Pipe Network Design Guide

Document Number: 10193_06

Part Number: 30009

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VESDA®

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Document Conventions

The following typographic conventions are used in this document:

Convention	Description
Bold	**Used to denote:** emphasis Used for names of menus, menu options, toolbar buttons
Italics	**Used to denote:** references to other parts of this document or other documents. Used for the result of an action.

The following icons are used in this document:

Convention	Description
	**Caution:** This icon is used to indicate that there is a danger to equipment. The danger could be loss of data, physical damage, or permanent corruption of configuration details.
	**Warning:** This icon is used to indicate that there is a danger of electric shock. This may lead to death or permanent injury.
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Codes and Standards Information for Air Sampling Smoke Detection

We strongly recommend that this document is read in conjunction with the appropriate local codes and standards for smoke detection and electrical connections. This document contains generic product information and some sections may not comply with all local codes and standards. In these cases, the local codes and standards must take precedence. The information below was correct at time of printing but may now be out of date, check with your local codes, standards and listings for the current restrictions.

FCC Compliance Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, the user is encouraged to try to correct the interference by one or more of the following measures; re-orientate or relocate the receiving antenna, increase the separation between the equipment and receiver, connect the equipment to a power outlet which is on a different power circuit to the receiver or consult the dealer or an experienced radio/television technician for help.

FDA

This VESDA product incorporates a laser device and is classified as a Class 1 laser product that complies with FDA regulations 21 CFR 1040.10. The laser is housed in a sealed detector chamber and contains no serviceable parts. The laser emits invisible light and can be hazardous if viewed with the naked eye. Under no circumstances should the detector chamber be opened.

FM Hazardous Applications

3611 Hazardous Approval Warning: Exposure to some chemicals may degrade the sealing of relays used on the detector. Relays used on the detector are marked “TX2-5V”, “G6S-2-5V” or “EC2-5NU”.

VESDA detectors must not be connected or disconnected to a PC while the equipment is powered in an FM Division 2 hazardous (classified) location (defined by FM 3611).

FM Approved Applications

The product must be powered from VPS-100US-120, VPS-100US-220 or VPS-220 only.

ONORM F3014

ONORM F3014, transport times for all tubes (including capillaries) must not exceed 60 seconds from any hole. This means that the pre-designed pipe networks that include capillaries cannot be used.

AS1603.8

The performance of this product is dependent upon the configuration of the pipe network. Any extensions or modifications to the pipe network may cause the product to stop working correctly. You must check that ASPIRE2 approves alterations before making any changes. ASPIRE2 is available from your VESDA ASD distributor.

AS1851.1 2005

Maintenance Standards. Wherever this document and the AS1851.1 differ, AS1851.1 should be followed in preference to this document.

European Installations

The product must use a power supply conforming to EN54: Part 4.

Table of Contents

1 Scope

The Pipe Network Design Guide guide introduces you to the principles of pipe network design.

While the ASPIRE2 software can help you to design an effective pipe network, this guide will cover the principals of good design and aims to assist you in producing the optimum design for a site.

The Pipe Network Design Guide will help you with the design specifications and management of Xtralis VESDA systems.

2 Introduction to Good Design

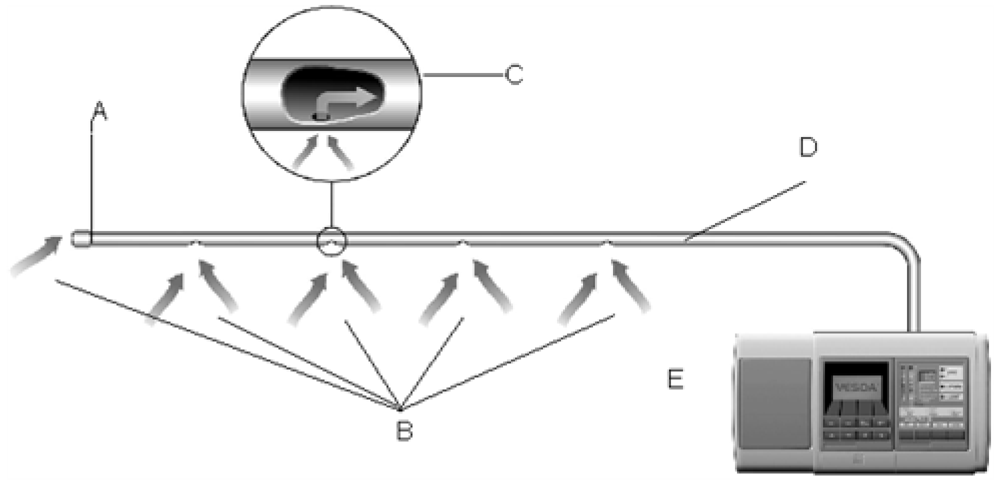
We recommend you use the following process to design site specifications.

1. It is assumed that you already understand the local codes and standards for the site
2. Attending accredited training will greatly assist you to produce an optimum site design
3. Gather information about the site. This guide will assist you to do this correctly.
4. Use the ASPIRE2 software to test and optimize the design

Exceeding the guidelines listed in this manual is allowable if the ASPIRE2 software confirms the design.

2.1 Introduction to Pipe Network Design

The Xtralis VESDA system collects air samples through sampling holes on a network of pipes. The airflow within a protected area carries the air samples to the sampling holes. Conventional smoke detectors wait for the smoke to migrate through the detector, while an aspirating smoke detection system actively draws air samples into the sampling pipes. These samples are transported through the pipe network to the Xtralis VESDA detector.



Legend					
A	End Cap with hole	C	Detail showing airflow entering a sampling hole	E	Xtralis VESDA detector
B	Air samples	D	Air sampling pipe		

Figure 2-1: An Xtralis VESDA Air Sampling System

2.2 Before You Start

To design an efficient pipe network you will need to:

- Have knowledge of your local codes and standards
- Undergo accredited training in pipe network design and the ASPIRE2 software
- Have access to a floor plan for the protected area. The floor plan must include details of existing or proposed fixtures, fittings and equipment.
- Have information about the purpose of the area to be protected. Warehouses, cold stores, computer rooms and other applications may require special consideration.
- Determine the protection level required.

3 Designing a Pipe Network

To design an effective pipe network, it is suggested that the following steps are taken. The order in which these are completed may differ with each project.

- Gather site information
- Define VESDA Addresses (also known as VESDA Zones)
- Select appropriate sampling method(s)
- Select appropriate detector
- Plan and map a pipe network
- Calculate design performance using the ASPIRE2 software
- Record the details of the optimum design

4 Gather Site Information

As a first step it is essential to gather information about the site to be protected. For an existing site this may include a site survey prior to designing a pipe network. Most of the information required for an effective pipe network design can be determined by a site visit. For sites yet to be constructed or where a site visit is not possible a site plan can be used to aid pipe design. The information required through a site survey includes:

- Site layout and measurements
- Regulatory requirements
- Air flow within the protected area
- The ambient conditions within the site
- The purpose for which the site is to be used
- Construction of the site (beams, beam pockets, and pipe obstructions)
- Likely influence of the external environment on the protected area

4.1 Site Layout and Measurements

Before designing can commence, a good knowledge of the site layout is necessary. A plan showing measurements of the area to be protected assists with the planning of fire zones and VESDA Addresses (also known as VESDA Zones). The site layout also shows areas designated for different uses and obstacles to free flow of air (partitions, air curtains, etc.). Areas requiring special protection, and the location of plant, machinery, equipment, cabinet layout, and the rack layout in warehouses, must be identified on the site plan.

4.2 Regulatory Requirements

The designer determines the local codes and standards that apply to the site. These need to be considered when creating fire zones, VESDA Addresses (also known as VESDA Zones), and the pipe network design.

Note: Local codes and standards have precedence over any Xtralis VESDA recommendations. Where the parameters set by a Xtralis VESDA product are not the same as those set by the local codes and standards, the local codes and standards should be adopted.

4.3 Air Flow

While designing a pipe network you will need to determine the natural airflows in the area to be protected. Allowances should be made for any existing or proposed mechanical ventilation systems, air curtains, roller doors, or partitions that are likely to influence the free flow of air. If possible conduct smoke tests to determine the air flow. The stability or fluctuation in air flow conditions need to be designed into an effective pipe network design. The correct interpretation of air flows impacts on the ability of a pipe network to detect at the earliest stages of a fire.

4.4 Ambient Conditions

Where possible the ambient conditions existing within the different areas of a site should be identified. It is likely that conditions within a site will differ from one area to the next. The efficiency of the Xtralis VESDA system is dependent upon the accurate determination of the ambient conditions of the monitored area.

4.5 Purpose of the Site

The purpose of the site as well as the protected area need to be considered when designing a pipe network. Typically a site may comprise of an office area, a warehouse, a factory, a computer room, and a cafeteria, each requiring special consideration when designing a pipe network. Certain manufacturing and processing areas may produce smoke, dust, steam, flame or heat. Allowances need to be made for these conditions in the Pipe Network Design Guide.

4.6 Site Construction

The designer should consider:

- The material used in the construction of the site. (It is easier to run pipes through plaster than concrete walls)
- The internal design and the material used for internal surfaces, decoration and furniture
- The types of rooms or areas to be monitored (high ceilings, high air exchange rate)
- The existence and use of ceiling and floor voids (beams and beam pockets)
- Obstructions to pipe layout or the free movement of air
- Placement of equipment requiring special protection (object detection)
- Location of mechanical ventilators, air handling units, return air ducts, and supply and exhaust air systems
- The beam layout, beam pockets and other ‘odd’ construction spaces

4.7 Surrounding Environment

Attention should be paid to the environment surrounding the site. If the site is situated in an area of high pollution levels, the VESDA zone(s) subjected to frequent exposure to external environment may record unexpected increase in the background level of smoke. To compensate for this reference detectors may be required. Typically certain areas within the site like warehouses and loading bay areas are normally subject to external environmental influences and require special attention during the design of the pipe network. See 5.10for further information.

5 Air Sampling Methods

Site requirements and conditions determine the best sampling method. Local codes and standards may have a bearing on the selection of sampling methods used. Air from an Address (Zone) is drawn through sampling holes in the pipe network. The pipe network transports the sampled air to the detector. The position and spacing of sampling holes is dependent upon the pipe network design. Refer to Table Table 5-3 for examples of sampling methods that can be used for various applications.

There are three basic air sampling methods (as described below). Typically, a site will use more than one.

5.1 Standard Pipe Sampling

These guidelines are used for all pipe network designs. In addition, guidelines specific to different sampling methods may also apply. For details see 9.

1. Parameters and values specified in your local codes and standards have precedence over anything suggested in Xtralis documentation.
2. We recommend smooth bore pipe with 25 mm OD and 3/4 inch IPS internal diameter. The preferred CPVC, PVC, ABS or UPVC pipe internal diameter is 21 mm (0.874 in).
3. Maintain at least 500 mm (20 inches) of straight pipe before the pipe terminates at the detector.
4. Use bend or elbow connectors to change the direction of the pipe. Bends maintain better airflow than elbows.
5. All sampling pipes should be fitted with an endcap. Use the ASPIRE2 software to assist in determining the size of the hole in the endcap.
6. For optimum detector performance you should keep pipe runs to a similar length.
7. For optimum detector performance you should keep a similar number of holes in each pipe.
8. It is better to use multiple pipes of shorter total length, than a single pipe of longer length.

A simple grid layout can be used to suit most rectangular spaces. See 7.1.

5.2 Capillary Tube Sampling

Capillary tubes are used to sample air some distance away from the sampling pipe and in enclosed areas like cabinets. The guidelines for capillary sampling are:

1. When possible use capillaries of the same length
2. The maximum capillary tube Internal Diameter (ID) should be 5 mm (3/8 in.)
3. Maintain balance within the pipe network by using the ASPIRE2 software to determine the size of the sampling hole required
4. Capillary tubes should not exceed 8 m (26 ft)
5. The positioning of the sampling hole for in-cabinet sampling is dependant on air flow conditions. In most instances the sampling hole is positioned close to the top of the interior of the cabinet. For more information, please see Figure 5-10.

If you wish to use capillary sizes outside these guidelines then please use the ASPIRE2 software to check that you will still have an acceptable design.

5.3 Open Area Protection

5.3.1 On-ceiling Sampling

Typically the pipe network is suspended approximately 25 mm to 300 mm (1 in to 1 ft) below the ceiling in the area to be protected.

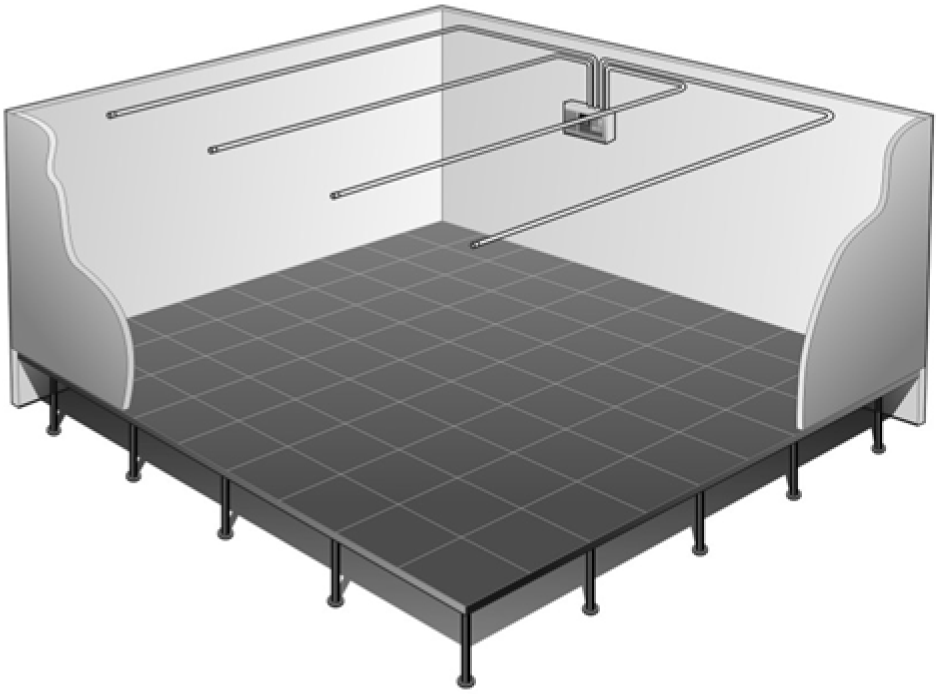


Figure 5-1: A typical on-ceiling installation

5.3.2 Concealed Sampling Pipe Network

Capillary tube sampling is ideal where the sampling pipe needs to be concealed for aesthetic or security reasons. The main pipe network is installed in the ceiling void with capillary tubes branching off at regular intervals to penetrate the ceiling panels or tiles.

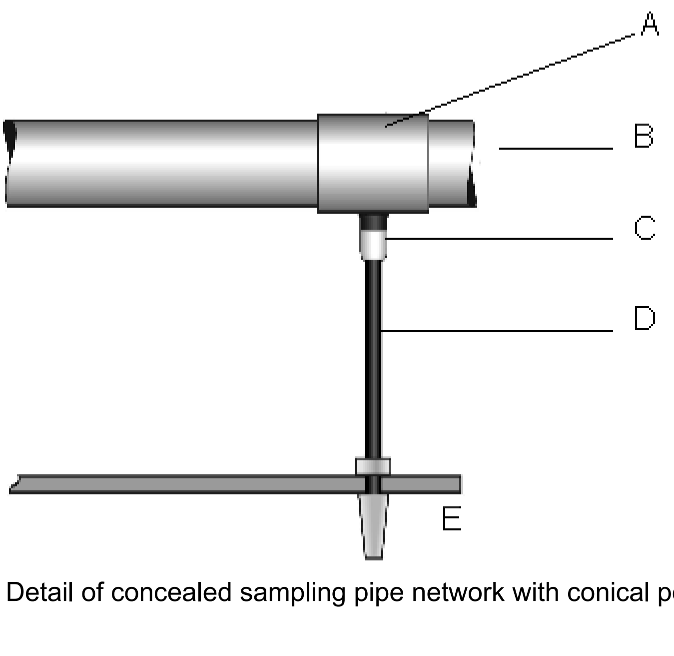
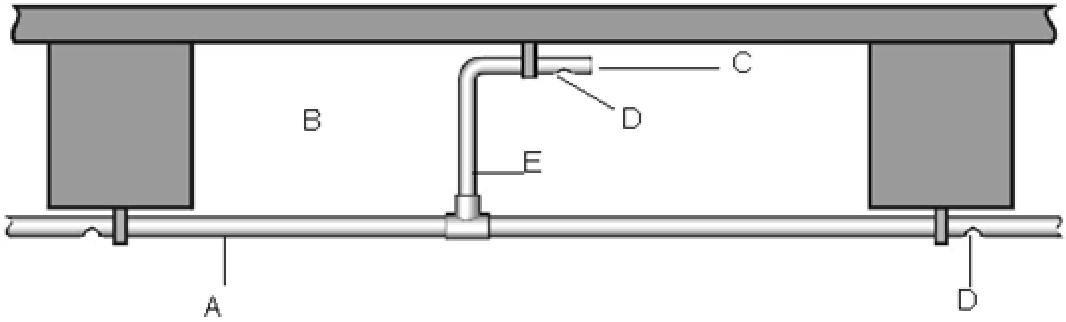


Figure 5-2: Detail of concealed sampling pipe network with conical point fittings

5.3.3 Inter-beam Sampling

Beam pockets are created between large ceiling beams. A typical on-ceiling air sampling pipe network would normally be mounted below these large areas and may not be able to sample the air between the beams. To overcome this a rigid pipe may extend vertically from the sampling pipe upwards into the space between the beams (E). At the top end the direction of the pipe is changed to horizontal. The end of the horizontal sampling pipe is capped with a sealed end cap which may, or may not have a sample hole in it (C). A sampling hole is drilled just before the endcap (D).



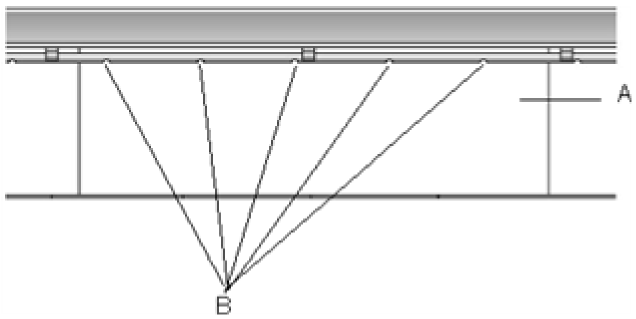
Legend					
A	Sampling pipe	C	End cap	E	Vertical sampling pipe
B	Beam pockets	D	Sampling hole		

Figure 5-3: Inter beam sampling

5.4 Return Area Protection

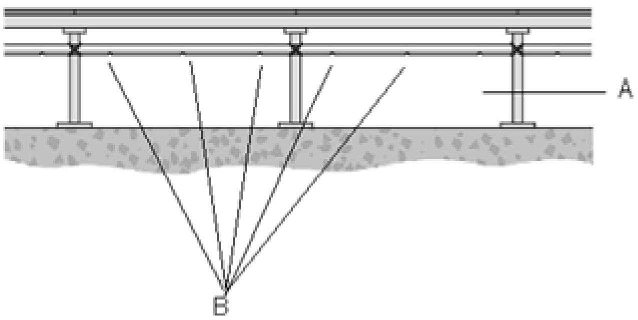
5.4.1 In-ceiling or Floor Void Sampling

Some applications use ceiling and under floor voids as return air plenums (ducts). The pipe network is designed to monitor the air flowing through the return air plenums. In-ceiling or floor void sampling is also used to monitor any cabling and equipment that may be installed in the ceiling and floor voids.



Legend	
A	Ceiling Void
B	Sampling Holes

Figure 5-4: Ceiling void sampling



Legend	
A	Floor Void
B	Sampling Holes

Figure 5-5: Floor Void Sampling

5.4.2 Return Air Sampling

Smoke tends to travel with any mechanically generated air flow. Correctly positioning sampling holes in a pipe network across the return air grille of an Air Handling Unit (AHU) or an exhaust ventilation system, ensures that any smoke is detected at the earliest stage. Air samples from inside a duct carrying the exhaust air may also be collected, see Figure Figure 5-13 for details. It is recommended that the sampling holes face between 20 and 45 degrees from the direction of the greatest airflow. See Figure 5-6.

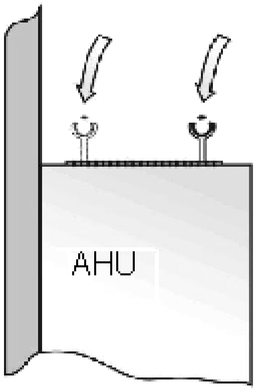
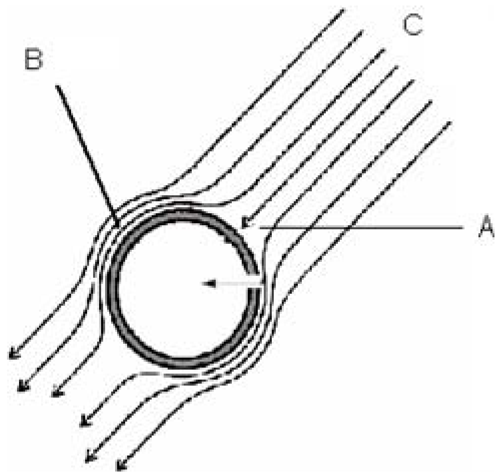


Figure 5-6: Cross section of pipe position on a return air grille

5.4.3 Hole Orientation

Industry experience shows that the pipework can be fine tuned to marginally increase the response time of an aspirating detection system by locating the sampling holes 20 or 45 degrees away from the airflow path. Sampling can be improved by avoiding the high and low velocity areas. One common problem with this model is that the detector needs to work in all possible situations. If you are installing pipework into a high airflow area keep in mind what will happen if/when the AHUs are turned off.



Legend	
A	Low velocity (high static pressure) area
B	High velocity (low static pressure) area
C	Airflow Streamlines

Figure 5-7: Sample hole orientation

5.5 Object Protection

5.5.1 Above Cabinet Sampling

The sampling pipe is installed directly over the cabinets to be protected. Sampling holes are placed over the cabinet ventilation grille. The holes are drilled so that they face into the air stream from the cabinet. Each monitored cabinet must have at least one sampling hole. The exhaust fan can cause sampling problems due to the high airflow around the sample pipe.

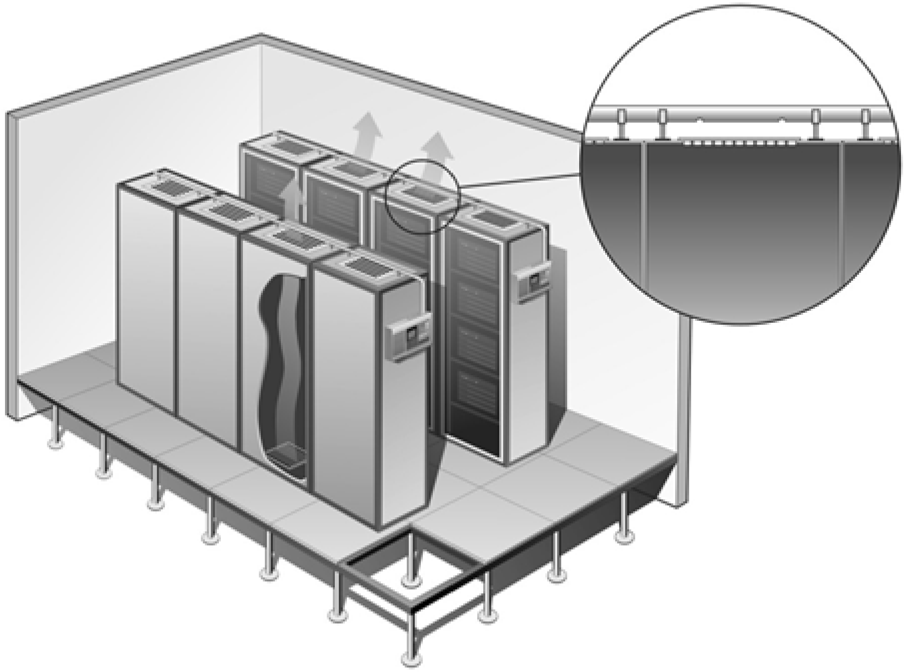
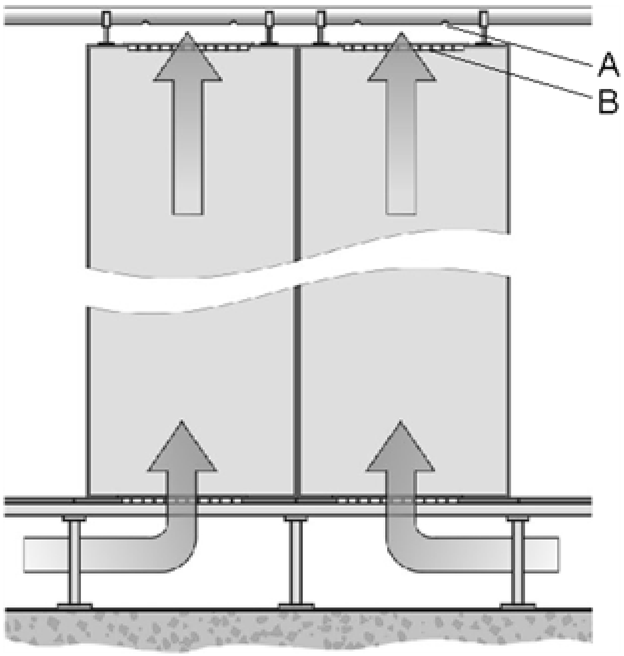


Figure 5-8: Exhaust grille sampling on a bank of cabinets

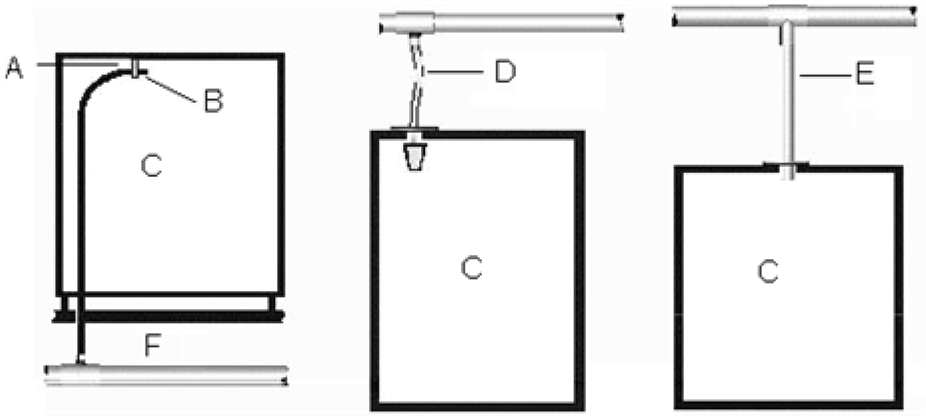


Legend	
A	Sampling Hole
B	Air Grille

Figure 5-9: Cabinet sampling for convection cooled cabinet

5.5.2 In-cabinet Sampling

Capillary tubes are used for enclosed in-cabinet sampling. A flexible capillary tube of a maximum length of 8 m (26 ft) is connected to the main pipe network using tee connection with reducing adaptors. A variation to the capillary sampling system uses a drop pipe. A 12.5 mm (0.5 inch) ID rigid pipe is connected to the sampling pipe via a tee connection.



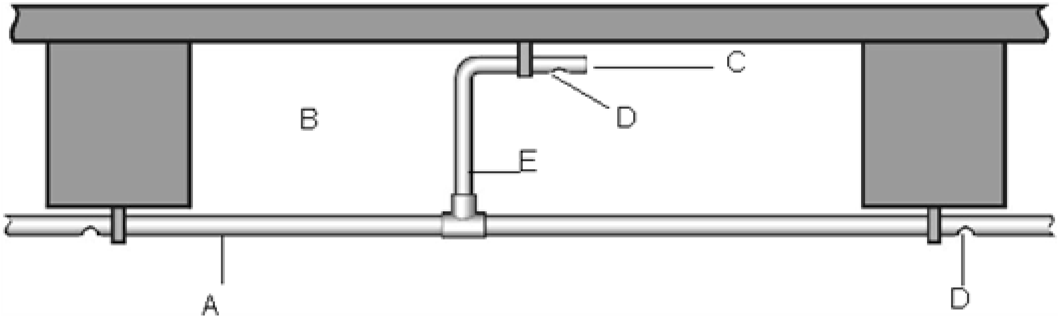
Legend					
A	Retainer clips	C	Equipment cabinets	E	Rigid drop pipe
B	Sampling hole	D	Capillary tube	F	Underfloor void

Figure 5-10: Illustration of in-cabinet sampling using capillaries & drop pipes

Note: Care must be taken when installing sample points on the top of cabinets with extractor fans. These fans may create low air pressure in the cabinet which may stop any air samples being able to enter the sampling point.

5.5.3 Inter-beam Sampling

Beam pockets are created between large ceiling beams. A typical on-ceiling air sampling pipe network would normally be mounted below these large areas and may not be able to sample the air between the beams. To overcome this a rigid pipe may extend vertically from the sampling pipe upwards into the space between the beams (E). At the top end the direction of the pipe is changed to horizontal. The end of the horizontal sampling pipe is capped with a sealed end cap which may, or may not have a sample hole in it (C). A sampling hole is drilled just before the endcap (D).



Legend					
A	Sampling pipe	C	End cap	E	Vertical sampling pipe
B	Beam pockets	D	Sampling hole		

Figure 5-11: Inter beam sampling

Guidelines for return air sampling include:

1. Place the sample pipe (probe) in the path of the greatest airflow.
2. More than one sampling hole may be required for large grilles. NFPA 76 recommendations specify that each sampling hole can cover a maximum of 0.4 m2 (4 sq.ft).
3. Care should be taken to keep the number of bends to a minimum.
4. We recommend that sampling holes should be angled at 20× to 45× to the airflow.
5. In high velocity air flows, it is advisable to use standoff fittings to keep the sampling pipes at least 50 mm to 200 mm (2 to 8 in.) in front of the grille. Installing any closer to the grille will put the sample point in an area of negative air pressure.
6. The pipe may require capping with an end-cap without a hole depending upon the ASPIRE2 software calculations.
7. Where maintenance requires the removal of the sampling pipes on a regular basis, the pipe network design should provide for use of socket unions to ensure correct orientation of sampling holes on re-connection.

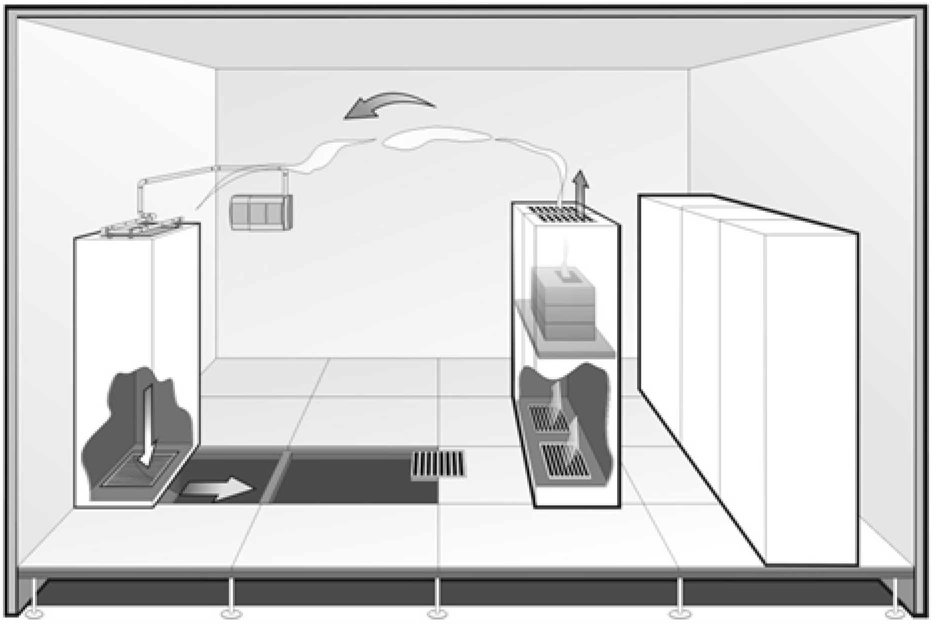
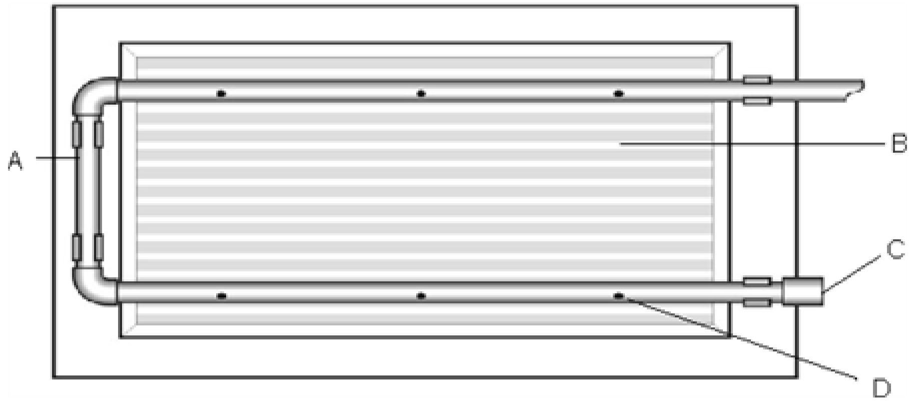


Figure 5-12: Typical return air sampling application

5.6 Return Air Grille Sampling

The sampling pipe is placed over the return air grille of a duct or an Air Handling Unit (AHU). Figure 5-13 illustrates pipe mounting over the return air grille to avoid dilution of air samples and possible build up of pressure in the pipe network. The number of AHUs that can be covered by different detectors is dependent on the suction power of the AHU and also on the size of the return air grille.

Generally, a VLP or VLS detector should not monitor more than four AHUs, a VLC should not monitor more than two, and a VLF should not monitor more than one AHU.



Legend			
A	Sampling pipe	C	End cap without hole
B	Return grill	D	Sampling hole

Figure 5-13: Return air sampling over a return air grille

Dilution of return air grille samples

Consideration should be given to the number of AHUs protected by a detector. Theoretically, the number of AHUs monitored is limited only by the maximum length of pipe runs (for details see 7.2). However, the nature of air movement and the degree of smoke dilution that can occur in installations of more than three AHUs monitored by one detector can adversely affect the system response times.

Banks of AHUs have localizing effects on air movement—air in one section of a fire zone tends to circulate between the supply and return ducts of the AHU in that section. Air movement at right angles to the main circulation is reduced and smoke generated by a fire occurring in an area covered by one AHU tends to be concentrated within that area.

If smoke concentrations occur at the extreme end of the sample pipe run, a smoke-laden air sample must pass a number of other sampling points, all of which are supplying only slightly polluted samples (if they are near the fire source) or completely clean samples (if they are far away from the fire source). The net result is the dilution of the smoke sample, leading to a lower reading after a longer time than would otherwise be the case.

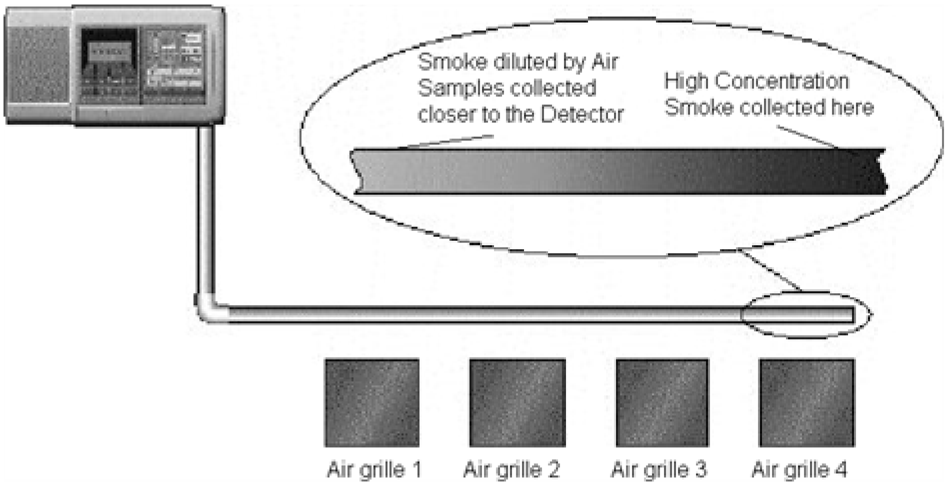


Figure 5-14: Smoke dilution effect over several air sampling points

5.7 In-duct Sampling

In a fire event, ventilation duct systems can convey smoke; usually hot toxic gases and flames from one area to another. Duct systems may also supply air to aid combustion in the fire location. Therefore, the effective management of smoke control, such as dampers and shutters to contain smoke spread and fire growth is essential for life safety.

VLC models VLC-500D and VLC-505D are recommended for duct applications. Xtralis has conducted extensive testing in duct environments to determine the optimum installation parameters.

Key Design Considerations

Sampling tubes should be oriented to overcome thermal stratification due to buoyancy of the smoke in the upper half of the duct. This condition occurs where duct velocities are low, buoyancy exceeds flow inertia, or the detector is installed close to the fire compartment. A vertical orientation of sampling tubes overcomes the effects of differential buoyancy.

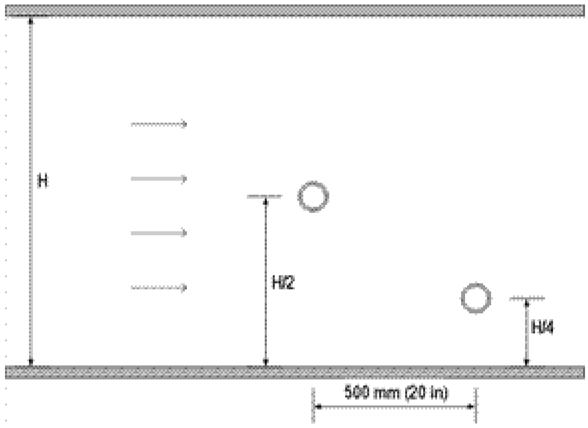
Where a detector is installed on a duct serving a single fire compartment, where the buoyancy exceeds the flow inertia of the air in the duct and the sampling tube cannot be oriented vertically, then the effects of thermal stratification can be minimized by locating the detector sampling tube in the upper half of the duct.

Thermal stratification due to buoyancy of the smoke occurs where duct velocities are low, buoyancy exceeds flow inertia, or the detector is installed close to the fire compartment. This condition occurs in the upper half of the duct. The effects of differential buoyancy are overcome by vertical orientation of sampling tubes. In a single fire compartment, the detector sampling tube is located in the upper half of the duct to minimize the effects of thermal stratification.

- The inlet pipe must be inserted at a distance between six to ten duct widths or diameters from any disturbances to the flow generated by sharp bends, plenums, nozzles, branch connections, etc.
- The inlet and exhaust pipes must have the same length. They must be sealed at the far end with an end-cap.
- The holes on the inlet and exhaust pipes should be facing the airflow as shown in Figure 5-16. Holes with the same orientation eliminate unwanted flow faults associated with cyclical operation, maintenance or power failure of the duct system. However, in some industrial applications where the quality of air inside the duct is poor, it is recommended to face all holes on the inlet and exhaust pipes downstream (i.e. 180× to incoming airflow).
- The pipes should always be supported at the duct walls by using fittings such as a rubber grommet. Silicon must be used to ensure an airtight seal.
- Make sure that the sampling hole at either end is at least 50 mm (2 in) from the duct walls.
- The exhaust pipe must have 4 x Ø10 mm 21/32 in) holes. The holes should be concentrated in the middle of the duct's width and spaced accordingly.

Small Duct: Width < 1 m (3 ft)

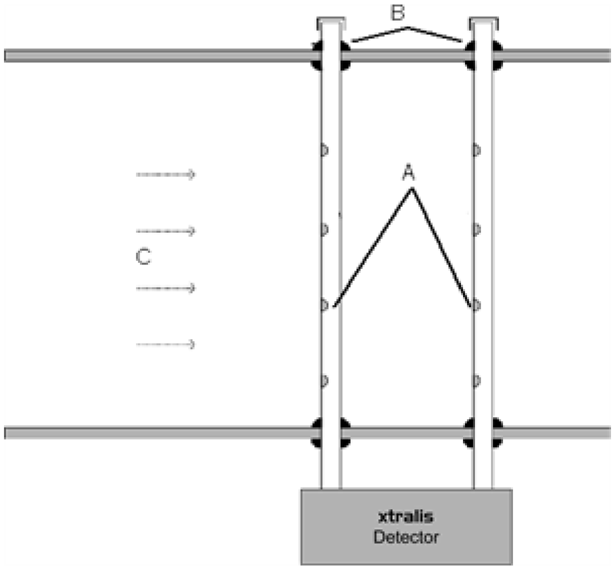
Figure 5-15 shows a side view of a duct section with the insertion positions for the inlet and exhaust pipes. The inlet pipe is to be installed in the middle of the duct height (H) or diameter. The exhaust pipe should be inserted approximately 0.5 m (1.64 ft) further downstream at a quarter of the height of duct.



Legend	
A	Exhaust Pipe
B	Inlet Pipe
C	Air flow

Figure 5-15: Small duct sampling - side view

The details of the number and size of the holes to be used can be found in Table 5-1.



Legend	
A	Holes with same orientation
B	Rubber Grommet
C	Air flow

Figure 5-16: Small duct sampling - top view

For small ducts, holes are nominally spaced each 200 mm (8 in)

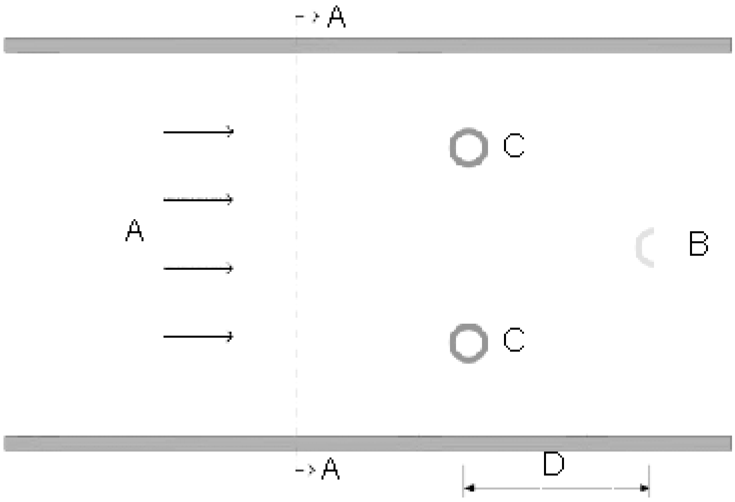
Table 5-1: Hole size for a small duct

Duct width	No. of holes	Hole Ø	Nominal pipe flow rate (L/min.) (cfm)
300 mm (12 in)	2	6 mm 15/64 in	39.0 L/min. (1.4 cfm)
500 mm (20 in)	3	5 mm 13/64 in	40.7 L/min. (1.4 cfm)
700 mm (28 in)	4	4 mm 5/32 in	35.6 L/min. (1.26 cfm)
900 mm (36 in)	5	4 mm 5/32 in	42.8 L/min. (1.51 cfm)

Large Ducts: Width 1 - 2 m (3 - 7 ft)

For large ducts, the inlet pipe is recommended to have two branches. Figure 5-18 shows a side view of a duct section with the relative insertion positions for the inlet and exhaust pipes. Both inlet branches enter at a quarter of the height of the duct from the top and bottom where H is the height of the duct.

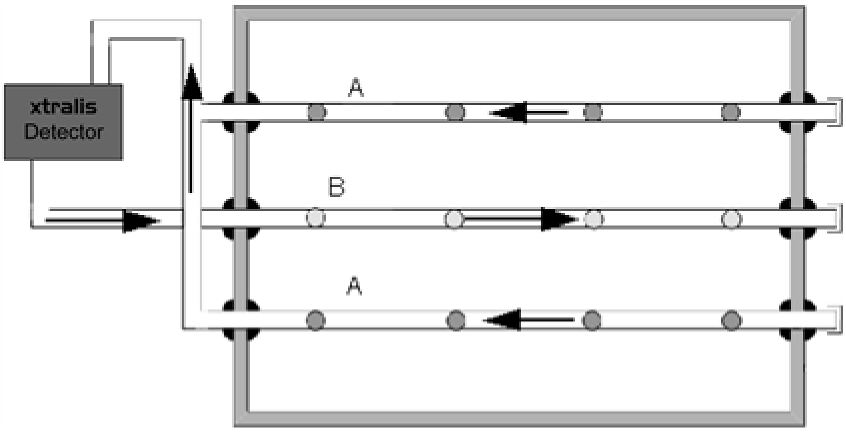
The exhaust pipe should be inserted approximately 0.5 m (1.64 ft) further downstream in the middle of the height of the duct.



Legend	
A	Duct Flow
B	Exhaust pipe H/2
C	Inlet pipe H/4
D	500 mm (20 in.)

Figure 5-17: Large duct sampling - side view

The diagram below shows a cross-section view of a duct with the locations of the inlet branches and exhaust pipe. A recommendation of hole size and spacing arrangement is shown in Table 5-2.



Legend	
A	Sampling Pipe
B	Exhaust Pipe
C	Air flow

Figure 5-18: Cross section view of pipe and hole setup for large duct

For large ducts, holes are nominally spaced each 400 mm (16 in).

Table 5-2: Hole size for large duct

Duct width	No. of holes	Hole Ø	Nominal pipe flow rate (L/min.) (cfm)
1 m (3 ft 4 in)	6	3.5 mm 9/64 in	42.2 L/min. (1.49 cfm)
1.5 m (5 ft)	8	3.0 mm 1/8 in	41.4 L/min. (1.46 cfm)
2 m (6 ft 6 in)	10	3.0 mm 1/8 in	50.0 L/min. (1.76 cfm)

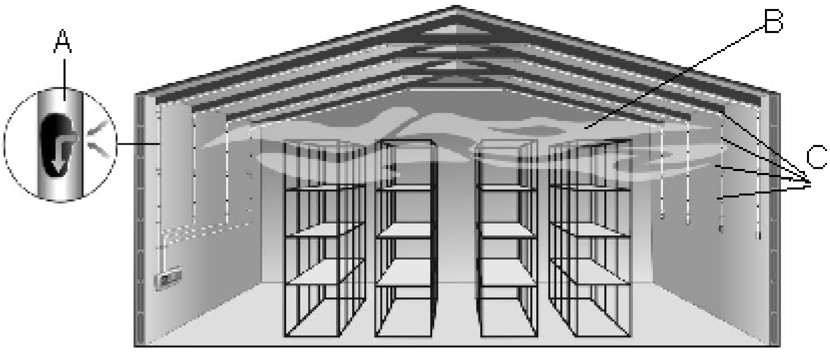
ASPIRE2 calculations shown in Table 5-1 and Table 5-2 apply to a 5 m (16.4 ft) inlet pipe and a 2 m (6.56 ft) exhaust pipe. Always check with local codes and standards for hole size and spacing.

5.7.1 Condensation from Ducts

Condensation may occur when the air being sampled is warmer than the air surrounding the detector. See the Xtralis VESDA Pipe Network Installation Guide for information on how to avoid condensation problems.

5.8 Large Area Sampling

Areas such as atriums and warehouses with high ceilings require special variations of the pipe network design rules. Stratification is a process where due to hot air layers closer to the ceiling, smoke loses its thermal energy, stops rising and levels out horizontally at a certain height. Stratification layers may be formed at different heights, restricting the smoke's ability to rise and reach the sampling pipe network. Factors such as temperature, ventilation, and roof height, all affect the degree of stratification and the level to which the smoke will rise. Changes in the above mentioned factors result in different stratification effects on a site. Where stratification is likely to occur, conventionally designed pipe networks may not be effective.



Legend	
A	Detail of sampling hole
B	Stratified smoke layer
C	Vertical sampling holes

Figure 5-19: Sampling air from areas with high ceilings

To overcome the stratification effect, a vertical sampling pipe may be installed in addition to the standard pipe on the ceiling. The vertical sampling pipe penetrates the stratification layers at different heights and samples the air at multiple levels.

5.9 Cumulative Sampling

If you have fans blowing air around inside a protected area, any smoke will be dispersed evenly around the area. Traditional point detectors will wait until one detector reaches 100% of the smoke threshold before alarming. Xtralis VESDA systems are able to **aggregate** the detected smoke from all of the sample points and can provide much earlier warning. As an example, If you have a room with four sampling points and each detects 25% of the allowable smoke level the Xtralis VESDA systems can aggregate the levels and alarm.

Cumulative sampling is a significant advantage in high air flow areas.

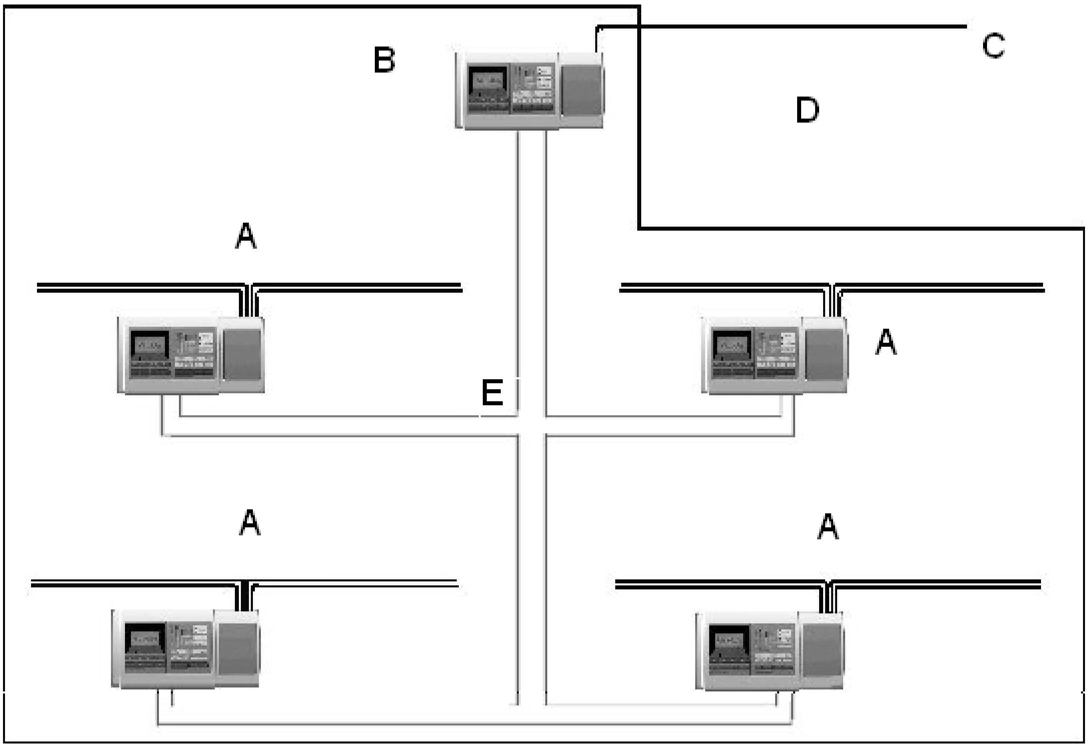
5.10 Reference Sampling

Periodically, smoke and other pollutants from external sources may enter a protected zone temporarily raising the smoke level. In this case the detector will detect the smoke and generate an alarm. Referencing is employed to compensate for the periodic rise in smoke levels and to avoid nuisance alarms in high sensitivity areas.

A separate Xtralis VESDA detector is used to draw air from the external source and produce a reference reading of the background level of smoke and pollutants. The reference reading is then subtracted from all Xtralis VESDA detectors monitoring the internal VESDA Addresses (also known as VESDA Zones). This allows the internal Xtralis VESDA detectors to determine if a rise in smoke levels is due to background pollution or a problem inside the VESDA zone of protection. The ability to check the background level of smoke greatly reduces the chance of detectors false alarming.

Xtralis VESDA detectors in large installations typically operate at varying sensitivity levels. In such instances the level of subtraction can be set differently for each detector.

Referencing is configured through Xtralis VSC, LCD Programmer or Xtralis VSM Software. See the respective manuals for details.



Legend			
A	Internal Xtralis VESDA detectors	D	Reference area (Car park, Loading bay etc.)
B	Reference Xtralis VESDA detector	E	VESDAnet
C	Reference sample pipe		

Figure 5-20: Reference sampling

5.11 Sampling Methods for Different Applications

Different sampling methods for some of the more common applications:

Table 5-3: Sampling Methods for Different Applications

	Standard Sampling			Capillary Sampling			Return Air	
	Below Ceiling	In-Ceiling/Floor	Above Cabinet	Concealed	In Cabinet	Drop Pipe	In Duct	Return Air Grille
Aircraft hangars	●							
Atria	●			●		●	●	●
Auditoria	●			●			●	●
Cable tunnels/trays	●					●		
Casinos	●			●			●	●
Clean rooms	●	●					●	●
Cold rooms	●						●	●
Computer/Server rooms	●	●	●		●		●	●
Control rooms	●	●	●		●		●	●
Dormitories				●			●	●
EDP environments	●	●	●		●	●	●	●
Elec/switching cabinets			●		●	●		
Equipment cubicles			●		●	●		
Historical buildings				●				
Hospitals	●	●		●			●	●
Hotels				●			●	●
Laboratories	●	●			●		●	●
Libraries/archival storage	●			●			●	●
Manufacturing facilities	●		●		●		●	●
Museums /art galleries				●			●	●
Offices	●	●		●			●	●
Prisons				●				
Schools	●			●				
Storage facilities	●							
Telecommunications	●		●		●			●
Substations	●	●	●		●	●	●	●
Theatres	●			●			●	●
Transportation								●

5.12 Third Party Monitoring Equipment

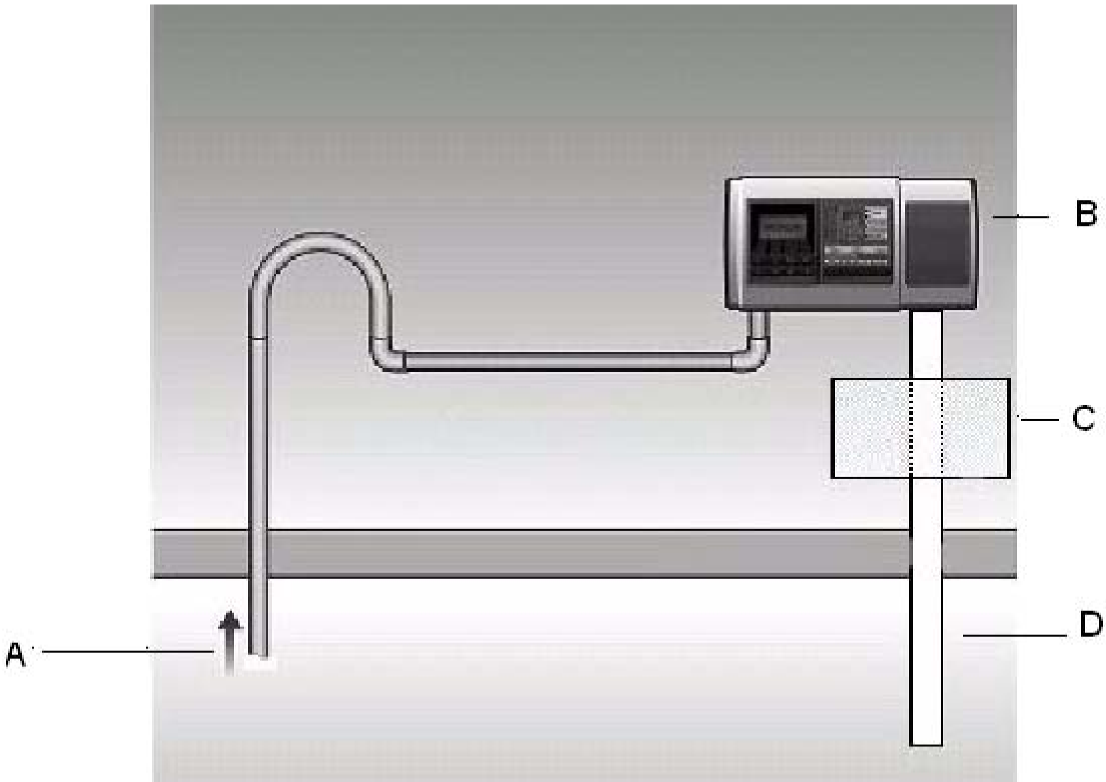
In many environments you will need to not only protect against fire, but also protect employees against dangerous environments.

5.12.1 Gas Detection

For occupational health and safety reasons, there is a need to monitor for dangerous gases in many environments. An example is the testing for the presence of the refrigeration gas ammonia in cold storage facilities.

It is possible to utilize the Xtralis VESDA air sampling technology by incorporating other off-the-shelf products to detect the presence of these gases in a protected environment. This turnkey solution provides many benefits including cost effectiveness, ease of maintenance and management.

The diagram below illustrates how to sample air coming out of the exhaust port to measure ammonia level using a NH3 sensor supplied by Drager Polytron. Refer to manufacturer's specifications and installation requirements for system integration and performance details.



Legend							
A	Air intake probe	B	VESDA detector	C	Third party equipment	D	Air exhaust probe

Figure 5-21: Third party gas detection equipment

Xtralis does not accept any responsibility for the use of third party gas detection products, and presents this concept as an option only. Use at designer's discretion.

6 Defining the Site

6.1 Regulatory Requirements

Local codes and standards determine the maximum spacing between pipes and sampling holes. These maximums may change depending on the environment being protected. Local codes and standards for aspirating smoke detectors will have precedence over any parameters suggested by Xtralis. Some of the key requirements are listed below.

- Maximum permissible transport time
- Maximum area for a fire zone
- Area of coverage per sample hole (point detector)
- Maximum spacing between sampling points
- Maximum area for aspirating systems

6.2 Fire Zones and VESDA Addresses

Fire zones are created to meet regulatory requirements, whereas, VESDA Addresses (also known as VESDA Zones) are areas that can be monitored by one Xtralis VESDA detector. VESDA addresses are created for the system to operate within defined parameters for optimum smoke detection.

Site conditions have an impact in defining VESDA Addresses. Some key guidelines need to be observed when creating an Address.

- One detector can monitor only one VESDA Address
- The VESDA Addresses must comply with the local codes and standards
- The environmental conditions within each VESDA address should be the same. For example, the level of pollution and ambient air pressure within each VESDA Address should not change.
- The appropriate Xtralis VESDA detector parameters are met.

Legend					
A	A single physical fire zone	C	CPUs and storage sub-systems	E	Power supply
B	Two VESDA Addresses	D	Modems, printers and multiplexers	F	Media storage

Figure 6-1: Constructing VESDA Addresses

7 Plan and Map a Pipe Network

In planning a pipe network, you must:

- Have an understanding of the area to be protected
- Understand the environmental conditions of the protected area
- Identify any forced air ventilation and air flows (fans, air conditioners etc.)
- Take into account any customer specifications
- Determine if the design needs to address:
    - Return air grille sampling
    - Make use of ceiling and under floor voids
    - Consideration for high ceilings and stratification effect
    - Any requirement for focused detection

The pipe network grid is mapped on to the construction drawings. The objective of mapping the pipe network is to determine the placement of sampling holes and to optimize the location of the Xtralis VESDA detector with a view to minimizing the pipe length. While mapping the pipe network care should be taken to minimize the number of bends and elbows used. We recommended that multiple pipes are used in preference to changes in pipe direction. Refer to Figure 11-1.

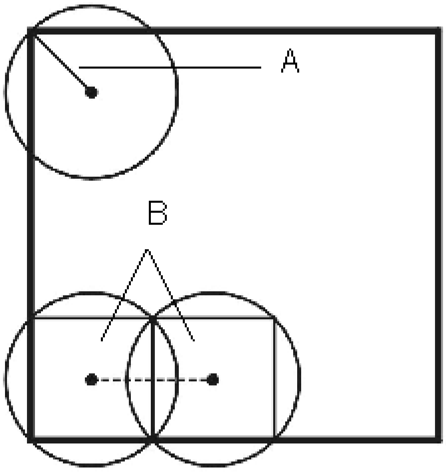
7.1 Grid Overlay

The Grid Overlay method is utilized to map the pipe layout and determine the position of sampling holes. The dimensions of the grid depend upon the required maximum or minimum sampling point separations and the required distance of sampling holes from the walls.

Ideally the aim should be a square grid, however, the measurements and the shape of the area to be covered will determine the grid.

Plot the first sampling hole in a manner that it does not exceed the maximum spacing as dictated by local codes and standards, or by installation requirements. Typically the maximum distance is likely to be to the corner of the room.

Note: The spacings imposed by your local codes and standards may well be related to the cost of conventional point detectors. With an Xtralis VESDA system it is possible to substantially increase the density of sampling points at negligible cost. Grids of 4 m X 4 m (13 ft X 13 ft), 6 m X 6 m (20 ft X 20 ft), or 4 m X 8 m (13 ft X 26 ft) are popular choices.



Legend	
A	Maximum distance of sampling hole from the wall. (Max 5.1m or 16ft)
B	Spacing between sampling holes (Max 10.2m or 32ft)

Figure 7-1: Illustration of plotting sampling holes and spacing between holes

7.1.1 Sampling Hole Conventions

1. The typical maximum size for a fire zone is 2000 m^2 (20 000 sq.ft)
2. The maximum area covered by a sample point is 104 m^2 (1120 sq.ft)
3. The sample hole will not be more than 5.1 m from walls (16 ft)
4. The maximum space between sampling holes is 10.2 meters (33 ft)
5. A sample point shall not be more than 7.2 meters (23 ft) from any point in the room

Plot the remaining sampling holes for the row. Normally these will be spaced at equal distance from each other.

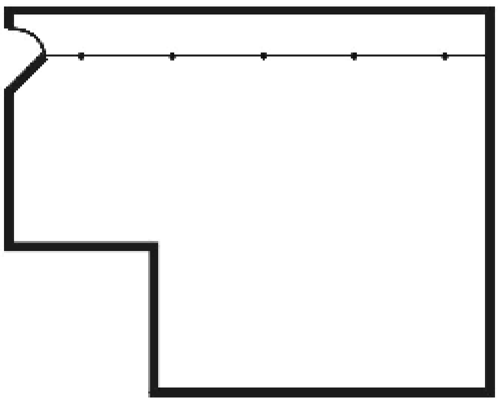
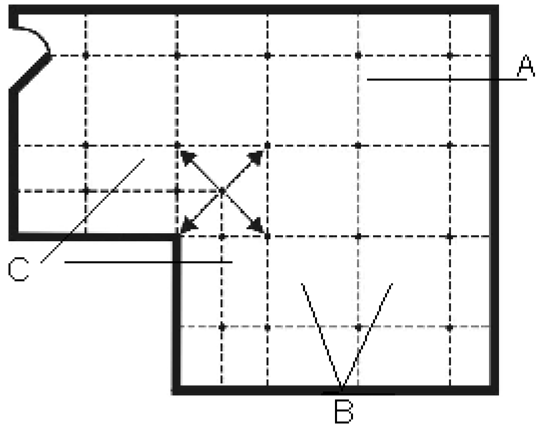


Figure 7-2: Plotting the first row of sampling holes

Plot sampling holes in equidistant parallel rows to form squares. If the area to be plotted is irregularly shaped a combination of square and/or rectangular plotting may be required.



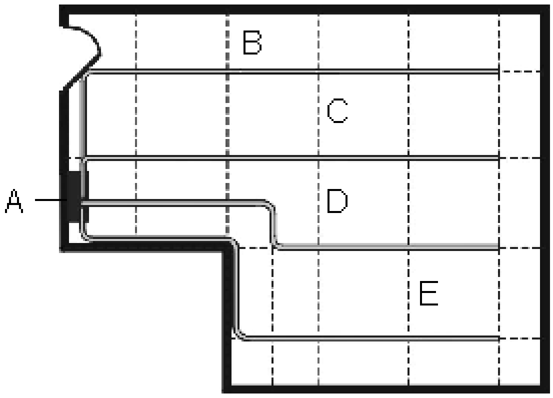
Legend	
A	Square plotting of sampling holes
B	Grid overlay
C	Rectangular plotting of sampling holes

Figure 7-3: Square and rectangular plotting of sampling holes

After plotting the sampling holes determine the optimum positioning of the Xtralis VESDA detector keeping in mind the good design principals of:

- Shorter multiple pipe runs. To find out why this is critical see the System Performance Graph in Figure Figure 11-2.
- Minimum changes in pipe direction

Next plot the pipes on to the site plan by joining the holes and terminating these at the detector.



Legend	
A	Detector
B	Sampling pipe 1
C	Sampling pipe 2
D	Sampling pipe 3
E	Sampling pipe 4

Figure 7-4: Plotting the sampling pipes by connecting the sampling holes and terminating at the Xtralis VESDA detector

7.2 Detector Parameters

Different detectors in the Xtralis VESDA range have different characteristics. The pipe network design parameters for each of these detectors may vary according to site conditions and requirements. The parameters for Xtralis VESDA detectors are given below.

Table 7-1: Xtralis VESDA detector parameters

Suggested parameters	**VLF-250**	**VLF-500**	**VLC**	**VLP**	**VLS**
Maximum area covered	250 m^2 2 500 $sq.ft^2$	500 m^2 5 000 $sq.ft^2$	800 m^2 8 000 $sq.ft^2$	2 000 m^2 20 000 $sq.ft^2$	2 000 m^2 20 000 $sq.ft^2$
Maximum number of Pipes	1 (2 branches)	1 (2 branches)	1 (2 branches)	4 (8 branches)	4 (8 branches)
Maximum aggregate length	25 m (80 ft)	50m (150ft)	80 m (260 ft)	200 m (650 ft)	200 m (650 ft)
Maximum length for each pipe	N/A	N/A	N/A	50 m (160 ft)	50 m (160 ft)
Maximum branch length	15 m (50 ft)	30m (90ft)	50 m (164 ft)	N/A	N/A
Maximum sampling holes per pipe (including end cap hole)	12	24	20	25	25
Maximum sampling holes per branch (including end cap hole)	6	12	20	Aggregate max 25	Aggregate max 25
Maximum length of capillaries	4 m (13 ft) for small bore (5.2 mm) tube and 8 m (26 ft) drop pipes.	4 m (13 ft) for small bore (5.2 mm) tube and 8 m (26 ft) drop pipes.	4 m (13 ft) for small bore (5.2 mm) tube and 8 m (26 ft) drop pipes.	4 m (13 ft) for small bore (5.2 mm) tube and 8 m (26 ft) drop pipes.	4 m (13 ft) for small bore (5.2 mm) tube and 8 m (26 ft) drop pipes.
Aspirator speed: minimum maximum	Fixed	Fixed	Fixed	3 000 rpm 4 200 rpm	3 000 rpm 4 200 rpm
Minimum system air flow	12 liters/minute	12 liters/minute	20 liters/minute	20 liters/minute	20 liters/minute
Minimum sector pressure	65 Pa	65 Pa	70 Pa	70 Pa	70 Pa

The parameters given above are for a typical pipe network. Site conditions and requirements will dictate the final parameters for each site. The aggregate pipe length can exceed the published values, provided the minimum pressure at each sampling point is at least 25 pascals. It is recommended that transport time for the network is maintained at 60 seconds or less and hole balance and hole share be at least 70% (use ASPIRE2 to calculate these values). These values may be relaxed subject to local fire codes and conditions. Exceeding the guidelines listed in this manual is allowable if the ASPIRE2 software approves the design.

7.3 Site Parameters

Each site presents its own unique set of parameters which the pipe network must meet. Some factors likely to influence pipe network design are:

- Level of protection required
- The area to be covered
- The environmental conditions
- The layout (of plant, machinery, equipment or furniture)
- Airflows
- External influences
- Special equipment to be protected (See 9.3)
- Combustibility of material (construction and stored)

7.4 Client Parameters

The client may specify certain requirements to be included into the design. These may typically relate to protection of certain equipment or the threshold levels for alarms. The pipe network design should incorporate such specifications subject to regulatory and detector parameters.

7.5 Performance Based Parameters

Performance-based design provides an alternate fire protection system to prescriptive fire codes. They do this by assessing the environmental risks at the concept design stage. This design approach offers significant advantages. The most important is the ability to provide early detection of a fire event.

It is recommended that smoke testing or Computational Fluid Dynamics (CFD) modelling be performed. This method of airflow simulation is used to determine the optimal location for the Xtralis VESDA system by accurately identifying smoke travel from previously acknowledged risks.

In areas where performance-based design is not recognized, its concepts may still be adhered to by incorporating the design basics from prescriptive codes (i.e. NFPA 318 and SEMI s14 - 2000), and the basics outlined in this guide.

The arrangement of process tools and equipment will alter the airflow dynamics (air speed and air direction) in the facility. To ensure that the system design is effective, it is recommended that performance tests are conducted during the completion stage of the site construction.

8 Choice of Detector

The appropriate Xtralis VESDA detector must be identified once site conditions are known and the sampling method has been selected. The detector should be selected based upon area coverage and the type of sampling method selected. The table below identifies the suggested Xtralis VESDA detector for different environments. Actual site conditions and pipe network design will determine the final choice of the detector.

Table 8-1: Detectors suggested for different applications

Detector	VLP	VLS	VLC	VLF
Aircraft Hangars	●	●		
Atria	●			
Auditorium	●			
Cable Tunnels/Trays	●		●	
Casinos	●	●		
Clean Rooms	●		●	
Cold Rooms	●		●	
Computer Rooms	●		●	●
Control Rooms	●	●	●	●
Dormitories	●	●	●	
EDP Environments	●		●	
Elect/Switching Cabinets			●	●
Equipment Cubicles			●	●
Historical Buildings	●	●	●	
Hospitals	●	●		
Hotels	●	●		
Laboratories	●		●	
Libraries/Archival Storage	●	●	●	●
Manufacturing Facilities	●		●	
Museums/Art Galleries	●	●		
Offices	●	●		●
Prisons		●	●	●
Schools	●	●		
Storage Areas	●	●		●
Substations			●	●
Telecommunications	●	●	●	●
Theatres	●	●		
Transportation	●		●	●

9 Designing Pipe Networks for Specific Applications

Xtralis VESDA systems can be fine tuned to most environments. Each environment presents its own special requirements and these are addressed during pipe network design. Table 5-3 suggests air sampling methods normally used for different types of applications. A combination of different sampling methods may be used to create the optimum protection for a site. Four basic applications are discussed below:

- Protecting standard rooms
- Protecting high air movement areas
- Focus detection
- High ceiling areas

9.1 Standard Rooms

The typical standard room pipe network is an on ceiling sampling method as described in Designing a Pipe Network in 3. This figure illustrates the on ceiling sampling method employed for protecting standard rooms.

9.2 High Air Exchange Rooms

High air exchange areas normally use some form of mechanical ventilation to maintain dust free operations. Most local codes and standards support that any environment with 7.5 air exchanges (or more) is classified as a high air volume exchange area. Most local codes and standards also require that the higher the airflow the smaller the area that can be protected by each sample hole. At the time of writing this manual the US NFPA 72 for traditional point detectors uses:

Table 9-1: Point coverage in high air exchange areas

Air changes/hour	60	30	20	15	12	10	8.6	7.5	< 7.5
m^2 covered per hole	12	23	35	46	58	70	81	84	84
Sq. ft covered per hole	125	250	375	500	625	750	875	900	900

Note: The US NFPA 72 code on spacings in high airflow areas has an exception for air sampling systems such as the Xtralis VESDA range.

The sampling methods used for high air movement areas are a combination of return air and on ceiling sampling. All fire codes require that the detector spacing is reduce in high airflow environments. The return air sampling may be conducted at a return grille or via in-duct sampling. In high air exchange environments the air flow direction is influenced by artificial means. Any air volume outside the direct air flow path may not reach the sampling points on the return grills.

Below ceiling sampling is used to sample air from areas that fall outside the direct air flow path created by air handling units. Figure 9-1 illustrates the use of return air sampling in combination with on ceiling air sampling in areas of high air exchange.

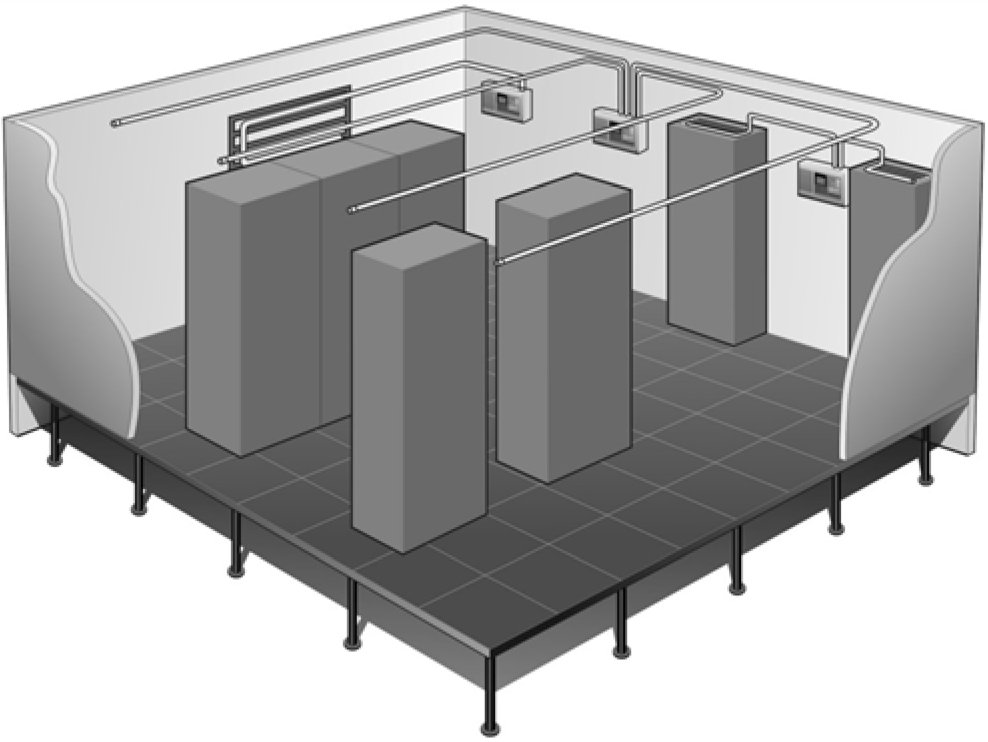
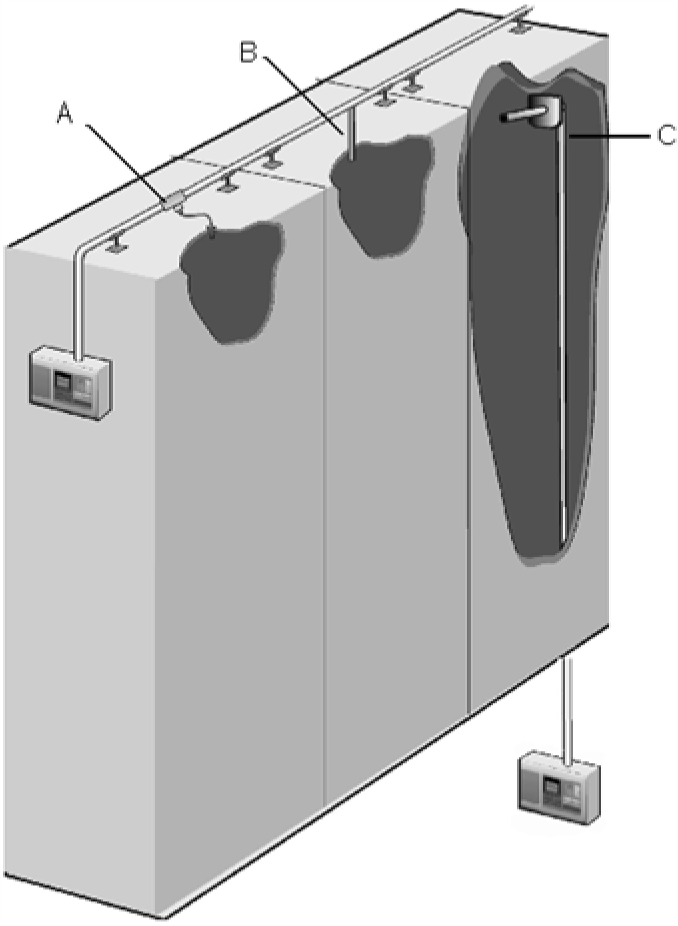


Figure 9-1: In-ceiling and return air sampling for rooms with high air exchange

9.3 Focused Detection

There are instances where a specific objects within a room requires special monitoring. In-cabinet sampling uses capillaries to sample air from inside cabinets which are used for electrical, IT, or other mission-critical purposes. The capillaries are suspended from a sampling pipe at the top of the equipment cabinet, or come up from an under floor void.



Legend	
A	Capillary
B	Drop pipe
C	Floor void capillary

Figure 9-2: In-cabinet air sampling with capillaries, drop pipes and under floor sampling methods

When installing in-cabinet sampling from under the floor, the capillary will still always be suspended inside the top of the cabinet.

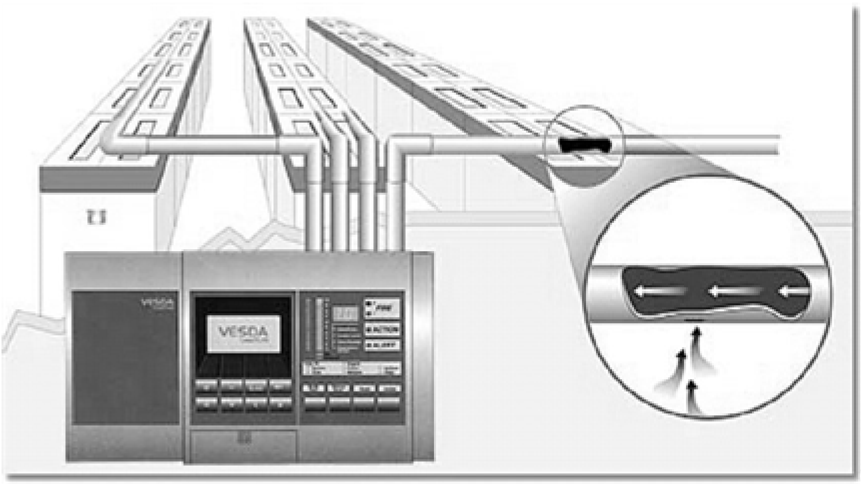
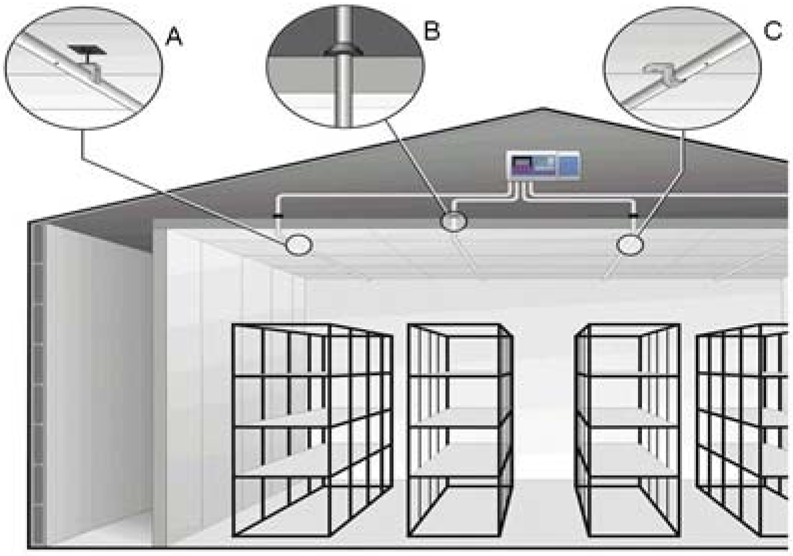


Figure 9-3: Above cabinet sampling

9.4 High Ceiling

VESDA Addresses (also known as VESDA Zones) with high ceilings require special consideration because of the stratification effect. To overcome the stratification effect one or more vertical pipes are installed in addition to the pipes on the ceiling. Refer to 5.8 for an example of pipe network installation for areas with high ceilings.

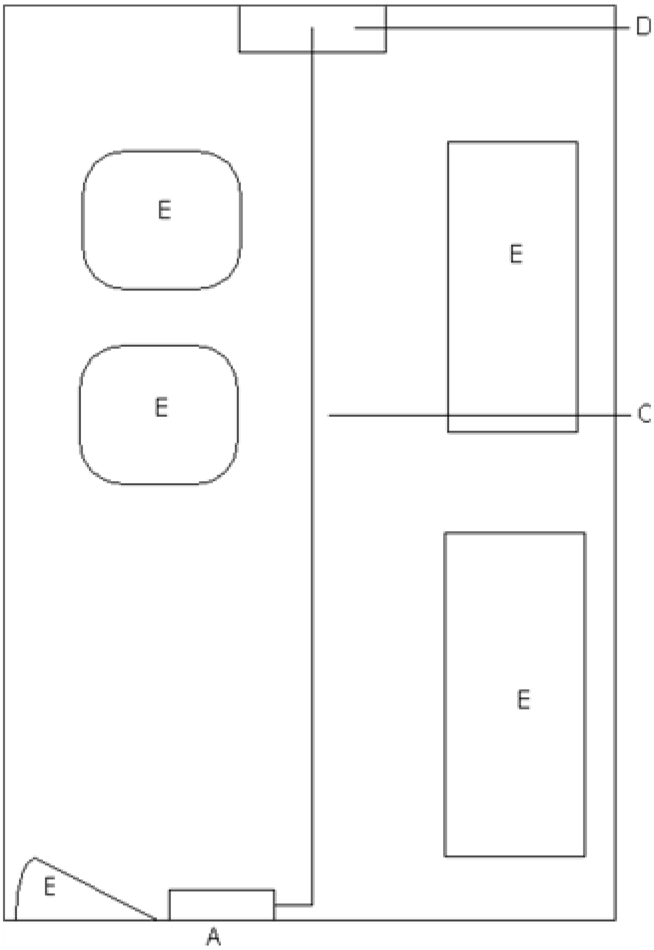


Legend	
A	Pipe held off roof
B	Sealed entry to freezer
C	Normal pipe installation

Figure 9-4: Freezer warehouse installation.

For further information on designing refrigerated storage, see the Xtralis VESDA Warehouse and Refrigerated Storage Design Guides.

9.5 Protecting Two Areas with the Same Pipe



Legend	
A	Detector
B	Smoky machinery
C	Sampling point
D	Protected cabinet
E	Door

Figure 9-5: Protecting two environments with one pipe/detector

This diagram above shows a detector (A) being used to protected a dirty workshop area (B) with fumes. Detection for this area needs to allow for the presence of workers who smoke. The detector is also providing focussed detection for the electrical cabinet (D) at the back of the room.

To be able to protect these two environments with a single detector you may be able to put a very small hole (2 mm) in the middle of the room (C) and put a very large hole for the sample point inside the cabinet.

This configuration may generate a Minimum Hole Flow error in ASPIRE2. You will need to fine tune the hole sizes to find a configuration that is acceptable to ASPIRE2.

10 Testing Design Performance

You can test the design performance with the ASPIRE2 software provided by Xtralis. The software is used to evaluate the performance differences that occur by making changes to the pipe design. For the latest version of the software see www.xtralis.com or contact your local Xtralis office.

The efficient performance of a pipe network design is dependent upon ASPIRE2 generating acceptable values for:

- Hole % balance
- Maximum transport time
- Hole sensitivity

Factors influencing these values are:

- Pipe length
- Number of sampling holes
- Size of the endcap hole
- Number and radius of bends
- Number of pipes
- Length of capillary tubes
- Size of sampling holes
- Aspirator speed

10.1 Hole Balance

Hole % balance is the amount of air being drawn from the sampling hole with the least amount of air flow, divided by, the average air flow through the other sampling holes.

Subject to local codes and standards, a minimum hole balance of 70% or greater is recommended

The aim of an optimum pipe design is to have a relatively equal air flow through **all** sampling holes. To achieve this, the Hole % Balance should be as close to 100% as possible. Pipe length, number of sampling holes, hole size, and endcap hole size all effect the Hole % Balance.

Reducing the number of holes per pipe, and using multiple pipes, will increase the balance.

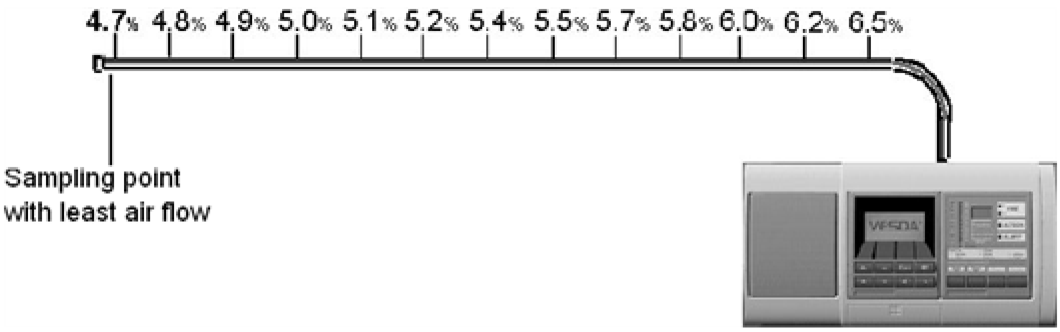


Figure 10-1: Hole balance

The mathematical formula is:

$$\text{Balance} = \frac{\text{Least Flow}}{\text{Average Flow}} \times 100 \qquad \text{Balance} = \frac{4.7}{5.4} \times 100 = 87\%$$

10.2 Maximum Transport Time

Maximum transport time indicates the longest time taken for smoke to travel from a sampling hole to the detector. You should aim to get the lowest possible time without compromising on the Hole % Balance and the Hole % Share values.

Note: Subject to local codes and standards the maximum transport time is 120 seconds. We recommend the maximum transport time of less than 60 seconds when early warning is desired.

Pipe lengths affect the time to transport a sample of air from the collection point to the detector. Factors like bends, diameter of sampling holes and endcap holes also affect the transport time. Figure 11-1 illustrates how the same area can be covered by different pipe lengths.

10.3 Hole Sensitivity

The relative sample hole sensitivity is a measure of the sample hole in relation to the detector's fire threshold sensitivity. Mathematically it is presented as:

Detector Sensitivity / (Sample hole flow / Sum of all sample point flows) = % obs/m (%obs/ft)

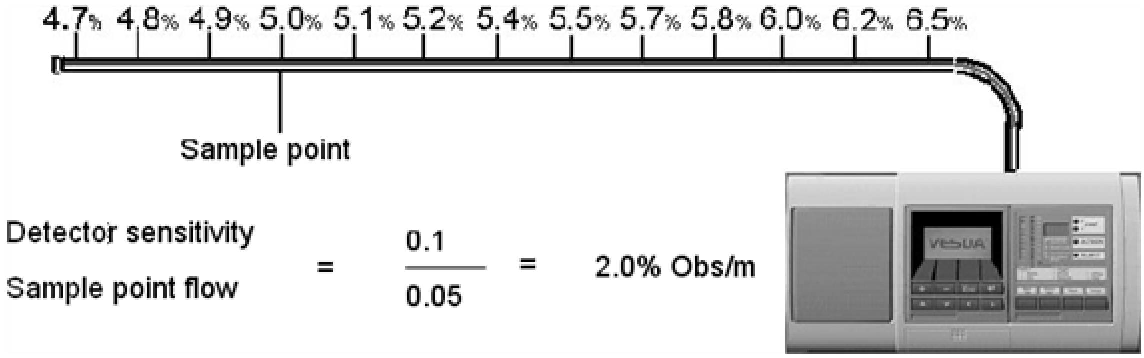


Figure 10-2: Hole sensitivity

11 Advantages of Multi Pipe Systems

Subject to the maximum length parameters for the detector it is possible to design a pipe network covering an entire zone with one pipe. However, for improved pipe network efficiency we strongly recommend you use shorter multiple pipes.

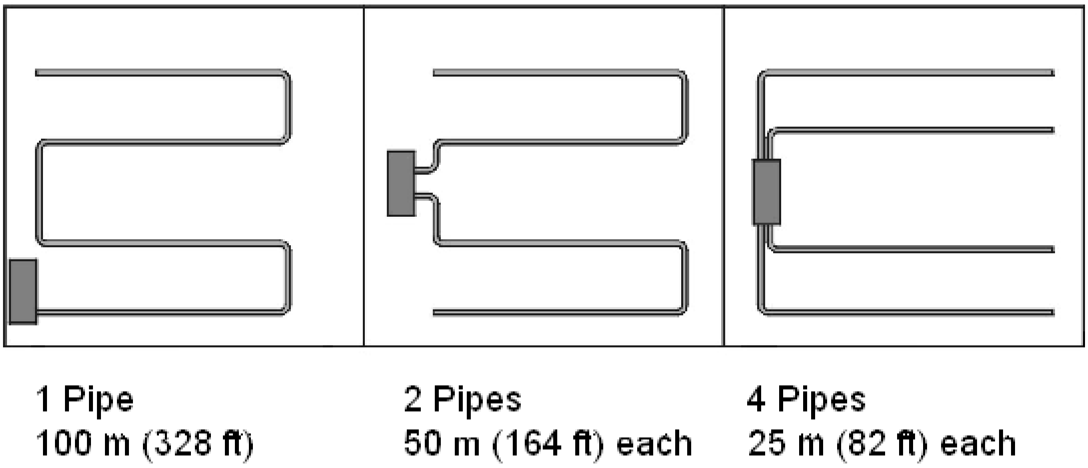


Figure 11-1: Illustration showing single and multiple pipe network systems for the same area

The advantages of multiple pipe systems are:

- Shorter pipes have better response times as the air transport distance from the end of pipe to the detector is reduced. See 10.2for details.
- Shorter pipes have less sampling holes per pipe and can have smaller endcap holes. This creates better hole share and hole balance. See 10.1.
- Shorter pipe lengths are likely to have fewer bends resulting in shorter transport times and better air flow
- System balance: multiple pipes provide better system balance

11.1System Performance Graph

The system performance graph illustrates the advantages of using shorter, multiple pipes over fewer, longer pipe lengths. A single pipe of 100 meters has a transport time of 80 seconds. Two pipes of 50 meters have a transport time of around 33 seconds. Four pipes of 25 meters have a transport time of 20 seconds. Each of these configurations will protect the same area, but have substantially different transport time performance.

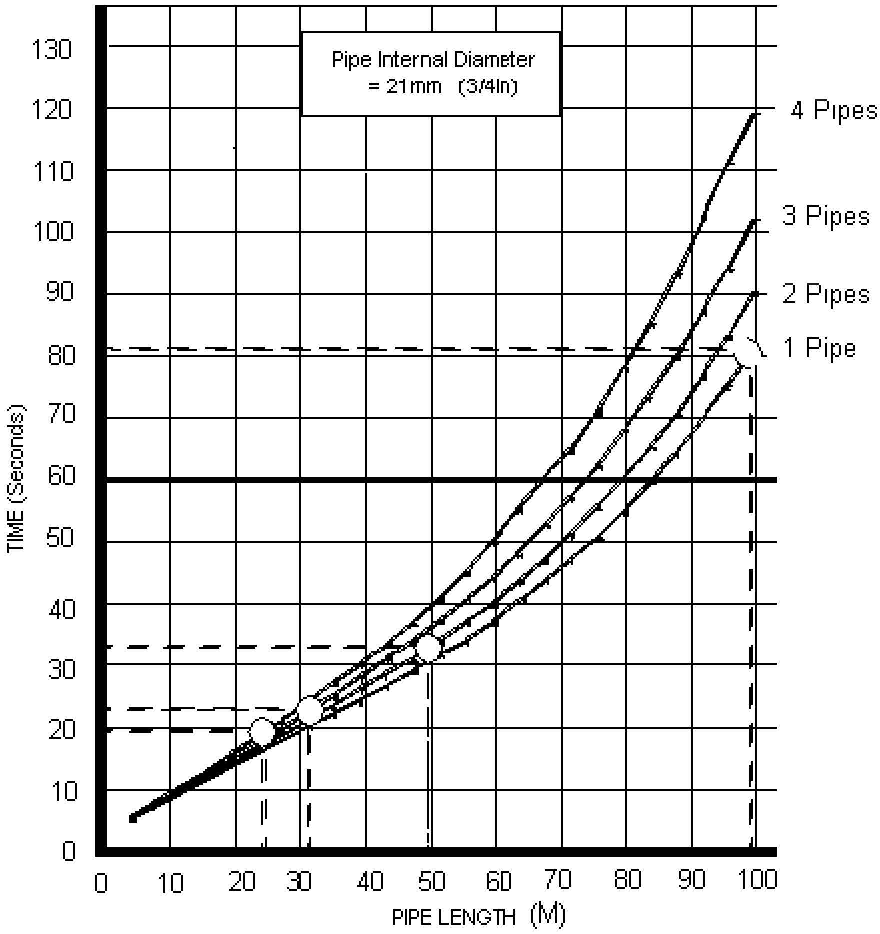


Figure 11-2: System performance graph

11.2 Sampling and End Cap Holes

The sampling holes are drilled into the pipe(s), once the pipe network has been installed. Endcaps must always be placed at the end of each sampling pipe. ASPIRE2 calculations will determine the diameter of each sampling hole and the end cap hole. The end cap hole can be used as another sampling hole, but is generally used to improve the transport time for the pipe. The diameter of the end cap hole is determined by the parameters of the pipe network, such as the pipe length and the number of sampling holes.

11.3 Pipe Connections

11.3.1 Joints

Pipe joints must be airtight. Glue together the pipes once the final form of the network has been determined. Do NOT glue the pipes to the pipe inlet and exhaust manifolds of the detector. The use of excessive amounts of glue can block or partially block pipe airflow to the detector and severely affect the detectors ability to detect smoke. Testing must be conducted after the pipes are glued together.

11.3.2 Bends

We recommend bends and elbows are used to change the direction of the pipe. Wide radius bends are preferred to elbows. Good pipe network designs keep the number of bends and elbows to a minimum as they interfere with the optimum airflow. We recommend you use multiple pipes instead of bends and elbows. Figure Figure 11-1 illustrates the advantage of multiple pipes over bends and elbows.

11.3.3 Tees, Y-pieces and J-Pieces

Tees, Y-pieces and J-pieces are used to branch the trunk pipe line. These may also be used for connecting capillary tubes and drop pipes.

Y-pieces and J-pieces must NOT be branched towards the detector. Branching against the natural airflow will disrupt the flow of air in the pipe and lead to unpredictable results.

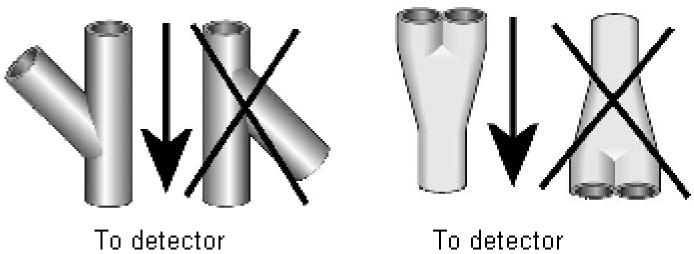


Figure 11-3: Correct placement of Y-pieces and J-pieces

12 Recording Pipe Network Design Specifications

Keeping an accurate record of the pipe network design specifications assists the installation engineer to correctly configure the pipe network. This information is also useful to complete the commissioning form. Information that needs to be recorded includes:

- Site name and address
- Site use (application)
- Site measurements and layout
- Factors requiring special attention
- The number and location of Xtralis addresses
- Grid overlay showing the pipe network layout with sampling hole positions
- Recommended sampling method(s)
- Recommended Xtralis VESDA detector
- ASPIRE2 results
- Recommended alarm thresholds