Guidance on the use of fire detection in rooms intended for sleeping

FIA Guidance for the Fire Protection Industry

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Background

BS 5839-1:2002 recommends the use of either heat or smoke detectors in rooms opening into escape routes. This would typically include rooms intended for sleeping, for example hotel bedrooms, student accommodation, etc. BS 5839-1:2002 also warns about the use of smoke detectors where situations such as steam from shower rooms may cause false alarms. This has often led to the selection of heat detection as the most appropriate detection method in sleeping rooms.

Recent advances in fire detection technology gives an opportunity to review current practices and discuss new methods to enhance life protection afforded in rooms intended for sleeping.

Introduction

In this document, rooms intended for sleeping are hereafter referred to as bedrooms. This includes hotel bedrooms, rooms in halls of residence and dormitories.

Different types of bedrooms are covered by various codes and regulations. For example, hotels/halls of residence would generally be covered by the recommendations of BS 5839-1, while dwellings such as Houses in Multiple Occupancies (HMOs) and private residences would be covered by BS 5839-6. Other applications such as hospitals and prisons are subject to their own specific codes.

It is important that, when considering the safety of those asleep in bedrooms, the fire detection technology used is as reliable as possible without substantially increasing the occurrence of false alarms. For this purpose, a wide range of available technologies are available and can be selected for a particular set of risks.

While any of the occupants are awake there will be an increased risk of fire and false alarm in their room, however, their safety will not be substantially enhanced by the presence of fire detection. This guidance document deals with the survival potential of the occupants in the event of a fire in their room, when one or more of them are asleep and with the false alarm risk while they are awake.

One of the prime objectives behind the latest developments in fire detection and alarm system technology is to reduce the incidence of false alarms. This document reviews how these developments can be used to benefit fire detection in bedrooms.

Scope

This FIA document provides guidance on the application of currently available fire detection technologies for rooms in buildings intended for sleeping.

This guidance document does not replace the existing recommendations in the British Standards BS 5839-1 or BS 5839-6 but is intended to supplement those Codes of Practice as it expands on the latest developments in detection technologies and their application to bedrooms. This guidance document is intended to be used in conjunction with the relevant Standards and Codes of Practice.

Perceived risk

False alarms actually reduce the safety of occupants in bedrooms because people will not respond if there have been too many false alarms; this includes staff as well as the occupants of the bedrooms.

Therefore, in bedrooms it is important that the type(s) of fire that may be encountered as well as potential sources of false alarms are established during the fire risk assessment. In particular, Table 1 gives specific issues applicable to risks in bedrooms which should be considered, such as:

- Occupant being asleep
- Fire alarm not initiated before life is endangered by combustion products
- Potential false alarm from steam from bathrooms, smoking, cooking, etc

Table 1: Factors to be considered when selecting applicable technologies

Bedroom type	Likely type of fire	Likely source of False alarm	Other considerations
Hotel bedrooms	Smouldering fire involving class A materials[1] resulting from discarded smoking materials or overheating electrical equipment[2]	Steam from showers and kettle Smoking[4] Aerosols from spraying can	Verification / investigation delays to confirm a fire incident.
Accommodations with multiple beds (school dormitories, youth hostel)	Smouldering fire involving class A materials[1] resulting from discarded smoking materials or overheating electrical equipment[2]	Steam from shower Smoking[4] Aerosols from spraying can	Verification/investigation delays to confirm a fire incident
Student Accommodation Bedrooms with cooking facilities	Smouldering fire involving class A materials[1] resulting from discarded smoking materials or overheating electrical equipment[2] Flaming Fire involving Class A or Class F materials[3] resulting from faulty cooking appliances or unattended cooking	Steam from shower and kettle, Smoking[4] Aerosols from spraying can Cooking fumes	Verification/investigation delays to confirm a fire incident
Bedrooms in nursing homes and hospices (no cooking or shower facilities)	Smouldering fire involving class A materials[1] resulting from discarded smoking materials or overheating electrical equipment[2]	Steam from showers and kettle, Smoking[4] Aerosols from spraying can	Early fire warning needed for evacuation of infirm persons
Bedrooms in secure institutions (e.g. homes for the mentally ill)	Smouldering fire involving class A materials[1] resulting from discarded smoking materials or overheating electrical equipment[3] Flaming Fire (arson)	Smoking[4] Malicious intent	Strong supervision by staff to control false alarms, accidental and deliberate fire setting Staff alarm to limit unnecessary evacuations
Bedrooms in temporary accommodations (e.g. hostels for the homeless)	Smouldering fire involving class A materials[1] resulting from discarded smoking materials or overheating electrical equipment[3] Flaming Fire (arson)	Smoking[4] Malicious intent	Security supervision by non-fire trained personnel to limit arson and malicious activations

1. In this case, Class A materials are likely to include soft furnishings, bed linen, cloths, wood paper and plastics.
2. In this case overheating electrical equipment would include lamps, heating appliances, faulty televisions and charges
3. In this case the Class A materials are likely to include fabrics, packaging material and foodstuffs and Class F materials are likely to include cooking fats and oils.
4. In the applications covered, smoking should be prohibited within the building; however smoking is still regarded as a potential false alarm risk if occupants ignore the regulations.

Available detection technology

Fire detectors are comprised of different sensors, used individually or in combination, which are typically of the following types:

1. Optical / Photo-electric

   Optical smoke point detectors generally use the scatter-light principle, where the light generator (normally infra-red (IR) LED) and the light detector (IR photodiode) are physically offset. When smoke is not present in the chamber, the light from the LED is blocked from striking the sensing area of the photodiode.

   When smoke enters the chamber, light scatters off the smoke particles to strike the photodiode. The signal generated by the photodiode is compared with a set threshold value, which determines the fire condition.

   Optical detectors are generally less sensitive to flaming fires when compared to ionisation detectors, but respond better to the larger particles (typically greater than 2 micron) generated by smouldering fires.

   The sensitivity of optical detectors to the larger particles makes them susceptible to false alarm risk from steam (from showers and kettles), dust, smoking and aerosol sprays such as air fresheners, deodorants and hair sprays. In addition, optical detectors can be susceptible to false alarm from insects inside the sensing chamber.

   Variations of optical detectors employ different light wavelengths and/or scattering angles to determine smoke particle characteristics. This is done to enhance detector performance.

2. Ionization

   Ionization chamber smoke detectors (ICSD's) use a small radioactive source to ionize air molecules and thus, produce a cloud of positive and negative ions within the chamber. This allows a small current to flow through the chamber between two electrodes. When smoke enters the chamber the ions adhere to the smoke particles, reducing the current. This current reduction is measured and compared to a set threshold level, which when crossed, initiates the fire signal.

   ICSD's generally respond well to invisible smoke particles (typically smaller than 1 micron) produced by flaming fires. This type of fire is less likely while people are asleep, so the selection of this type of detector is not common in bedrooms except in situations where arson might be anticipated.

   The sensitivity of ionization detectors to the smaller particles makes them susceptible to false alarm risk from toasters, cooking fumes from frying and grilling and dusty electric fires.

   Handling, storage, transport and disposal of ICSDs must be carried out to the relevant regulations, see Fact File 46 - Guidance on the Disposal of ICSD's.

3. Heat Detectors

   Heat detectors typically employ thermistors which are electronic components that change their resistance when heated (or cooled). This change can then be detected by other circuitry. Heat detectors can typically be configured to give an alarm at a specific temperature and/or when the rate-of-rise of temperature exceeds a threshold.

Several classifications of heat detectors are available. Detectors classified as A1R are the most appropriate for use in sleeping accommodation. Heat detectors rely on large amounts of heat output from a fire and are not suitable for detection of the early products of combustion.

False alarms from heat detectors are unlikely in sleeping accommodations.

4. <u>Carbon Monoxide (CO)</u>

   Typically carbon monoxide fire detectors employ electrochemical cells to measure levels of CO emitted by a fire by converting gas molecules into an electric current. This current is measured and compared to a set threshold level, which when crossed, initiates the fire signal.

   CO detectors are able to give a fast response to smouldering fires, however, a number of fire types do not generate significant amounts of CO; hence this technology alone should not be used to simply replace traditional smoke detection technologies in all applications.

   Ambient sources of CO such as car fumes and faulty gas appliances can present a risk of false alarm when using CO fire detectors. Detectors based on electrochemical cells may also be vulnerable to other interfering gases such as those produced by spray cosmetics.

5. <u>Flame Detection</u>

   Infra Red and Ultra Violet sensors are commonly used to detect flames. These sensors monitor different wavelengths of light emitted (radiation) from fires and/or flame flickering characteristics.

   Flame detectors are suitable for the detection of flaming fires. This type of fire is not generally found in bedrooms though, in certain situations, it may arise from arson.

   Flame detectors can give false alarms from expected sources of radiation such as heating and cooking appliances, cigarette lighters as well as from welding, modulated sunlight and heat radiated by hot bodies.

6. <u>Other technologies</u>

   Other technologies such as linear optical beam smoke detection, aspirating smoke detection are also available.

   Optical beam detectors operate by both light obscuration and scatter along the line of detection rather than at a single point. These detectors require line of sight along the beam path.

   Optical beam detectors present a risk of false alarm due to inadvertent obscuration of the beam caused by human intervention or by the false alarm sources that affect point optical smoke detectors.

   Aspirating smoke detectors operate by sampling air drawn through a pipe network and analysing it remotely for the presence of smoke particles using an optical scatter or obscuration chamber. Aspirating detectors rely on the integrity of the sampling pipe work. The sensitivity of aspirating detectors can be adjusted to suit particular site requirements.

   Aspirating detectors present a similar risk of false alarm as for optical detectors. This particularly includes dust, cooking fumes and smoking. However, the sensitivity of aspirating detectors can be adjusted and the air sample conditioned by filters and condensation traps to minimize this false alarm risk.

   Both these technologies can be suitable for use in sleeping accommodation covering large and high open spaces, e.g. dormitories.

Other technologies may also be applicable. These are not described here as they are not commonly used.

7. Combinations of sensors

   A combination of the individual technologies described above can improve detection performance and/or provide better false alarm immunity. Typical combinations are:

   - Optical smoke-Heat
   - CO-Heat
   - Optical smoke-CO-Heat
   - Optical-Heat-Flame
   - Optical-CO-Heat-Flame

Combination of sensors enables a broader response to fires than that offered by a basic single technology. For example, the addition of heat sensors to an optical smoke detector or a CO fire detector potentially improves the sensitivity to flaming fires. Similarly, the addition of CO gas sensors to a smoke sensor potentially improves the sensitivity to slow smouldering fires.

By combining different types of sensors it is possible to improve discrimination between a real fire and specific source false alarms by balancing the response of individual sensors prior to making the fire decision. For example, adding a heat sensor to an optical smoke sensor will enable it to be less affected by false alarm sources such as cigarette smoke, aerosol sprays and dust. The use of a CO gas sensor with an optical smoke sensor may provide a means of distinguishing between smoke and steam.

Because of the diversity of possible algorithms employed in the combination of sensors, it is important that the manufacturers' recommendations are followed when selecting a detector with a combination of sensing technologies for a particular risk.

Available processing technologies

Fire detectors provide signals to control and indicating equipment. The process of establishing an alarm decision can take place either in the detector itself or at the control and indicating equipment (CIE). When sensors of different technologies are used, the sensor responses can be combined by numerous means, ranging from a simple AND/OR function, to complex algorithms. There are three basic types of systems:

1. Conventional systems (non-addressable)

   In conventional systems, detectors are interconnected in fixed detection zones and the location of any alarm is identified by searching the indicated zone. The fire decision is achieved inside the detector and any changes in detector performance can only be implemented at the detector. Any logical processing to confirm an alarm signal can be achieved on a zone basis; for example, pre-alarm signalling, temporary resetting and coincidence between two zones.

2. Addressable systems

   In addressable systems each detection point is given a unique identifier which enables its exact location in the system to be displayed at the CIE. In these systems the fire decision is often made at the detector and the detector performance can sometimes be initially programmed and modified remotely at the CIE. This permits better false alarm management compared to a conventional system by offering, for example, coincidence detection between individual detectors rather than detection zones.

3. Analogue addressable systems

   These systems use addressable sensors to communicate environmental data to the CIE which then make the fire decision. In these systems the detection performance can usually be programmed and modified at the CIE. This permits a better control on detection sensitivity as well as false alarm rejection, e.g. day/night operation mode, coincidence between different sensor types in the same area.

Notification technologies

An alarm at the CIE is brought to the attention of the occupants of the building using diverse notification technologies depending on the type of building, its use and the specific needs of its occupants. In bedrooms the objective of the notification system is to awaken the occupants and thereby alert them to the danger. The main notification technologies available include:

1. Sounders and bells

   Most buildings use sounders/bells as the main means of notifying fire alarms. They are effective in providing adequate warning to building occupants which have been suitably trained. Zoning of sounders is used to provide limited notification to parts of buildings and to effect a phased evacuation. However they do not provide intelligent information to guide occupants through the development of an emergency situation.

   Both BS 5839-1 and BS 5839-6 recommend that a minimum sound pressure level of 75 dB(A) at the bed head should be achieved. However, it should be understood that this will not necessarily be sufficient to wake people under the influence of alcohol or other drugs.

2. Voice alarms

   When the evacuation strategy of a building necessitates a more intelligent notification to occupants of emergency situations, the CIE can be linked to voice sounders giving pre-stored messages or a voice alarm sub-system. The voice alarm sub-systems can broadcast messages according to a pre-determined evacuation plan and can offer the option for live message broadcast. System operators can have the ability to tailor and direct the messages to suit a particular emergency situation. Voice alarm systems can normally support other forms of alarm warning devices such as conventional sounders, visual alarm devices and tactile devices.

   Recommendations on the design, installation, commissioning and maintenance of voice alarm systems are given in BS 5839-8:2008.

   In bedrooms, the attention drawing signal should also achieve a minimum sound pressure level of 75 dB(A) at the bed head as recommended in the British Standard Code of Practice.

3. Visual alarm devices

   The need to cater for occupants that are deaf or hard of hearing has led to an increased use of visual alarm devices (strobes) in support of sounders or voice alarm sub-systems. In general, visual alarm devices are considered to be ineffective in waking sleeping people and will need to be used in conjunction with another notification device such as a pillow vibrating pad. Recommendations on the planning, design, installation, commissioning and maintenance of systems using visual alarm devices complying with BS EN 54-23 are given in the joint BRE/FIA Code of Practice, CoP 0001.

4. Tactile devices

   Tactile devices are commonly used to alert deaf people of an emergency. Pillow vibrating pads are specifically used for waking such people. Vibrating pagers have a more general use when the protected person is either in a specific room or circulating within the building.

System management tools

The CIE often uses a number of techniques to reduce unwanted alarms or reduce the impact of unwanted alarms. Some of the most widely used techniques are listed below:

1. Coincidence detection or dependencies

   BS EN54-2 allows three general types of dependency, which may be combined when more than one alarm signals are present.

   A. Type A dependency (7.12.1) allows for the fire alarm condition to be inhibited following a first fire signal from a detector. A fire alarm condition occurs only after a further fire signal from the same fire detector, or from a detector in the same detection zone, occurs within a certain time period.

   B. Type B dependency (7.12.2) is similar to type A; however the confirmation fire signal could be in a different detection zone. Commonly the same detector is not used for the confirmation fire signal.

   C. Type C dependency (7.12.3) specifies that, following the first fire signal from a fire detector or manual call point, the CIE enters the fire alarm condition but may inhibit the activation of outputs until a confirmation signal is received from the same or a different detection zone. Delays to outputs are normally used to activate outputs if a confirmation fire signal is not received within the delay period.

   Additionally some CIE manufacturers provide an option for two confirmation fire signals being required before the fire alarm condition is entered.

2. Delays to outputs (Verification delays)

   BS EN54-2 allows delays to occur generally from fire detectors, and/or individual detection zones. Manual call points may also be used to delay certain outputs.

   Delays to outputs (7.11) appears similar to type C dependency; however a second fire detector will not override the delay, while a manual call point may.

3. Day/night mode delays and/or sensitivity adjustment

   During periods when activities may be carried out in a building, automatic fire detection may be switched to a "Day mode" where verification delays may be enabled and/or fire detector sensitivity may be reduced. For example an optical heat multi-sensor detector may switch to a low smoke sensitivity mode or a heat detector only mode.

   During periods of reduced activities, i.e. when people may be sleeping, the system may revert to "Night mode", where delays are disabled and higher detector sensitivity may be used.

4. Local alarms and phased evacuation

   A local alarm (which could be from an integral strobe and/or sounder on a fire detector) could be used to output a fire alarm only in the area protected by the triggered fire detector. This allows for a phased evacuation of the area in which the alarm is triggered before a general evacuation is signalled.

A variation on the above is a staff alarm, where the triggered fire detector may only cause a local alarm to alert trained staff to take appropriate planned actions.

Alternatively the CIE may be set to give only an alert signal upon receiving a first fire signal. Then, a general evacuation alarm or phased evacuation can occur after a delay or when the alarm is verified. This technique is generally used to activate a voice alarm system.

5. Local alarms with a local delay function

   This is normally used in housing of multiple-occupancy.

   A single delay function button and local indicator is provided in each apartment. If a local fire signal occurs in an individual apartment, then only the local alarm devices activate and a delay is set. This delay can be extended by the local delay button, however if the button is not pushed the delay will timeout and the main CIE enters a general fire alarm condition. Pushing the delay button just before a local fire signal occurs also extends the delay period.

Recommendations

Table 2 gives recommendations regarding the detector technologies that should be used in the applications listed. Since there are a multitude of techniques used in the design of detectors, it is important to refer to manufacturer's recommendations. The table is ordered in terms of reliability of fire detection for a given technology and, for each application considered; it gives a suitability grading related to the balance between reliable detection of expected fires and the risk of false alarm.

Siting of detectors is an important consideration in the reduction of false alarms. It is recommended that detectors are sited as far away as possible from any potential source(s) of false alarm such as steam, cooking areas, etc.

In addition to the selection of suitable detector technology, there is also the option of system design solutions which may achieve the same objectives, see section on "System management tools".

Table 2: Detection technology recommendations

Technologies	**Applications** **(1=preferred, 2=suitable, 3=not recommended)**	**Comments**
Multi-sensor fire detectors (with nuisance alarm suppression algorithms)	**1** Bedrooms without cooking, showers or permitted smoking **2** Bedrooms with showers and kettles **2** Bedrooms with cooking facilities **2** Bedrooms with permitted smoking	As there are different types of multi-sensor detectors it is important to consider their resistance to nuisance alarms from steam, aerosols such as spray cosmetics, cleaning agents. Since there are different sensor and algorithm combinations possible, there is a need to refer to manufacturer's recommendations.
CO Fire Detectors and heat enhanced CO fire detectors	**1** Bedrooms with showers and kettles **2** Bedrooms with cooking facilities **2** Bedrooms with permitted smoking **2** Bedrooms without cooking, showers or permitted smoking.	Many of the likely fires in this application are smouldering for which CO is a good option. However they have limitations related to fast flaming type fires. Consideration needs to be given to possibility of false alarm from car fumes (near parking facilities), use of spray cosmetics.
Optical smoke detectors and heat enhanced optical smoke detectors	**1** Bedrooms without cooking showers or permitted smoking **2** Bedrooms with permitted smoking **3** Bedrooms with cooking facilities **3** Bedrooms with showers and kettles	Consideration needs to be given to possibility of false alarms from steam, aerosols etc. Some detectors use techniques to minimize this risk.
Heat Detectors	**1** Bedrooms with cooking facilities **2** Bedrooms with showers and kettles **2** Bedrooms with permitted smoking **3** Bedrooms without cooking, showers or permitted smoking	Heat detectors have a slow response to developing fires. This should be taken into account when considering their use.

References and applicable standards

FIA Guidance note on application guidelines for point type multi-sensor fire detectors (v2 Dec 10)

BS 5839-1:2002 + A1:2004 + A2:2008, Fire detection and fire alarm systems for buildings, Code of practice for system design, installation, commissioning and maintenance

BS 5839-6:2004, Fire detection and fire alarm systems for buildings, Code of practice for the design and installation of fire detection and alarm systems in dwellings

BS 5839-8:2008, Fire detection and fire alarm systems for buildings, Code of practice for the design and installation, commissioning and maintenance of voice alarm systems

BS EN 54-2:1997+A1:2006, Fire detection and fire alarm systems – Part 2: Control and indicating equipment

BS EN 54-3:2001, Fire alarm devices - Sounders

BS EN 54-5:2000 + A1:2002, Fire detection and fire alarm systems – Part 5: Heat detectors - Point detectors.

BS EN 54-7:2000 + A1:2002 + A2:2006, Fire detection and fire alarm systems – Part 7: Smoke detectors – Point detectors using scattered light, transmitted light or ionization.

BS EN 54-10:2002 + A1:2005, Fire detection and fire alarm systems – Part 10: Flame detectors – Point detectors.

BS EN 54-12:2002, Fire detection and fire alarm systems – Part 12: Smoke detectors – Line detectors using an optical light beam.

BS EN 54-20:2006, Fire detection and fire alarm systems – Part 20: Aspirating smoke detectors.

BS EN 54-23: 2010, Fire alarm devices – Visual alarm devices

BS EN 54-25, Fire detection and fire alarm systems – Part 25: Components using radio links

BS ISO 7240-8:2007, Fire detection and alarm systems – Part 8: Carbon monoxide fire detectors using an electro-chemical cell in combination with a heat sensor

CEA 4021:2003, Fire Protection Systems – Specifications for fire detection and fire alarm systems - Requirements and tests methods for multisensor detectors, which respond to smoke and heat, and smoke detectors with more than one smoke sensor.

Loss Prevention Code of Practice CoP 0001, Code of Practice for visual alarm devices used for fire warning

Loss Prevention Standard LPS 1265: Issue 1.1, Requirements and Testing Procedures for the LPCB Approval and Listing of Carbon Monoxide Fire Detectors Using Electrochemical Cells.

Loss Prevention Standard LPS 1274: Issue 1.0, Testing Procedures for the LPCB Approval and Listing of Carbon Monoxide/Heat Multisensor Fire Detectors using Electrochemical Cells.

Loss Prevention Standard LPS 1279: Issue 1.0, Testing Procedures for the LPCB Approval and Listing of Point Multisensor Fire Detectors using Optical or Ionization Smoke Sensors and Electrochemical Cell Carbon Monoxide (CO) Sensors and, optionally, Heat Sensors.

Loss Prevention Code of Practice CoP 0001: Issue 1.0, Code of Practice for visual alarm devices used for fire warning

NOTE 1 Revisions of BS 5839-1, and BS 5839-6 and BS 5839-8 are under preparation at this time.

NOTE 2 Various additional European standards or revision of existing European standards are being drafted at this time.

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