

DESIGNING AN AIR SAMPLING NETWORK

Introduction

This section gives general guidance on the design of sampling pipe networks for Stratos aspirating smoke detection systems. A sampling pipe network that has been correctly designed for a given application will be more efficient and therefore offer significantly higher performance. All Stratos-HSSD detectors incorporate ClassiFire™ artificial intelligence, and this feature allows the designer to engineer systems to protect a very wide range of applications, including those having diverse environmental conditions.

Regulatory Requirements

When designing an air sampling system, consideration must be given to the requirements of relevant local Codes of Practice, Standards and Regulations that are used to govern the design of detection systems. What the designer must bear in mind is that these documents may only deal with the minimum acceptable requirements, often related to the performance and cost of 'conventional' detectors, for a very general range of applications. High Sensitivity Smoke Detection systems such as Stratos-HSSD® can offer performance equivalent to, and far in advance of traditional smoke detection systems and various bodies such as BFPSA (British Fire Protection Systems Association) have produced what are in effect performance requirements for High Sensitivity Smoke Detection systems.

These documents specify what performance is required from a detection system when exposed to smoke generated during a controlled test/fire simulation rather than basing the minimum acceptable requirement on the density or positioning of point or beam type detectors. Some of these test requirements are company or industry specific (e.g. British Telecom. Document WNP/CPG 57200) that are tailored to particular applications. The most widely known test specifications are given in British Standard 6266 which is a Code of Practice for Fire protection for Electronic Data Processing installations. Appendix A of BS6266 gives a range of performance tests suitable for a wide variety of applications.

The most recent and comprehensive UK generated document is the British Fire Protection Systems Association Ltd Code of practice for Category 1 Aspirating Detection Systems. This refers to the Appendix A of BS6266 and includes other test specifications. It is strongly recommended that the system designer becomes familiar with these documents.

It is also recommended that when designing a sampling pipe network the designer aims to achieve an air sampling network design that offers sampling hole (detector) area coverage that is within the minimum requirement for point type detectors. At minimal cost this takes advantage of the very significant sensitivity advantage that a Stratos-HSSD system has over point detection systems and offers the user a more effective smoke detection system rather than a system that simply satisfies a minimum requirement.

Planning the air sampling network

This manual does not offer specific planning guidelines but recommends a basic planning procedure that should be developed and employed to ensure all elements are considered that may affect the system design.

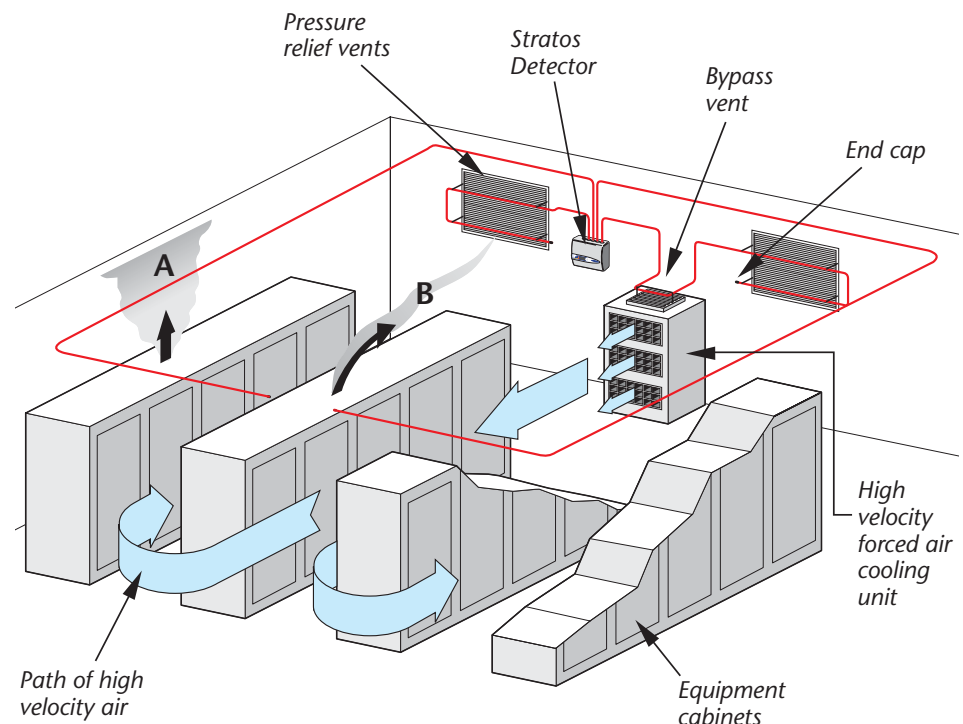
Before beginning the planning and design process it is important to determine what is expected from the installed Stratos-HSSD® system. In the absence of a specification the planner should confer with the client or their representatives to formally agree on which code, standard, or regulation the system must satisfy. For example, there is a huge variation in the levels of smoke generated by the BS 6266 Appendix A.1. and A.4. tests. The sampling pipe networks required to satisfactorily achieve them are also very different - as would be the overall project cost.

Types of system

As already stated it is important to define appropriate requirements/ expectations for an aspirating smoke detection system at the earliest possible stage. There are two main types of aspirating system:

- **Primary sampling system:** a system that is designed to work in conjunction with any air handling or ventilation systems and will not provide optimum performance when these are inoperative. The advantage is that this type of system can detect small quantities of cool smoke from a minor incident that would not normally rise to the ceiling – the ‘conventional’ location for a smoke detection system. This type of system is often used as an ‘early warning’ detection system in conjunction with a conventional point detector system. The aspirating system could be used to switch off or reduce the mechanical ventilation which allows the point detection system to operate effectively.

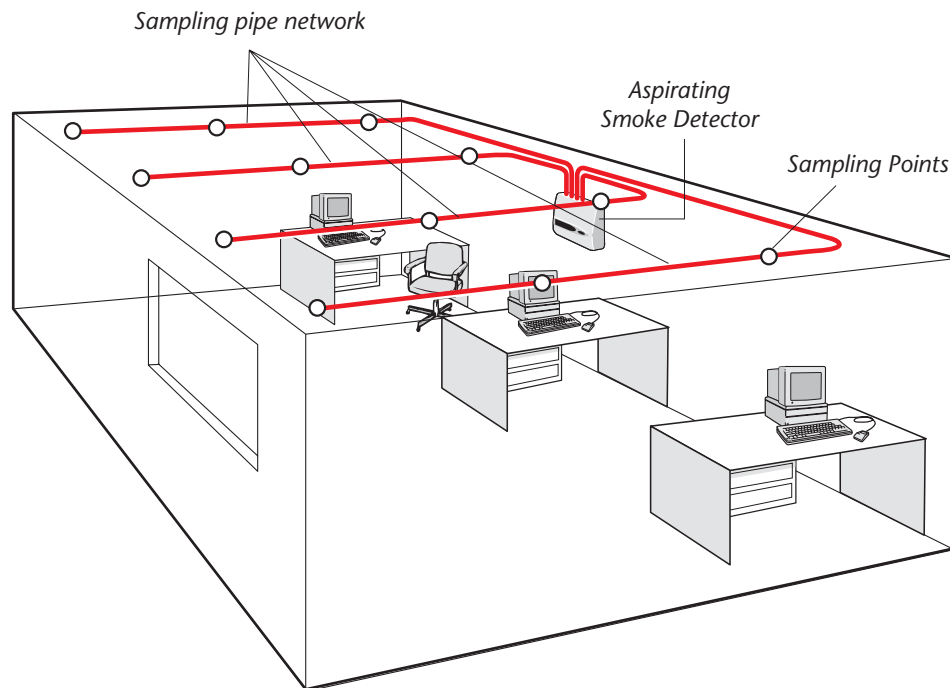
Fig. 1 Primary sampling - via air handling system



A = Smoke path - static air
 B = Smoke path - maximum ventilation

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

Fig. 2 Secondary sampling - layout for normal point detection



The sampling pipe network and system sensitivity may also be designed and adjusted to achieve one of three levels of sensitivity:

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

The obscuration values refer to the sensitivity at each sampling hole and not the claimed sensitivity of the detector. This is discussed in more detail at the end of this section in 'Understanding Stratos Basic design principles'.

Surveying the Site

Before the designer surveys the space(s) requiring protection it is worthwhile determining whether or not current drawings are available for the site and whether or not a specification is available that will indicate what level of performance is expected from the completed Stratos system.

Assuming none of these exist and the client is looking for recommendations and a proposal the following should be considered.

Activities within the space

The type of activity within the space requiring protection and its physical characteristics will form the basis to choose which sampling methods should be used and what is an appropriate level of performance. Examples are as follows:

- Microelectronics clean rooms.
- Electronic data processing rooms, communications switch rooms, control rooms
Offices
- Public spaces such as shops theatres, leisure centres, libraries, conference centres, cinemas, churches
- Dormitory areas such as hotels, detention centres, barracks, hostels, hospitals
- Historic buildings
- Warehouses, factories, plant rooms
- Chill and Cold stores

Enquiries should also be made about the common or expected hours of operation, whether the space is manned or unmanned and are there periods when customary activities create unusually high levels of smoke pollution.

Physical Characteristics

- What are the spaces requiring protection – Are they rooms, void spaces, cabinets, enclosures.
- Floor and ceiling voids – does the space have floor or ceiling voids. If so do they extend beyond the space, are they sub-divided into compartments, are there any trenches or ducts, what are the voids used for, what services already run within them, are the voids accessible.
- Dimensions of the space(s) - measure and record the lengths, widths and heights.
- How is it built – What materials have been used to build the space, are they substantial, what decorative materials are used, what notable fixtures are there.
- Compartments – Is the space sub-divided into smaller compartments, are the compartments substantial, do walls or partitions fully enclose the compartment or does it share a floor or ceiling void with another space. Are there fire barriers across shared voids, are the barriers complete.
- Existing fire protection systems. Are there any existing systems and where are they situated.

Environmental conditions

Factors that effect the environment within the space have a very significant bearing on the particular sampling method used to protect it.. During the site survey care should be taken to note any of the following.

- Is there mechanical ventilation within the space – how is it achieved, in which direction does the air flow, is a void used as a feed or return air plenum, is the air conditioned (heated/cooled/humidified) or filtered, if so what standard is the filtration. What is the number of air changes per hour.
- If mechanical ventilation is employed, what are the patterns of air movement. These can be determined using a small smoke generator. Does the ventilation quickly dissipate the smoke or does it circulate in stratified flow paths. Are there any points within the area where the airflow appears static.
- Is make-up fresh air introduced into the ventilation system and at what rate, where is the fresh air drawn from, is it filtered and to what standard. If there is a real risk of polluted air entering the area consideration must be given to installing a reference detector to reduce unwanted effects.
- Does the area rely on natural ventilation and what are the sources of the air. Is there the possibility that there are sources of external pollution that could enter the space, particularly when there are variations in the prevailing winds.
- The normal state of the air within the area. Are temperatures and relative humidity stable or fluctuating.
- Are there any activities that produce smoke heat, fumes, dust, steam or flames If so, are they a continuous process or do they only occur at a particular time. Examples are incense burning or perhaps barbecues.
- Is the smoking of tobacco allowed in the area.

It is important that careful notes are taken of the ambient conditions, particularly any air movements, as these have a considerable bearing on the design of the sampling pipe network and the location and type of sampling hole.

Materials risk assessment

Having made a detailed survey of the physical and environmental characteristics of the area to be protected, careful notes must also be taken of the position and type of combustible material. Whilst the purpose of providing a high efficiency detection system may be to protect a particular object it must be remembered that, given the right circumstances, anything in the space case present a fire or smoke hazard.

It is possible the support services present the highest risk and knowledge of this will assist in determining what sampling methods are used, the position of the sampling holes and the potential sensitivity range required from the detector. Examples are:

- Electrical and electronic cabling. Modern offices, computer rooms and communications facilities require large quantities of cabling and connectors that is often concealed and often poorly managed.

- Paper and paper goods particularly in high speed printer rooms, libraries, archives, printing works, offices and storerooms.
- Synthetic materials and foams usually found in furnishings, carpets, partitions and office equipment. In modern premises these should be self extinguishing and of a low smoke and fume type but in older premises older, more hazardous materials may still exist.
- Natural fibres and wood found in furniture and furnishings. Flammable liquids or gels. These may also be innocently held in considerable quantities in office storerooms.

It would also be worthwhile selecting potential sites for the Stratos Detector during the survey. Consideration should be given to the availability of suitable power supplies, the location of any existing fire protection systems to which the Stratos system must be connected and the suitability of the site for mechanically fixing the unit, safety and aesthetics.

All the information, sketches notes and drawings form the basis of the final system design.

Logical detection

Within the overall area requiring protection it is sometimes desirable to distinguish between compartments or areas in which different activities are undertaken or different levels of potential risk exist. By dividing an area in this way the complete system is logically divided into sub-compartments that may require different responses or actions from the Stratos systems.

It should be noted that these areas are not readily described as 'zones' as the Stratos is a detector that normally reports back to a main fire system. It is the main fire system that should determine what overall area constitutes a fire zone.

As an example consider a modern computer suite with an automated data retrieval unit, a printer room and 'bridge' or control room. The computer room and bridge share a common ceiling and floor void and air handling system. The automatic data retrieval unit sits within the computer room but is sealed from it. The printer room has partitions that extend between the floor and ceiling slab and has its own air conditioning unit.

Fig. 3a *An Electronic Data Processing suite - one Stratos detector could give general secondary detection in this area.*

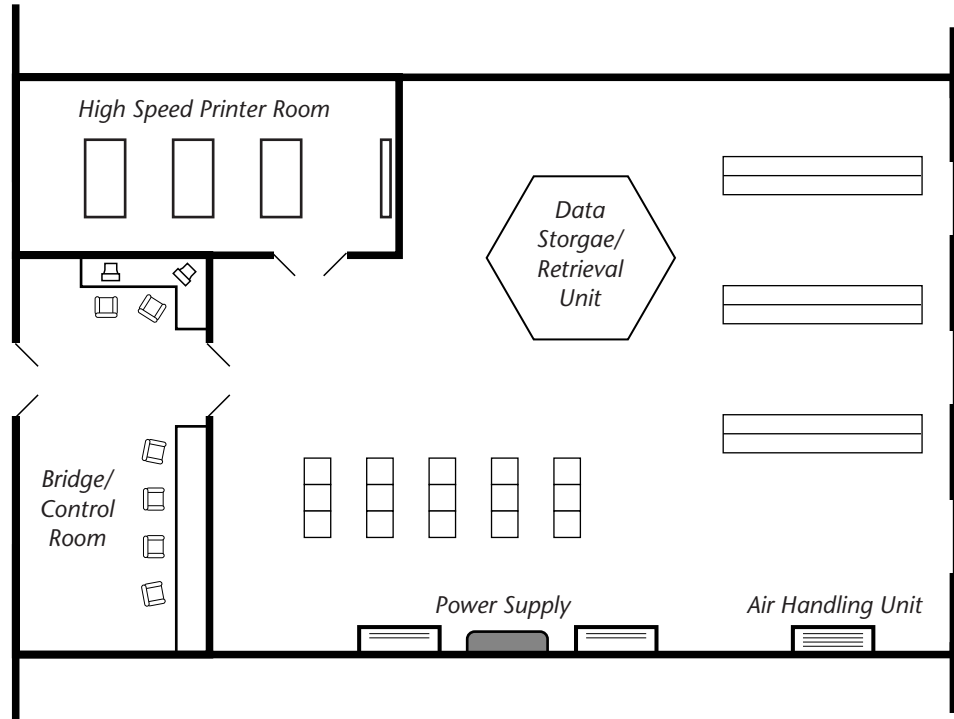
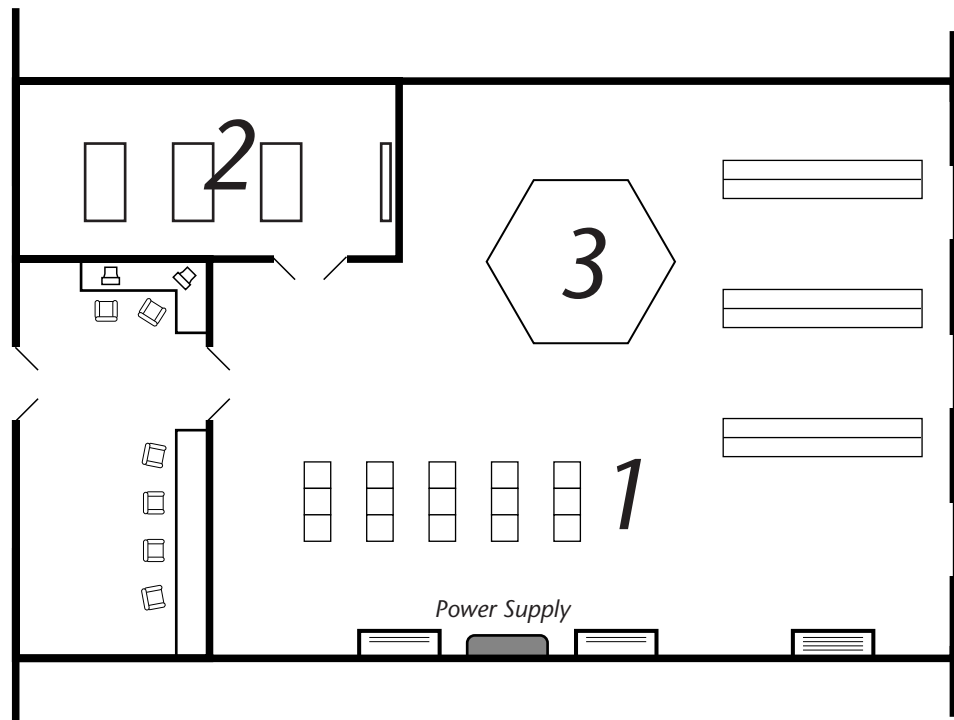


Fig. 3b *The Electronic Data Processing suite broken down into logical areas as each requires a different reaction from its Stratos system.*



Whilst the overall area of the suite is such that a single Stratos-HSSD® could be employed, the response or actions required from the Stratos would be different for each part of the suite.

- The printer room has high speed printers that need to be stopped if smoke or aerosols are detected.
- The data retrieval unit is sealed from the room and an alarm raised the instant smoke and aerosols are detected.
- The computer room and bridge require early warning of an incident but no shut down. A signal to the BMS will shift processing to an alternative site.

It can be seen that a single detector could not achieve the variety of responses and levels of potential sensitivity required. Logically, three detectors are required, each detector having its sensitivity and responses tailored to the particular risk.

Selecting a sampling method

Selecting the most appropriate sampling method involves careful consideration of the information taken during the site survey and the requirement to give a logical detection system. The designer can then choose the most effective sampling method(s) for the area requiring protection.

There are some circumstances where a particular sampling method, although preferred, will not be completely effective or appropriate and it is the designer's responsibility to employ a sampling method that provided the maximum level of protection. The chart shown in figure ** shows a range of applications and the most appropriate sampling method in each case.

The chart is only a general guide and the designer should use the information gained during the site survey as the determining factor in the final choice of sampling method.

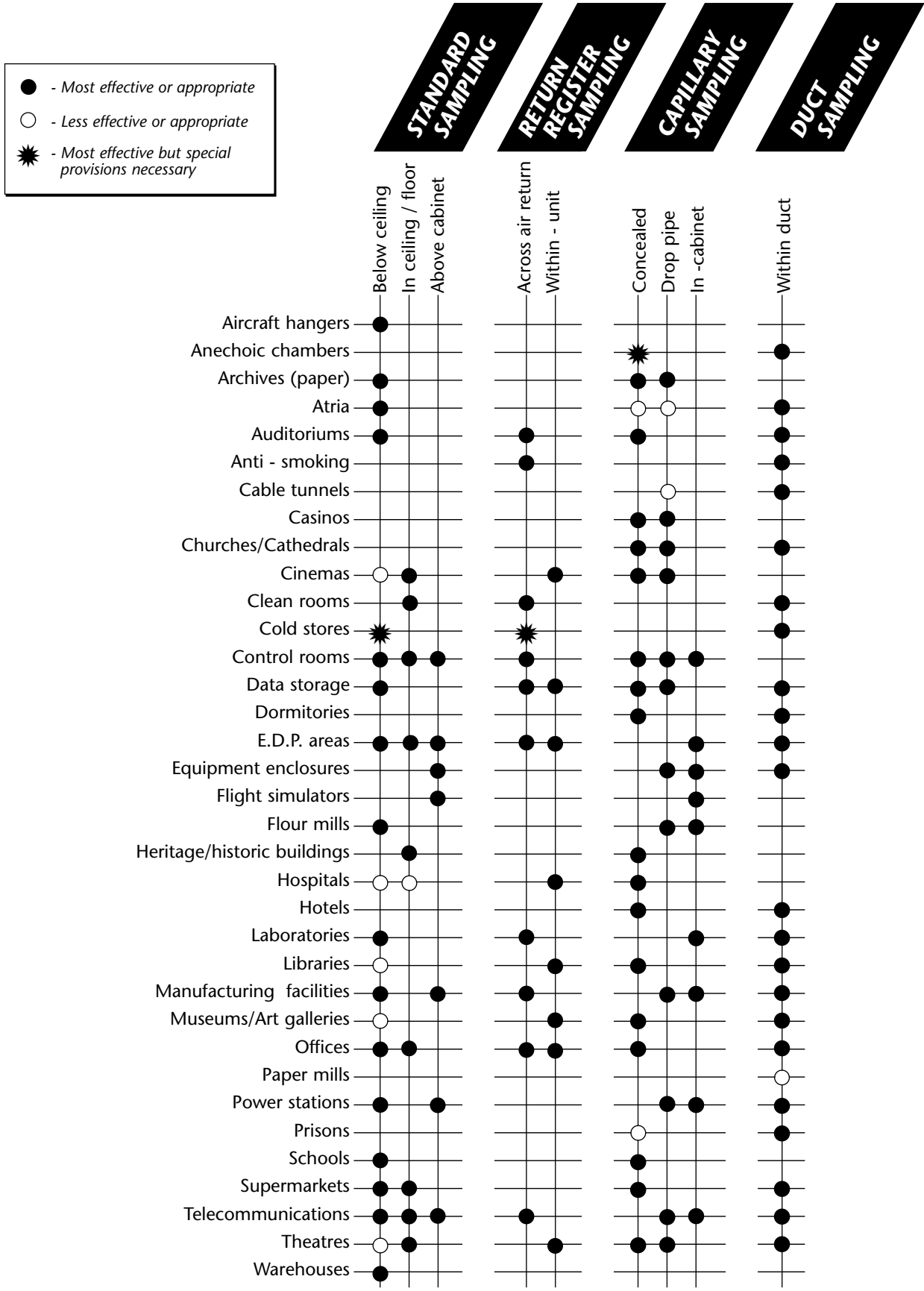


Fig. 4

Detector thresholds and potential sensitivity

The unique ClassiFire® artificial intelligence used in all Stratos smoke detectors eliminates the need to set detector thresholds that compensate for normal variations in ambient pollution levels. Choosing from a range of known false alarm rates (Alarm Factors) during the commissioning process allows the Stratos system to begin a learning process about the environment from which it is sampling air. Once it has completed an initial learning phase it will operate at the highest possible sensitivity to maintain the statistical probability of an unwanted alarm. The adjustment of sensitivity is a continually on-going process.

Choosing an alarm factor that offers the greatest possibility of an unwanted alarm (e.g. once a year) will increase the potential sensitivity of the detector.

Choosing an alarm factor that offers the least possibility of an unwanted alarm (e.g. once in 1000 years) will reduce the potential sensitivity of the detector.

More details and guidance about the ClassiFire® feature are given in the Installers Manual.

Mapping the sampling pipe network

Once a choice has been made on a sampling method or methods for the area(s) requiring protection, the designer can begin the process of producing a map of the sampling pipe and air sampling hole network.

Basic do's and don'ts

Sampling pipe design is essentially very simple. Indeed, provided some simple rules are adhered to, it may be difficult NOT to obtain satisfactory performance. These rules may be summarised as follows: -

- ❶ Locate sampling points only in positions that smoke may reasonably be expected to propagate to. Failure to do this will increase the dilution of smoke entering the detection system and will reduce performance. For example, in high airflow environments it is unlikely that satisfactory performance will be attained with ceiling mounted sampling points because the cool pre-combustion particles generated by an electrical overload is unlikely to have sufficient thermal buoyancy to allow them to rise to ceiling level. In this case locate sampling points ONLY at the air intake to A/C systems.
- ❷ Do not expect to sample satisfactorily from areas of different air pressure. Areas employing 'close-control' air conditioning such as computer environments may have significant air pressure differential between different parts of the protected area e.g. underfloor and room areas. In extreme circumstances the suction generated by any aspirating detection system may not be sufficient to draw air to the detection chamber.
- ❸ Verify system test method before undertaking design/offer/installation. Acceptance

criteria for the project may determine a greater or lesser quantity of detectors. Remember that just because it is possible to attach 200 metres of sampling pipe and to utilise 100 sampling holes does not mean that this is an acceptable design limitation for all systems.

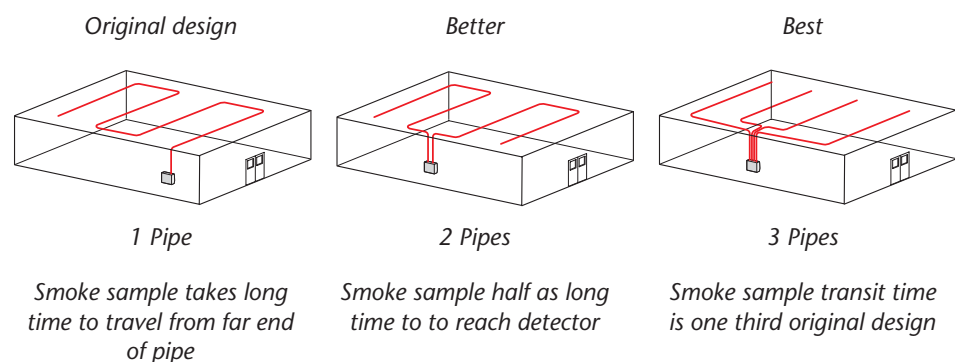
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The designer will require scaled drawings or plans of the area for this process. If these are not available, basic drawings will need to be produced from the information recorded during the site survey.

The primary objective in mapping the sampling pipe network is to decide where sampling holes are to be sited to achieve the performance required and also to satisfy the requirements of any Code, Standard or Regulation applicable to the installation. The secondary objective is to determine the optimum position for the Stratos detector. Whilst attempting to achieve maximum coverage the designer should attempt to minimise the overall length of sampling pipe required and also to maintain a minimum variation between pipe lengths. The optimum position will reduce sample transport times through the sampling pipe network.

Wherever practical the designer should attempt to use as many of the four air inlets available. This will also assist in minimising the transport times of sampled air through the network. This is discussed in more detail at the end of this section under the title ‘Understanding Stratos basic design principles’

Fig. 5 *The advantage of multiple sampling pipes*

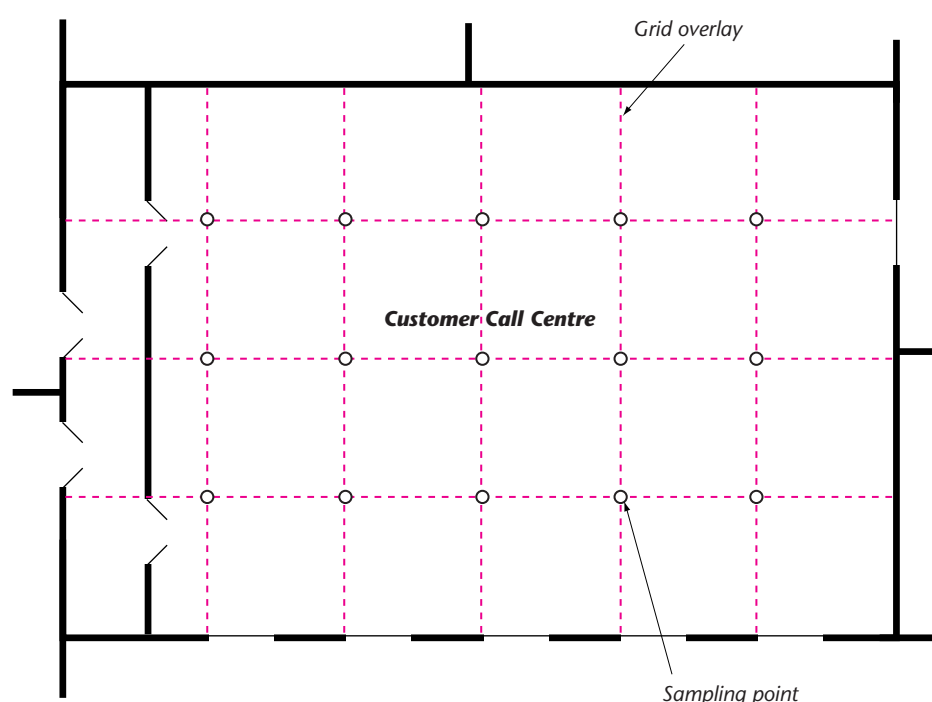


Using a square grid overlay

These can be used where a secondary type of detection system is required. To do this requires up-to-date scaled drawings of the site or accurate outline drawings produced from information collected during the site survey.

The designer can then produce an equivalent-scale square grid overlay whose dimensions are based on the minimum or maximum sampling point separation specified in the standard or code of practice applicable to the project. Care should be taken that sampling holes fall within those maximum distances from side walls and corners that are often required in standards or codes. Figure *** illustrates the principle.

Fig. 6 *Laying a tracing overlay square grid on the plan of the area to be protected*



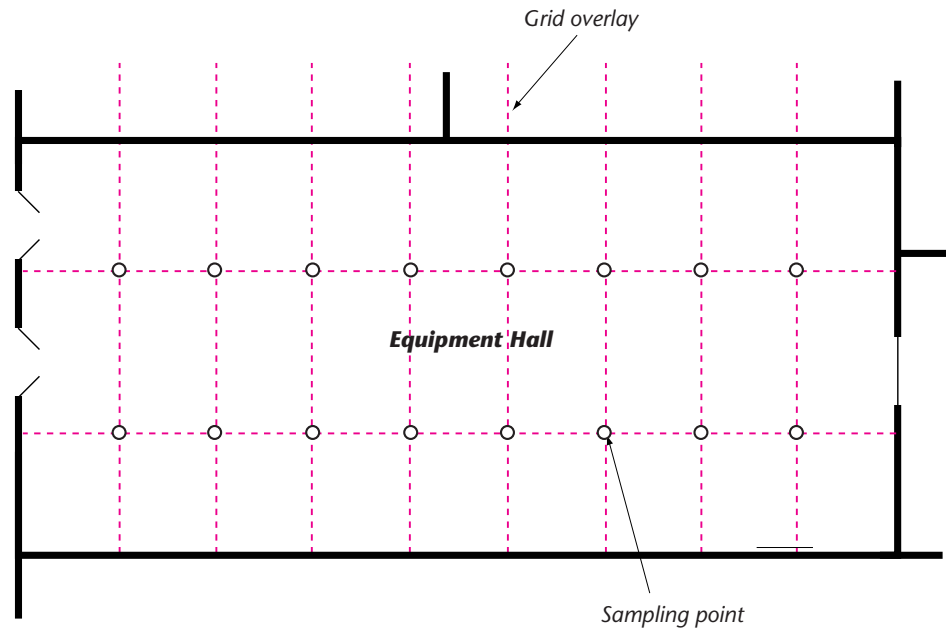
For those designers who are often involved with aspirating smoke detection systems, it may be worthwhile drawing up a set of A.3 overlay sheets in the most common scales, e.g. 1:50, 1:100, 1:200.

There are often cases where a square grid arrangement is not suitable and a rectangular grid would be appropriate. These are usually:

- A). *In small areas that may only practically accommodate one or two sampling pipe runs.*
- b). *Larger spaces whose area would place the sampling holes outside the maximum limits for sampling hole separation when using a square grid overlay.*

In the smaller area a rectangular grid may be used that decreases the spacing of sampling points in one direction whilst maintaining the specified spacing in the other direction. Figure *** illustrates how this is done.

Fig. 7 Using a rectangle grid



Where the required square grid overlay does not give adequate cover over a larger area it would be necessary to reduce the grid size from, say, 8 metres to 6 metres. This reduction is likely to require an additional sampling pipe run.

The increased density of air sampling points would be beneficial providing the total number does not exceed our recommendations. The effect is explained in more detail at the end of this section under the title 'Understanding Stratos basic design principles'.

If a satisfactory pattern of sampling holes is not possible using one detector then it may be necessary to use a second Stratos detector and associated sampling pipe network. This has the benefit of the same area being protected by two detectors with smaller sampling pipe networks.

Fig. 8 Proposed 3 pipe layout not acceptable. Radius of cover does not meet requirement

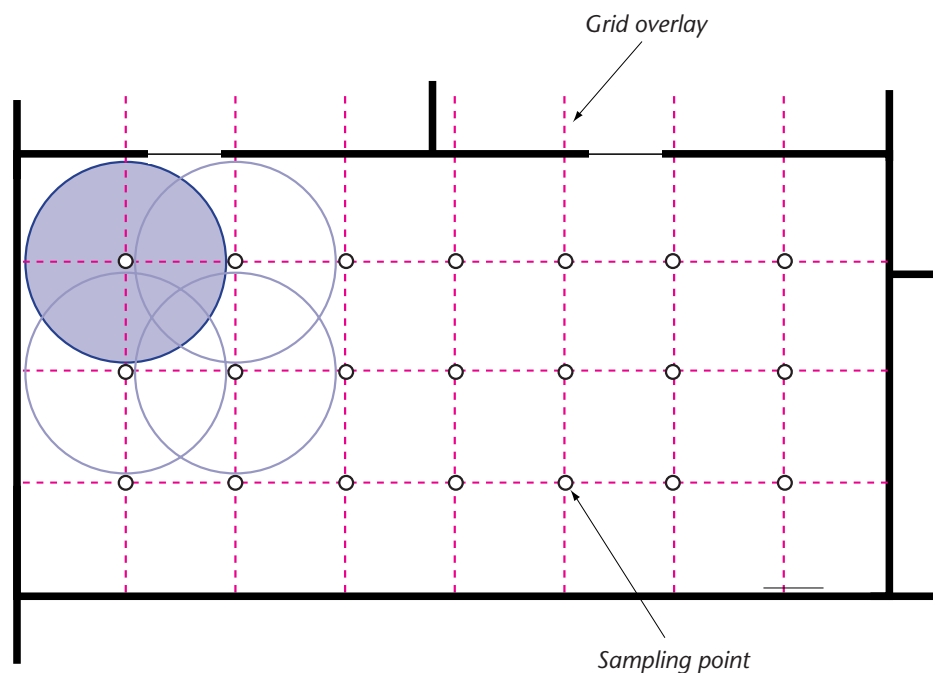
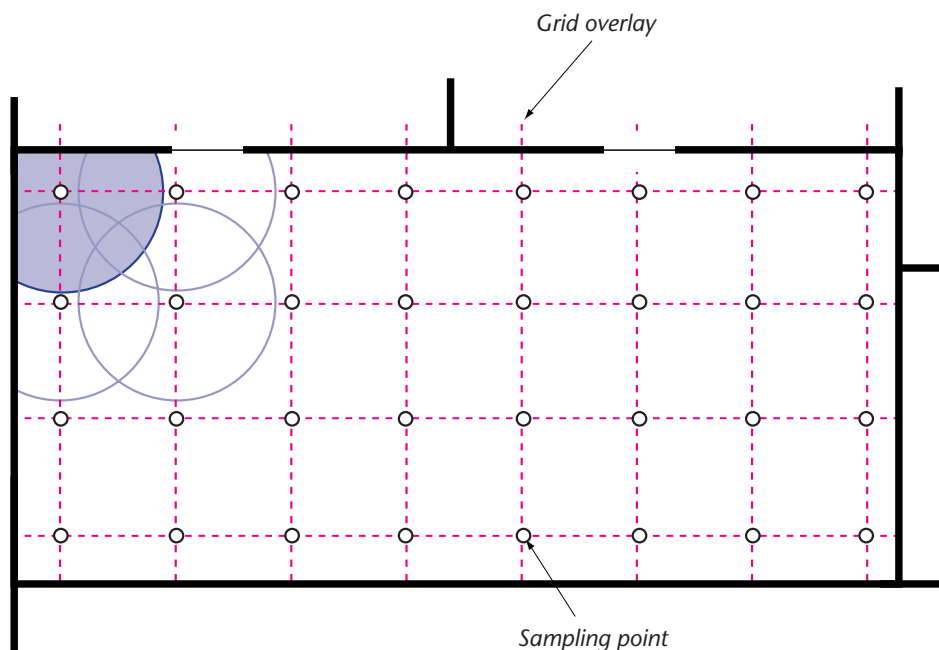


Fig. 9 *4 pipe layout offers full cover to all parts of area as exceeds minimum requirement*



Compared to the spacing of detectors required by various codes and standards, the spacing of sampling holes in these examples may seem extravagant. It must be remembered the spacings required by these codes are almost wholly related to the cost and performance of conventional point smoke detectors whereas the cost of drilling a few more sampling holes is almost negligible.

At this stage of the process the designer should have produced a provisional sampling pipe network design that includes the position of the sampling pipes and air sampling holes. If a specification was not available, a provisional specification should be produced qualifying what type of system is offered and performance expectations, e.g. what published performance test specification the system is intended to achieve or surpass.

Calculating the system performance

The final stage in the design process is to predict how the installed system would perform and AirSense Technology Ltd recommend the use of their PipeCAD® system modelling software to achieve this.

Having entered the relevant information into the modelling the designer will be able to determine the efficiency of the system design in relation to the performance specification. When evaluating the results of the modelling calculation the designer should remember the program can only estimate sample transit times within the sampling pipe network itself. The physical characteristics of the protected area and the time taken for any by-products of combustion to reach the network should also be considered when evaluating the results. More information on this subject is given at the end of this section in 'Understanding Stratos basic design principles'.

Having fully evaluated the results of a PipeCAD® model, the designer may consider that the proposed sampling pipe network would not meet the performance targets. For example, a network designed using three sampling pipes produce response times that, because of their length, are on the limit of what is considered acceptable, particularly as the area involved is above average height. For this reason it would be necessary to redesign the sampling pipe network to incorporate a fourth run. This may also involve repositioning the Stratos detector.

With the sampling pipe layout design revised to incorporate four shorter runs of pipe, the system should be re-modelled on PipeCAD® to check the validity of the changes. The most likely result is that the far-end response times will fall significantly and if a larger number of holes are included, the area covered by each sampling hole will reduce. The overall result is that the revised system will offer more efficient detection and will exceed the minimum acceptable performance requirements.

The PipeCAD® modelling program also allows the designer to modify the size or number of sampling holes to increase (or decrease) the general sensitivity of the system in particular regions of the area to be protected. For example, in a general office there may be one piece of equipment that is considered to be an asset of high risk and high value. By increasing the diameter of the sampling holes protecting this region of the room a greater proportion of the total air sampled will be drawn from it and will therefore have a proportionally higher overall sensitivity. It should be remembered the remainder of the sampling holes would have a proportionally lower sensitivity.

Increasing the diameter of the holes is equivalent to drilling a greater number of holes in the same stretch of sampling pipe but this may not always be practical, particularly when using capillary sampling point techniques.

Understanding Stratos basic design principles

There are basic principles that should be understood when designing the sampling network, all of which have an effect on the performance of the aspirating smoke detector.

■ Pipe length = 200 metres maximum

The maximum recommended aggregate length of all sampling pipes connected to the four inlet ports of a Stratos system is 200 metres with a maximum single pipe length of 100 metres. For example:

4 x 50 metre lengths

3 x 65 metre lengths

2 x 100 metre lengths

For best system performance the designer should aim to use several shorter lengths of sampling pipe rather than a single longer length.

The reason for this limitation is that it takes a finite time for the aspirating fan to draw air from the furthest point of the sampling pipe(s). Using the experience drawn from installations performed when HSSD systems were a relatively new technology, performance standards were devised for the testing of HSSD systems. A range of test procedures has subsequently been devised to suit almost every possible application where HSSD would prove effective.

For all the tests, except those where large volumes of hot smoke (aerosols) are produced, a period of 120 seconds is allowed after the smoke generation equipment is stopped for the HSSD to show a response. The time allowed for the smoke generation equipment to operate would be between one and three minutes. Therefore the total time allowed between the start of the performance test and a definite HSSD system response would be between three and five minutes. The 120 seconds is the allowance for smoke to travel from the most distant sampling hole back to the Stratos detector and for the detector to register the smoke. The remainder of the test time period is available for the smoke to reach the sampling hole.

Fig. 1 *Keeping the sampling pipe lengths as short as possible*

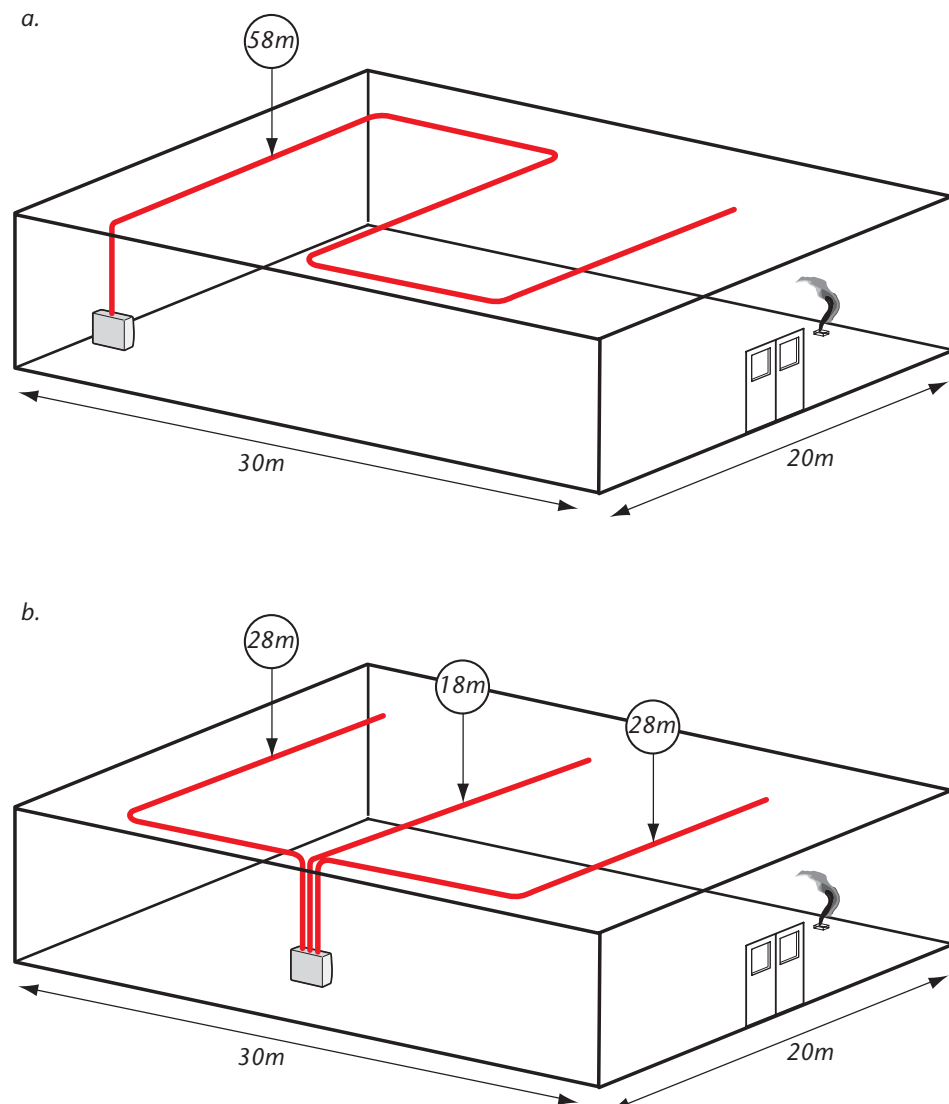


Figure 1) shows two illustrations of the same room with sampling holes (detectors) spaced to give the maximum area coverage recommended in BS 5839. Illustration A) shows a Stratos detector using a single pipe with a total length of 58 metres. Illustration B) shows a Stratos detector using three pipes, the longest being 28 metres. Should an incident occur in the position shown then the time taken for the smoke to travel from the closest sampling hole in design A) would be at least twice as long as from the nearest hole in design B). PipeCAD® modelling shows that the difference is 40 seconds!

Fig. 2 Distances that affect the performance of an aspirating system

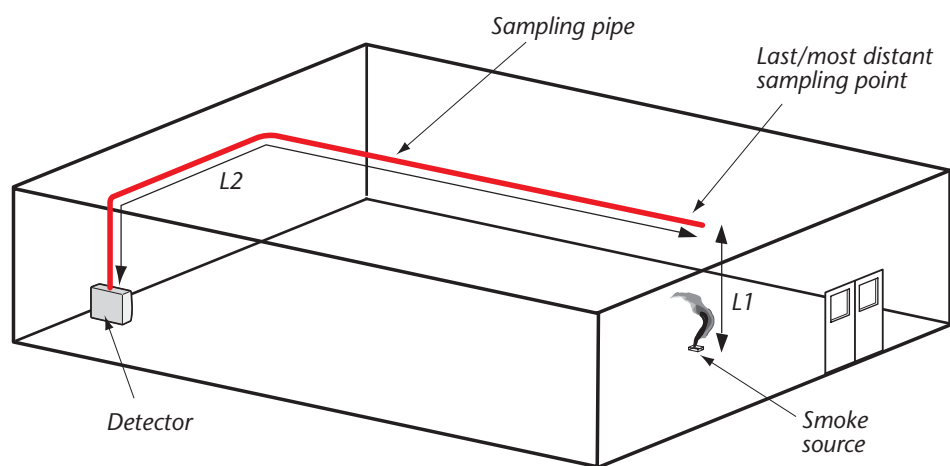


Figure 1). Shows two distances that must be considered when designing a sampling pipe network. In a small room (say 120m²) monitored by a single Stratos detector, the distance between the smoke source and the last sampling hole (L1) is short. Relatively little thermal energy would be required to lift the smoke up to the sampling hole and the time taken for it to travel distance L1 would be brief. As the room is small, the length of the sampling pipe (L2) would also be short and the time between smoke entering the last hole and it being registered by the detector will also be brief.

Under these circumstances the completed system is likely to pass a fairly stringent performance test. (e.g. BS6266 Appendix A.4.) where little smoke and thermal energy are produced.

At the other extreme, consider a system in a warehouse where L1 could be 21 metres and L2 is 100 metres long. The first consideration is how long will it take for aerosols produced during combustion to actually reach the sampling point? It would take an incident with considerable thermal energy to lift the aerosols up to this level. Ventilation within the building may cause the aerosols to dissipate and cool or a thermal inversion level may exist. This is where the temperature of the air may be equal or greater than that of the aerosols and smoke. At this point the smoke will stratify and stop rising toward the sampling pipe.

It may take several minutes for the smoke to reach the sampling hole and when it does it still has to travel a further 100 metres before it can be registered by the detector. This

journey could take over a further 100 seconds and is the only figure that can be assessed by using the PipeCAD® modelling software.

For this application the Appendix B1.1 test as described in the BFPSA Code of Practice would be appropriate. For this test a heat source of 5.8kW is required and depending on environmental conditions, over 5 minutes can be allowed before a detector response is seen.

■ **Sampling Holes = 100 maximum.**

The maximum number of calibrated sampling holes that should be drilled in an aggregate length of 200 metres of sampling pipe is 100.

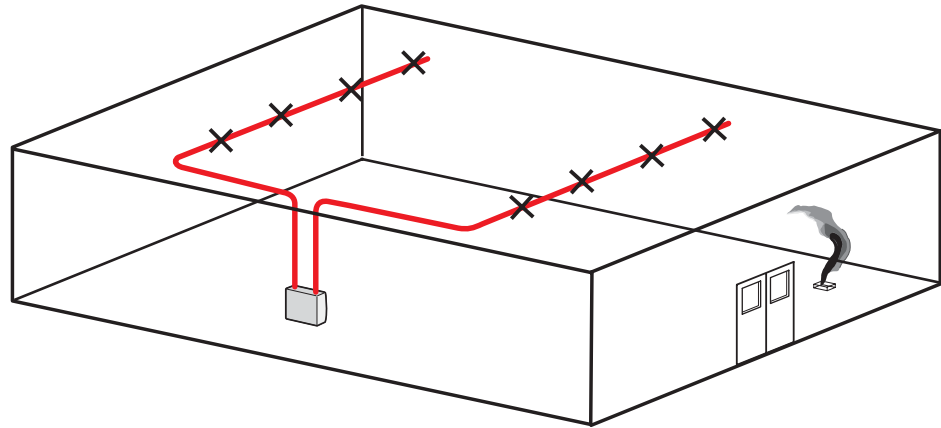
The maximum number of calibrated sampling holes that should be drilled in a single length of sampling pipe is 25.

This recommendation is based on a LPCB test house requirement that the sensitivity at a single hole should not be less than 5% obscuration per metre. This is equivalent to the sensitivity of an average point-type optical smoke detector.

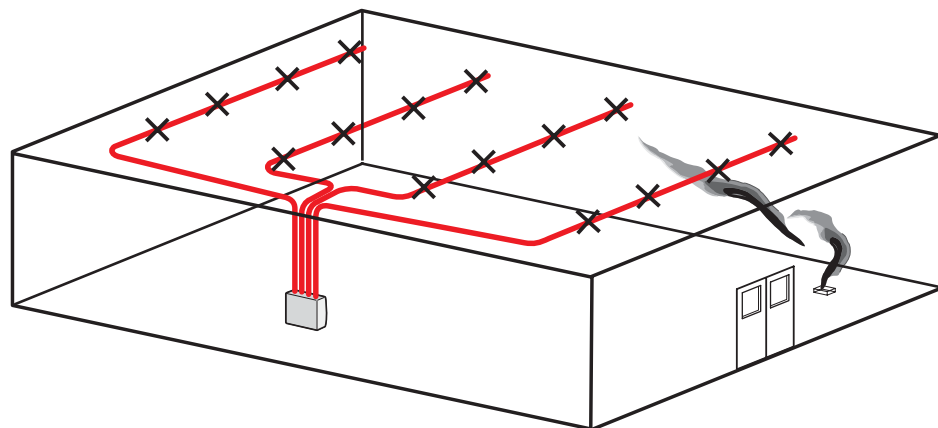
To understand this requirement, take a sampling pipe network of 4 x 50 metre lengths, each with 25 calibrated sampling holes each drawing a similar quantity of air. Smoke at a density that creates a 5% obscuration in each metre to light is introduced into only one of the sampling holes. The other 99 continue to draw uncontaminated air. It will be appreciated that by the time the smoke has reached the Stratos detector inlet plenum and passed through the aspirating fan the smoke will have been diluted in the ratio of 1:99. Simplistically this means that the detector now has to respond to smoke which causes a 0.05 % obscuration to light.

The definition of 'respond' depends on the source of a document relating to aspirating smoke detectors. For this test it was understood that a 'fire' should have been signalled and the appropriate fire indicator lit. On the Stratos system this output is fixed against the eighth level (Level 8) of the bargraph display that means the Stratos-HSSD® system was able to recognise changes in smoke density of 1/8th of 0.05% obs./m. or 0.0063%. The fact that during testing the output of the Stratos-HSSD® went well over twice the capacity of the bargraph display indicates why we are confident that the Stratos-HSSD® has the potential to detect aerosols that create an obscuration of 0.003% in a metre. The question of where and how many holes should be drilled is discussed later in this section. What should be understood is the effect of drilling more or less holes in the sampling pipe network.

This example is given with an aspirating detector that would generate a 'Fire' signal when the smoke density in the sampled air reached a value that would cause an obscuration of 0.1% in a metre.



This room has 8 calibrated sampling holes drilled to give a certain area coverage. Assuming smoke enters a single hole the sensitivity of that hole at the detector would be $0.1 \times 8 = 0.8\% \text{obs/m}$. If the number of sampling holes were then doubled the apparent sensitivity of each hole would be halved, i.e. $0.1 \times 16 = 1.6\% \text{obs/m}$. This may seem a disadvantage but whilst the sensitivity of each hole has been reduced the likelihood is that smoke will enter more than one hole.



In this example smoke has entered 3 sampling holes and the apparent sensitivity will be 0.1×16 divided by $3 = 0.53\%$ obs/m. The total system is more sensitive even though there are more, less sensitive, sampling holes.

But this is theoretical only. In reality the density of aerosols rising in a smoke plume or being transported by mechanical ventilation plant are unlikely to be homogenous. Their density will vary moment by moment and the response of the Stratos system will be to whatever density happens to reach the sampling holes at a particular time. The detector response may not accurately reflect what is actually happening at the source of the smoke and aerosols.

Absolute v Relative Scaling

We have noted that others are promoting as an advantage the fact that their products operate on the lesser technology of 'absolute scaling'. A few moments looking into the fundamental differences between the two technologies will highlight the fact that far from being an advantage, 'absolute scaling' is a major disadvantage. Although there is no very simple way of explaining the operation of the ClassiFire Artificial Intelligence system used in the Stratos-HSSD®, a few moments studying this document should provide a useful insight into the advantages of the system.

Until the advent of Stratos-HSSD®, the only method of adjusting a high sensitivity smoke detector to suit its operational environment was by estimating or preferably measuring over some days the effects of normal airborne pollution. The basis of this technique is that the alarm thresholds could be manually set to compensate for this pollution and respond only to abnormal smoke densities. It is worth mentioning that such 'measuring' is now rarely undertaken due to commercial constraints and (probably) a lack of understanding of the value of such action.

With detectors having absolute scaling (any aspirating system other than Stratos), the smoke level bargraph is arranged so that a zero level on the bargraph corresponds to the detector output given by a perfectly clean environment. Although this sounds logical, it is fraught with problems... With fixed/absolute scaling, the pollution present in most environments will result in the detector output bargraph showing the background, or underlying smoke density as a significant proportion of the bargraph. This means that in a typical environment there will be a smoke density reading on the bargraph that also fluctuates as the detector responds to pollution changes in the underlying environment. This response can, and frequently has, caused nuisance alarms and unwarranted concern to casual observers.

Most environments will be subject to fluctuations in underlying smoke and pollution density caused by doors and windows opening, cooking, exhaust fumes, soldering, smoking etc. On a typical installation of an 'absolutely' scaled detector there may be

5 to 30% of its bargraph segments illuminated by this 'background' smoke...which means that there may only be 70% of the segments left in which to place the multiple alarm thresholds. The level at which the major alarm threshold is set has to be fixed at one of these bargraph levels and consequently the rise in smoke density required to give a major alarm will vary as the background level varies.

There is only one way that a detector with absolute scaling can cope with this variation without having the potential to give unwanted alarms. That is to monitor the protected area and record the variations in the standing levels of normal pollution over an extended period (perhaps one year) to determine the maximum long-term detector output and bargraph deflection. To achieve optimum performance (i.e., highest sensitivity without nuisance alarms) the alarm outputs should then be set against the bargraph display at points above the worst (highest) recorded level of standing pollution and which correspond to the desired response from an increase in smoke density from an incipient fire.

Final alarm threshold settings are a matter of judgement on the part of the commissioning engineer when he has taken the above considerations into account. It may seem that simply setting the alarm level just above the highest level that may normally be expected from the underlying level is the right sensitivity to use. However what may normally be expected is never assessed with such systems because the underlying level is frequently random in its maximum and minimum levels, even though the average may be reasonably constant.

The question of what are normal variations must be considered. If a high smoke level occurs on average once every week, would the user require to tolerate a nuisance alarm at the rate of once every week? The answer is probably... 'NO'. It is likely that the user would demand that the sensitivity be reduced in order to cure what he considers an unacceptable nuisance alarm situation. If nuisance alarms were to occur at the rate of once every year or more the user may tolerate them.

How would this frequency be calculated for a fixed sensitivity system in an environment that has variable levels of background pollution? The answer is that for an absolutely scaled detector it is an impossible task.

Stratos-HSSD is the only high sensitivity aspirating smoke detection system to apply Relative Scaling. This fundamentally different and patented 'ClassiFire technology' automatically adjusts the detector bargraph so that only pollution greater than the 'mean' (average) levels measured over the preceding hours is indicated on the bargraph. The assessment of the mean level is an automatic and continually updating process. The variation in the underlying signal is also measured and bargraph scaling calculated which is relative to the underlying fluctuations in background pollution and the probability of those fluctuations creating an unwanted alarm. Both these features are integrated into the ClassiFire process, allowing an optimum sensitivity to be set automatically and continuously maintained.

Consider the following scenario:

Take an Absolute scaled detector fixed to 0.1% obscuration per metre full scale, 0.01% obs/m per bargraph segment. Fire alarm level is set at bargraph 8 (0.08% obscuration per metre) - (The alarm level could be set at any level between say 4 and 10.)

With an underlying room pollution level of 0.02% obs/m (which would be a typical level in most 'clean' environments), the absolutely scaled system will show 2 bars illuminated in 'normal' operation. If the pollution level were to increase by 50% to 0.03% obs/m., then only one more bar would illuminate. To a security guard or other user looking at the display it would not be immediately obvious that a 50% increase in pollution level had occurred.

When bargraph level 6 is reached, the level is just over halfway between its 'normal' reading and alarm. This will not be apparent though.

By comparison...

A Stratos-HSSD system operating in the same environment (0.02% obscuration per metre smoke normal density in the protected area) would set the zero on the bargraph to be 0.02% obs/m absolute in normal operation. No bargraph segments would be illuminated. This makes it obvious that there is no unexpected smoke particles being produced within the area.

If this level then increased by 50% to 0.03% obs/m then the bargraph would illuminate one segment, alerting any user that there was a potential problem in the protected environment.

When the bargraph 6 is illuminated the level is three quarters of the way between its normal reading and alarm which is apparent (alarm always being at 8).

Further....

The commissioning engineer permanently sets the sensitivity of an absolute detector when he chooses the positions for the alarm outputs against the various levels of the bargraph as being appropriate for the moment in time the settings are made. After this time no allowance can be made for changes in the background levels of pollution and the system sensitivity and probability of an unwanted alarm are totally uncontrolled.

The commissioning engineer sets the sensitivity of the Stratos-HSSD detector by selecting a known probability of a nuisance alarm from one of six ranges (The 'Alarm Factors'). Thereafter the sensitivity of the detector will be continuously adjusted by ClassiFire to maintain this probability of nuisance alarm. If an Alarm Factor were chosen that had a probability of nuisance alarm of, say, once per year the sensitivity of the Stratos-HSSD® would be maintained at a high level. Conversely should no nuisance alarms be acceptable an Alarm Factor giving a probability of, say, once in 1,000 years would be chosen. The sensitivity of the Stratos-HSSD® system would then be automatically maintained at a considerably lower level.

Other major benefits of Relative Scaling

Most aspirating smoke detectors use particle/dust filters to prevent unwanted dust particles from the sampled air from reaching the detector. As a filter gets contaminated it actually becomes more efficient and prevents progressively smaller and smaller particles from entering the detector. Eventually it can stop virtually all smoke particles without noticeably inhibiting the airflow. When an absolutely scaled detector is first installed, it is running at a known sensitivity, typically around 0.1% obs/m. This level of sensitivity is however highly dependent on the filter efficiency. For example, if a soiled filter is removing 50% of the smoke then although the detector 'head' was calibrated to a 0.1% sensitivity, the SYSTEM sensitivity is only 0.2% obs/m. The amount of smoke needed to create an alarm has doubled!

The only solution is to regularly change the air filter. As there is no practical method of determining its condition, in many cases it could well be an unnecessary expense.

It is a disquieting fact that an 'absolutely scaled' detector has no way of compensating for filter degradation. The layman may think that airflow monitoring could be used to indicate that the filter is becoming blocked. Unfortunately this is impossible, as the level of particle compaction that affects filter performance is too low for there to be any appreciable reduction in air flowing through the filter medium.

The Stratos-HSSD[®] system automatically compensates for filter contamination. As filter contamination causes the mean (average) detector output and the normal variations to reduce Stratos-HSSD[®] uses historical information from its ClassiFire memory to apply compensation to maintain the original level of performance. This means that filter contamination has negligible effect on Stratos system sensitivity. This function is continually monitored and the actual level of compensation can be checked on the integral programmer or via a lap-top computer using the software issued with every Stratos-HSSD[®] detector. Therefore the engineer maintaining the system can replace the filter as and when appropriate. Once the level of compensation corresponds to 120% of the original signal value, the Stratos-HSSD[®] generates a dedicated filter fault signal.