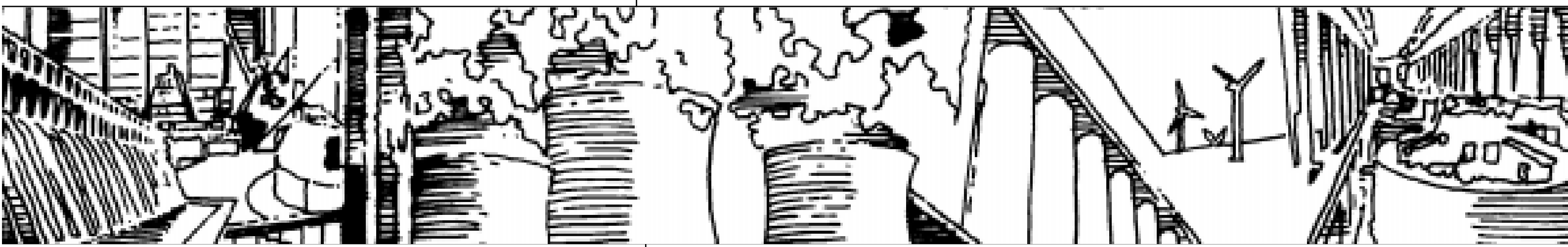
VESDA®

ASPIRATING SMOKE DETECTION



INDUSTRY GUIDE

SUBSTATIONS

DISCLAIMER

CONTENTS

1. INTRODUCTION

The transmission and distribution of electricity are important functions in the entire power generation and supply cycle.

Electricity generated at a power plant is transformed to higher voltages (typically between 66,000 to 500,000 volts) for efficient long distance transmission. The voltage is then transmitted to a power grid for further distribution.

At the delivery end, the voltage is reduced to the primary distribution voltage, usually 23,000 volts. This is then supplied directly to large industrial users or further transformed down to 4,100 or 2,300 volts for commercial, industrial and domestic distribution.

The purpose of a substation is to act as the switching interface to convert the generated power to the voltage required for transmission. Another substation is then used to transform the transmission voltage to the correct distribution voltage.

An early warning smoke detection system not only reduces the risk of fire and prohibitive cost of equipment repairs, but may also prevent the incidence of nuisance alarms, which could result in transmission and/or distribution downtime, power outage within the system and loss of revenue. VESDA can provide reliable warning in a substation by detecting a fire at the incipient (pre-combustion) stage.

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

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 in a substation:

- Local Fire Codes and Standards;
- Power Generation and Transmission Industry Codes of Practice;
- Key fire risks in different operational areas;
- Airflow aspects in different operational areas;
- Manning levels and remote sites.

3. OPERATING AREAS OF A SUBSTATION

Substations generally have four operating areas that have specific equipment, operating processes and environmental requirements. Additionally, each area exhibits a varied degree of fire risk. It is imperative that the specification of the air sampling system be designed to address the requirements of the operational areas. The following guidelines are to assist consultants and designers achieve the optimum level of detection required within the identified 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 substation in which VESDA can be used.

Areas	Essential	Recommended
Switch/Relay Rooms		
- Room Sampling		✓
- In-Cabinet Sampling	✓	
Control Rooms		
- Room Sampling	✓	
- In-Cabinet Sampling	✓	
- Under Floor Sampling	✓	
Cabinet Protection	✓	
Battery Rooms		
- Room Sampling	✓	
Cable Trenches		
- Area/Space Sampling		✓

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 substation and the requirements of local fire codes and standards. VESDA's ability to provide performance-based solutions provides the opportunity to address individual site and equipment specifications. 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 sites' 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 and analysis of on-site tests (ie. smoke testing) to determine airflow, 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 to a substation fire event 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 of a substation.

5. CHALLENGES TO SMOKE DETECTION

The Environment

A substation is generally considered a 'clean' site, compared to a 'dirty/dusty' environment. The site contains operational areas that exhibit specific challenges to smoke detection. (Refer to Figure 1)

For example, Cable Trenches are typically located underneath the substation; primarily under the Switch/Relay Room. If a fire was to occur, the confined space and limited accessibility to the area could impede the identification of smoke by conventional detection systems.

Fire Risks

Primary risk factors include the concentration of high voltage cable networks, high and low voltage switch gear and control equipment (usually cabinet-enclosed), and banks of high capacity batteries that are used to supply the on-site back-up power systems.

Typical sources of ignition in a substation are:

- Arcing and static electrical charge.
- Overheated electrical control equipment, eg. switchgear and cables.

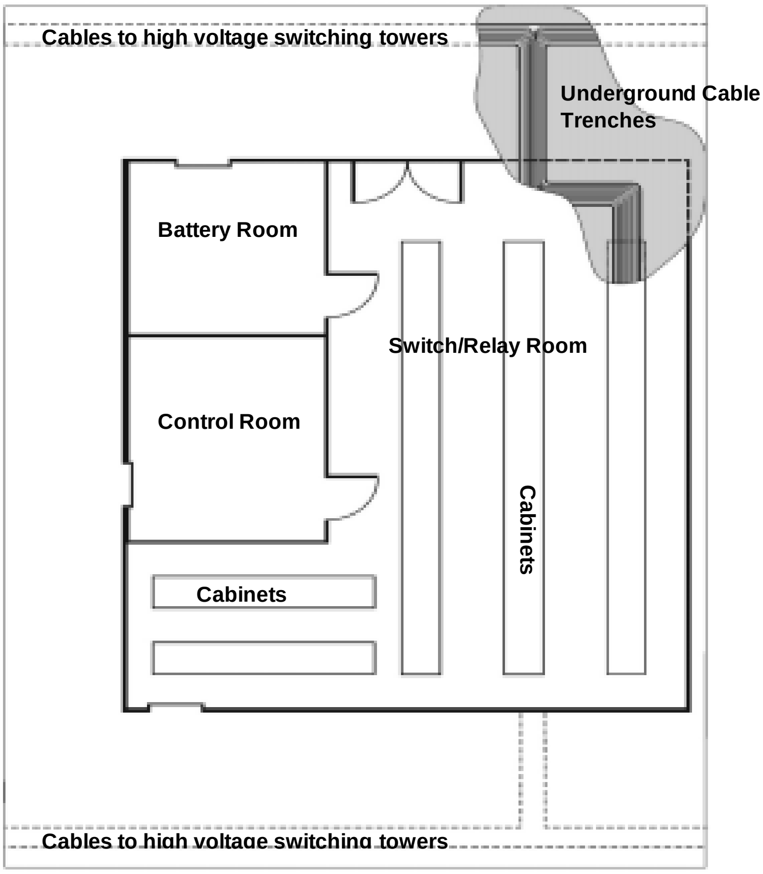
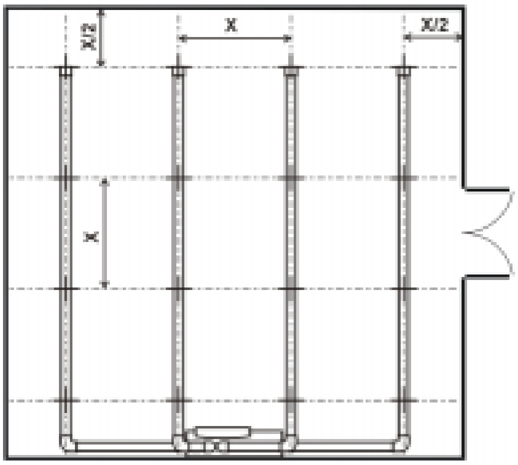


Figure 1 – Typical Substation Layout

6. PIPE DESIGN FOR SMOKE DETECTION

6.1. STANDARD ROOM SAMPLING

Standard room sampling is typically installed in a grid format so that each sampling hole corresponds (as a minimum) to the location of a point detector (Refer Figure 2 and 3). Reference should always be made to local fire codes and standards.



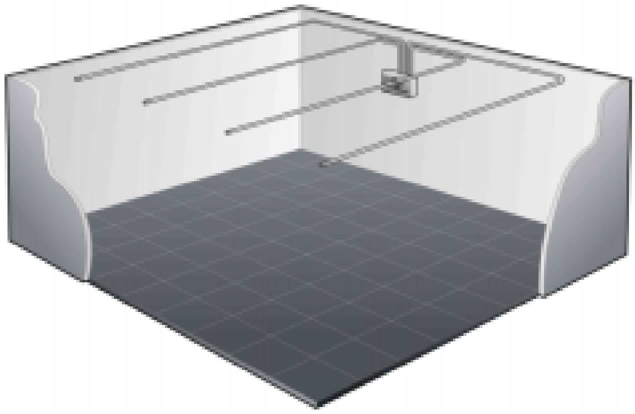


Figure 2- Grid Layout

Figure 3- Standard Room Sampling Layout

7. SWITCH ROOMS

The Switch Room is a dedicated space that accommodates a high concentration of electronic cabinets and automated switchgear. The in-cabinet equipment maintains the primary functions of the substation, 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 the demand for 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 event 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. In-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 9: Cabinet Protection for further explanation on the above air sampling methods.

8. OFFICE/CONTROL ROOMS

The office/control room is the main command centre of the substation. The entire site operation is monitored, maintained and adjusted from this central location. The office/control room is a key consideration due to the control equipment, electronic switching devices and underfloor cabling. While the actual risk of fire is low, the consequential impact of an office/control room fire necessitates earliest warning.

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

Office/control rooms may provide a challenge to traditional detection methodologies as the computer and control equipment may be housed within cabinets, which can impede the detection of smoke at ceiling level. The ability of conventional systems to detect the early stage of fire can also be affected by smoke dilution.

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

Locating sampling pipework at ceiling level and in the floor void provides the earliest possible detection at the incipient stage of a control room fire. (Refer to Figure 4)

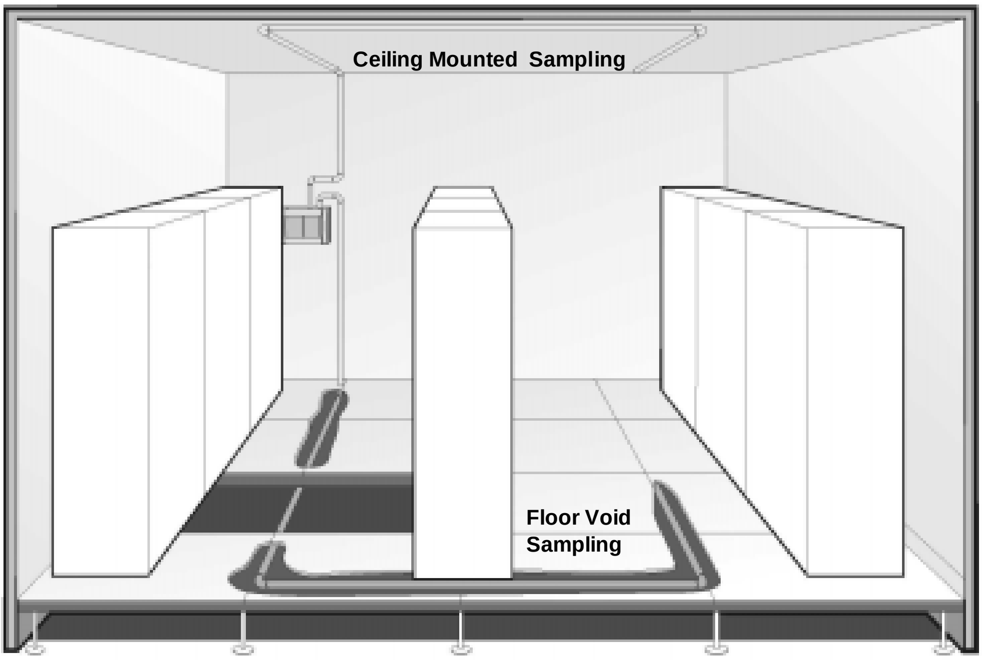


Figure 4 – Ceiling Mounted and Floor Void Sampling.

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 9: Cabinet Protection for further explanation on the above air sampling methods.

9. 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 potential for the equipment or wiring within a cabinet to overheat presents as a primary 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 installing VESDA to detect overheating wiring and equipment in the pre-combustion (incipient) stage of a fire.

In the event 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 (convection 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.

VESDA protects 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.

NOTE: In retrofit installations, it is recommended that the cabinets be sectioned off while the pipework is mounted. This minimises interruption to the substation’s operation and avoids the risk of site downtime and/or shutdown.

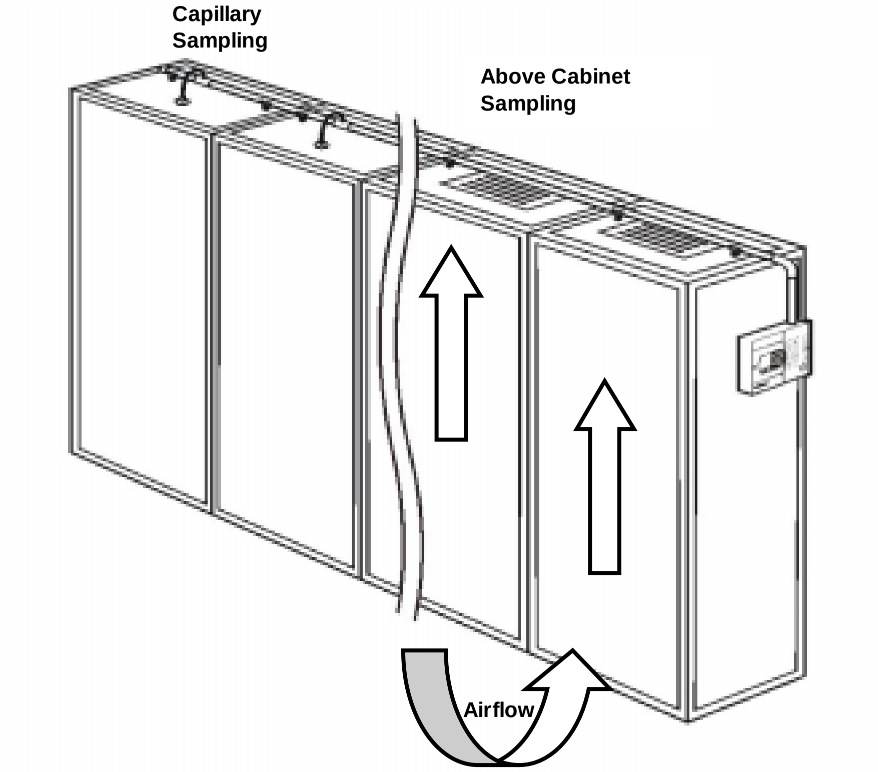


Figure 5 – Capillary and Above Cabinet Sampling

10. BATTERY ROOMS

The Battery Room contains 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 operate the substation in the event of a major outage. The size and configuration of the Battery Room is dependent on the power required by the UPS to operate the site.

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. Monitored fans, which operate on a continual basis, are usually installed in the Battery Room area to extract the build up of hydrogen gas and to provide ventilation.

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

Ceiling Mounted 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 6)

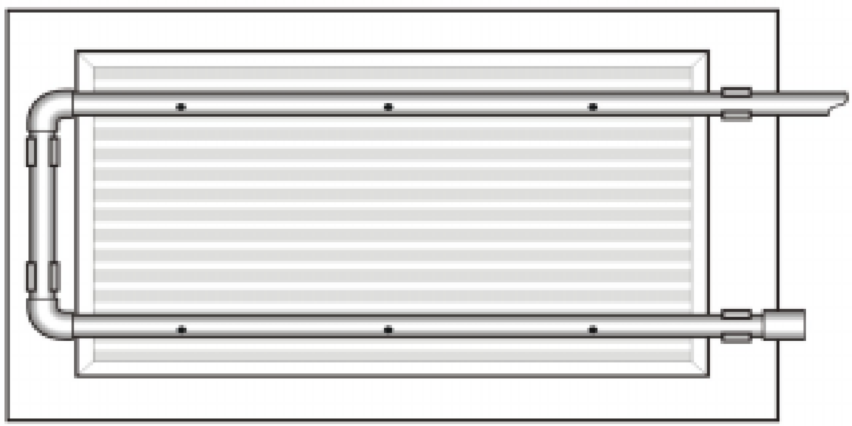
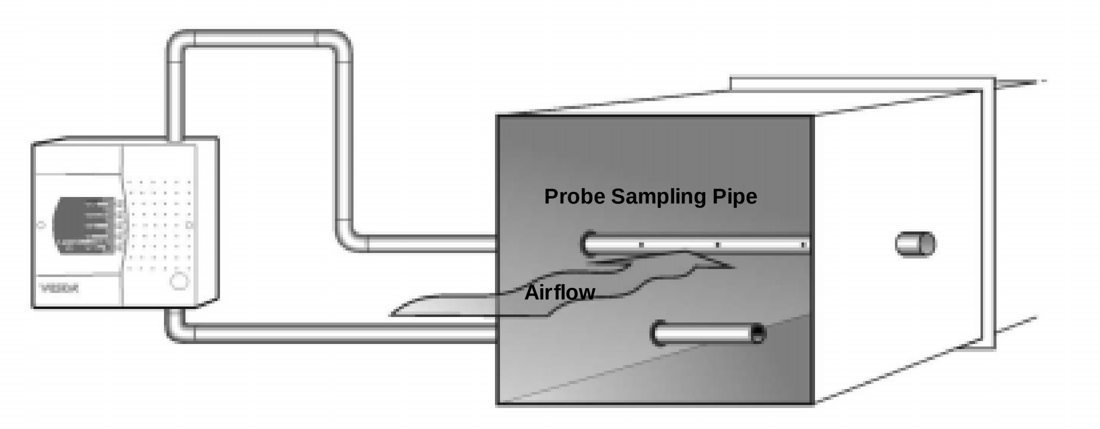


Figure 6 – Exhaust Air Grille Sampling

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 7)



NB: Illustration is not to scale

Figure 7 – In-Duct Sampling

Sampling holes are drilled into the probe and positioned between 0^o to 20^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 entry and exit points of the probe are properly sealed and airtight.

NOTE: Separate detectors are required for Room and In-Duct Sampling.

11. CABLE TRENCHES

Cable Trenches house the communication, control and various power cables that connect the substation's operational areas, and also transport power to the external high voltage switching towers. The information distributed by the cables is fundamental to the uninterrupted operation of the site. Numerous lengths of Cable Trenches link the Control Room, Switching Room and the Battery Room, and are typically located under the Switch/Relay Room.

Cable Trenches are a significant fire risk due to the large and constant amount of power located on the cables.

Generally classified as a hostile environment, Cable Trenches demonstrate an increased level of ambient background pollution. Additionally, the configuration and location of the trenches not only impede general access, but can also affect the response to, and containment of a fire by conventional smoke detection systems.

The most efficient way to protect a Cable Trench is to install sampling pipework in the top 10% of the trench height. (Refer to Figure 8)

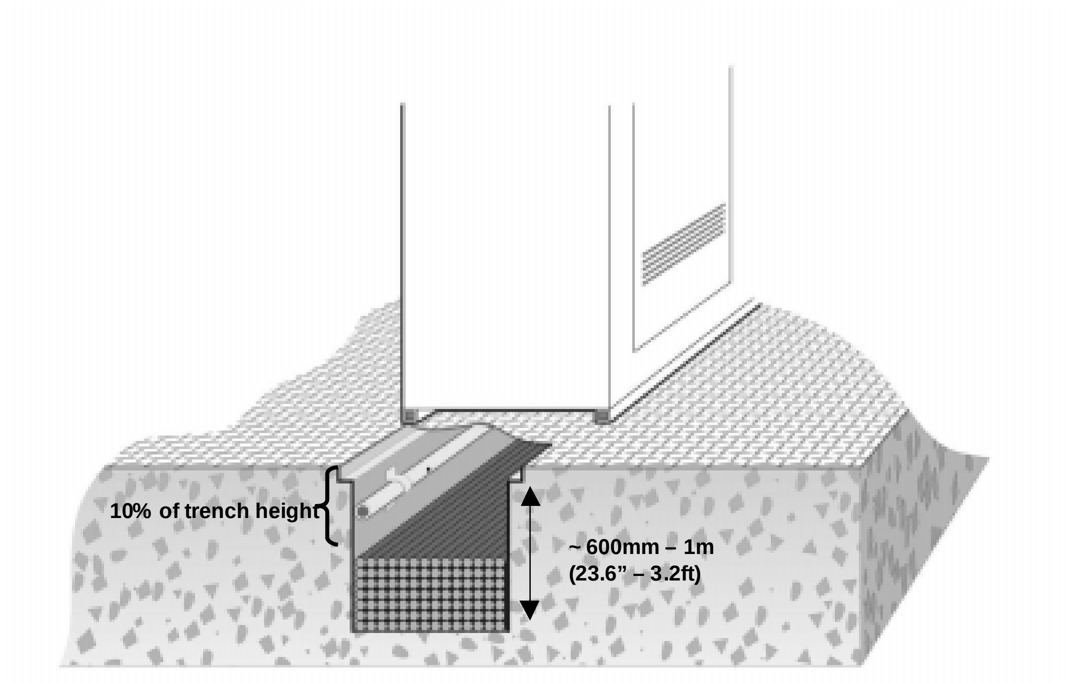


Figure 8 – Cable Trench with Sampling Pipe

12. GLOSSARY

High Voltage Switching Towers	Towers that convert the generated voltage for long distance transmission.

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