subclause can be considered a ‘backstop’.

26. Installation

Section 3 of the revised Code refers to various aspects of installation only. Previously, BS 5839-8 included commissioning in its Section 3. The revised Code now has Section 3 covering installation and Section 4 covering commissioning and handover. This new arrangement closely follows that of BS 5839-1:2013, which was considerably expanded from previous versions of that standard. Section 3 is divided into three clauses, 32, 33 and 34, covering different aspects of installation. It would not be particularly helpful to repeat all the detail of Section 3 in this book, so comments made below are restricted to those applying specifically to VA systems. In fact, most of the recommendations in this section are reiterations of recommendations made previously in Section 2 of the Code. It is, nevertheless, a good idea to include these in Section 3 because it is quite likely that an installer would read this section of the Code without having read all the previous design considerations and recommendations.

Responsibilities of the installer

It is important to recognize that VACIE is generally heavier and bulkier than fire alarm system CIE, and it can emit considerable heat. The recommendations therefore include the provision of adequate space around the equipment for access for maintenance; for example, a riser cupboard 10 cm wider than a voice alarm equipment rack is unlikely to be adequate! Also, the need for adequate cooling or ventilation for the equipment is stressed; some VACIE contains forced ventilation, sometimes in the power amplifiers and sometimes in the equipment cabinet/rack, while other equipment can be designed to operate without any internal forced air cooling. Careful consideration needs to be given to the cooling requirements even when the equipment does not have its own internal cooling arrangements; it might be necessary to provide air conditioning of the room containing the VACIE. Voice alarm equipment racks usually contain heavy batteries as well as heavy amplifiers; a further recommendation is therefore that the floor loading be assessed before the equipment is installed. High-power loudspeakers can also be heavy and a recommendation reminds the installer/reader that, for example, a safety chain may be needed for a suspended loudspeaker.

There is a 'reminder' recommendation that emergency microphones need to be installed in appropriate locations. As explained in the commentary to clause 18, non-emergency use of such microphones is very common and the need to prevent access to a microphone's emergency mode has to be taken seriously. This is not always easy to achieve because, while an 'emergency mode' switch may readily be fitted, this needs to be operable quickly and reliably in an emergency.

Another 'reminder' refers to the need for loudspeaker power tappings as installed to be recorded. This makes it easier to assess the overall intelligibility/audibility pattern, particularly in a large building, for future reference, and could also help to avoid subsequent disputes. (The commentary explains that loudspeakers are commonly provided with several power tappings that, if incorrectly set, can result in overloading of the amplifier circuit or difficulty in adjusting the system for intelligibility.)

End of line devices of varying complexity are often required for monitoring loudspeaker circuit integrity (see Chapter 10). Sometimes these devices are mounted within loudspeakers but sometimes they are mounted in detached boxes; for maintenance purposes, it is obviously desirable that their locations are known. As the commentary explains, there may be several such devices on each circuit, for example where individual loudspeaker circuit spurs are monitored. Making these accessible and recording their locations on the as-fitted drawings, as recommended, should help minimize the cost of, for example, fault finding.

For obvious reasons, the positions of all VACIE, loudspeakers, microphones and equipment/devices requiring routine attention, such as end of line devices, should be recorded by the installer on the as-fitted drawings.

Installation practices and workmanship

This clause (33) reiterates the corresponding clause in BS 5839-1 and therefore does not require any comment here.

Inspection and testing of wiring

The text of this clause (34) again closely follows BS 5839-1.

One of the recommendations, however, calls for a test of the 1 kHz impedance of each loudspeaker circuit. This measured impedance can be compared with the calculated parallel impedance of the loudspeakers and should confirm, for example, that all loudspeakers are present and connected.

The recommendation, 'Continuity of all circuits should be tested' appears to be quite correct but, perhaps as an oversight, has been omitted from the corresponding Subclause 38.2 of BS 5839-1.

27. Commissioning and handover

The relevant Section 4 of the revised Code is divided into five clauses, 35, 36, 37, 38 and 39, covering different aspects of commissioning and handover. As in Section 3, most of the recommendations in this section are reiterations of recommendations made previously in Section 2 of the Code but will be immediately apparent to potential project or commissioning engineers reading only Section 4.

Commissioning

This clause is almost a direct repeat of Clause 39 in BS 5839-1. Only one comment appears necessary.

There is a recommendation that 'the provision of any visual alarms conforms to the system specification'. The reader of the Code could be forgiven for not realizing that visual, as well as audible, alarms are covered by BS 5839-8. There are only two references to this: in the commentary to Clause 11 and in this recommendation. No guidance is given about, for example, fault monitoring of visual alarm circuits or where/when they should be used. Perhaps some recommendations could be given at the time of a revision of the Code.

Documentation

This clause is almost a direct repeat of Clause 40 in BS 5839-1 and requires no major comment. The recommendations of the Code relating to information needed on as-fitted drawings substitute loudspeakers, microphones, etc. for the detectors and sounders referred to in BS 5839-1.

Certification

Once again, there is great similarity between Clause 37 of the Code and Clause 41 of BS 5839-1.

Model certificates for the various modules (design, installation, commissioning, acceptance, verification, inspection and servicing, and modification) are included in Annex D. In practice, many voice alarm companies will not use these exact models, usually preferring their own versions. This is perfectly acceptable, provided that they contain all the required information and are signed as appropriate.

A note to recommendation 37.4 makes it clear that 'Where a single organization is responsible for the appropriate design, installation and/or commissioning of both the fire detection and fire alarm system and the VA system, it is acceptable for BS 5839-8 and BS 5839-1 modular certificates to be combined.' This is a sensible way of cutting down on paperwork!

Acceptance

Text has been taken from BS 5839-1 and modified and extended to cover VA systems. The recommendations in this Clause (38) relating specifically to VA systems are discussed below.

In addition to accepting that the system broadcasts recorded emergency messages correctly, the user or purchaser is recommended to ensure that live voice broadcasts are satisfactory from all installed emergency microphones; this should include checking that audibility and intelligibility of emergency broadcasts meet the recommendations of Clauses 21 and 22 of the Code. The agreed priority structure for emergency broadcasts should also be checked by the user or purchaser, e.g. that live voice messages from the emergency microphone(s) override any pre-recorded emergency message broadcast. For these judgements to be made, there will generally be some form of demonstration of the system to that person by the commissioning engineer.

An addition to the transferred wisdom of Clause 42 of BS 5839-1 is a recommendation that the user or purchaser should be satisfied that 'the system fully operates when the primary power supply is removed'. This is an admirable recommendation but, in the absence of a technical representative, e.g. a consultant employed by the user or purchaser, one wonders if this check will be made!

Verification

This clause (39) has a much shorter commentary than the BS 5839-1 (Clause 43) equivalent.

The suggested reasons for the user or purchaser deciding to have a verification undertaken are the division of work elements between different organizations, the evolution of the building design during construction and/or the lack of detailed information at the time of design. It is worth pointing out that, while these reasons would make a verification almost essential, independent consultants are often requested to undertake verifications because the user or purchaser has perhaps felt remote from the technicalities of the design and installation and therefore is not sufficiently confident to accept the system on the basis of their own knowledge and understanding of the system. The larger the system, the more likely such a verification would be undertaken.

28. Maintenance

Routine testing

In the revised Code, the clauses on maintenance have been expanded considerably compared with those in its previous version. This is once again because it was decided to give the section similar treatment to that in BS 5839-1. Obviously, emergency broadcasts replace alarm signals in the text. However, in a VA system, there may be more than just one alert and one evacuate message to be broadcast during the testing. For example, phased evacuation or a building of complex or unusual design will often require a number of emergency messages; also, 2nd sequence alert messages are commonly employed in buildings with phased or staged evacuation (see Chapter 18). *All* these messages need to be checked regularly.

In VA systems other than those of Type V1, emergency microphones will be included; these also need to be tested for live voice announcements. Likewise, the facilities in Type V4 and possibly V5 VA systems for manually starting and stopping recorded emergency messages from the VACIE require to be checked regularly for correct operation.

A note to recommendation 40.1a) makes it clear that, when carrying out a weekly test on a VA system, it is not satisfactory for emergency broadcasts to be initiated directly from the VACIE. This would not test that there is a working link from the associated fire detection and fire alarm system; therefore a manual call point needs to be operated to start the broadcast. The recommendations (40.1b)) for testing various types of system do not include testing all possible combinations of broadcast messages and loudspeaker zones, e.g. 'for Type V3 and V4 systems, check that the live message is broadcast correctly in at least one zone'. Unfortunately, this may lead to one combination only of broadcast and zone being repetitively tested each week; in some ways it would have been better if the Code had recommended that a different combination was tested each week, so that all combinations would be tested over a specific period. Perhaps this could be considered by the appropriate working group at the time of the next amendment or revision of the Code.

There is some anecdotal evidence that occupants of a building may tend to disregard a genuine emergency message if they are exposed too regularly to test broadcasts that use that same message. So, for a fire detection and alarm system using a VA system for emergency signalling, there are conflicting needs: the need to hear and learn emergency messages (from regular testing) and the need not to be exposed to such tests so often that they are not listened to thoroughly – a genuine alarm could be mistaken for 'yet another test'! There is no obvious way of achieving both these needs but changes have been made to this Clause in the Code to effect a compromise. The commentary has been altered to place less emphasis on the need for broadcasting of multiple emergency messages during tests and a short passage on systems using phased evacuation has now been omitted.

A new passage, 40.1b), has also been added; this recommends that, '…a minimum number of staff and public are exposed to the emergency message during the weekly testing of the VAS recommended in 40.1a), except that, at intervals of not more than three months, but preferably monthly, depending upon an appropriate risk assessment for the building, the VAS test recommended in 40.1a) should be carried out in normal working hours, so that all or most building occupants hear the emergency message broadcast;'. This means, in practice, that security staff (at least) would hear an actual emergency message every week, broadcast out of hours, as part of the fire alarm test; all building occupants would hear that message generally once per month, during normal working hours, unless a risk assessment found that a longer period, of up to three months, was appropriate between such tests. Additionally, non-emergency test messages could, of course, be broadcast to test for coverage and intelligibility at other times, but no specific recommendations for regular testing of this kind are given in the Code.

Appropriate messages should be broadcast before and after routine tests (see also Chapter 18) to ensure that people do not evacuate the building unnecessarily. Note 2 has been added to 40.1 a) to reinforce this point, although 40.4 contains the actual recommendation. In a note to 40.4, it is suggested that 'the "test over" announcement may also ask that any lack of intelligibility is reported to the responsible person'. This request is already sometimes incorporated into PA messages relating to tests of fire detection and fire alarm systems.

Inspection and servicing

Since the recommendations are following those in BS 5839-1, only those referring specifically to VA systems are the subject of comment below (where necessary).

There is a recommendation that vented batteries be attended to on a three-monthly basis, as in BS 5839-1, but, additionally, that 'the date of installation of the batteries should be checked against the battery life recommended by the supplier and replacement batteries installed, if appropriate'. This latter recommendation refers to any battery type and to the labels referred to in 26.3.3 of the Code.

Because of the need for intelligibility as well as audibility, it is, if anything, even more important than for fire detection and fire alarm systems that areas of a building are not devoid of adequate broadcast messages because of structural changes that might occur between maintenance visits. It is therefore recommended that a check be made that loudspeaker locations are all as they should be. Likewise, it needs to be checked that ambient noise has not increased in an area because, for example, of a change of use.

A point is made in the recommendations that the company normally handling maintenance of a VA system might not be sufficiently competent to carry out modifications necessary because of changes of use, structural alterations, etc. This would be particularly true in a large, complex building with, for example, 'difficult' acoustic surfaces that could have excessively high reverberation times. The services of an electro-acoustic designer might then be required.

Another recommendation not applicable to fire detection and fire alarm systems is that 'all emergency microphones should be visually examined for damage and tested to check that the selected areas receive an intelligible broadcast'. This is particularly important for hand-held microphones where a microphone is regularly clipped and unclipped for test purposes and for microphones, both hand-held and desk-mounted, that are used for non-emergency announcements as well as in emergencies.

The recommended recording of sound pressure levels in the logbooks, so that they can be compared with previous test results carried out at the same locations, is a good idea, since it will highlight any fall-off in performance of loudspeakers, changes in acoustics because of structural modifications, etc.

It is very important in a VA system that a check is made on the system's performance on primary (mains) power only and, separately, on standby power only. Sometimes, in the past (it is to be hoped), cost-reduced design of power amplifiers could include using the batteries to supplement the primary power supply to cope with maximum loudspeaker loading at high volume; a similar design shortcoming often resulted in a considerable drop in average power output capability on operating from batteries as compared with that from mains power operation. For some reason, these design practices were tolerated for a long time but it is believed that the situation is now much improved. Recommendations 41.2h) and k) now specifically disallow such malpractice.

'All ancillary functions of the control and indicating equipment should be tested' is another recommendation. This, at first sight, might appear to be a mistaken import from BS 5839-1. In fact, there are ancillary functions that can apply to VA systems: visual alarm devices can be controlled via voice alarm as can shutdown of ancillary systems such as third-party sound systems, e.g. for entertainment or non-emergency announcements.

The servicing work to be carried out at intervals not exceeding 12 months is an extension of the equivalent text in BS 5839-1. In addition to these latter recommendations, orientation of loudspeakers is recommended to be checked where necessary; this would apply to, for example, projection loudspeakers mounted along a wall, directional horn loudspeakers and multi-driver unit column loudspeakers. Now that the revised Code covers radio-linked VA systems, it is recognized that electromagnetic field strengths need to be checked.

Non-routine attention

Without repeating the recommendations in the Code (which closely follow those in BS 5839-1 once again), it is worth commenting on 42.3, which relates to system tests after modifications. Often, modifications to a system may be very minor and it is therefore 'over the top' to issue a modification certificate in these circumstances. Usefully, the Code now tries to quantify when a certificate is needed in a note advising that a

> …modification certificate will generally be necessary where the system changes include addition or removal of e.g. more than 5% of the loudspeakers or voice sounders, addition or removal of any emergency microphone or power amplifier, any change to the number of emergency loudspeaker zones, or any change to the VACIE that will alter the previously agreed "cause and effect" requirements.

There may be complaints from those who have to fill out certificates for modifications marginally above those limits but at least this removes an otherwise totally subjective idea of what constitutes a modification!

29. User responsibilities

These responsibilities are naturally very much the same as the familiar equivalents in BS 5839-1. Because VA systems replace fire detection and fire alarm systems, the duties of the member of the premises management 'appointed to supervise all matters pertaining to the VAS' include training in the use of the microphone (in VA systems other than those of Type V1). It is really important to ensure that appropriate new staff members in an organization can make clear announcements in an emergency.

The recommendations for a logbook also parallel those in BS 5839-1. A recommendation in the Code makes it clear that a combined fire detection and fire alarm system and voice alarm system logbook is permitted but adds the rider, to avoid confusion, that the dual purpose of the book should be clearly indicated in/on it.

The Design, Installation, Commissioning and Maintenance of Voice Alarm Systems

A Guide to BS 5839-8:2013

Douglas F. Mason and Colin S. Todd

BS 5839-8:2013 is the current code of practice that makes recommendations for the design, installation, commissioning and maintenance of voice alarm systems which broadcast speech or warning tones in response to signals from fire detection and fire alarm systems.

Compliance with BS 5839-8 is very commonly required throughout the UK by building control bodies, fire and rescue authorities and other authorities who may enforce provisions for fire safety in certain occupancies.

This new book, fully revised and updated in its third edition, is the comprehensive guide to BS 5839-8:2013. Based on in-depth experience of developing this code of practice as well as its use in the field, this book provides full background explanation and discusses the practical application of its recommendations.

About the authors

Douglas F. Mason is a senior consultant in fire protection. He is a chartered engineer, corporate member of the Institution of Engineering and Technology and a member of the Audio Engineering Society. He is a past chairman of the working group that generated the original British Fire Protection Systems Association Code of Practice for voice alarm systems as well as serving on the BSI committee which prepared BS 5839-8:2013.

Colin S. Todd is a leading specialist in fire detection and fire alarm systems and has been a significant player in the development of this important code of practice. He sits on several national fire technical committees and has drafted numerous codes and standards on behalf of BSI and other leading bodies. His published works include: *A Comprehensive Guide to Fire Safety*; *A Guide to BS 5839-1*; *A Guide to BS 5839-6 and PAS 79*.

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BSI Group Headquarters
389 Chiswick High Road
London W4 4AL

www.bsigroup.com

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