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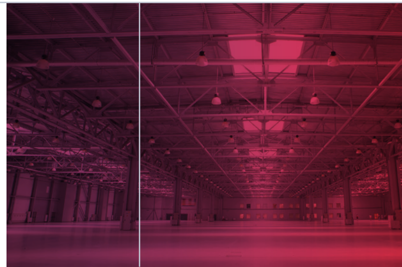

Pocket guide to Optical Beam Detection

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Contents

Foreword

The purpose of this guide is to provide information on the correct installation of Beam Smoke Detectors in life-safety and property protection applications. This guide briefly summarises the principles of operation of Beam Smoke Detectors, their design requirements and practical applications for their use as a component of a fire alarm system.

Beam Smoke Detectors can be important components of a well-designed fire alarm system. Their unique capabilities enable them to overcome many of the limitations of other detection methods. This guide has been developed to help give you an understanding of the Beam Smoke Detector's capabilities and limitations, and how they differ from Point Detectors.

Please note: this document is intended only as a general guide to the application of Beam Detectors. Reference should always be made to the detector manufacturer's installation requirements and instructions, and local standards.

Glossary of terms

Optical Beam Smoke Detector (Beam)
A fire detector which uses a beam of light (usually infrared) projected across an open area to monitor for smoke emitted by an incipient fire. There are two types of Beam Detector:

- **End-to-End:** Transmitter and receiver are mounted at either end of the protected area.
- **Reflective:** Transmitter and Receiver are mounted in the same housing and the beam is directed at a specially designed Reflector, mounted at the opposite end of the protected area.

Aspirating Smoke Detectors
Air is drawn through a network of pipes to detect smoke. Smoke flows into the sampling chamber which detects the presence of smoke particles suspended in air by detecting the light scattered by them in the chamber.

Transmitter (aka Projector, TX)
This device is paired with a dedicated Receiver, in an End-to-End Beam Smoke Detector system, which emits the light signal through the area to be protected. The Transmitter can be integrated with the Receiver into a single unit.

Receiver (aka Sensor, RX)
This device is paired with a dedicated Transmitter, in a projected Beam Smoke Detector system (End-to-End), which monitors the signal level of the light received after it has passed through the protected area.

Controller
This is a component of an Optical Beam Smoke Detector system that allows the fire alarm engineer or competent person to set up, configure, troubleshoot and test at ground level, in replacement of using high level access equipment.

Beam range
This is the total distance between the beam Transmitter and Receiver for End-to-End type detectors, and Transmitter/Receiver to Reflector for reflective type detectors.

This is often expressed as 'A to B', where A is the minimum operating range from 0, and B is the maximum operating range from 0 m. For example: 5 to 100 m (16 to 328 ft) range is a beam that can operate over a distance no less than, 0 to 5 m (0 to 16 ft) and maximum of 0 to 100 m (0 to 328 ft).

Glossary of terms

Detector coverage
Detector coverage is the area wtihin which a detector is considered capable of detecting an emerging fire effectively. This area is defined by local and international standards.

Prism (Reflector)
This component is used on reflective based beams. The highly reflective properties allow it to bounce incoming light back to the source of the light to a nearby sensor over long distances.

Distances of up to 120 m (394 ft)can be achieved with additional prisms set-up in an array.

Drift compensation
A feature where the Detector will automatically adjust position and/or signal transmitted to maintain optimum alignment. This feature is limited to ensure slow developing fires (smouldering fires) are detected while mitigating the effects of dirt build up on the Detector surfaces and compensate for mild building movement.

Obscuration
Obscuration is the amount by which a beam of light is reduced by the presence of translucent, non-transparent particles or material in the beam's path, normally expressed as a percentage or as dB attenuation.

Sensitivity
The ability of a smoke detector to respond to a given level of obscuration. This is often an adjustable feature in Beam Smoke Detectors.

Point Detector
A device, which senses a fire at its early stage at a single location, most commonly using optical or ionisation smoke detection or heat detection. The area of coverage of a Point Detector is defined in local or national standards.

Stratification
The effect which occurs when a smoke plume slows or stops rising at a an elevation below the ceiling, potentially causing delayed detection times for ceiling mounted devices.

Who should read this guide?

You should read this guide if:

- You specify or design fire detection systems
- You are responsible for your building's fire protection system
- You are the Fire Marshall for your workplace
- You are planning to install a Beam Smoke Detector or other smoke detection system
- You are in a risk assessment role for fire protection
- Your role is to support or sell fire detection systems
- You work in the fire and rescue service

The guide offers general guidance; you should also consult local and national regulations and the manufacturer's technical specifications for particular detectors.

Optical Beam Detector applications: Industrial units and warehousing

What is an Optical Beam Smoke Detector?

The most common type of smoke detector is the Optical Point Detector. This contains an infrared light beam projected across a small sensing chamber inside the body of the device. When smoke enters the sensing chamber through the outer holes in the body of the Detector, it affects the infrared beam and triggers the device into alarm, alerting individuals present to a fire.

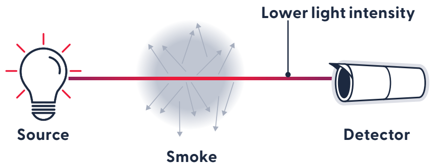
Optical Beam Smoke Detectors work on a similar principle except that the infrared light beam is projected across the open area of a building. This effectively transforms the building into the sensing chamber with the optical beam detecting smoke along the entire beam path.

**Point Detector:
sensing chamber
less than 10 cm (4") long**

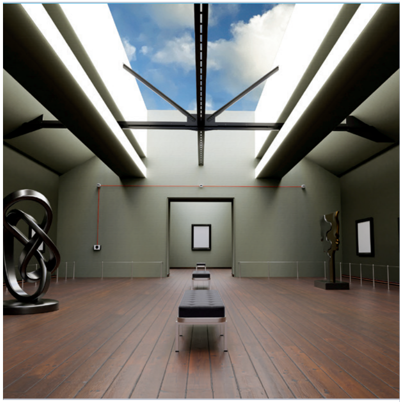
**Beam Detector:
'sensing chamber'
up to 120 m
(394 ft) long**

How does Optical Beam Detection work?

When smoke passes through the invisible infrared beam, the solid particles and liquid droplets in the smoke reflect and scatter the photons of light. The result is that the intensity of the light is reduced on the far side of the cloud of smoke. This reduction in intensity, known as obscuration, can be detected and used to signal a fire.



The important thing to note is that this effect occurs equally at all points along the beam path, no matter where the smoke passes through the beam, so that the detector behaves effectively as though it was made up of an infinite number of Point Detectors arranged along a line. This makes Optical Beam Smoke Detectors ideal for protecting long distances (up to 120 m/394 ft for a single beam), providing that the beam is completely unobstructed and correctly aligned with the Detector.



Did you know?
Infrared light is used in Optical Beam Smoke Detectors because it is sensitive across a large range of particles and the beam is invisible to the naked eye, therefore the detectors can operate discreetly in a building.

Types of Optical Beams available?

There are two main configurations of Optical Beam Smoke Detectors: Reflective and End-to-End. Both consist of a Transmitter T (the light source) and Receiver R (the Detector).

Reflective

End-to-End

ATTRIBUTE | **REFLECTIVE** | **END-TO-END**

Installation and maintenance

Reflective Detectors are easier and less expensive to install and maintain than End-to-End Detectors, as the electrical cabling is needed on only one side of the protected space, there is only a single device to clean and maintain during servicing.

Alignment

It is usually easier to align a reflected beam as there is only a single piece of equipment to adjust at one end of the beam (the Reflector is usually not adjustable), whereas End-to-End Detectors require adjustment at both ends of the beam.

Space required by beam

The reflected beam diverges as it passes back across the space from the Reflector, so the space needed by the beam is greater. An End-to-End beam can pass through a narrower gap.

Optical Beam Detector applications:
Heritage buildings

How do they differ from others?

Point Smoke Detectors, as their name suggests, detect smoke over very short distances using a chamber inside the Detector itself. Some models use the principle of light scattering, where the presence of smoke changes the direction of a light beam so that it is detected by a photodiode. Other models detect a change in the electrical characteristics of the air inside the Detector caused by the presence of smoke.

Aspirating Smoke Detectors draw air into a sensing chamber from an array of sampling points connected via a pipe network. Smoke is detected using similar principles to Point Smoke Detectors.

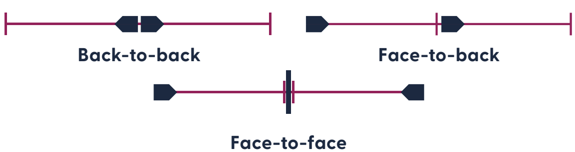
The most significant difference between these technologies is how the protected area is monitored.

How should they be installed?

Following the guidelines below will maximise the performance of Optical Beam Detectors and minimise the occurrence of faults and false alarms:

Mount on to solid, structural surfaces: Mount the beam Transmitter/Receiver/Reflector on solid, structural parts of the building which experience minimal movement due to temperature changes, vibration, settling, etc. Use Detectors with re-alignment routines to compensate for long-term building movement.

Select the correct beam type for the installation: If the space needing protection is too long for a single beam, consider 'back-to-back', 'face-to-back' or 'face-to-face' arrangements. Alternatively, use Detectors equipped with Dynamic Beam Phasing to prevent interference between beams and avoid the need for extra shielding.



Ensure a clear line-of-sight for the beam: Avoid shiny surfaces along the beam path, and preferably keep such surfaces at least a metre from the centre of the beam in Reflective Detectors (this distance can be lower for End-to-End Detectors).

Ensure the beam is aligned: Use Detectors with effective alignment indicators or automatic alignment routines to avoid misaligned beams being placed into service.

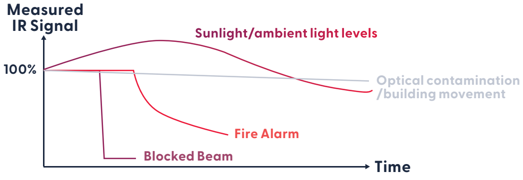
Arrange beams as needed for optimum coverage of the space: Beams can be crossed without causing spurious signals at receivers.

Avoid direct sunlight: If unavoidable (for example in glass atria), use Detectors with light compensation algorithms to adjust for fluctuations in ambient light levels.

How should they be installed?

Determine appropriate maintenance tasks/ intervals: Assess the likely level of optical contamination due to dust or condensation by examining surfaces close to the Detector positions. Configure alarm thresholds to suit likely contamination levels. Use Detectors with algorithms that monitor and adjust the gain to compensate for slow changes in signal. Schedule maintenance visits to clean optics at appropriate intervals.

Select appropriate system settings: Configure the Delay to Fault settings to suit building operations, for example, to allow for brief beam blockages by machinery if this is unavoidable. If operational changes occur regularly, mount a low-level Controller to allow easy access for quickly adjusting and optimising settings. Use advanced Detectors that monitor trends in beam intensity to separate real fires from other effects.



Take steps to prevent birds from perching on the detectors and possibly blocking the beam (when necessary).

Maintain a system log: Optical Beam Smoke Detectors are life safety devices and on-site documentation of the installation is vital for recording future maintenance and to assure users of a safe and competent installation.

Standard recommendations (BS 5839 Part 1)
BS 5839 Part 1 gives a code of practice for the design, installation, commissioning and maintenance of automatic fire detection systems in non-domestic buildings. Some of the key recommendations for Optical Beam Smoke Detectors are summarised in this guide. This is provided for general guidance only; refer to the standard for detailed information.

BS 5839 guidance

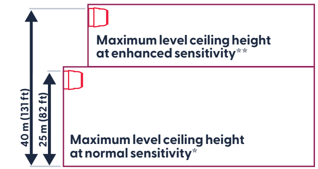
Standard recommendations (BS 5839 Part 1)

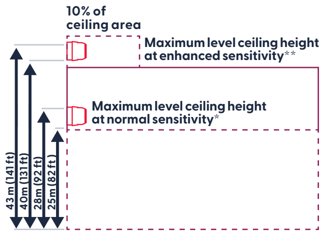
Height of Detectors

Optical Beam Detectors should be mounted as close to the ceiling to take advantage of the accumulation and spreading of the smoke plume that occurs there during a fire.

The maximum room height that can be protected by a single set of Detectors depends on whether or not the ceiling is flat and also on the sensitivity of the Detectors.

Taller spaces require extra or 'supplementary' detection at lower heights (see 'Horizontal spacing of Detectors').





* Normal sensitivity = detector alarm threshold >35% attenuation.

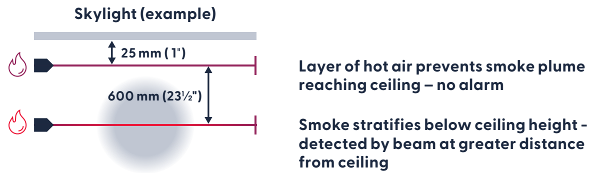
** Enhanced sensitivity = detector alarm threshold ≤35% attenuation; supplementary detection also recommended (see 'Horizontal spacing of Detectors').

Optical Beam Smoke Detectors can be installed at much greater heights than Point Detectors (maximum 10.5 m/ 34½ ft) because the longer length of the protected space offsets the problem of detecting a lower smoke density as the plume disperses.

Narrow plume with high smoke density activates beam and point detectors

Dispersed plume with low smoke density only activates beam detectors

In some locations, such as in atria or under skylights, it is safer to mount beams close to the maximum distance below the ceiling so they can detect stratified smoke layers that do not reach the ceiling:

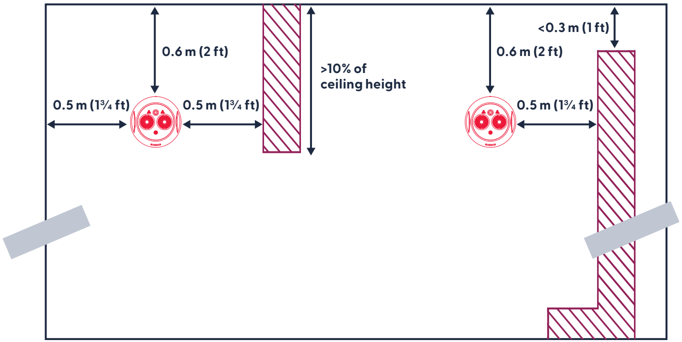


BS 5839 guidance

Distance from vertical surfaces

Detectors must be at least 0.5 m (1¾ ft) from:

- The nearest vertical wall
- Any ceiling-mounted surface such as a beam or duct which projects a distance of more than 10% of the total ceiling height
- Any floor-mounted surface which reaches closer than 300 mm (12") to the ceiling.



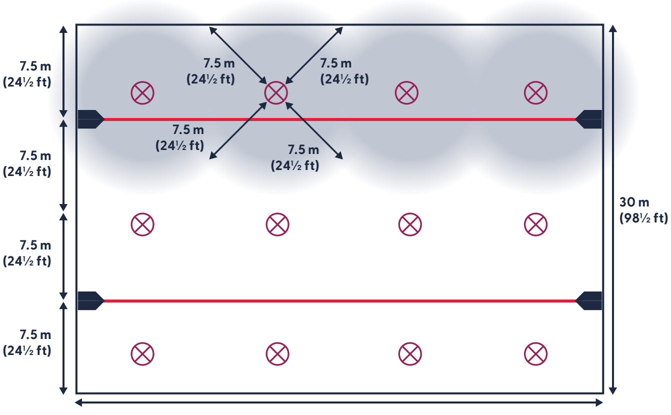
Optical Beam Detector applications: Museums & galleries

BS 5839 guidance

Horizontal spacing of Detectors

At ceiling height, the maximum horizontal distance between any point and part of a beam must be 7.5 m (24½ ft).

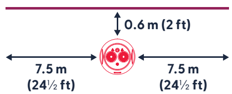
The same limit of 7.5 m (24½ ft) also applies for Point and Aspirating Smoke Detectors, which gives a clear advantage to Beams for large areas as the coverage is much more efficient. In the example shown for a floor area of 1260 m² (4134 ft²), 2 Beam Detectors are sufficient whereas 12 Point Detectors or aspirating sampling points are required.



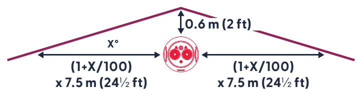
42 m (138 ft) plan view

Detectors mounted at the apex of pitched roofs can cover wider horizontal areas due to the “funnelling” effect of the roof. Increase the distance by 1% for every 1° of roof pitch up to a maximum increase of 25% (to give a maximum spacing of 9.38 m/30¾ ft):

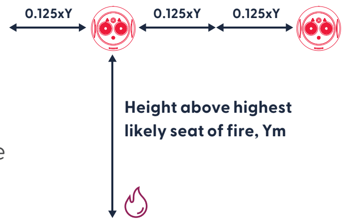
Flat roof



Pitched roof



Supplementary detection is recommended for buildings with very high ceilings. This can provide earlier detection of a fire and avoids the effect of stratification. The horizontal spacing limits are lower than at the ceiling because there is no surface above the protected volume to restrict the dispersion of the smoke plume.



NFPA 72 guidance (2022 edition)

Standard recommendations (NFPA 72 Section 17.6.3)

NFPA 72, the National Fire Alarm and Signaling Code, is the leading standard in the U.S. for the installation, performance, inspection, testing and maintenance of fire detection and alarm systems. For beam-type smoke detectors, which are used in large open spaces such as warehouses, atriums, and sports halls, Chapter 17 of the 2022 edition outlines specific installation guidelines to ensure effective smoke detection.

Spacing: smooth ceilings (NFPA 72 Section 17.7.3.4.7)

On smooth ceilings, a spacing of not more than 18.3 m (60 ft) between projected beams and not more than one-half that spacing between a projected beam and a sidewall. (i.e. wall parallel to the beam travel) should be used as guide. Other spacing should be determined based on ceiling height, airflow characteristics and response requirements.

In some cases the light beam projector is mounted on one end wall, with the light beam receiver or reflector mounted on the opposite wall. However, it is also permitted to suspend th projector and receiver/reflector from the ceiling at a distance from the end walls not exceeding one quarter the selected spacing(S) See figure A. 17. 7. 4. 7.)

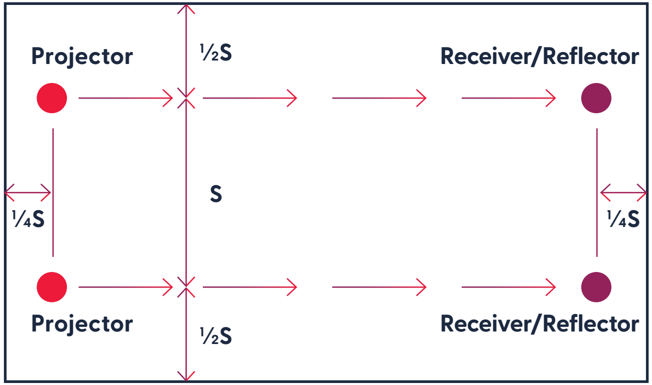


Figure A17.7.4.7: Maximum distance at which celing suspended light Projector and Receiver/Reflector can be positioned from end wall is one quarter selected spacing (S)

NFPA 72 guidance (2022 edition)

Spacing: high ceilings (NFPA 72 Section 17.7.4.7.2)
Projected beam smoke detection is often used in large open spaces with high ceilings where the use of spot-type detectors is impractical due to the problems of smoke stratification. In these spaces, there is questionable basis for the use of the prescriptive spacings presented in Section 17.7. However, beams can be installed such that, regardless of the fire origin, the plume will intersect at least one beam. To employ this strategy, the plume divergence is calculated as a function of the altititude at whch the projected beam detectors are installed. The region of relatively uniform temperature and smoke density in a buoyant plume diverges at an angle of approximately 22 degrees, as shown in Figure A.17.7.4.7.2.

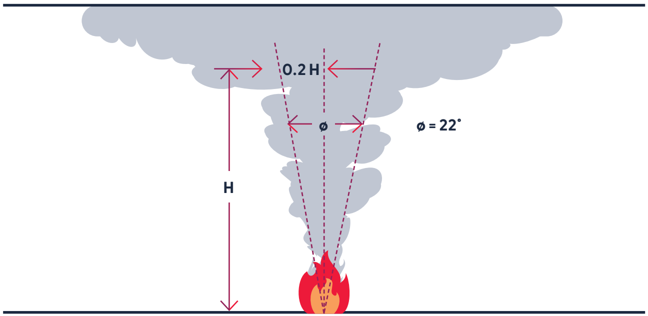


Figure A17.7.4.7.2: The plume divergence of an unconstrained fire

Another method inolves assessing the smoke obstruction through the plume to determine the reduction in light from the receiver to the transmitter of the beam-type smoke detector to determine whether the detector might respond ["Projected Beam Smoke Detectors –More Than Just a Substitute for Spot Detectors"; Fire Protection Engineering, Issue No. 23, Summer 2004, SFPE.]

(NFPA 72 Section 17.7.4.7.8)
Where the light path of a projected beam-type detector is abruptly interrupted or obscured, the unit should not initiate an alarm. It should give a trouble signal after verfication of blockage.

(NFPA 72 Annex A17.7.5.1)
Detectors should not be located in a direct airflow or closer than 910 mm (36") from an air supply diffuser or return air opening. Supply or return sources larger than those commonly found in residential and small commercial establishments can requrie greater clearance to smoke detectors. Similarly, smoke detectors should be located farther away from high velocity air supplies. See B.4.9.

NFPA 92 guidance

NFPA 92 is the standard for smoke control systems. Although it may not apply directly to your project, it has clear prescriptive guidance for high ceiling spaces. The design techniques are sometimes used for spaces where smoke stratification is a concern.

Stratification of Smoke (NFPA 92 Section 6.4.4.1.5)
For large spaces where smoke stratification can occur, one of the following detection schemes can be used:

(1)* An upward beam to detect the smoke layer
(2)* Detection of the smoke layer at various levels
(3)* Horizontal beams to detect the smoke plume

What tools do you need for installation

The instructions for installing, aligning and testing Optical Beam Smoke Detectors vary depending on the model and manufacturer and so you should follow the guidance provided with your system. However, the following tools and equipment are useful to have available when installing any type of detection system:

Tools for mounting detectors to building structure: Drill, cross-head and flat-head screwdrivers, etc.

Commissioning and test kit: Available from your supplier, this contains all the necessary tools to test the detector for fire and fault.

Multimeter and test leads: To check incoming power supply when fault-finding.

Scissor lift or other high-level access equipment: For use when mounting detectors. Access poles are also useful when testing detectors after installation, saving time and avoiding the need to work at height.

How should Optical Beam Detectors be maintained?

Follow the steps below periodically to maintain the performance of the Detectors (the frequency will depend on the cleanliness of the operating environment):

1. Isolate the Detectors from the fire alarm control panel.

2. Clean the optical components (Transmitter/Receiver/Reflector) with a soft, lint-free cloth.

3. Re-align the Detectors to ensure signal levels are optimal.

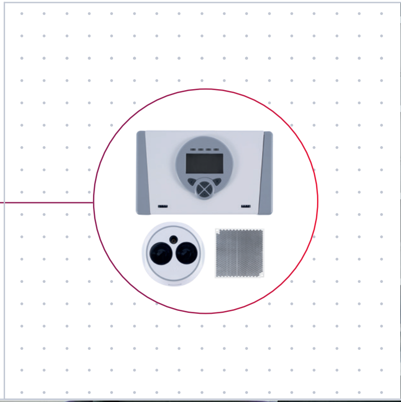
4. Reconnect the Detectors to the fire alarm control panel.

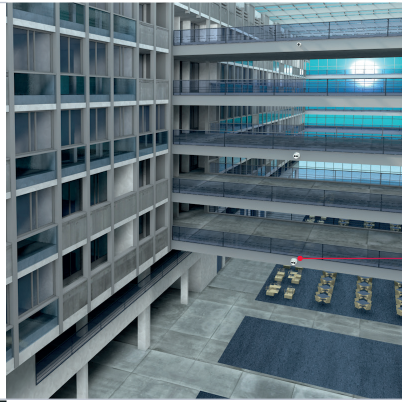
5. Test the Detectors (this usually involves blocking the beam at the Receiver).

Did you know?
Some Optical Beam Detectors can be connected to a Controller mounted at low level to allow installation and maintenance to be performed without the need for equipment to gain access to the Detectors themselves. Certain Detectors can also give a signal to inform you when the optics need cleaning.

Where can you install them?

Long unobstructed distances
- Aircraft hangers
- Airport terminals
- Lift shafts
- Sports centres
- Warehouses

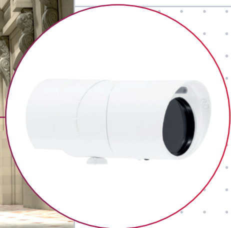




Tall buildings
- Aircraft hangers
- Airport terminals
- Manufacturing facilities
- Atria
- Churches

Restricted access
- Airport terminals
- Government buildings
- Mass transit terminals
- Manufacturing sites

Where can you install them?



Restricted numbers of Detectors acceptable

- Architectural concerns (heritage buildings, modern minimalist styles)
- Ceiling mounting not possible (atria, glass ceilings)
- Open-plan offices
- Unobtrusive detection desirable (art galleries, museums, libraries)

Explosive atmospheres

- Electronics can be sealed in explosion proof housings
- Low-level controller located remotely in safe area for system monitoring

Did you know?
Beam Smoke Detectors are not only able to protect spaces horizontally. They have also been successfully used to protect vertical installations such as lift shafts, where only one or two Detectors need to be installed and maintained to protect multiple floors, instead of a much larger number of Point Detectors.

Which Detector works best?

Application	Reason	Preferred Detector
Highly cluttered or restricted spaces (e.g. roof voids)	Beam detection requires a clear, unobstructed path	**Point Smoke Detectors**
Areas where the beam path may be blocked (e.g. warehouse racking)	Obstructions can lead to faults or false alarms	**Point or Aspirating Smoke Detectors**
Locations with no suitable structural mounting surface (e.g. cladding, plasterboard or timber only)	Movement or instability can affect beam alignment	**Point or Aspirating Smoke Detectors**
Very dusty environments	Detector optics may become contaminated beyond compensation limits	**Flame or Heat Detectors**
Outdoor areas or spaces with high air flow	Smoke may not accumulate predictably around the Detector	**Flame Detectors**

Further information

FFE offers continuous professional development (CPD) training for anyone interested in learning more about the optimal design of optical beam smoke detector networks and how to configure and maintain systems to ensure peak sensitivity for accurate fire detection.

For details contact **marketing@ffeuk.com**