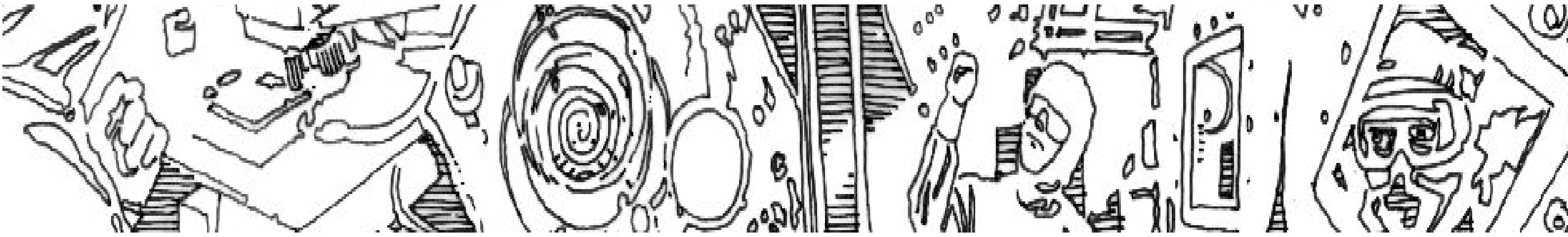
VESDA®

ASPIRATING SMOKE DETECTION



DESIGN GUIDE

SEMICONDUCTOR CLEAN ROOMS

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1. INTRODUCTION

Clean Room sites such as semiconductor manufacturing plants, research and development operations, and pharmaceutical production facilities represent a considerable fire risk due to the constant supply of flammable material. The increased airflow and high level of oxygen adds to the risk by accelerating the fire growth, subsequent distribution of smoke and resultant contamination. However, the major risk is the protected environment itself. The smallest of fires can contaminate the process tools, destroy product and result in unrecoverable manufacturing and operational downtime. Additional concern is the physical logistics of evacuating these types of facilities if there is a real or false alarm.

A reliable, early warning smoke detection system can drastically reduce this risk while providing the lowest incidence of nuisance alarms which would otherwise cause costly production downtime.

As an innovative pioneer of aspirating technology, VESDA provides the earliest possible warning of a potential fire by detecting the incipient (pre-combustion) stage of a fire event. A team of VESDA engineers who have extensive design and installation knowledge in Clean Room environments have assisted in the development of this Design Guide.

The content herein is to be used as a reference by designers and consultants when specifying a VESDA system. It discusses the relevant design consideration, and recommends the correct method of installing of an aspirating smoke detection system in Clean Room facilities.

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

1.1. DESIGN CONSIDERATIONS

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

- The classification level of the Clean Room, i.e. Class 0.1, 1, 10, 100, 1000, etc (Class 1 – 6).
- The airflow characteristics of the protected area, including how the installed hardware and equipment in the room affects airflow.
- The presence and location of primary fire risks such as process tools (i.e. wet bench, stepper, stockers, ion implanters etc.)
- Local codes/standards requirements (i.e. NFPA 318, British Standard 5295)
- Industry standards (i.e. SEMI Safety S2 and S14)
- Location of filtering/pre-filtering systems and Air Handling Units (AHU)

NOTE: The ‘Class’ of a site is dictated by the level of particles equal to or greater than 0.5µm in one cubic foot of air sampled from the Clean Zone. A Clean Room that is identified as Class 1 has a maximum of one particle equal to or greater than 0.5µm per cubic foot of air. In comparison, a Class 1000 Clean Room has a maximum of no more than 1000 particles equal to or greater than 0.5µm per one cubic foot of air.

The alternate method of rating a Clean Room is by Class 1 (i.e. Class 0.1) and continuing to Class 6 (i.e. Class 100,000)

1.1.1. LEVEL OF PROTECTION

While a Clean Room fire typically begins in the utility and process tool equipment[1] (e.g. steppers, wet benches, etc) electronic equipment (control cabinets, high voltage switching systems, etc) and cabling (cable trays, ducts, etc) can pose a risk. It is imperative to identify ALL possible areas that a fire may start and ensure that adequate detection and protection is allocated.

The following guidelines are to assist consultants and designers achieve the optimum level of detection required within Clean Room environments. International 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 Design Guide.

Table 1 shows the possible areas of protection of a Clean Room.

Areas	Essential	Recommended
Clean Zone		
- Floor Void	✓	
- In-Cabinet	✓	
Sub Floor		
- Cooling Coil	✓	
- Ceiling		✓
Ceiling Void		✓

Table 1 Areas of Protection

The following sections will describe design recommendations related to the different detection areas. All pipework 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.

1 DeGiorgio, V., Johnson, P. , Mingchun, L., (2001) Fire engineering approach to detection of smoke in semi-conductor fabs

2. PERFORMANCE BASED DESIGN

Performance-based design provides an alternate fire protection system by assessing the environmental risks at the concept design stage. For Clean Room environments, 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 VESDA detection system by accurately identifying smoke travel from previously acknowledged risks.

In areas where Performance-based design is not recognised, 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 application basics outlined in this Design Guide.

NOTE: 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 be conducted during the completion stage of the Clean Room. It is ESSENTIAL that these tests be conducted with the full co-operation of the facility Safety Officers.

3. PRIMARY SAMPLING

The main fire risk in a Clean Room facility is the high-value manufacturing and production equipment, i.e. utility and process tools such as steppers, stockers, lithography machines and wet benches etc.

To adequately protect the high-risk equipment with aspirating smoke detection, it is important to consider the following guidelines:

- Locate detection on the process tools. Various equipment manufacturers install VESDA as a standard internal feature of the actual process tool.
- Maintain short sampling pipe runs to reduce smoke transport time.
- Sampling holes on Return Air Systems should be placed in the direct line of airflow to achieve a consistent flow to the detector.[2]
- Sampling hole concentration should be increased proportionally in relation to air speed (Refer Table 2).
- The detectors used in the Sub Floor (under the waffle floor) area should individually cover no more than 400 square metres.

3.1. CLEAN ZONE PROTECTION

In a high-airflow environment, it is important to acknowledge that smoke generated will quickly dissipate. The most efficient way of detecting the low levels of smoke is to position sampling pipework in the direct line of the airflow and in close proximity to the identified risk (i.e. process tool equipment).

NOTE: The number of air changes determines the density and number of sampling points required to overcome the incidence of increased air dilution.

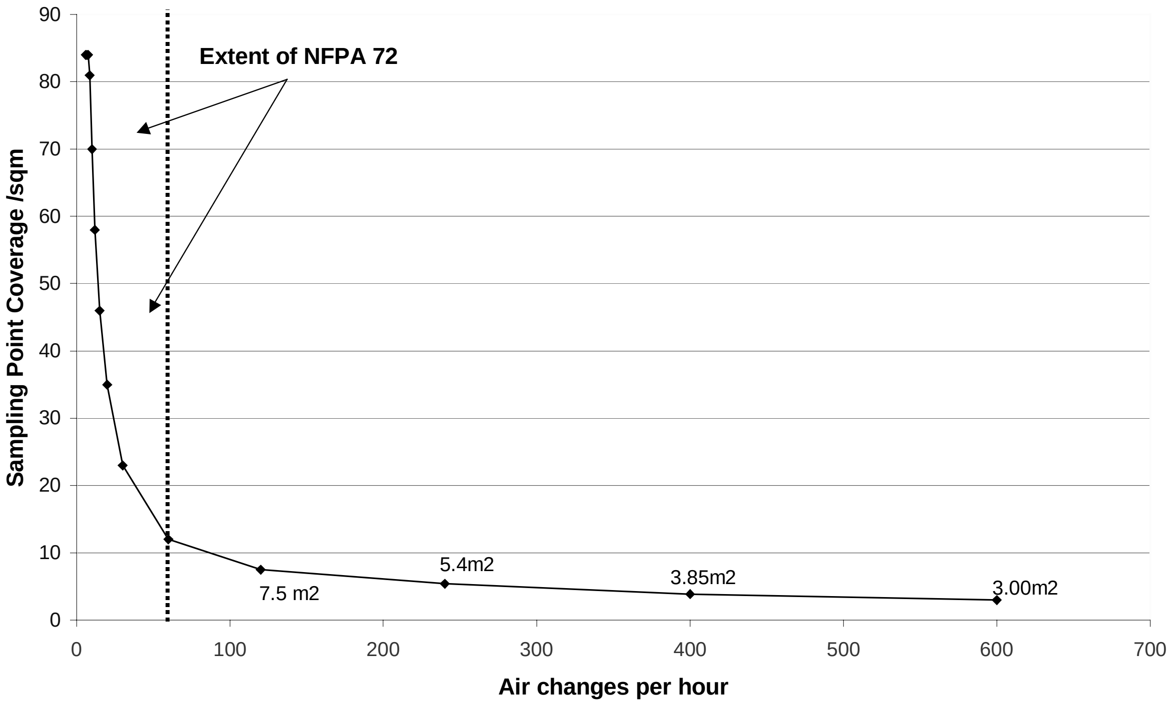


Table 2 Air changes/hour versus sampling hole concentration for underfloor protection

NOTE: In areas with more than 350 air changes per hour, it is recommended that each detector not sample more than 45sq/m.

2 DeGiorgio, V. (2001) Performance-Based Design Evaluation for Fab Smoke Detection Systems

3.2. OBJECT DETECTION

Clean Room facilities accommodate a large number of utility/process tools that are housed within freestanding cabinets. In-cabinet or floor void sampling located at the cabinet exhaust provides optimal detection of a fire originating in these units. This can be achieved by locating sampling holes at the cabinet exhaust air duct, typically located in the floor void (Refer Figure 1), or inside the cabinet. (Refer Figure 2).

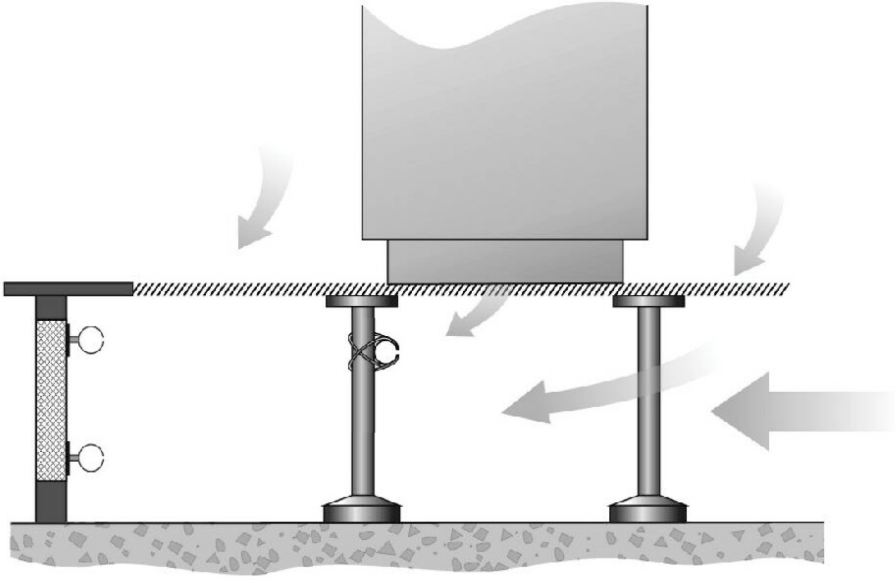
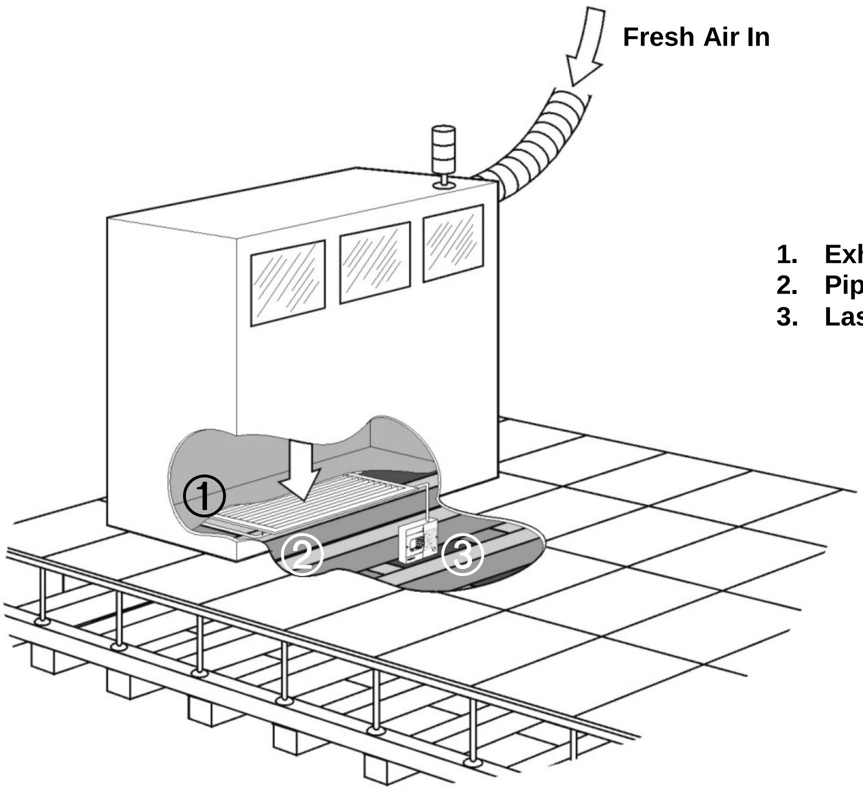


Figure 1 Sampling the airflow from a process tool exhaust



1. **Exhaust**
2. **Pipework under exhaust**
3. **LaserCOMPACT**

Figure 2 Sampling the airflow from inside a process tool cabinet

3.3. SUB FLOOR PROTECTION

Protecting the Sub Floor (i.e. lower level of a Clean Room facility) is difficult to address due to the wide range of risks associated with this area. The Sub Floor area may simply act as a return air plenum or additionally may contain the cooling coil, Uninterruptable Power Supply (UPS) systems, the Air Handling Unit (AHU) or other associated equipment.

Listed below are several features common to the Sub Floor area and their associated risks. Suggested pipework sampling configurations are discussed for each.

3.3.1. COOLING COIL

The cooling coil is a primary sampling location in the Sub Floor area. Positioning the pipe across the cooling coil allows sampling to occur in the direct line of the Clean Room airflow prior to it entering the AHU. This provides the earliest possible warning of a potential fire. (Refer to Figure 3)

NOTE: It is also important to sample air before it enters the cooling coil, as the unit may also be fitted with a pre-filter, which can remove particulate before it reaches the AHU.

Due to the high amount of airflow through the cooling coil, it is important to decrease the spacing between sampling holes on VESDA pipe. In Clean Zones with less than 350 air changes per hour, it is recommended that the number of sampling holes correlate with Table 2. In areas with more than 350 air changes per hour, it is recommended that each detector not sample more than 45sq/m.

Pipework should be located between 50 and 200mm away from the surface of the cooling coil to avoid turbulence at the cooling coil surface.

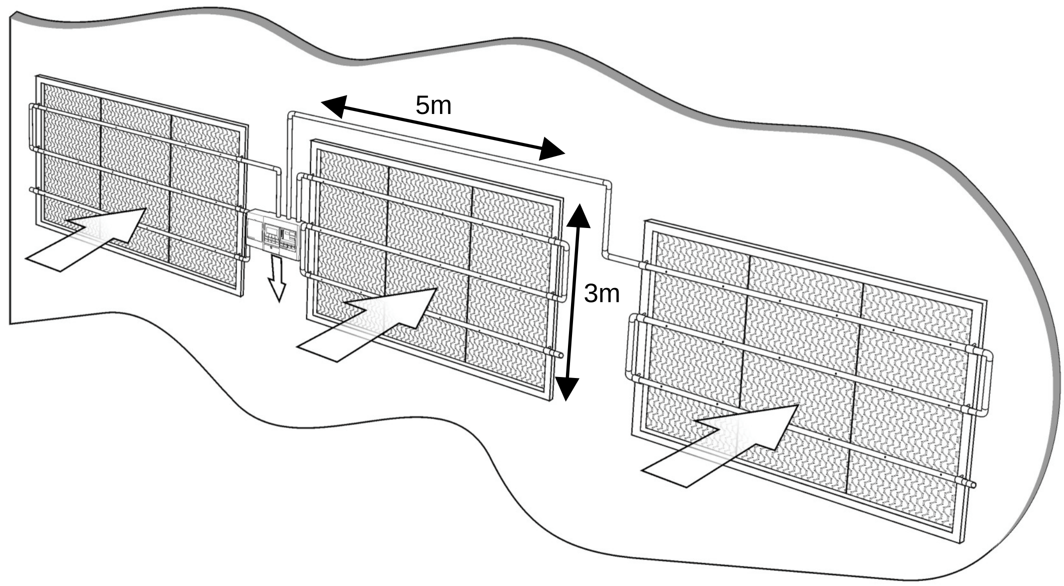


Figure 3 Sampling at the Cooling Coil

3.3.2. AIR HANDLING UNIT

The level of airflow and class of a Clean Room is highly dependent on the size and capacity of the air handling system. The AHU is primarily a large, powerful unit that generates the high airflow required to maintain the ultra-clean environment of the Clean Room. If a potential fire event were to occur within the AHU, it would need to progress to a substantial phase to be detected inside the Clean Zone. As smoke particles pass through the HEPA/ULPA filters, it is recommended that sampling pipework is placed in the immediate airflow of the AHU (Refer Figure 4), or inside individual AHU cabinets, if many AHU's are used (Refer Figure 5).

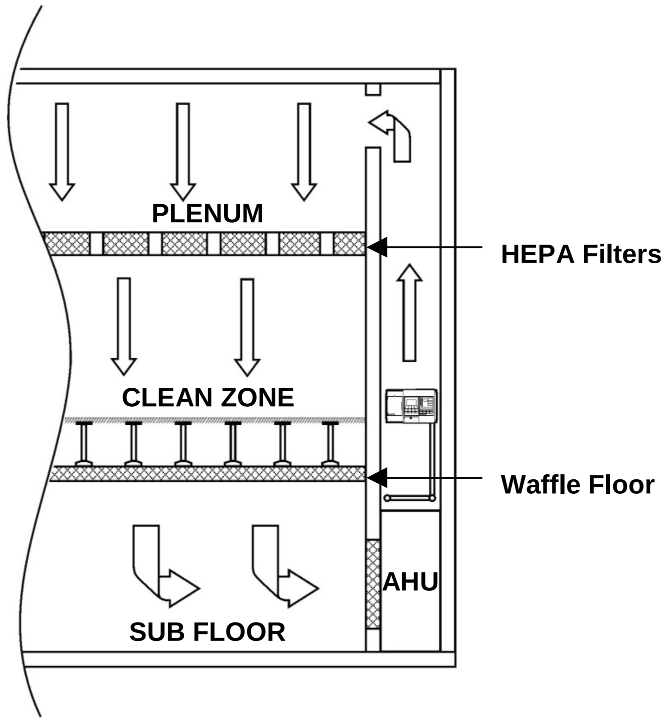


Figure 4 Sampling above the AHU system

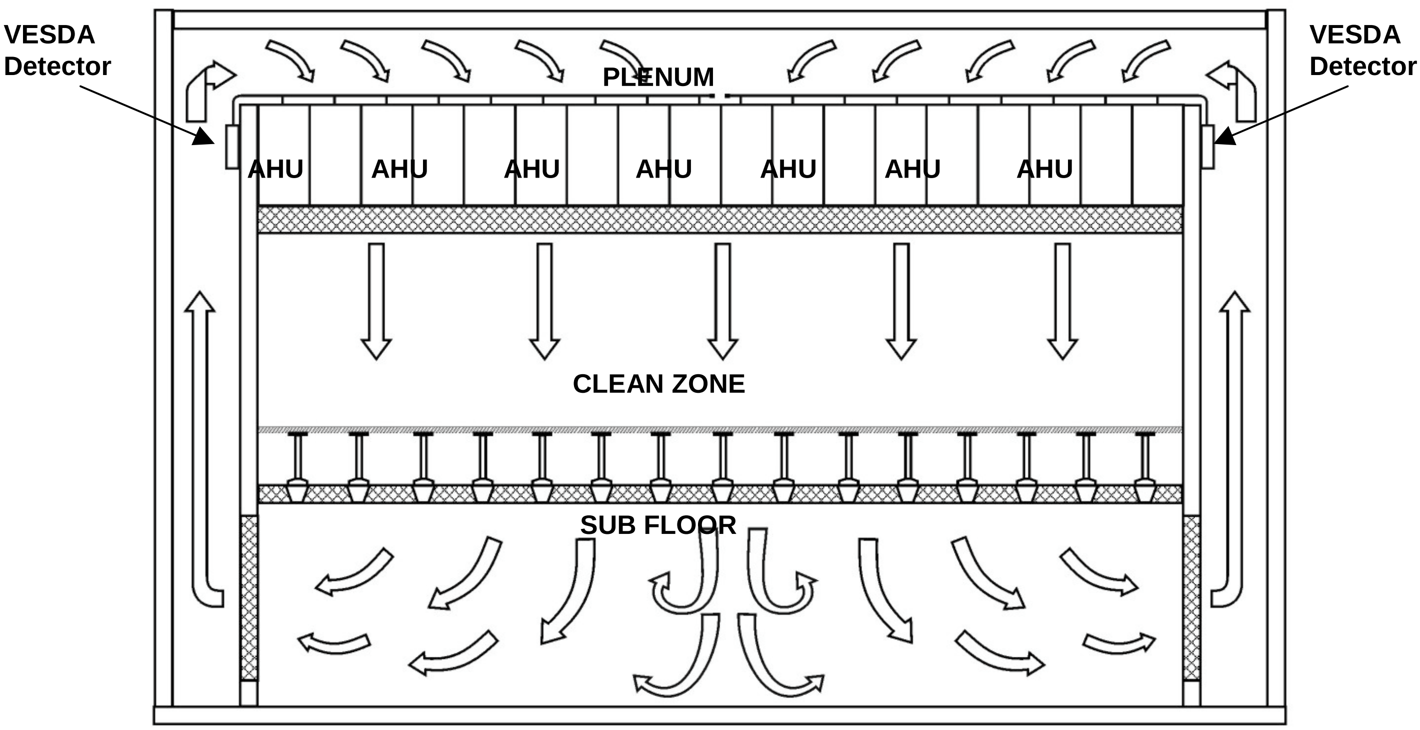


Figure 5 Sampling inside the AHU cabinets

3.3.3. UNINTERUPTABLE POWER SUPPLY SYSTEMS (UPS)

Clean Room facilities consume an enormous amount of power and typically operate 24 hours a day, 7 days a week. If a power failure occurs mid-process, the manufacturing downtime will lead to a substantial drop in Integrated Circuit (IC) yield. While Uninteruptable Power Supply (UPS) units address the risk of Clean Room power shutdown, their high electrical demand is a further fire hazard.

The installation of in-cabinet or above-cabinet sampling (Refer Figure 6) of the UPS unit provides the earliest detection of a fire incident. VESDA detectors can be configured to provide sampling of multiple units.

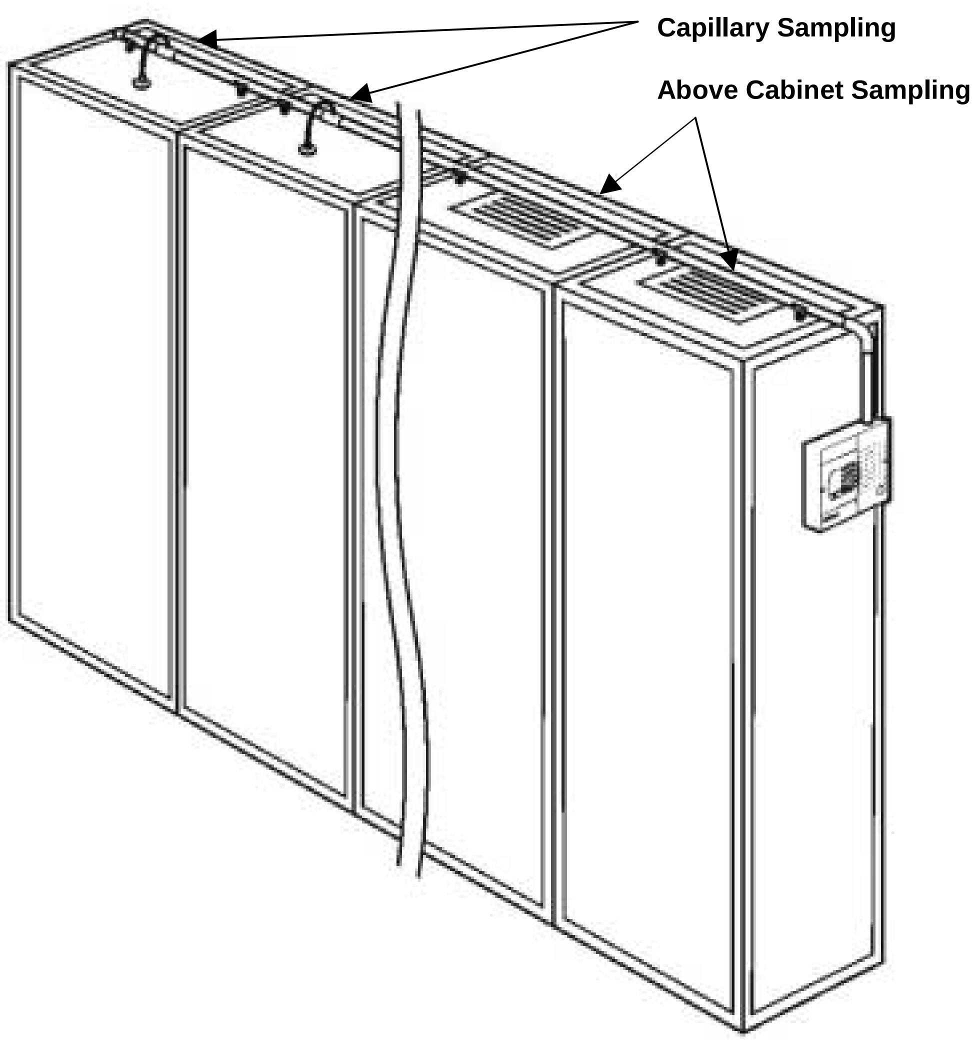


Figure 6 Capillary and Above Cabinet Sampling

4. SECONDARY SAMPLING

In addition to the primary sampling methods, additional sampling may be necessary depending on the particular Clean Room environment.

4.1. SUPPLY AIR MONITORING

In a Clean Room facility, there is an entry point for fresh air to be introduced into the air cycle. This external air is typically pre-filtered by the HEPA/ULPA filter and therefore unlikely to cause an alarm, however, pollution from the fresh air makeup can reduce the lifespan of the HEPA/ULPA filters. By locating pipework at the fresh air input, both the level of pollution and possible degradation of the filter unit can be monitored.

5. MAINTENANCE

VESDA reduces the long-term costs of maintenance and servicing. Normal maintenance does not require regular access to the pipework or sampling points, and there are no logistic issues or requirements such as disruption to operations (i.e. Clean Zone closure). This is particularly advantageous if detection is located above the HEPA filter. The need to service sampling points is lessened, therefore reducing the requirement to remove the filters and the subsequent cost this can incur.

The VESDA detector is mounted at an easily accessible height and position within the Clean Room facility, allowing for ease of maintenance and servicing.

6. GLOSSARY

CFD Modelling: Computational Fluid Dynamics modelling provides an accurate, computerised simulation of the airflow in a Clean 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.

Clean Zone: The area of a semiconductor Clean Room where Integrated Circuits (ICs) are produced. The Clean Zone is maintained at a certain level (or class) of cleanliness.

Clean Room 'Class' levels: The 'Class' of a site is dictated by the level of particles equal to or greater than 0.5µm in one cubic foot of air sampled from the Clean Zone. A Clean Room that is identified as Class 1 has a maximum of one particle equal to or greater than 0.5µm per cubic foot of air. In comparison, a Class 1000 Clean Room has a maximum of no more than 1000 particles equal to or greater than 0.5µm exist per one cubic foot of air.

The alternate method of rating a Clean Room is by Class 1 (i.e. Class 0.1) and continuing to Class 6 (i.e. Class 100,000)

Cooling Coil Unit: (Also known as a dry coil.) The cooling coil is located in the Sub Floor area of the Clean Room. It is the cooling element of the air handling system and is positioned in the direct path of the airflow to maintain the temperature of the Clean Room.

FACP: Fire Alarm Control Panel

HEPA/ULPA Filters: High Efficiency Particulate Air (HEPA) and Ultra Low Particle Air (ULPA) filters are available in different classes. The type of filter has direct reference on the class of the Clean Room they are installed in, as they dictate the number of particles present in the air once airflow becomes a factor.

Integrated Circuit: Commonly referred to as a microchip.

Sub Floor: The area below the Clean Zone, which acts as a return air plenum and typically, contains utility and support equipment.

Waffle Floor: The structural framework which suspends the Clean Zone above The Sub Floor. Typically constructed of overlaid concrete pylons, when viewed from above, this typically resembles a 'waffle cone'.

µm Unit of measurement. 1µm = 1 micron

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