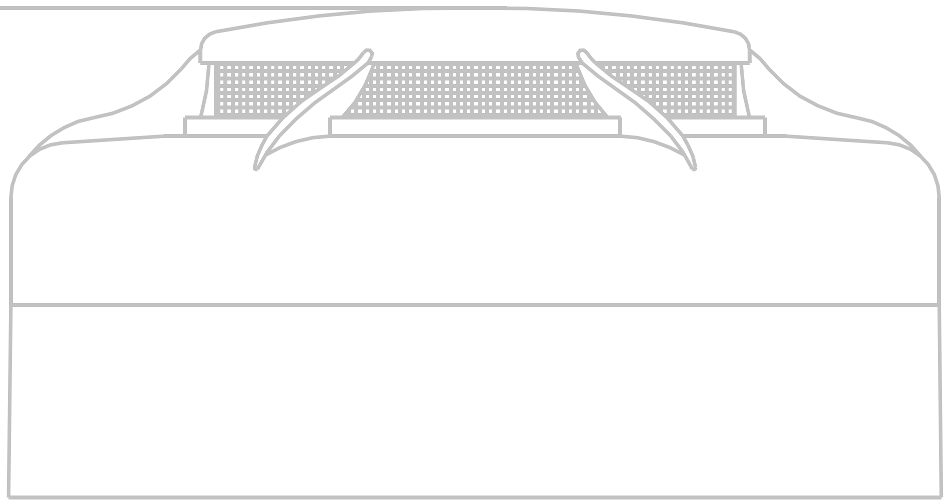

GUIDE TO CONVENTIONAL FIRE SYSTEMS

Contents

Disclaimer

This document is intended purely as a guide to the issues facing the installer or specifier of fire equipment to be used in fire protection systems. It is recommended that those involved in the design and installation of fire protection systems also seek guidance from recognised authorities and relevant local standards.

1. Conventional Fire Alarm Systems

A conventional fire alarm system normally consists of a control panel linked to a number of circuits of smoke, heat detectors and manual call points, with a similar number of sounder zones. A simple single zone system is shown in *Figure 1.*

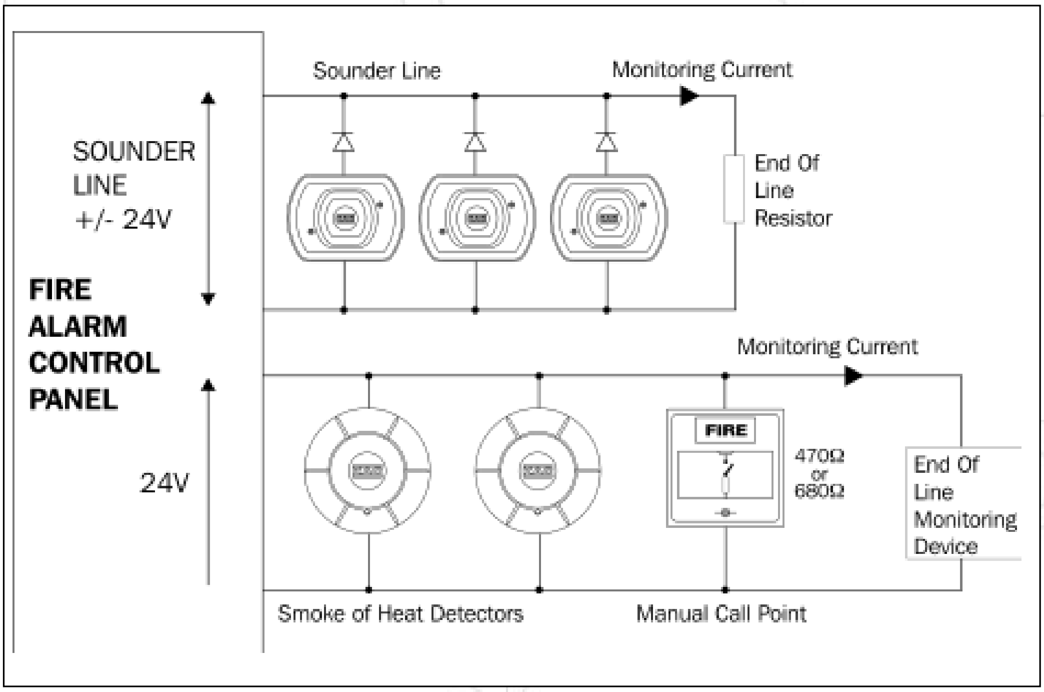

Figure 1 Simple Fire Alarm System

1.1. Control Panel

The control panel drives the detection lines and the sounder lines, provides LED indications of fire, fault or normal conditions and contains switches to allow the sounders to be activated or silenced and the detectors to reset after an alarm. The control panel is powered from 230V mains, but contains back-up batteries to allow the system to function in case of a mains failure. Most fire alarm systems use an internal voltage of 24V, provided by two 12V rechargeable lead acid batteries as their backup supply.

1.2. Detection Line

Most conventional fire alarm panels have several detection lines or 'zones' which consist of a mixture of conventional smoke or heat detectors and manual call points. Except in the case of very small systems, it is not usually possible to simply use one large zone. BS 5839 part 1 (the British Standard for fire alarm systems) limits the area of a building which can be protected by a single zone of detectors. This is partly in order to ensure that in case of a wiring fault, only a small part of the system is prevented from functioning and partly so that the location of a fire can be determined at the fire alarm panel and limited to a sufficiently manageable search area.

The detection line is normally supplied with 24 Volts DC. Conventional fire alarm systems use an end-of-line device to allow the control panel to verify that there are no breaks in the wiring. In simple systems a resistor may be used as the end-of-line device, but more modern systems use an active electronic device, for reasons explained later. The end-of-line device draws a constant current (say 6 milliamps for a typical system) which is higher than the standby current drawn by the smoke detectors and heat detectors, but lower than their normal alarm current. If the cable is broken, the control panel detects that the end-of-line device is no longer drawing current and signals a fault.

When there is no alarm condition, the smoke and heat detectors draw a low standby current of around 100 microamps or less. Should the detector sense smoke, it latches into an alarm condition with its LEDs illuminated, drawing a high current (say 30 milliamps, depending on the panel design). The control panel senses the high current drawn, illuminates its fire LED and activates the sounder lines. The fire detector will remain latched in its alarm condition even if it no longer senses smoke, until it is reset by the control panel momentarily removing power from the detection lines. Latching the detector ensures that the location of the fire can be found even if the detector is only sensing smoke intermittently. It also ensures that it is possible to locate which detector caused the alarm, should a false alarm have been caused by a smoke detector located close to a toaster, for example!

When the detector is in its alarm state, the voltage across the detector is normally around 5 Volts. This allows the panel to distinguish between an alarm condition and a short circuit condition caused by a wiring fault. If a short circuit occurs the voltage across the lines will be zero.

A manual call-point consists of a simple switch with a resistor in series with it, usually 470 Ohms or 680 Ohms. The resistor limits the amount of current drawn by the call-point in alarm, so that the panel can distinguish between an alarm condition and a short circuit condition.

The control panel should therefore be able to distinguish between four states. The table below shows how a typical panel could identify the four states. The figures will vary from panel to panel but the principle of operation is the same.

Monitoring of detection line (Example only)

Condition	**Current**	**Voltage**
Open circuit	<5mA	24V
Normal	5mA (dependent on EOL device)	18V
Fire	50mA (dependent on control panel)	4-15V
Short circuit	(dependent on control panel)	0V

1.3. Remote LEDs

Most system smoke detectors are equipped with a terminal to allow the connection of a remote LED. Remote LEDs are often used outside bedroom doors in hotels so that in case of a fire, it is easy for the fire brigade to identify the location of the fire without needing to enter every room in the building. They may also be used where a detector is located in a hidden position, such as a floor void or cable tunnel, for example, to provide a visual indication that the detector is in an alarm state.

1.4. Compatibility Issues

Most modern conventional control panels do not require the use of a resistor in the detector base, however some control panels can not distinguish between a short circuit condition and an alarm condition without the use of a special base containing a resistor. It is essential to check with the manufacturer of the control panel used that the panel is compatible with the detector you wish to use, and also to check which bases are suitable for the panel you are using. Do *not* assume that because the detector appears to function correctly with the control panel it is compatible. It may be that the system will work under certain circumstances, but not others. The system may work when the mains supply is functioning, but fail when running on back-up batteries, for example.

1.5. Sounder Lines

As with detection lines, it is important to monitor sounder lines to check that the cable has not been broken, disconnected or shorted. The operation of sounder circuits is, however, different from that of detection lines.

Fire alarm sounders contain a diode, which allows them to operate when a voltage is applied in one direction, but not when the voltage is reversed. When the system is in standby, the panel applies a voltage in the 'wrong' direction, so that the sounders do not operate and do not draw any current. An end-of-line resistor draws a constant monitoring current which allows the panel to verify that the wiring is intact. Should the panel sense that no current is being drawn, it signals an open circuit fault. In the case of a short circuit, a high current is drawn from the sounder line so that the voltage on the line drops to zero and a fault condition is shown. To activate the sounders, the control panel reverses the polarity of the voltage to the sounders.

1.6 Cable Types for Use in Fire Alarm Systems

BS 5839 part 1 specifies a number of different cable types suitable for use in fire alarm systems. These cable types fall into two categories – those capable of prolonged operation in a fire, and those for use in applications where prolonged operation in a fire is not required.

BS 5839 requires that cables used for supply of power to the panel, those controlling the sounders and any cables used to transmit an alarm signal to the fire brigade be capable of prolonged operation in case of a fire. The standard does not require detection lines to be protected against fire, but it has become standard practice in the UK fire alarm industry to use fire protected cables throughout the system. The table below shows some of the types of cable suitable for use in fire alarm systems.

Cable Type	Capable of prolonged operation in fire?	Standard to which cable should conform
Mineral-insulated copper-sheathed cable (MICC)	Yes	BS 6207
Other types of fire protected cable	Yes	BS 6387 (category AWS or SWX)
PVC insulated cable	No	BS 6004 or BS 6231
Steel-wire-armoured cable	No	BS 5467

1.7. Head Removal Monitoring

Most fire alarm systems use plug-in detectors and special detector bases, so that the detectors can be easily removed for maintenance. BS 5839 part 1 requires that if a detector is removed from its base, a fault signal should be displayed at the panel. This is normally achieved by the use of a base with separate in and out terminals and some method of switching the terminals when detectors are inserted or removed from the base. When the detector is inserted into the base, the two terminals are shorted out, so that there is continuity between the panel and the end-of-line monitoring device. When the detector head is removed, the terminals are no longer connected, there is no longer continuity between the panel and the end-of-line monitoring device, and therefore the panel registers an open circuit fault.

One problem caused by this method of monitoring head removal is that it can make testing the wiring of a system difficult because the detection line is broken when the detectors are removed. KAC bases overcome this problem by means of a shorting spring which allows the head–removal terminals to be temporarily shorted out. This allows the installer to perform a full test of the system wiring, including high voltage insulation testing if necessary, without the need to install the detectors.

1.8. Schottky Diode Bases

BS 5839 part 1 states that 'Where detectors are designed to be removable from the circuit, removal of any detector from the circuit should not affect the operation of any manual call point....' Since most systems using plug-in smoke detectors work on the principle that the line is broken when a detector is removed, this obviously presents a problem.

The most common method of overcoming this problem is by use of a 'Schottky diode base'. In these bases, a diode is fitted across the contacts, so that when the detector is removed from its base, current can still flow in one direction, allowing the detectors and call points to be powered. The end-of-line monitoring device used with this type of system is usually an active electronic unit, rather than a simple resistor. The monitoring device contains a resistor which, during normal operation, is connected across the line in the same way as an end-of-line resistor. The monitoring device sends a sequence of voltage pulses back towards the control panel. The panel contains a capacitor which, in normal operation, absorbs the voltage pulses. If one of the detectors is removed from its base, the voltage pulse is blocked from reaching the panel by the diodes.

The end-of-line monitoring device can therefore detect that the voltage pulses are not absorbed by the capacitor and it disconnects its internal resistance, therefore generating an open circuit fault at the panel. Since the diode conducts in one direction, it allows power from the control panel to reach all devices on the loop even when a detector is removed from its base.

In this way, the system can detect the removal of a detector from its base, without affecting the operation of other devices on the same loop. A Schottky diode, rather than an ordinary diode, is used because the voltage drop across a Schottky diode is lower than that across a normal diode. This means that multiple devices can be removed without significantly reducing the voltage on the line, allowing many detectors to be removed without affecting the operation of the rest of the system.

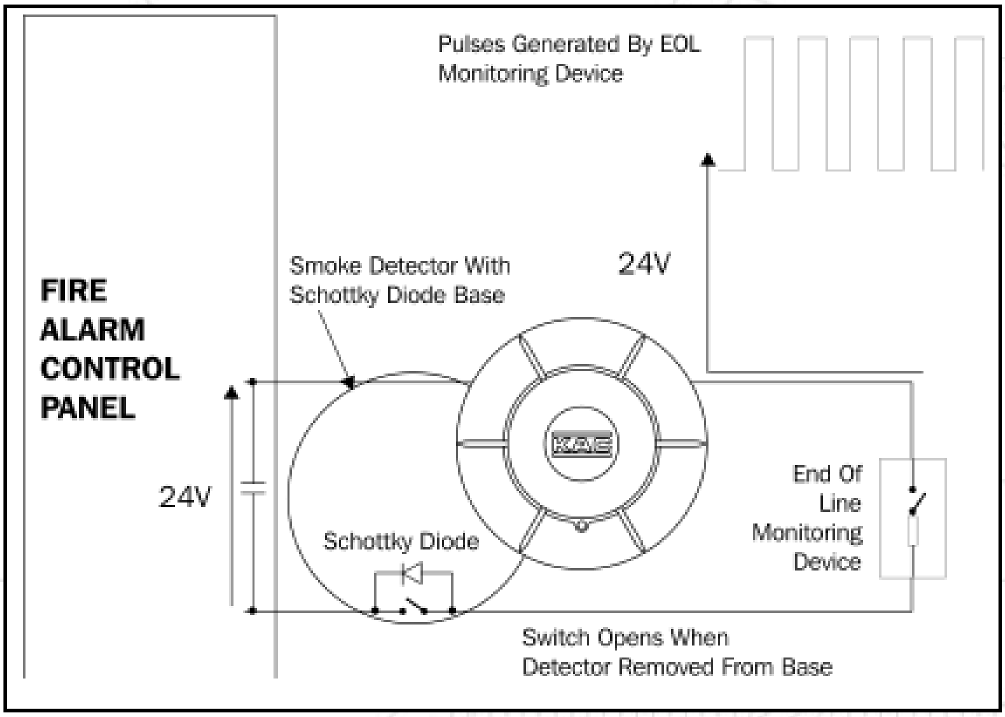

Figure 2 – Operation of Schottky diode base with typical end-of-line monitoring circuitry.

2. Use of Fire Detectors with Security Panels

In some instances, it may be more cost-effective to integrate a small fire alarm system into a security system. Most security system control panels operate differently to fire alarm panels, however. *Figure 3* illustrates the operation of a typical security system.

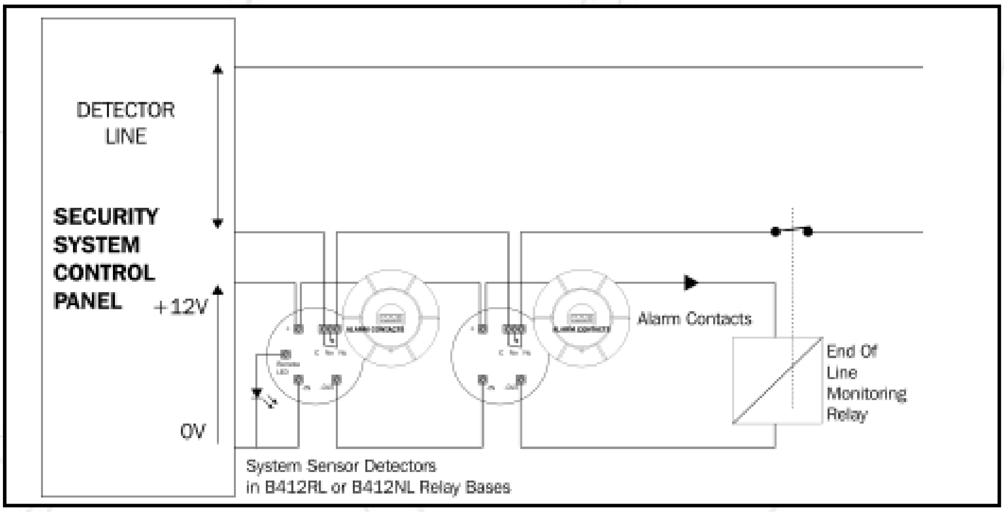

Figure 3– Connection of System Smoke Detectors to a 12V Security System

The security control panel supplies the sensors with a 12V power supply. The sensors transmit their alarm signal to the control panel by means of a second pair of cables. The alarm contact is usually of a 'normally closed' type. An end-of-line relay is used to monitor the 12V supply wiring, ensuring that an alarm is triggered if the 12V supply to the detectors is broken. Unlike a fire alarm control panel, most security control panels have no facility to reset the detectors by interrupting the supply, although some panels may be equipped with a 'fire zone' which interrupts the 12V supply when the system is reset, in order to reset the detectors from their alarm state.

In order to allow the use of detectors with security systems, KAC offer two bases specifically designed for these applications. The non-latching relay base is suitable for use in 12V security systems without a fire zone. The base allows connection of a conventional smoke detector to a 4-wire security system. Because it is designed for use in systems which do not provide a reset, the base automatically resets the detector every few seconds when it is in an alarm state.

The latching relay base is suitable for use in 12V or 24V systems which provide a reset facility by interrupting the power to the detector.

3. Selection of Fire Detectors

Smoke detectors are the most sensitive method of detecting a fire and should be used wherever conditions allow. Smoke detectors are, however, inherently vulnerable to false alarms caused by dust, steam or smoke from cooking. Where there is a likelihood of false alarms caused by any of these effects, a thermal detector should be used instead.

It is important to choose a smoke detector which conforms to British or more recently European standards for system smoke detectors. KAC's detectors are listed to EN standards with LPCB.

3.1. Photoelectric smoke detectors

Photoelectric or optical smoke detectors work by generating pulses of infra red light and sensing any reflected light. If smoke is present in the sensing chamber, the light is reflected by the smoke particles onto a photodiode which senses the presence of the smoke.

Photoelectric smoke detectors are most sensitive to smoke containing large particles, such as that given off by smouldering fires. A photoelectric detector would therefore be a good choice in an environment where a smouldering fire could be expected, such as a room containing modern fabrics and furnishings.

Photoelectric smoke detectors tend to be more sensitive to false alarms caused by cigarette smoke, so an ionisation smoke detector would be a better choice in an environment where dense cigarette smoke could be expected.

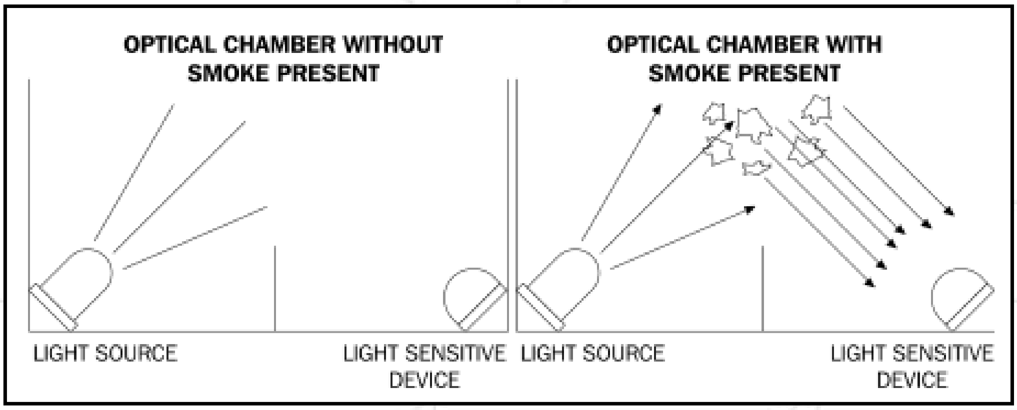

Figure 4 - Operation of Optical Chamber

3.2. Heat Detectors

Heat detectors are normally used in environments where a smoke detector would generate false alarms – such as kitchens or shower rooms. Two basic types are available – rate-of-rise heat detectors will alarm if the temperature goes above a fixed threshold (58°C for the WDET-TH-ROR-1) or if the temperature is rising very quickly. This type of detector would be the first choice in an environment where a smoke detector could not be used.

In some environments, such as boiler rooms, fast rates of rise of temperature can be expected and so there would be a risk of false alarms when using a rate-of-rise device. In this case a fixed temperature detector, such as WDET-TH-FIX-1 would be more suitable.

Optical beam detectors

3.3. Optical Beam Detectors

Optical beam detectors work on the principle that when a beam of infra red light passes through smoke, the intensity of the beam is attenuated. *Figure 5* shows the principle of operation of a beam detector.

The KAC beam detector consists of a transmitter and receiver and is designed to function with a beam length between 10m and 100m. The receiver monitors the light signal received from the transmitter and if the signal strength drops below the detector's sensitivity threshold an alarm is triggered.

The receiver contains a microprocessor which compensates for slow changes in the signal caused by dust build-up on the lenses of the transmitter and receiver. If the beam is suddenly completely blocked, this is not the normal pattern of a fire and so the detector triggers a fault condition, not a fire.

Point-type smoke detectors tend to be less sensitive to smoke as the ceiling height is increased, because the smoke is diluted. Since an optical beam detector senses smoke along the whole of its beam length, it tends to be affected less by the smoke dilution.

Optical beam detectors are a good choice for large rooms, particularly with high ceilings, since a single beam detector can protect a large area and since beam detectors are affected less by smoke dilution in rooms with high ceilings. Beam detectors are more complex to install than ordinary point smoke detectors.

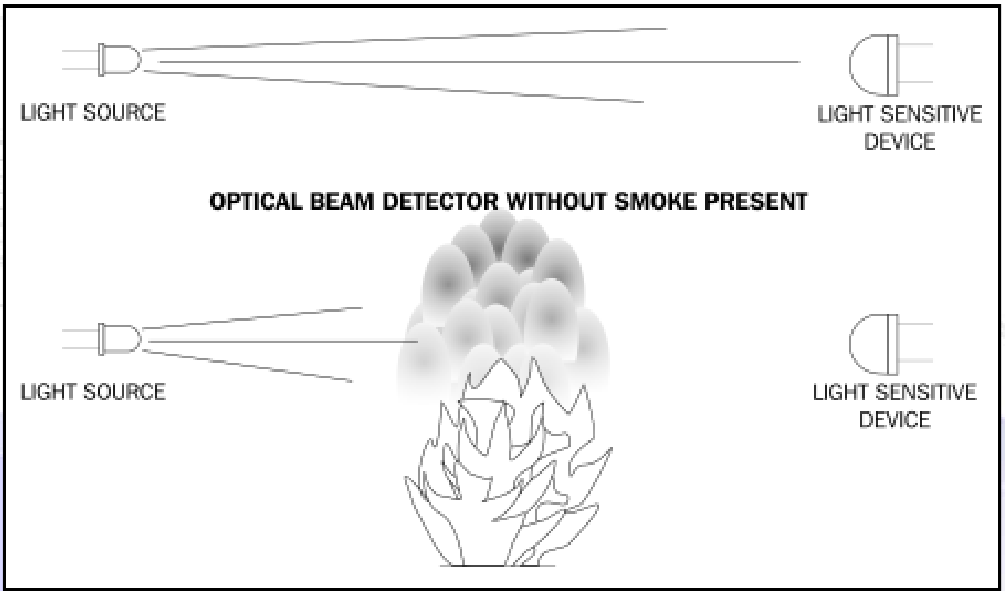

Figure 5 - Operation of Optical Beam Smoke Detector

4. Location and Spacing of Fire Detectors

It is important to consult the applicable National standards when choosing the spacing and location of fire detectors. The following information is intended as a rough guide to the siting and spacing of detectors.

4.1. Siting and Spacing of Detectors on Flat Ceilings

The horizontal distance from any point in the area to the detector nearest that point should not exceed 5.3m for a heat detector or 7.5m for a smoke detector within a horizontal direction. Detectors should not be mounted on walls, or within 0.5m of a wall. *Figure 6* and *Figure 7* show two alternative spacing patterns for smoke detectors which meet these requirements. The pattern shown in *Figure 8* is more efficient when protecting large areas, providing an increase in the area protected of around 30%. In practice the arrangement of detectors is usually dictated by the layout of the room.

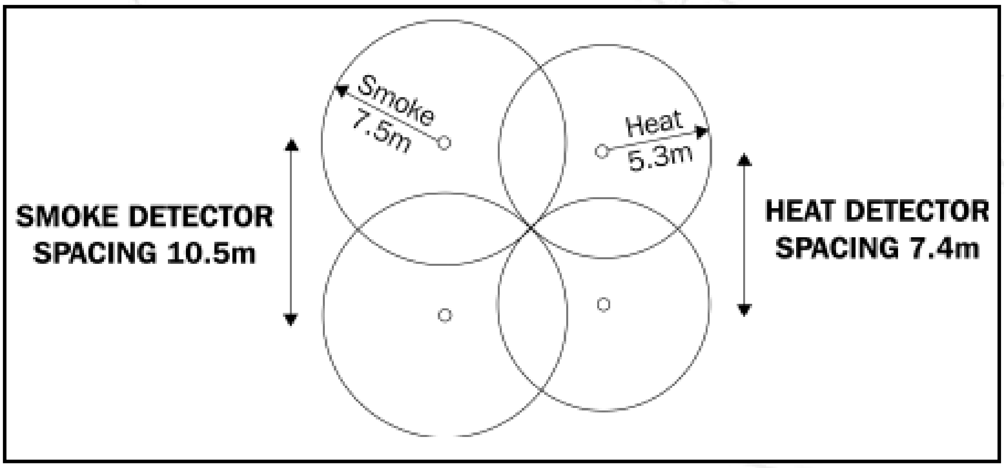

Figure 6 - Simple Spacing Plan for Smoke or Heat Detectors

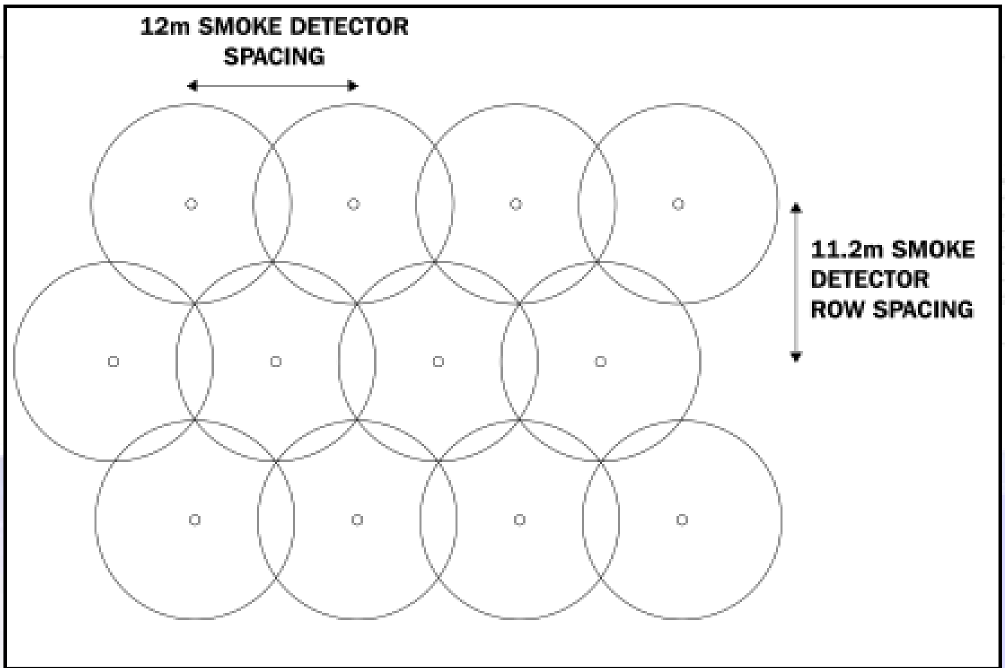

Figure 7 - More Efficient Spacing Plan for protecting large areas

Detector location

KAC

4.2. Ceiling Height

As smoke or heat rises from a fire, it will be diluted by clean, cool air. The size of fire needed to operate a heat or smoke detector therefore increases as the height of the ceiling increases. The following table illustrates the maximum ceiling heights for different types of fire detector.

Detector Type	Maximum Ceiling Height
Point smoke detector conforming to BS 5445 part 7 e.g. 1151E, 2151E	10.5m
Heat detector conforming to BS 5445 part 5 (grade 1) e.g. 5451E	9m
High temperature heat detector conforming to BS 5445 part 8 e.g. 4451E	6m

Smoke detectors should normally be mounted with their smoke entry 25mm—600mm below the ceiling to ensure that smoke can enter the detector and generate an alarm. Heat detectors should be mounted 25mm—150mm below the ceiling.

4.3. Obstructions

If the passage of smoke or hot gas is blocked by an obstruction on the ceiling, such as a beam, with a depth greater than 150mm but less than 10% of the ceiling height then the spacing between detectors should be reduced. The spacing should be reduced by twice the depth of the obstruction – so for a beam 300mm deep on a ceiling 5m high the spacing for a smoke detector would be reduced from 10.5m to 9.9m. As with detectors near walls, detectors should be spaced at least 500mm from any obstruction on the ceiling.

Small ceiling attachments such as light fittings should not affect the spacing of detectors, but detectors should not be mounted closer to the fitting than twice its depth.

Obstructions deeper than 10% of the ceiling height should be treated as walls – the two sections should be considered as separate rooms.

Partition walls or storage racks which reach to within 300mm of the ceiling should also be treated as walls.

4.4. Sloping Ceilings

Where the ceiling is pitched or sloping, smoke will tend to rise towards the apex of the roof, therefore a row of detectors should be placed in the apex. The slope of the roof tends to reduce the delay before smoke or heat reaches the detectors. It is therefore permissible to use a greater spacing distance for the row of detectors mounted in the apex of the roof –as shown in *Figure 8*. The spacing of the smoke detectors in the apex may be increased by 1% for every degree of slope of the ceiling up to a maximum of 25%. Note that this increase in spacing applies only to the row of detectors in the apex of the roof.

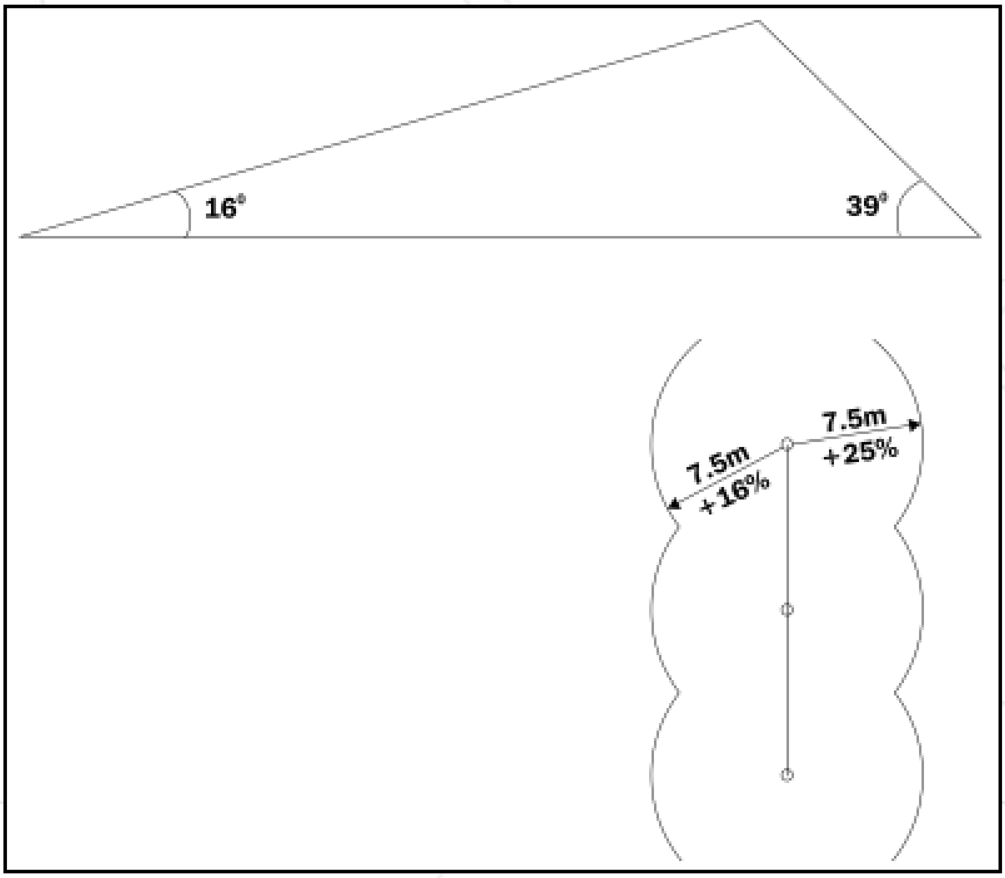

Figure 8 - Spacing of Smoke Detectors under a Pitched Roof

4.5. Corridors

In narrow corridors, the walls cause smoke and heat to move faster along the corridor than it would in an open room. In corridors less than 5m wide, the spacing of detectors can therefore be increased as shown below:

Corridor width	Maximum cover radius	Maximum distance Between detectors	Maximum distance between detector and end wall
Smoke detectors			
5m or less	7.5m	14.2m	7.1m
4m or less	8.0m	15.5m	10.8m
3m or less	8.5m	16.7m	12.2m
2m or less	9.0m	17.9m	13.4m
Heat detectors			
5m or less	5.3m	9.3m	4.7m
4m or less	5.8m	10.9m	10.8m
3m or less	6.3m	12.2m	12.2m
2m or less	6.8m	13.4m	13.4m

4.6. Stairways

In internal stairways, a detector should be mounted at the top of the stairway and on each main landing.

4.7. Voids

Detectors need not normally be installed in voids less than 800mm deep, unless it is thought likely that fire could spread extensively through the voids before detection. Where they are installed, they should be installed in the top 10% of the void space. Although it can be difficult to install detectors the correct way up in void spaces, where possible detectors should always be installed the correct way up, as installing detectors upside down can lead to false alarms caused by dust settling in the detector chamber.

4.8. Lantern Lights

A detector should be mounted in any lantern light used for ventilation or having a height above the ceiling exceeding 800mm. The temperature in lantern lights can change rapidly owing to heating by sunlight, so rate-of-rise heat detectors should not be used and heat detectors should be protected from direct sunlight.

5. Testing & Maintenance of Smoke & Heat Detectors

5.1. Testing

Detectors must be tested after installation and following periodic maintenance. However, before testing, notify the proper authorities that the system is undergoing maintenance and will be temporarily out of service. Disable the zone or system undergoing maintenance to prevent unwanted alarms.

Test smoke detectors as follows:
Using generated smoke, or synthetic smoke aerosol from an approved manufacturer. Subject the detector to controlled amounts of smoke in accordance with local codes of practice and manufacturer recommendations. The detector should latch into alarm within 30 seconds, activating the control panel into alarm.

Test heat detectors as follows:
Use a proprietary heat detector tester or use a hair dryer of 1 to 1.5kW, bydirecting the heat toward the side of the detector and ensure that it is present until an alarm occurs on the detector. Hold the heat source approximately 15cms from the detector whilst maintaining the heat to the detector in order to achieve the alarm condition.

The red alarm LED should latch on within 30 seconds indicating an alarm and activating the panel into a condition to indicate the detector under test.

5.2. Maintenance of Smoke Detectors

Before cleaning, notify the proper authorities that the system is undergoing maintenance and will be temporarily out of service. Disable the system to prevent unwanted alarms.

1. Remove the detector to be cleaned from the system.
2. Gently release each of the cover removal tabs that secure the cover in place and remove the detector cover.
3. Vacuum the outside of the screen carefully without removing it.
4. Carefully Remove the screen from the sensing chamber. Replacement screens are available.
5. Use a vacuum cleaner and/or clean, compressed air to remove dust and debris from the sensing chamber and the inside of the screen.
6. Re-install the screen by aligning the arrow moulded on it with the arrow on the sensing chamber, sliding the screen over the chamber and applying gentle pressure to secure it in place.
7. Reinstall the detector cover. Align the LED with the cover assembly and snap the cover into place, ensuring that all the cover removal tabs are correctly engaged.
8. When all the detectors have been cleaned, restore power to the circuit and test the detector as described in **Testing** above.

After completion of all tests notify the proper authorities that the system is operational.

5.3. Maintenance of Heat Detectors

Before cleaning, notify the proper authorities that the system is undergoing maintenance and will be temporarily out of service. Disable the system to prevent unwanted alarms.

1. Remove the sensor to be cleaned from the system.
2. Use a vacuum cleaner (or compressed air) to remove dust and debris from the sensing element protruding through the chamber cover.
3. When all sensors have been cleaned, restore power to the circuit and test the sensor(s) as described in the TESTING section of this manual.

After maintenance has been completed, notify the proper authorities that the fire system is operational.

6. Other information

6.1. Standards and Approval bodies

To ensure that a fire alarm system provides adequate protection, it is advisable to ensure that it meets all relevant standards. The components of the fire alarm system should be certified to a British or European standard by an independent certification body such as LPCB who specialise in the certification of fire and security systems. The system should be designed in accordance with the British Standard for Fire Detection and Alarm Systems – BS 5839 part 1.

British Standard for fire detection systems	BS 5839 part 1
British Standard for manual call points	BS 5839 part 2, EN54-11
British Standard for fire alarm control panels	BS 5839 part 4, EN54-2, EN54-4
British/European standard for system smoke detectors	BS EN54 part 7
British/European standard for heat detectors	BS EN54 part 5

6.2. Major British Approval bodies for fire detection products

The Loss Prevention Certification Board
BRE Certification Limited
Garston, Watford,
Hertfordshire
WD25 9XX

British Standards Institution
389 Chiswick High Road
London
W4 4AL

6.3. Suppliers of Detection Products, Sounders and Manual Call Points for use in Fire Alarm Systems

KAC Alarm Company Ltd.
Unit 15-19 Trescott Road
Smallwood
Redditch
Worcestershire
B98 7AH

6.4. Suppliers of Smoke Detector testers and removal poles

No-Climb Products Ltd.
15/17 Alston Works
Alston Road
Barnet
Herts
EN5 4EL

6.5. Suppliers of Accessories for Fire detectors

Safety Technology International (Europe) Ltd.
Unit 3
Oulton Warf
Richard Rd
Oulton
Solihull
B92 7RN