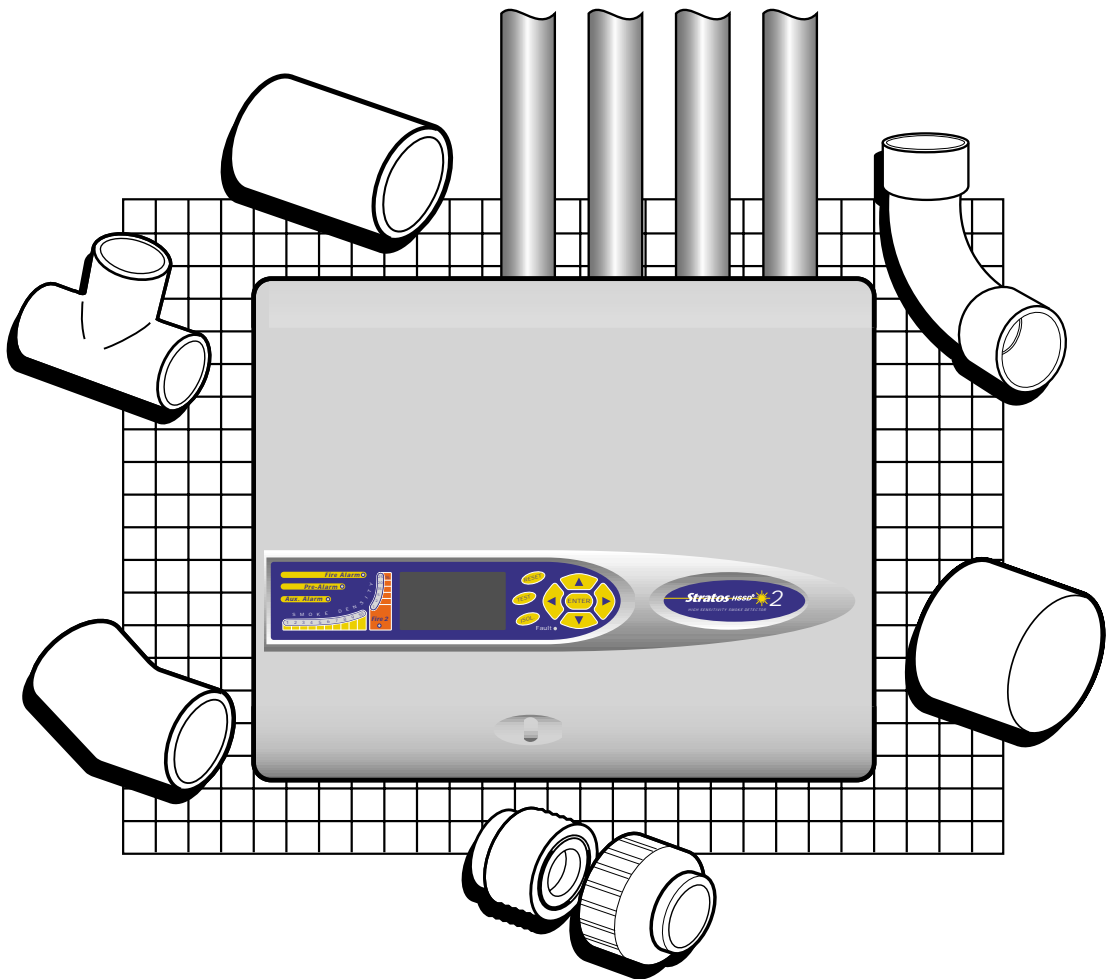
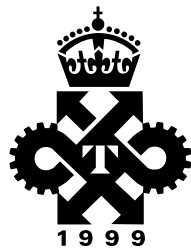


# Aspirating Smoke Detection



- a brief guide for the Designer -



THE QUEEN'S AWARD  
FOR TECHNOLOGICAL  
ACHIEVEMENT

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## Introduction

Aspirating smoke detection is a system that uses an aspirating fan to draw air from the protected area via a network of sampling pipes and sampling holes. The sampled air is then passed through a high sensitivity precision detector that analyses the air and generates warning signals when appropriate. This system has a number of benefits, particularly in the areas of performance, installation cost and routine maintenance. This guide is intended to provide an overview of this type of system, although local standards and codes of practice should always be taken into account. Guidance on the design of systems is given in BS 5839, BS 6266 and/or BFPSA Code of practice for category 1 aspirating detection systems.

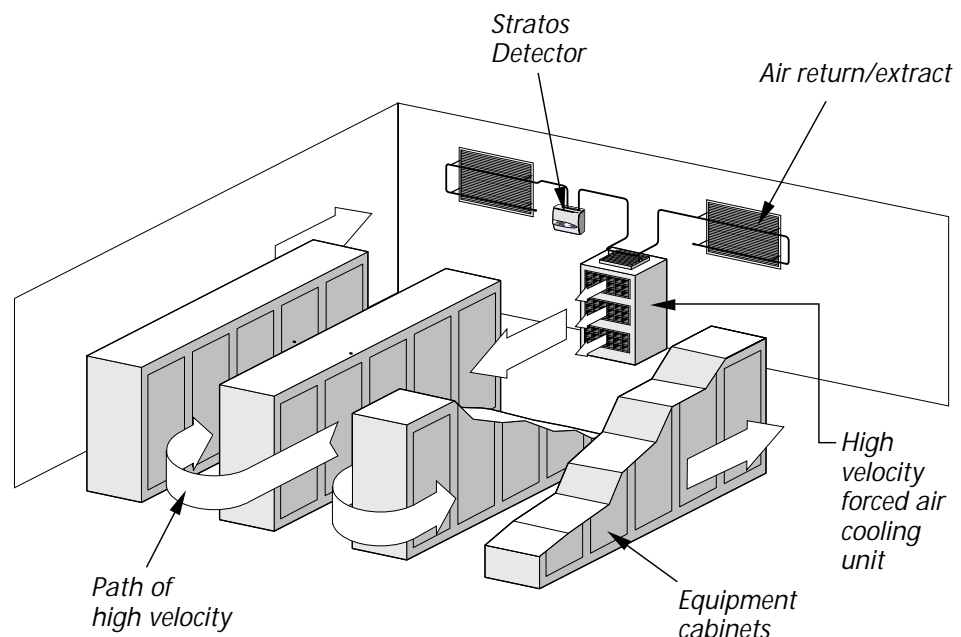
### **Types of system**

It is important to define appropriate requirements/expectations for an aspirating smoke detection system at an early stage.

*The two main types of system are;*

- **Primary Sampling System:** the system is designed to work in conjunction with any air handling systems and will not provide optimum performance when these are inoperative. The major advantage is the detection of cool smoke from a minor problem that does not rise to the ceiling, which would be the 'conventional' location.

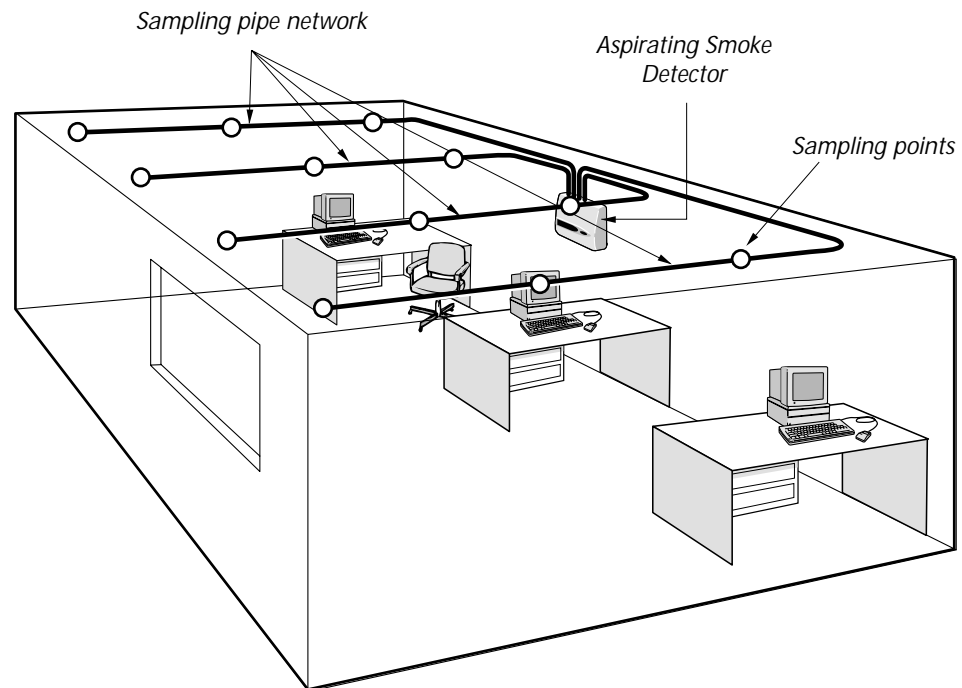
**Fig. 1** Primary sampling  
- via air handling  
system



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- Secondary Sampling System: the system is designed with sampling holes in the same positions as normal point detectors to an appropriate standard e.g. BS 5839, BS 6266 etc.

**Fig. 2** Secondary sampling - layout for normal point detection



*These sampling pipes may be designed and installed to achieve one of three levels of sensitivity:*

- Normal Sensitivity: the same sensitivity as normal point detectors (typically @ 3% - 5% obscuration per metre).
- Enhanced Sensitivity: responding to smoke at concentrations of between 2% and 0.8% obscuration per metre.
- High Sensitivity: responding to smoke at concentrations of less than 0.8% obscuration per metre.

It is important to note that the detector sensitivity is shared over the network of sampling points associated with it. In other words, if a system having a detector registering a 'Fire' signal when the smoke density within it reached 0.05% obscuration per metre was connected to a pipe network with 20 sampling holes the mean system sensitivity at each hole would be 1.0% ( $0.05\% \times 20$ ). This sensitivity is calculated on the basis smoke only enters one of the twenty holes. If the same density of smoke entered two holes the mean sensitivity would double. Normally, smoke will enter from the majority of sampling holes, in which case system sensitivity can be very high indeed.

### **Types of Detector**

*There are currently three types of technology used in commercially available aspirating smoke detectors:*

- **Light Scatter:** A stream of sampled air is continually passed through a detection chamber in which a high-energy light source is pulsed. This light would be scattered by any smoke particles in the sample and the quantity of scattered light is analysed by a solid state light receiver. The quantity of scattered light is proportional to the level of smoke pollution. Light scatter systems are sensitive to smouldering fires and particles given off by overloaded electrical cables and are therefore particularly useful where early warning is required. They can be vulnerable to dust however, which is why most detectors incorporate sophisticated filters and/or electronic dust rejection.
- **Cloud Chamber:** A stream of sampled air is continually passed through a detection chamber that contains water vapour. Any very small particles cause the vapour to condense around them to form larger droplets of equal size. The number of these droplets is regularly measured optically using a pulsed LED. Because cloud chambers consume water they require regular maintenance. Cloud chamber detectors are resistant to dust. In comparative field tests, cloud chamber detectors have shown very good response in detecting the particles released by flaming fires, but poor response in detecting the particles common to smouldering fires and are therefore of limited use for early warning.
- **Particle Counting:** A stream of sampled air is continually drawn through a focused laser beam and light scattered from each particle is measured. This provides an output relative to the number of particles that have traversed the laser beam. Particle counting systems are sensitive to smouldering fires and overloaded cables but need to have their air flow vigorously regulated as their output is proportional to the flow rate. Particle counting systems are generally resistant to dust but fibres seen 'end on' or large volumes of dust have been known to cause unwanted alarms.

### **Signal Processing**

How signals are processed is fundamental to the reliability of an aspirating detection system. *There is no point in having the most sensitive detector in the world if this results in a large number of unwanted (false) alarms.* Provision should be made to accommodate changes resulting from a drift in detector calibration, contamination of filters or changing environmental conditions within the protected area, thus ensuring a consistent level of protection.

Early aspirating detection systems were of fixed sensitivity where the detector was calibrated to a known value and the alarm thresholds fixed at pre-determined points depending on the site conditions measured during commissioning. These systems were unable to accommodate fluctuation in site conditions and this rapidly led to a perception that high sensitivity automatically meant a high incidence of unwanted (false) alarms. All fixed sensitivity detectors require annual recalibrating in addition to normal maintenance test procedures.

To overcome this problem, a modern aspirating system uses Artificial Intelligence (AI) to maintain a known probability of alarm by varying the sensitivity of the detector to match variations in site conditions. This type of system also automatically compensates for component drift or detector contamination, thus ensuring optimum performance is always achieved.

**General Design**

*Aspirating smoke detectors are often used where early warning is required and higher than normal sensitivity is needed. They are also suitable for many other applications where there are problems using conventional forms of detection. This could be because:*

- there is an access or maintenance problem
- the protected area is too high and/or may suffer from smoke stratification problems
- an invisible installation is required
- the environmental conditions are extreme (hot, cold, dirty, etc)

When specifying or designing an aspirating smoke detection system it is essential to define the performance required from the system. There are various specifications for performance tests given in BS 6266 and in the BFPSA Code of Practice and it is advisable to nominate one of these tests before the project is tendered. System sensitivity should be appropriate and realistic. High sensitivity and rapid response can be achieved from a single detector in a small computer room. Normal sensitivity and response would be more appropriate when protecting 2000m<sup>2</sup> of warehouse space where height and volume dissipate and dilute the smoke sample.

*Pipe limits and design criteria are different for each type of aspirating system, but the following holds true for the most popular LPCB (Loss Prevention Certification Board) approved systems:*

- maximum aggregate sampling pipe length 200m (e.g. 4 x 50m, 2 x 100m)
- maximum single sampling pipe length 100m (limited by transport time from end of pipe to detector of 120 seconds)
- maximum number of 4 sampling pipes
- sampling pipe is normally red ABS which is extremely robust and clearly defines its use. Another material may be used provided it has a 20 - 22mm nominal bore and slow bends are used to keep air flow as laminar as possible.
- remote sampling points may be used, up to 6m long, in smaller bore flexible 'capillary' tube.
- pipe lengths should be continuous without 'tee' intersections.

*The total allowable number of sampling points varies for each manufacturer and it should be remembered that the sensitivity at each hole is a function of 'detector' sensitivity and the number of sampling holes. The more sensitive the detector, the more sampling holes can be drilled in the pipe network.*

**Primary Sampling  
Systems Design**

(air movement >1ms<sup>-1</sup>)

These systems are based on the assumption that 'any smoke in the protected area will end up going through the air handling system'. Sampling points are therefore arranged across the inlet grilles to the air handling units.

As high sensitivity is often required in a high airflow and therefore high dilution area, a reasonable guideline is to allow for one detector per 1500m<sup>3</sup>. In extreme cases such as

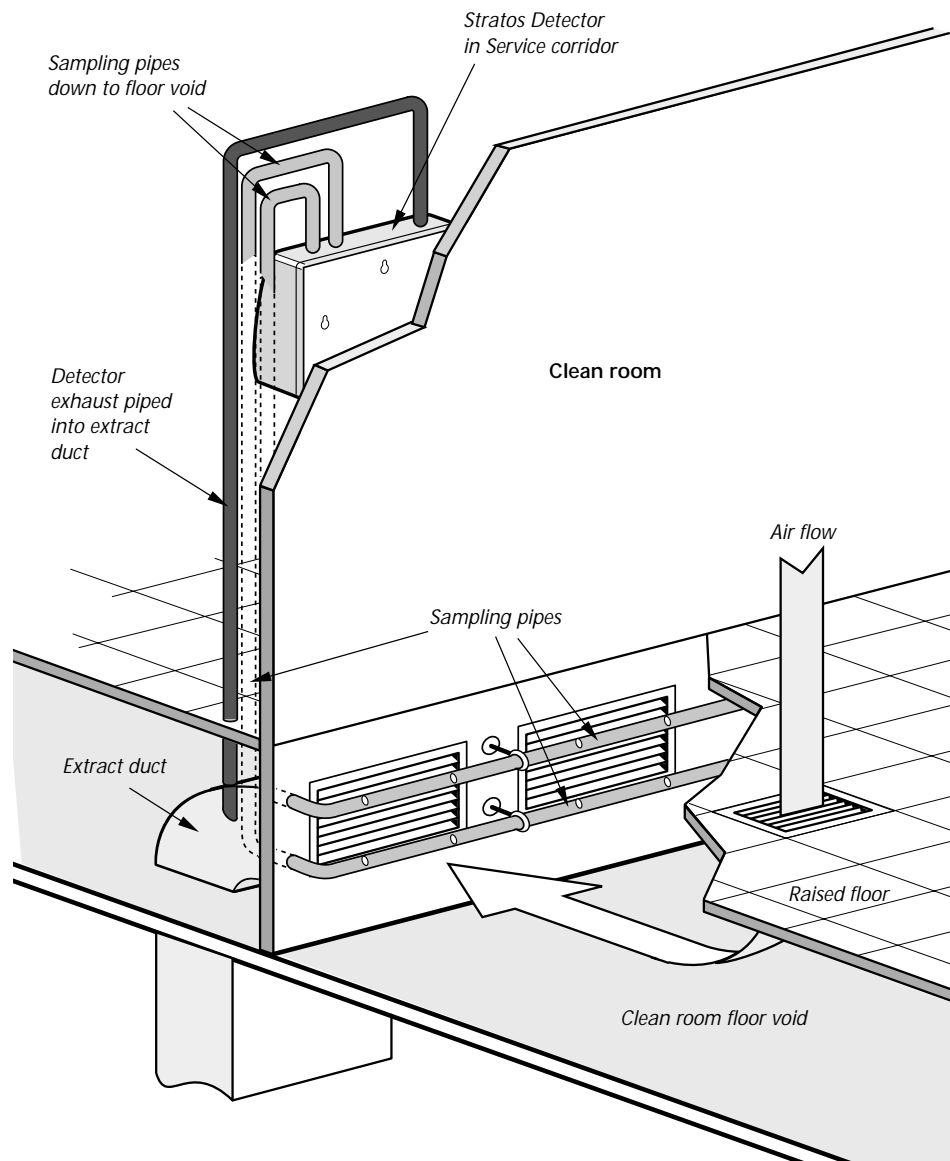
### ASPIRATING SMOKE DETECTION

clean-rooms etc this figure will need to be reduced further. It is good practice to use a separate sampling pipe for each air handling unit to balance out as many pressure variations as possible.

If it is necessary to mount the aspirating smoke detector outside of the protected area the detector exhaust should always be piped back to the protected area. This will prevent the sampled air, and perhaps smoke, contaminating other areas and balance any pressure variations between the protected area and the detector location as shown in Fig. 3.

Because primary sampling systems are designed to work with the air handling system active, they offer limited performance when these systems are inactive. Consequently, consideration should be given to additional detection should full protection be required under these circumstances.

**Fig. 3** Primary sampling with exhaust air return in a clean room



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**Reference Detection**

Because many air handling units add a percentage of fresh air, a Reference Detector should be considered to prevent false alarms caused by external pollution entering with the 'fresh' air. The Reference Detector monitors the incoming fresh air and 'offsets' the alarm thresholds of other Detectors if polluted air is detected. This will help prevent false alarms occurring from this source.

**Secondary Sampling  
Systems**

(low air movement)

Secondary sampling systems generally have sampling points positioned in the same locations and using the same design criteria as normal detectors (e.g. area coverage as per BS 5839, 6266 etc). Where enhanced or high sensitivity systems are required the normal area coverage per detector (sampling point) should be reduced as detailed in the table below:

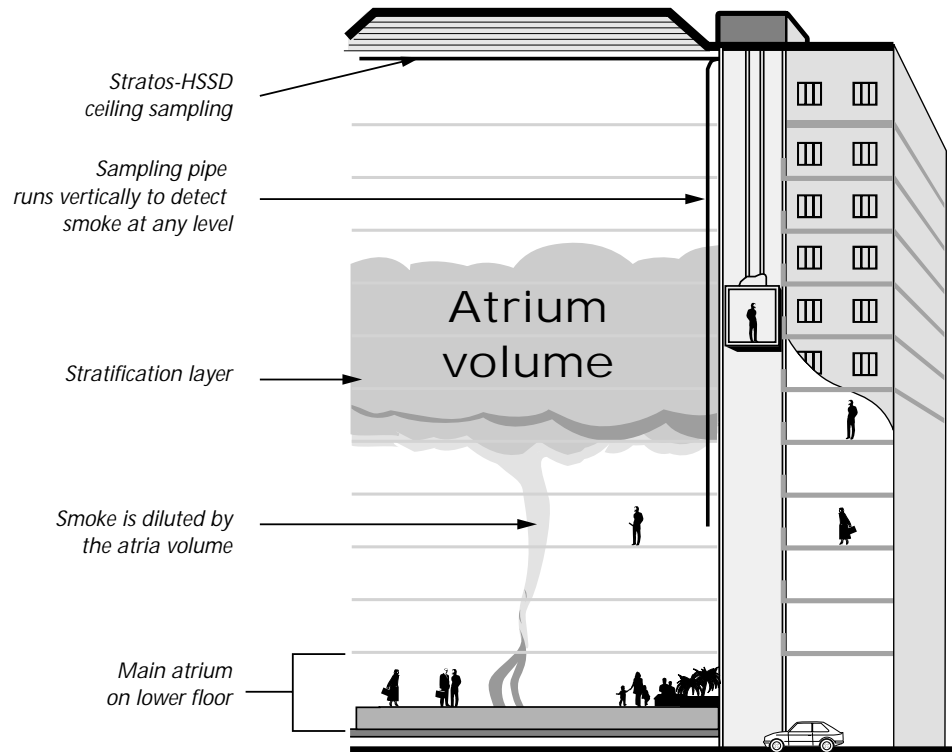
<i>Sensitivity Test</i>	Still Air		Comfort Cooling		Fast Air
	<i>Area</i>	<i>Any point</i>	<i>Area</i>	<i>Any point</i>	<i>Area</i>
High Sensitivity	7-12m <sup>2</sup>	2.5m	25m <sup>2</sup>	3.5m	BS 6266
Enhanced Sensitivity	25m <sup>2</sup>	3.5m	50m <sup>2</sup>	5.0m	BS 6266
Normal Sensitivity	BS 5839	7.5m	BS 5839	7.5m	BS 6266

Because more heat is required to lift smoke to great heights the amount of smoke that can reach high level areas can be minimal if the fire is small (see fig. 4). Tests appropriate for normal areas need to be upgraded in recognition of this. The following Table details the recommended tests and height limits for aspirating smoke detection systems:

<i>Sensitivity Test</i>	<i>System Sensitivity</i>	<i>Ceiling Height Limit</i>		<i>Ceiling Areas &lt;10% of main area</i>	
		<i>General</i>	<i>Rapid Attendance</i>	<i>General</i>	<i>Rapid Attendance</i>
<i>Normal</i>	Normal	10.50m	15.00m	12.50m	18.00m
<i>Normal</i>	Enhanced	12.00m	17.00m	14.00m	21.00m
<i>Normal</i>	High	15.00m	21.00m	18.00m	26.00m
<i>Enhanced</i>	Enhanced	8.00m	10.00m	9.00m	11.00m
<i>Enhanced</i>	High	10.50m	15.00m	12.50m	18.00m
<i>High</i>	High	4.00m	6.00m	5.00m	7.00m

If less than 10% of the protected area exceeds the ceiling height limit detailed above, then the limit detailed in the <10% column may be used for these higher areas. If rapid attendance is available (as defined by BS 5839 clause 12.2.6) then the rapid attendance column may be used.

**Fig. 4** Secondary and vertical sampling in an atrium



Where protection is provided to high level racking it may be necessary to install multiple levels of sampling points to achieve best performance as smouldering fires produce a relatively small amount of heat.

Most secondary sampling systems will need to comply with local Codes, Standards or Regulations (e.g. BS 5839 in the UK or perhaps NFPA in the US). Where the aspirating detection system is the sole form of protection in any given area, it is inappropriate to use a sequential sampling system (as adjacent areas would lose their protection while the system sequences through its cycle). *Sequential sampling systems are not suitable for Protection of Life Systems.*

### **Unusual Applications and Adverse Environments**

Modern intelligent aspirating detection systems are often used in adverse environments where site conditions cause unusual effects. Many diverse areas can be protected as hot air can be cooled down, cold air warmed up, dusty air filtered, dirty air recognised as part of normal operating conditions and contaminated air returned back to where it was sampled from. In such applications it is important to site the detector in a more environmentally friendly area and ensure that the sampling pipe network is constructed from a suitable material. If the protected risk is a Hazardous Area (e.g. flammable vapours present) then the detector should be suitably certified (even if sited in a Safe Area).

**ASPIRATING SMOKE  
DETECTION**

Consideration should always be given to where smoke will actually travel in order to identify the best detection locations. For example; a covered sports arena is likely to have lots of gantry lighting that generates significant heat, which may create a stratification layer. The lights themselves are a fire risk and should be protected from above, whilst lower level sampling should also be considered to detect beneath any thermal stratification barriers.

*Aspirating smoke detection is a very effective method of smoke detection. It may be useful to note the following points when protecting unusual areas:*

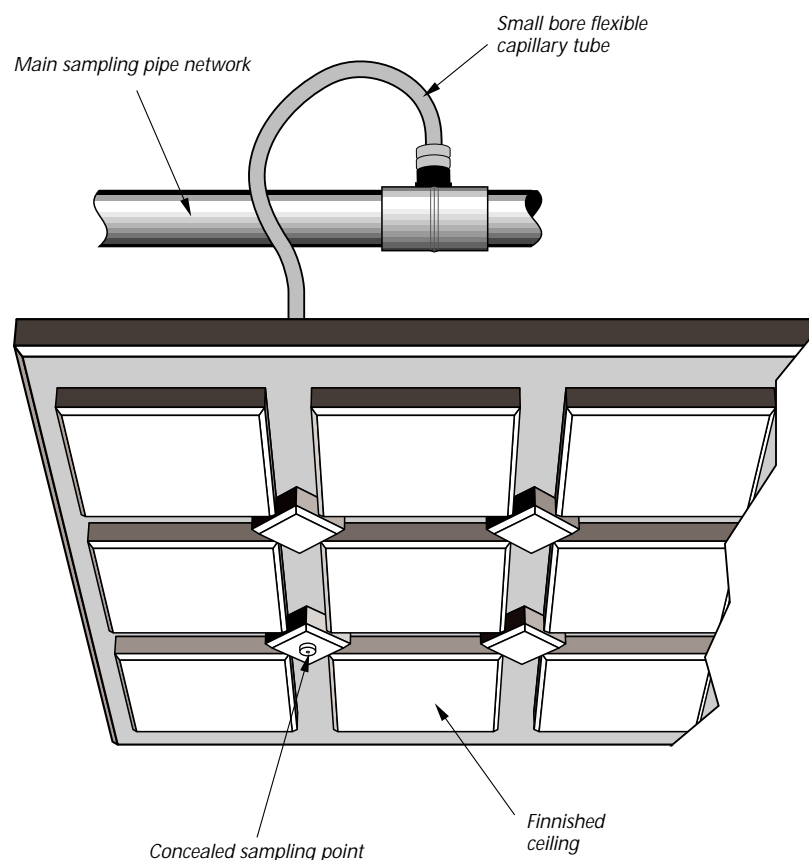
- **Smoke Testing:** There is no substitute for smoke testing to identify the path of air currents within a protected area and thus define the optimum position for air sampling points. This is relevant for all types of risk from large open structures, such as cathedrals with natural ventilation, to telecommunication rooms with high volume mechanical air handling. It is worthwhile making the effort as the detection performance improvements are often surprising!
- **Atria / High Areas:** Atria have stratification layers that vary with seasonal temperatures, making it difficult to predict the optimum level(s) for best detection. This type of area often benefits from a 3D approach with vertical sampling in addition to the normal area coverage. Where 3D protection is considered, whether in atria, vertical shafts or high level warehousing, then vertical sampling should be at 3m or 2°C intervals. At each vertical sampling position an attempt should also be made to maintain coverage in the horizontal plane.
- **Voids:** Sealed void areas may be effectively protected with an aspirating smoke detection system but consideration should be given to the fitting of remote test points. This will allow functional performance tests to be carried out during routine maintenance without needing full access into the protected space. Sampling points should be positioned in the top 10% of the protected space.
- **Restricted Access / Containment Areas:** Some areas may be difficult to gain normal access to, either because of high security or because the protected area is a health hazard. Such areas can often be protected with aspirating systems where the detector is sited outside the problem area. This minimises any required maintenance access into the protected area. It is important to pipe the detector exhaust back to the protected area to prevent contamination.
- **Complex Roof Structures:** Many buildings have unusually shaped roof profiles that may successfully be protected with aspirating smoke detectors. These may range from a heritage building glazed rotunda to a modern exoskeleton 'tent'. Sampling pipe networks can be lightweight and semi-rigid, thus enabling many unusually shaped or curved surfaces to be protected where normal point detectors or beam detectors have problems.
- **Dusty Areas:** These areas can be protected by detectors that contain dust recognition systems and/or filter out dust particles. Contaminated filters reduce the performance of the system and provision should be made to ensure a consistent level of protection (see Signal Processing).

- **Cold Stores:** Apart from low temperatures damaging the detector transducers, the main problem in Cold Stores is from condensation which can cause sampling points to become blocked with ice. These problems can be avoided by ensuring that the sampling pipe work 'falls' away from the sampling points into a moisture trap outside the cold store and by heating the air sample prior to it entering the detector (which should be sited outside the cold store).

Remote sampling points should be avoided. These use small bore pipes that can easily become blocked from condensation that runs back down the sampling hole and freezes. Only pipe with a nominal bore of 20-22mm should be used within the cold store and this should be installed at least 300mm from the ceilings (as far as possible).

- **Hot Areas:** Most aspirating smoke detectors are designed to operate below 60°C. If the air sample is above this temperature, the detector may be sited remotely and the air sample cooled by either extending the pipe length or running it through a heat exchanger (water jacket).
- **Invisible Installations:** Where concealed pipe networks are required, the main pipe sections may be hidden within the fabric of the building and remote sampling points with smaller bore flexible tube can then be used that terminate in a very small air sampling point. Because the remote sampling point may be up to 6m long, the main pipe network routes may be optimised to suit the building fabric. The air sampling point may be fabricated to a design and in a material that best enables concealment.

**Fig. 5** Remote sampling point with capillary tube



### ***Installation of Pipe Networks***

It is essential that pipe networks are air-tight as any leaks will affect the performance of the system. Pipe networks are normally flow monitored to detect both blocked and cut pipes/sampling holes. Pipe sections should be clearly marked as aspirating detection pipe. Typically pipe will be supported every 1.2m.

The size of sampling holes will vary for each system and can be optimised using the manufacturers computer software modelling packages. The sensitivity of each sampling point is proportional to the amount of air-flow through it and there are two approaches to take with regard to sampling point hole sizing:

- Identical sampling hole sizes - This makes it easy for site engineers as all holes are the same, but means that each sampling point will have a different sensitivity. This is because the air-flow through each sampling hole will be affected by the pressure gradient down the main pipe run(s). The holes closest to the detector will draw most air and therefore be more sensitive.
- Varying sampling hole sizes - This requires additional care from site engineers, but also means that each sampling point will draw similar quantities of air and therefore have a similar sensitivity.

### ***Power Supplies***

Aspirating smoke detectors need mains-fail power supplies to the same requirements as any other detection system (including 240 volt supply integrity). A major component in this type of system is the aspirating fan, which is power hungry, and consideration should be given to the effects of a requirement for extended standby times. This will result in quite large battery sizes, which apart from needing wall space, require ever larger chargers to meet 24 hour recharge times. To reduce standby times all systems should be remote fault monitored on a 24 hour basis.

### ***Interfacing to Other Systems***

Most aspirating smoke detectors have multiple alarm levels and consideration should be given to best utilising them. A high sensitivity system will often detect component failure and it may be more appropriate to call out the building manager initially and then the Fire Brigade when higher alarm levels are activated. Where it is desirable to provide local alarm sounders provision should be made to monitor these circuits for faults.

### ***Commissioning***

If aspirating systems are being installed in an area under construction the system should not be powered up and commissioned until all builders works are complete. Any air handling systems should be functional as they have a significant effect on the performance of the system. The specified performance tests should be carried out and the results noted as a foundation for maintenance records.

### ***Other Relevant Publications***

British Standards Institute	<i>BS5839 Fire Detection and Alarm Systems for Buildings</i>
British Standards Institute	<i>BS6266 Fire protection for electronic data processing installations</i>
BFPSA	<i>Code of practice for aspirating detection systems</i>
AirSense Technology Limited	<i>Design and installation manual for Stratos-HSSD®</i>



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