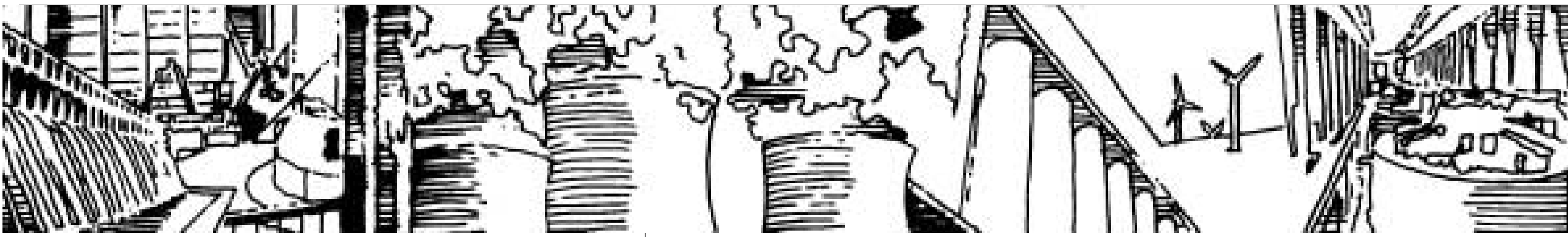
VESDA®

ASPIRATING SMOKE DETECTION



INDUSTRY GUIDE

COAL POWER GENERATION

DISCLAIMER

CONTENTS

1. INTRODUCTION

The Power Generation industry uses different types of fuels to generate electricity. The type of power generation plant is classified by the source of fuel, including coal, gas, oil, nuclear, hydro-electric etc.

Not only can an early warning smoke detection system reduce the risk of a power plant fire, but it may also prevent the incidence of nuisance alarms, which could result in costly generation downtime, and subsequent re-power-up of the power plant. VESDA can provide reliable warning in a coal-fired power plant by detecting a fire at the incipient (pre-combustion) stage.

This Industry Guide has been developed by a team of VESDA engineers who have extensive design and installation knowledge in power generation environments.

The content herein is to be used as a reference by designers and consultants when specifying a VESDA system. It discusses relevant design considerations and recommends the correct method of installing an aspirating smoke detection system in a typical coal-fired power plant.

NOTE: This Industry Guide has been produced as a global reference. It should be used in conjunction with regionally specific fire codes and national standards.

2. PRIMARY CONSIDERATIONS

The following design aspects should be considered during the specification of an aspirating smoke detection system:

- Local Fire Codes and Standards;
- Power Generation Industry Codes of Practice;
- Key fire risks in different operational areas;
- Airflow aspects in different operational areas;
- The presence and location of primary fire risks such as processes;
- Manning levels at the power plant.

3. OPERATING AREAS OF A COAL-FIRED POWER PLANT

Coal-fired power plants have a number of operating areas. The equipment, processes and internal environment of each operational area have varying degrees of fire risk and it is imperative that the specification of the air sampling system be designed to address the requirements of the respective operational areas. The following guidelines are to assist consultants and designers achieve the optimum level of detection required within the identified operational areas. Local standards and codes of practice should always be taken into consideration.

Alarm levels and appropriate levels of response are determined by individual application environments and are not addressed in this Industry Guide.

Table 1 indicates the operational areas of a coal-fired power plant in which VESDA can be used.

Areas	Essential	Recommended
Switch/Relay Rooms		
- Room Sampling		✓
- In-Cabinet	✓	
Control Rooms		
- Room Sampling	✓	
- In-Cabinet	✓	
- Under Floor	✓	
Cabinets		
- In-cabinet	✓	
Cable Tunnels/Chambers	✓	
- Room Sampling		
Coal Bunkers		
- Room Sampling	✓	
- Return Air Ventilation		✓
Battery Rooms		
- Room Sampling	✓	
High Voltage Annexe		
- Room Sampling	✓	
- In-Cabinet		✓
Low Voltage Annexe		
- Room Sampling	✓	
- In-Cabinet		✓

Table 1 - Areas of Protection

The following sections describe design recommendations related to the different detection areas. All pipe work designs should be verified using the VESDA Sampling Pipe Modelling Program – ASPIRE™. This program illustrates the significance of various parameters in an aspirating smoke detection system so that the most appropriate design can be applied.

4. DESIGNING A SYSTEM ACCORDING TO STANDARDS

The choice and level of protection is dependent on the characteristic risks of the power plant and the requirements of local fire codes and standards. VESDA's ability to provide performance-based solutions provides the opportunity to address the individual site specification. This is in addition to the normal method of installing the sampling pipework to replace conventional point or beam detectors.

4.1 PERFORMANCE BASED DESIGN

Performance-based design determines alternate fire protection systems by assessing the environmental risks at the concept design stage. Traditional prescriptive codes and standards have proven to provide an appropriate level of fire protection with a reasonable safety margin. However, as tools and industry expertise continues to develop, the fire protection strategy in many installations is being designed from a risk and performance-based design approach. This may include the use of computerised modelling tools (ie. Computational Fluid Dynamics) and analysis of on-site tests (ie. smoke testing) to determine airflows, fire loading, ventilation, ignition sources and other physical/environmental conditions that may affect the likely development of a fire.

VESDA systems complement performance-based designs by providing an appropriate early warning and response in a coal-fired power plant compared to conventional detection systems. VESDA is also easily incorporated into the overall Fire Response Plan, and verification tests can be administered to confirm that the installed system is providing the specified protection.

The following sections address physical conditions and risks that may occur in a coal-fired power plant.

4.2 CHALLENGES TO SMOKE DETECTION

The Environment

The diverse range of operational areas within a coal-fired power plant vary between the 'clean', relatively dust free environments of Switch Rooms, Command and/or Control Rooms, to 'dirty' areas that exhibit extremely high levels of airborne particulate, such as coal bunkers and cable tunnels. The performance of conventional smoke detectors may be reduced in many of these operational areas.

For example, coal bunkers and conveyors exhibit a high concentration of coal dust. The combination of dust particulate with a low humidity level can expose the plant to a high fire risk due to the occurrence of combustion and deflagration. The high level of coal dust also has a tendency to cause chamber contamination in conventional detectors and results in an increased likelihood of nuisance alarms.

Fire Risks

The main areas classified at risk of fire and/or deflagration include coal stockpiles, conveyors, pulverisers, feeders, crushers, dust collectors and silos/bunkers. Deflagration occurs as a result of the coal dust that is present in the air, and which typically settles over the interior of the power plant. As the particle size and moisture content decreases and the ambient temperature increases, there is less thermal energy required for a slow burning fire or explosion.

Typical sources of ignition in a coal-fired power plant are:

- Rotating machinery parts (including conveyor belt rollers) that create friction.
- Failed bearings that overheat and come in contact with coal dust.
- Sparking and static electrical charge.
- Electrical equipment and switchgear overheating.
- Cables and wire overheating.
- Lubrication and hydraulic oils reaching their flash point.

5. PIPE DESIGN FOR SMOKE DETECTION

5.1 STANDARD ROOM SAMPLING

Standard room sampling is typically installed in a grid format so that each sampling hole corresponds to the location of a point detector (Refer Figure 1 and 2). Reference should always be made to local fire codes and standards.

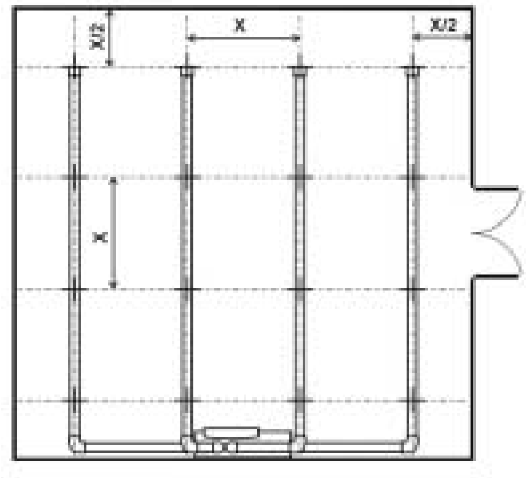


Figure 1 - Grid layout

Figure 2 - Standard room sampling layout

5.2 INTERBEAM SAMPLING

Certain operational areas may have support beams and voids as part of the ceiling configuration. In areas with ceiling voids exceeding 600mm (1.96ft) it may be necessary to sample within the voids for code compliance. This is most easily achieved by incorporating 'walking stick' style capillary sampling, rather than using pipe bends. This method of sampling allows the shortest possible smoke transport time while allowing a longer pipe run than would otherwise be possible. (Refer to Figure 3)

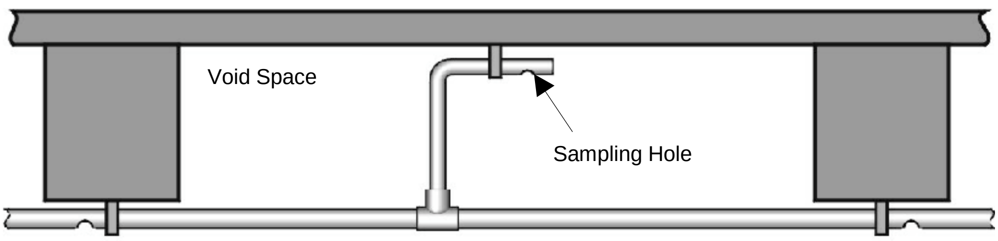


Figure 3 – Walking stick capillary sampling

5.3 STRATIFICATION

The occurrence of smoke stratification must be considered when installing sampling pipework. Stratification refers to the incidence of smoke layering that results from heating and cooling of air within an enclosed area, such as Cable Risers. Factors such as temperature, ventilation and roof height can affect the degree of stratification and level of smoke rise.

To overcome the effect of stratification, it is recommended vertical sampling pipe be installed in addition to standard room sampling. The vertical sampling pipe allows air to be drawn from multiple heights or layers, and therefore provide earlier detection.

6. SWITCH ROOMS

The Switch Room is a dedicated space that accommodates a high concentration of electronic cabinets and automated switch gear. The in-cabinet equipment maintains the primary functions of the power plant, and is the switching interface between the Control Room and the field equipment. Additionally, the area accommodates a significant amount of metering and logging equipment.

Although the fire risk may be considered low, it is imperative to install early warning fire detection due to the critical nature of the equipment and demand on the continuous operation of the Switch Room.

There are several challenges to the detection of a Switch Room fire. The electrical demand of the in-cabinet equipment is a major risk and is the primary cause of a fire incident.

In the occurrence of an in-cabinet fire, the initial low thermal energy inside the cabinet may affect the external detection of smoke during the incipient (pre-combustion) stage. The poor ventilation of cabinets can also affect the detection of smoke by external devices during the crucial incipient stage.

A further consideration is that the nature of the in-cabinet equipment may require a high level of airflow to maintain a suitable operational temperature. Forced air ventilation within the cabinet can increase the risk of smoke dilution and therefore limit the ability to detect within the cabinet when using conventional detection systems.

It is recommended that both ceiling mounted and in-cabinet sampling be located in the Switch Room. Cabinet sampling eliminates the risk of delayed smoke detection, which can result from low thermal energy and/or smoke dilution.

Ceiling Mounted:
The positioning of ceiling mounted pipework and sampling holes is dependant on the layout and configuration of the Switch Room. Reference should be made to local standards regarding the appropriate spacing and density of the sampling holes (detection points).

Cabinet Sampling:
The cabinet configuration is the main consideration when determining the type of pipework sampling method for cabinet protection. Depending on the cabinet construction, either in-cabinet (fully-enclosed) or above-cabinet (top-vented) sampling is recommended.

Above cabinet sampling is achieved by locating the sampling pipe directly over the ventilation grille of the cabinet. It is recommended that each cabinet must have a minimum of one dedicated sampling hole that faces the direct airflow out of the cabinet.

In-cabinet sampling is achieved by installing capillary sampling pipes either through the top of the cabinet or through the bottom (via the floor void) of the cabinet.

Refer to Section 8: Cabinet Protection for further explanation on the above air sampling methods.

7. CONTROL ROOMS

The control room is the main command centre of the power plant. The entire site operation is monitored, maintained and adjusted from this central location. Control rooms are a key consideration due to the high concentration of computers, control equipment, electronic switching devices and underfloor cabling. While the actual risk of fire is low, the consequential impact of a control room fire necessitates earliest warning.

A control room may range from a small, seldom manned, non-ventilated room, to a massive high-tech air conditioned command and control station with multiple consoles and operators controlling every function of the facility.

Control rooms provide a challenge to traditional detection methodologies due to the fact that most computer and control equipment is housed within cabinets, which can impede the detection of smoke at ceiling level. The ability of conventional systems to detect a fire can also be affected by smoke dilution caused by the control room's HVAC system.

VESDA system design provides several methods to overcome the issue of compartmentalised and/or diluted smoke.

Locating sampling pipework at ceiling level, under the floor void and across the return air grille of the air conditioning units provides the earliest possible detection at the incipient stage of a control room fire event. (Refer to Figure 4)

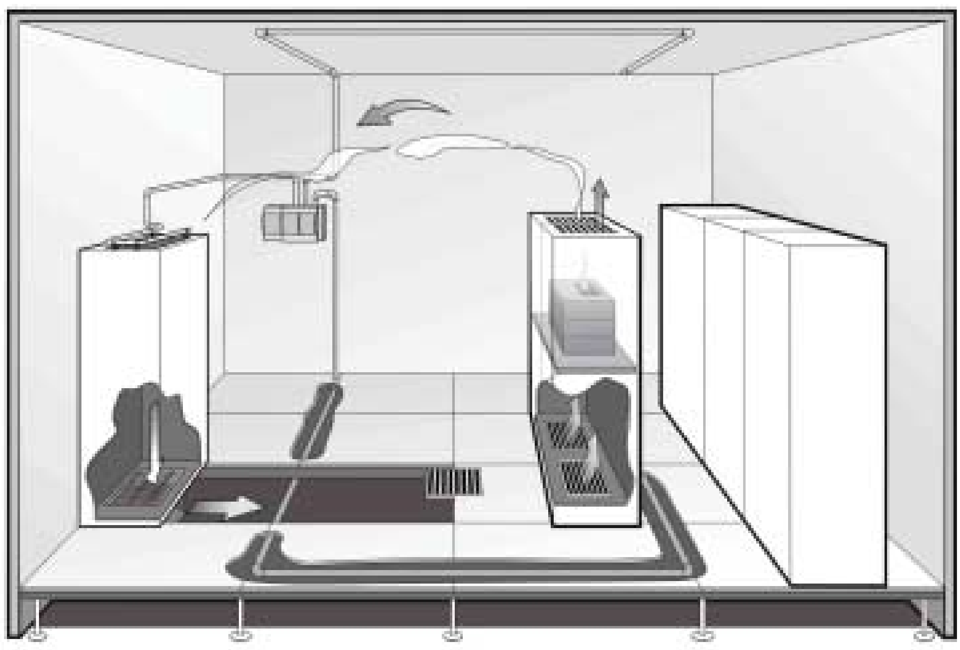


Figure 4 – Underfloor, ceiling mounted and return air grille sampling.

In addition, the presence of equipment cabinets and consoles may require direct in-cabinet sampling. VESDA's high sensitivity and cumulative sampling allows very small levels of smoke to be identified at the earliest stage.

Refer to Section 8.3: Pipework Design for further explanation on the above air sampling methods.

8. CABINET PROTECTION

Electrical, relay and communication equipment is typically mounted on equipment racks and housed within enclosed cabinets. These cabinets may be fully enclosed or have a ventilation system. The ventilation system may either be located as a grille at the top of the cabinet, or as forced ventilation with fans and grilles located at various points within the cabinet.

The equipment or wiring within a cabinet may overheat presenting a fire risk. Smoke or fire within a cabinet may not be detected outside the cabinet until either a fire is already in progress or significant damage has occurred. Cabinet protection can be maximised by using a VESDA Laser System designed to detect overheating wiring and equipment in the pre-combustion (incipient) stage of a fire.

In the occurrence of an in-cabinet fire, the low thermal energy inherent in the cabinet may affect the detection and response of an external smoke detector during the incipient (pre-combustion) stage.

In addition, the poor ventilation (convectional cooling only) of cabinets can also affect the external detection of smoke during this crucial incipient stage.

A further consideration is that the nature of the in-cabinet equipment may require a high level of airflow to maintain a suitable operational environment. The forced air ventilation can increase the risk of dilution and therefore the ability to detect smoke.

The VESDA Laser System can protect in-cabinet equipment by continuously sampling the internal cabinet environment. This is achieved by In-Cabinet or Above Cabinet Sampling. (Refer to Figure 5)

In-Cabinet Sampling:
Capillary tubes or drop pipes are inserted into a cabinet from the top or from the under floor void to sample the air within a cabinet.

In-Cabinet Sampling - Top Mounted:
Sampling pipe is positioned over the cabinet and capillaries or drop pipes are attached to the sampling pipe at appropriate intervals. It is recommended that, unless specified otherwise, the capillary tube or drop pipe should enter the interior of the cabinet to a depth of 25 - 50mm (1 – 2’).

In-Cabinet Sampling - Floor Void:
Sampling pipe is installed in the under floor void. Capillary tubes or riser pipes are attached at appropriate intervals. Holes are then drilled in the floor and the base of the cabinet. Capillary tubes or riser pipes are run through the bottom of the cabinet to the top, and supported at the cabinet’s roof by a mounting clip. It is recommended that the sampling hole is faced downwards and, unless specified otherwise, it should be 25 - 50mm (1 – 2”) below the interior of the cabinet top.

Above Cabinet Sampling:
Above cabinet sampling is achieved by locating the sampling pipe directly over the ventilation grille of the cabinet. Stand-off posts are then used to mount the sampling pipe 25 - 200mm (1 - 8”) above the grille (depending upon air movement). Each cabinet must have at least one dedicated sampling hole that faces the direct airflow out of the cabinet.

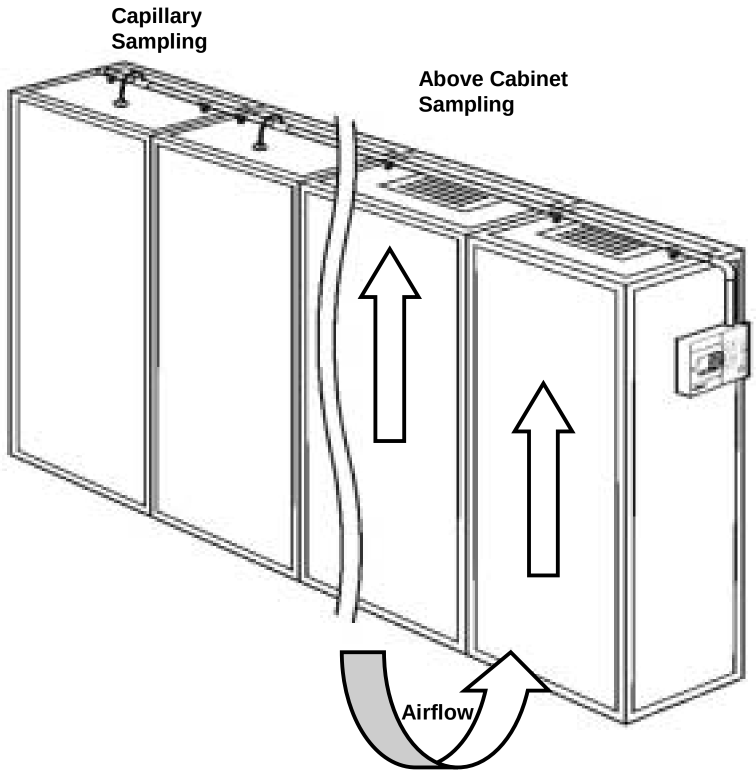


Figure 5 – Capillary and Above Cabinet sampling options

9. CABLE TUNNELS

Cable Tunnels are long passageways that accommodate lengths of racking that support the communication and control cabling, and the various power cabling to and from specific operational areas. The information distributed by the cables is fundamental to the uninterrupted operation of the facility. In a typical layout, numerous lengths of Cable Tunnels link the Control Room, Switch Room and High/Low Voltage Annex areas.

Cable Tunnels generally range in size from 1 - 3m (3 - 9.8ft) in width and 2-3m (6.5 – 9.8ft) in height.

Cable Tunnels are a significant fire risk due to the large and constant amount of power being carried on the cables. The entire operational function of the power plant is dependent on the uninterrupted transportation of information.

Generally classified as confined spaces and located underground, Cable Tunnels are classified as a typically hostile environment, with an increased level of ambient background pollution. Additionally, the configuration and location of the tunnels not only impede general access, but can also affect the response to, and containment of a fire.

The most efficient way to protect the Cable Tunnel area is to install ceiling mounted pipework with long single pipe runs extending in two directions from a central detector. (Refer to Figure 6)

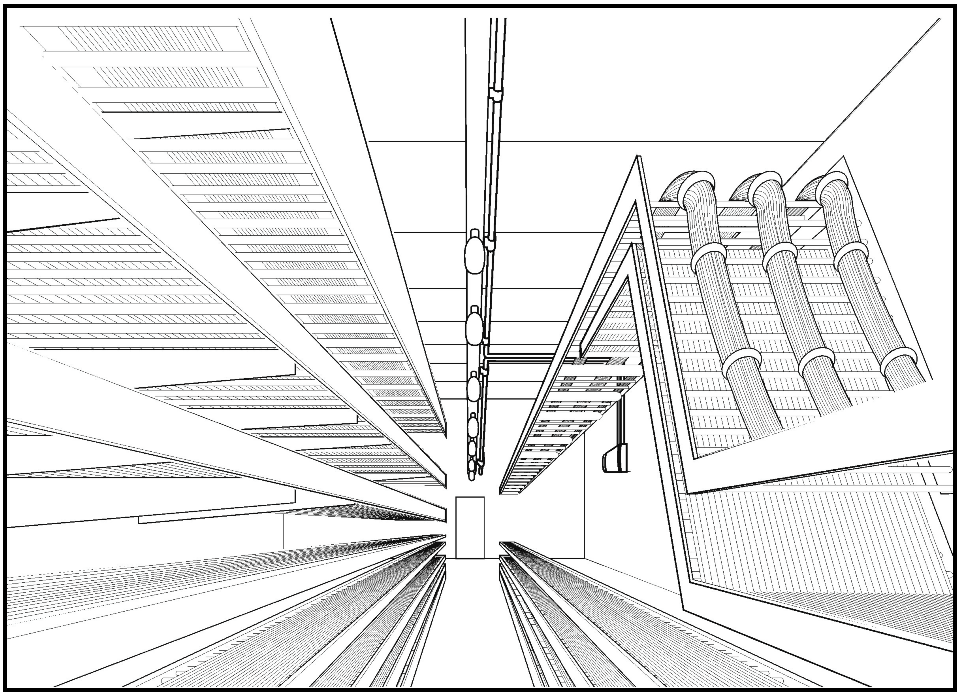


Figure 6 - Cable tunnel protected by VESDA detector

10. CABLE CHAMBERS

Cable Chambers are an integral link to the control and coordination of a facility. The cables located along the Cable Tunnels are grouped together in Cable Chambers for further distribution into various cabinets and control equipment.

Cable Chambers can range in size from 5-30m (16 – 98ft) in width and length and 2-3m (6.5 – 9.8ft) in height.

Cable Chambers are a high fire risk due to the extremely large amount of power that is continuously flowing in the cables. Although the cables are have minimal voltages with relatively low power, when grouped together and overlaid, the risk of damage increases, particularly during cable mining and replacement operations.

The Cable Chamber area is typically located below ground level and is a confined space with a low rate of airflow.

The most efficient way for a VESDA system to protect Cable Chambers is to install ceiling mounted pipework with multiple pipe runs. The sampling holes are usually configured in a code-based format. VESDA's high sensitivity and cumulative sampling allows very small levels of smoke to be identified.

NOTE: Interbeam Sampling

It is common for Cable Chambers to have support beams that support the floor above (usually a Switch Room). It may be necessary to sample within the voids produced by these beams for code compliance. This is most easily achieved by incorporating 'walking stick' style capillary sampling, rather than using pipe bends. This method of sampling allows the shortest possible smoke transport time while allowing a longer pipe run than would otherwise be possible. (Refer Section 5.2 – Interbeam Sampling)

11. BATTERY ROOMS

The Battery Room houses lead acid or nickel cadmium batteries that supply the site's uninterrupted power supply (UPS). The UPS is used as a back-up power source and to start the facility in the event plant shutdown. The size and configuration of the Battery Room is dependent on the power required by the UPS to operate the facility.

VESDA's system design detects the incidence of overheating cells and links, and failures in high current cables and bus bars.

The environment within the Battery Room may become explosive due to the build up of high concentrations of hydrogen gas.

It is recommended that either ceiling mounted and/or Exhaust Air Sampling be installed to protect Battery Room environments.

On Ceiling Sampling:
The pipework is mounted approximately 25 to 100mm (1 to 4") below the ceiling. The spacing, diameter of the sampling holes, and the end cap vent size are determined using ASPIRE calculations.

Exhaust Air Sampling:
Exhaust Air Sampling can either be positioned at the exhaust air grille of the duct (Exhaust Air Grille Sampling), or located in the duct (In-Duct Sampling)

Exhaust Air Grille Sampling:
Incipient smoke generally tends to travel with the natural airflow. By positioning pipework with sampling holes across the air grille of an exhaust ventilation system, any smoke generated in the Battery Room is detected at the earliest stage. (Refer to Figure 7)

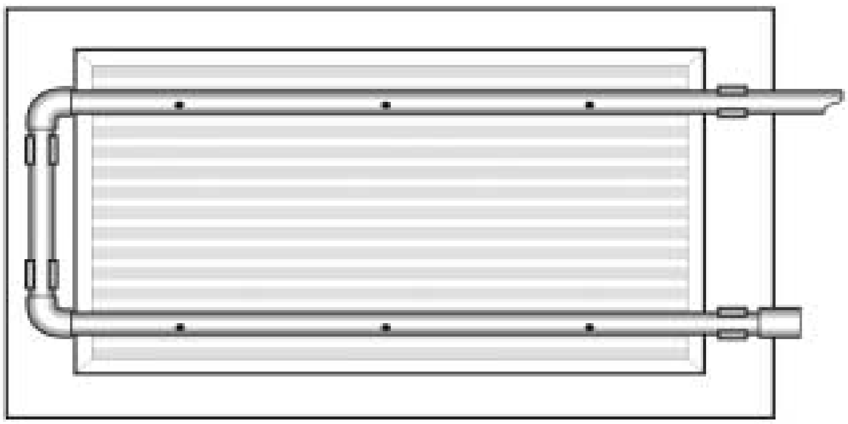
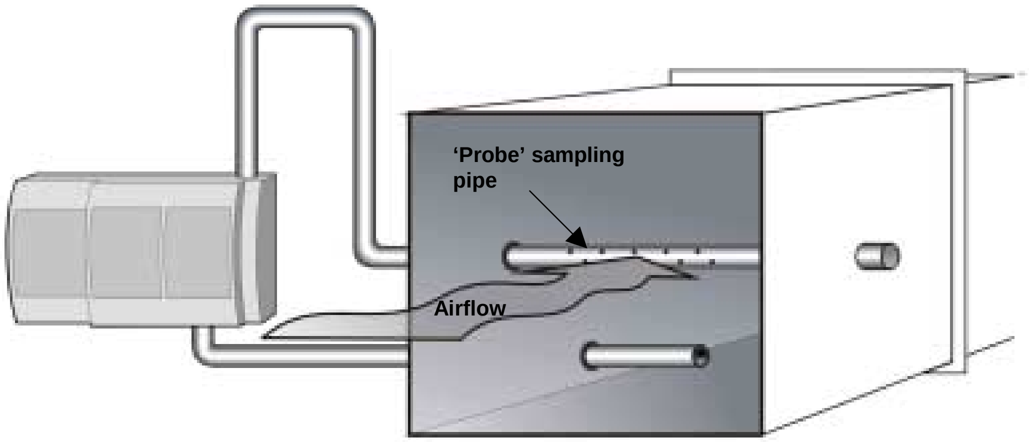


Figure 7 – Exhaust Air Grille Sampling

In-Duct Sampling:
In-Duct Sampling is achieved by locating a sampling pipe across the entire width of the duct, and along its centre line. In this particular application, the sampling pipe is commonly referred to as a 'probe'. (Refer to Figure 8)



NB: Illustration is not to scale

Figure 8 – In-Duct Sampling

Sampling holes are drilled into the probe and positioned 20^{o} to 45^{o} above or below the centre line of the airflow stream. The sample air is then exhausted from the detector back into the duct. To avoid air disturbances from the inflow of air, the in-take probe should be diagonally offset at least 300mm (1ft). The exhaust probe is typically inserted to a third of the duct's width.

NOTE: It is important to ensure that the points where the probes enter the duct are properly sealed and made airtight.

Separate detectors are required for in-room and in-duct sampling.

12. HIGH/LOW VOLTAGE ANNEXES

High/Low Voltage Annexes contain the voltage control and transmission equipment, which is necessary for the operation of any facility. These areas typically consist of rows of cabinets which may be either fully enclosed, or have a top mounted ventilation grille.

A failure of the circuitry or wiring within a cabinet may cause it to overheat; presenting as a significant fire risk. Cabinet detection and protection can be maximised by installing a VESDA detector to detect overheating wiring and equipment in the pre-combustion (incipient) stage of a fire.

The low thermal energy produced by a smouldering cable and/or poor ventilation of a cabinet can impede the external detection of an in-cabinet fire condition.

VESDA can protect high/low voltage cabinet equipment by continuously sampling the internal cabinet environment. There are two methods, which may be implemented to protect high/low voltage cabinets.

In-Cabinet Sampling – Top Mounted:
Sampling pipe is positioned over the cabinet and capillaries are attached to the sampling pipe at appropriate intervals. It is recommended that the capillary tube enter the interior of the cabinet to a depth of 25-50mm (1-2”).

In-Cabinet Sampling - Floor Void:
Sampling pipe is installed under the floor void and capillary tubes or riser pipes are attached at appropriate intervals. Holes are then drilled in the floor and the base of the cabinet. Capillary tubes or riser pipes are run through the bottom of the cabinet to the cabinet roof by a mounting clip. It is recommended that the sampling hole faces downwards and should be 25-50mm (1-2”) below the interior of the cabinet top.

Above Cabinet Sampling:
Above cabinet sampling is achieved by locating the sampling pipe directly over the ventilation grille of the cabinet. Stand-off posts are then used to mount the sampling pipe 25-50mm(1-2”) above the grille. Each cabinet must have at least one dedicated sampling hole that faces the direct airflow from the cabinet.

Refer to Section 8: Cabinet Protection for further explanation on the above sampling methods.

13. GLOSSARY

CFD Modelling:	Computational Fluid Dynamics modelling provides an accurate, computerised simulation of the airflow in a room and allows changes/additions in the placement of equipment to be factored without expensive real world tests. It also provides an estimation of the direction that a particulate stream would follow in the modelled airflow.
Cable Riser/s	A vertical Cable Tunnel.

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