Preface

System Sensor has produced this Design Guide as a reference, to be consulted when designing and specifying System Sensor fire protection solutions for Clean Rooms of all sizes. There is a significant fire risk within such environments due to the high volume of electrical equipment, continuous air supply, operation of fully automated processes and presence of flammable/explosive substances. In addition to the fire risk, smoke detection is made more difficult by air movement caused by the forced ventilation required to maintain the sterile environment.

In this Design Guide we will discuss the relevant design considerations and make recommendations regarding the most effective way in which to install a System Sensor solution in the particular Clean Room environment for which it is being designed.

The majority of Clean Rooms are typically found in the following facilities:

- Semiconductor manufacturing plants.
- Electronic device manufacturing plants.
- Pharmaceutical processing plants.
- Research and development laboratories.

**Important Note:** The information contained in this Design Guide should be used in conjunction with specific local fire codes and standards as well as the guidelines provided in the System Sensor System Design Manual[1]. Where applicable, other regional industry practices should also be adhered to.
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Note: This document intended only as a guide to the application of fire detection systems.
Reference must be made to relevant national and local standards.
1. Background Information

1.1 Fire Safety Considerations in Clean Rooms

The major fire risks and detection difficulties within Clean Rooms arise as a result of the following:

- Utility and process tool equipment faults.
- Electrical faults in cabling or other electrical and electronic equipment.
- The Over Head Transport (OHT) System.
- The presence of large amounts of flammable and explosive materials.
- Potential rapid fire growth resulting from the delayed control of forced ventilation.
- Rapid fire spread as a result of the air circulation used to filter out pollutants.
- Air movement dilution of and interference with the normal dispersion of smoke (Figure 1), making its detection by conventional technologies extremely difficult.

![Low air velocity smoke distribution.](image1)

![High air velocity smoke distribution.](image2)

*Figure 1 – Examples of the way in which different air velocities affect the dispersion of smoke.*

**Important Note:** For new generation facilities, it is recommended that smoke tests or Computational Fluid Dynamics (CFD) models be used to determine the optimum arrangement of the System Sensor sampling pipes, based on predicted smoke movement paths with reference to the above risks.

1.2 Performance-Based Design

The unique environments within Clean Rooms present a challenge to both early and reliable fire detection. There is a high likelihood that detection system performance will be dependent on air change rate, air velocity in the particular area and the geometry of the area to be protected. The flexibility of Performance-Based Design, while still following rigorous engineering processes, allows the fire protection system to be tailored to the specific requirements of each individual application’s environment, with the commercial drivers to manage the risks.
Detector spacing or, for a System Sensor pipe, sampling hole spacing is traditionally dictated by local prescriptive codes and standards. In a more performance-based approach, each installation is assessed according to its specific environmental conditions. Sampling hole spacing and location can then be altered easily to suit the particular performance requirements.

The Performance-Based Design approach is widely used since it can provide evidence to justify divergence from prescriptive requirements, particularly in cases where there are practical limitations or a need for an improved level of fire protection. There are some specific guidelines for the use of Performance-Based Design and risk management concepts.

Examples of these codes and standards are listed below:

- International Fire Engineering Guidelines (Edition 2005)\textsuperscript{[2]}
- British Standard BS 7974\textsuperscript{[3]}
- SFPE Engineering Guide to Performance-Based Fire Protection\textsuperscript{[4]}
- AS/NZ 4360 Risk Management Standard\textsuperscript{[5]}
- SFPE Handbook of Fire Protection Engineering Third Edition\textsuperscript{[6]}

Performance-Based fire protection solutions can be made to comply with local and international codes and standards for buildings and life safety. Assessments of the environmental risks and performance requirements, specific to the particular Clean Room Facility, are conducted as part of the design process.

**Note:** The SFPE Code Officials’ Guide to Performance-Based Design Review\textsuperscript{[7]} is also a very good source of information for Authorities Having Jurisdiction (AHJs) reviewing and assessing a System Sensor system design for a Clean Room.

### 1.3 Key Design Considerations

The following should be considered when designing a System Sensor system for a Clean Room:

1. What level of protection is required and how will fire safety be managed?
2. Do local codes and standards recognise Aspirating Smoke Detection (ASD) technology for primary protection or will it be necessary to employ Performance-Based Design principles to design a System Sensor system with point (spot) type smoke detector equivalent performance?
3. Which areas require protection (Fab, Under Floor Void (UFV), Sub-fab, Dry Coils, Air Handling Unit (AHU), ceiling void and/or individual tools)?
4. What equipment represents a primary fire hazard, process tools (e.g. wet benches, steppers, stockers, ion implanters, photolithography equipment etc), and where is it located within the Clean Room?
5. Where are the AHUs, filter and pre-filter systems located?
6. What will be the effect on airflow patterns and smoke detection of parameters such as ceiling height, room geometry and equipment locations/dimensions?
7. Are there likely to be future operational changes such as new equipment, a change in perforated floor tile location etc?
8. Will particular pieces of equipment require additional individual ‘object’ protection?
9. Is the integrity of the pipe network adequate with respect to being air-tight?
10. Where fire suppression is also installed, how can the System Sensor system be used to actuate it?
11. How are the fire protection and security systems to be integrated within the site emergency control centre?
12. What do local industry codes of practice for Clean Room fire safety dictate?
13. What do industry fire codes and standards recommend (e.g. NFPA 318\textsuperscript{[8]} and BS 5395\textsuperscript{[9]})?
14. What are the relevant Performance-Based Design practices (e.g. the International Fire Engineering Guidelines\textsuperscript{[2]}, BS 7974\textsuperscript{[3]} or those of the SFPE\textsuperscript{[4]})?
Important Note: The arrangement of process tools and other equipment will affect the speed and direction of the airflow. It is strongly recommended, therefore, that performance tests be conducted once the system is installed. All such tests should be carried out with the full cooperation of the facilities safety officers.

1.4 Why Use System Sensor Smoke Detection?

It is essential that fire events in Clean Rooms be detected as early as possible, to avoid asset damage, leading to costly business disruption, and to ensure occupant safety.

The limitations of point (spot) type smoke (even the ones with high sensitivity) and heat detectors must be considered. The comparatively low sensitivity of point (spot) type smoke detectors, for instance, can mean that fire events will not be detected soon enough in many cases. Rather than behaving as they normally would, both smoke and heat from low energy fires will tend to follow the air streams created by the AHUs with the following consequences:

- Air movement, filtering and the introduction of clean air during the air conditioning cycle will all cause smoke dilution. This consequence impairs the performance of point (spot) type smoke detectors.
- The cooling effects of the air conditioning will decrease the temperature of the smoke plume. This consequence impairs the performance of both point (spot) type smoke and heat detectors.

Note: The performance of point (spot) type smoke detectors may also be restricted by the velocity of the air/smoke passing across the detection chamber and/or its temperature.

The Very Early Warning Fire Detection (VEWFD) capability of the System Sensor system allows it to minimize the risks, discussed in section 1.1, and combat the detection difficulties caused by air movement in the following ways:

- System Sensor detectors can be configured as both early warning and very early warning devices, thus, if both are required only one technology need be installed.
- A System Sensor system can detect fires very early, at the incipient (smoldering) stage. This provides staff with an opportunity to investigate and take action, before the smoke contamination can irreversibly damage process tools or the products being manufactured.
- The very early warning capability of the System Sensor system also minimizes the rapid fire growth and spread facilitated by the high air movement.
- Since the security precautions necessary to ensure the maintenance of the sterile environment within the Clean Room also complicate evacuation, very early warning will allow more time to execute an evacuation.
- A System Sensor system has a better chance of detecting smoke that has been diluted than conventional point (spot) type smoke detectors. This is due to the fact that air collected by several sampling holes, at different locations within the protected area, is being analyzed simultaneously by the same detector (aggregated sampling effect).
- A System Sensor system actively draws air into its sampling holes which increases the chance of smoke being detected. Passive smoke detectors rely on smoke reaching them via diffusion or using the thermal energy of the fire. Thus the detection of smoke by passive detectors would be less likely where air movement is being artificially directed as well as being cooled.
- There is a comparatively low incidence of nuisance alarms with a System Sensor system; a feature which will minimize the possibility of unnecessary evacuations.
- In cases where fire suppression is to be included, as part of the overall fire protection system, the System Sensor detectors' wide sensitivity range of 0.005 to 20%Obs/m (0.0015 to 6%Obs/ft) means that appropriate alarm thresholds can be set for both early detection and, at a later stage in the fire event, the activation of the suppression release mechanisms.
2. Levels of Protection From the System Sensor System

2.1 Protection Areas

The recommended levels of protection, for the various areas within a Clean Room, are presented in Table 1.

Table 1 – The type of protection necessary in various areas within a Clean Room.

<table>
<thead>
<tr>
<th>Area</th>
<th>Essential</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAB Area Ceiling</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Under Floor Void (UFV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Perforated UFV</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>• Solid UFV Space</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>• Solid UFV Dry Coils/Return Air Vents</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Sub-fab Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• UWS Ceiling</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>• Dry Coils/Return Air Vents</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>• Ancillary High Risk Areas</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Air Handling Unit (AHU)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Object Protection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Utilities &amp; Process Tools</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>• Power Rooms</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Truss and Ceiling Void</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Over Head Transport Utilities</td>
<td></td>
<td>✔</td>
</tr>
</tbody>
</table>

The System Sensor Fire alarm levels can be set to provide sampling hole sensitivities equivalent to point (spot) type smoke detectors. The Alert and Action alarm levels are used as part of the emergency procedure controlled from the site Emergency Response Centre.
2.2 The Effects of Airflow

Detector coverage is dependent on the air movement within the Clean Room area. Rather than using air change rate, which is a function of the volume of the enclosure, airflow within Clean Rooms is represented by a quantity known as the average air velocity. Measurements of the average air velocity are usually made at the following locations:

- 0.3 m (1 ft) beneath the Filter Fan Units (FFUs).
- Under Waffle Slabs (UWSs).
- Across the Dry Coils/Return Air Vents.

Since all Clean Rooms vary in size and have differing ventilation arrangements (FFUs, AHUs or Fan Towers), their average velocities will also vary. However, the guidelines outlined in this Design Guide are applicable to any Clean Room. The average air velocity can also vary widely from one area, within the Clean Room, to another. This must be taken into account when designing a VEWFD system. Table 2 contains examples of a typical range for measurements of the average air velocity.

### Table 2 – Examples of typical average air velocity measurements.

<table>
<thead>
<tr>
<th>Average Air Velocity Level</th>
<th>Below The FFUs (m/s (fpm))</th>
<th>At The Dry Coils/Return Air Vents (m/s (fpm))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.15 (30)</td>
<td>0.75 (150)</td>
</tr>
<tr>
<td>Average</td>
<td>0.30 (50)</td>
<td>1.10 (220)</td>
</tr>
<tr>
<td>Medium</td>
<td>0.60 (120)</td>
<td>2.30 (460)</td>
</tr>
<tr>
<td>High</td>
<td>1.20 (240)</td>
<td>4.70 (940)</td>
</tr>
<tr>
<td>Very High</td>
<td>2.40 (480)</td>
<td>9.50 (1900)</td>
</tr>
</tbody>
</table>

**Note:** The average air velocity, in the locations listed above, can usually be obtained from the Mechanical Services designers before beginning the Fire Protection System design.

2.3 Detector Coverage Comparisons

For the purposes of this Design Guide, the recommended area of coverage for System Sensor detectors is based on the following factors:

- The fire size to be detected.
- Air velocity in the protected area.
- Maximum Transport Time permitted by the PipeIQ pipe network modelling program.
- Sampling hole spacing rules.

Throughout the remainder of this Design Guide, recommendations regarding the appropriate System Sensor detector area of coverage and sampling hole spacing will be provided.

Critical areas within a Clean Room require Very Early Warning Fire Detection (VEWF), while other areas may only require Early Warning Fire Detection (EWFD). System Sensor systems can be designed to provide VEWFD or EWFD depending on the area in question. When designed to provide EWFD, the cost of the System Sensor system deployment is reduced.

Table 3 illustrates the relationships between detector coverage and the factors listed above for VEWFD in comparison to EWFD.
Table 3 – Comparison of the factors affecting detector area of coverage for VEWFD and EWFD.

<table>
<thead>
<tr>
<th>Factor</th>
<th>VEWFD</th>
<th>EWFD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of Protection</td>
<td>Very High</td>
<td>High</td>
</tr>
<tr>
<td>Detector area of Coverage</td>
<td>Smaller</td>
<td>Larger</td>
</tr>
<tr>
<td>Air Velocity</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Sampling Hole Spacing</td>
<td>Reduced</td>
<td>Increased</td>
</tr>
<tr>
<td>Maximum Transport Time</td>
<td>Shorter</td>
<td>Longer</td>
</tr>
</tbody>
</table>

It is clear from the information presented in Table 3 that as the air velocity within the protected area increases, all other factors shall be decreased in order to achieve VEWFD.

**Important Note:** All pipe network designs should be verified by System Sensor’s Pipe Network Modelling Tool, PipeIQ™.

3. **Fab Area Ceiling Protection**

The Fab area contains the manufacturing and process tools (Figure 2) which represent some of the major fire risks outlined previously (Section 1.1).

![Figure 2 – Illustration of a typical Fab area in a Clean Room.](image)

Circulating air, introduced through the ceiling and removed through the floor, will dilute smoke and affect its dispersion pattern. Therefore, in comparison to conventional point (spot) type smoke detectors, ceiling mounted System Sensor sampling pipes are a reliable and effective way of detecting smoke under these circumstances.

**Note:** The sampling pipe network can be placed directly on the ceiling below the FFUs with the sampling holes facing downward.

The System Sensor system is designed to replace point (spot) type smoke detectors with equivalent or better detection performance. The point detectors, acting as a benchmark of the performance, are subject to local or international fire codes or standards, such as NFPA 72, regarding detector spacing. Following similar sampling spacing, the recommended detector coverage, for a single System Sensor detector’s pipe network, varies from 600 to 1,000 m² (6,455 to 10,760 sq ft) (Figure 3). While not specified by local code, the System Sensor sampling hole spacing can be selected as from 8x8 m to 4x4 m (26x26 ft to 13x13 ft) accordingly.

**Important Note:** The spacing listed in this DG are sampled values. The actual dimensions of the spacing may vary according to the building structure.
Figure 3 – Recommended detector coverage and spacing for ceiling mounted sampling pipes in the Fab area.

Shown in Figure 3 are guidelines for designing System Sensor systems. Increasing sampling hole density (reducing sampling spacing) or reducing detector coverage does raise up the protection level. An example may be applying 6x6 m (20 ft x 20 ft) spacing to a Fab area with lower FFU velocity (<0.6 m/s (120 fpm)) and keeping detector coverage as 600 m² (6,455 sq.ft). In such case required spacing for point (spot) type smoke detector may be even greater than that for the System Sensor. Designers should select the parameters by considering local codes for ASD and point type smoke detectors as well as industrial practice in regions.

**Important Note:** Since all Fab areas vary with respect to layout and specifications, an assessment of each should be conducted to determine factors such as air change rate, equipment location etc as part of the design process. Different detector coverage and sampling spacing may be applied in the same Fab structure.

**Note:** Future Clean Rooms are expected to have higher Fab and Sub-fab area ceilings. This will make the System Sensor system’s VEWFD capabilities even more crucial.

Even certain level of protection can be received from System Sensor Fab ceiling detection under relatively high room air flow rates, it’s not recommended to apply this protection option for Fabs with FFU velocity above 0.3 m/s (60 fpm) while Sub-fab ceiling detection presented. Under such conditions, the Sub-fab ceiling detection can provide more reliable and cost-effective protection, see Section 5.

4. **Under Floor Void (UFV) Protection**

The Under Floor Void (UFV), used to house cable trays, is located between the Fab and Sub-fab areas. There are two possible configurations for the UFV: a perforated or solid (non-perforated) floor void as shown (Figure 4). For solid floor void, it usually also serves as a return air plenum, feeding air back to the AHU or return air shaft via Dry Coils.
Figure 3 – Recommended detector coverage and spacing for ceiling mounted sampling pipes in the Fab area.

Shown in Figure 3 are guidelines for designing System Sensor systems. Increasing sampling hole density (reducing sampling spacing) or reducing detector coverage does raise up the protection level. An example may be applying 4x4 m (13x13 ft) spacing to a Fab area with lower FFU velocity (<0.6 m/s (120 fpm)) and keeping detector coverage as 600 m$^2$ (6,455 sq.ft). In such case required spacing for point (spot) type smoke detector may be even greater than that for the System Sensor. Designers should select the parameters by considering local codes for ASD and point type smoke detectors as well as industrial practice in regions.

Important Note:
Since all Fab areas vary with respect to layout and specifications, an assessment of each should be conducted to determine factors such as air change rate, equipment location etc as part of the design process. Different detector coverage and sampling spacing may be applied in the same Fab structure.

Note:
Future Clean Rooms are expected to have higher Fab and Sub-fab area ceilings. This will make the System Sensor system’s VEWFD capabilities even more crucial.

Even certain level of protection can be received from System Sensor Fab ceiling detection under relatively high room air flow rates, it’s not recommended to apply this protection option for Fabs with FFU velocity above 0.3 m/s (60 fpm) while Sub-fab ceiling detection presented. Under such conditions, the Sub-fab ceiling detection can provide more reliable and cost-effective protection, see Section 5.

4. Under Floor Void (UFV) Protection
The Under Floor Void (UFV), used to house cable trays, is located between the Fab and Sub-fab areas. There are two possible configurations for the UFV: a perforated or solid (non-perforated) floor void as shown (Figure 4). For solid floor void, it usually also serves as a return air plenum, feeding air back to the AHU or return air shaft via Dry Coils.
4.1 Perforated Floor Void Protection

In this configuration, air exits directly downwards into the Sub-fab area through the perforated floor tiles. These tiles form part of the Under Waffle Slab (UWS) ceiling structure of the Sub-fab area.

For a single System Sensor detector, the recommended areas of coverage relative to the average air velocity, measured at the FFU in an UFV with a perforated floor void, are shown (Figure 5).

![Figure 5 – Recommended detector coverage, for different average air velocities, in an UFV with a perforated floor void.](image)

Both detector area of coverage and sampling hole spacing are reduced as average air velocity increases, to maintain high System Sensor detection performance. The sampling pipe network is positioned at approximately half height of the void.

**Important Note:** In general, it is acceptable for sampling holes to face in the same direction as the airflow. However, in cases where the airflow characteristics are likely to vary, it is necessary to orientate the sampling holes at an angle of 30º to the direction of airflow. This neutralizes pressure difference effects at the sampling holes.

If conventional point (spot) type smoke detectors are being used to protect the Fab ceiling in a high airflow environment (FFU average air velocity of >1.2 m/s (240 fpm)), the area of coverage per System Sensor detector and sampling hole spacing within the UFV must be reduced to provide VEWFD. Detector coverage should be between 200 and 300 m² (2,100 – 3,200 sq.ft); sampling hole spacing being 4 m (13 ft). Under these circumstances, the System Sensor system should still detect Fab area fire events which would not be detected by point (spot) type smoke detectors mounted on the Fab ceiling.

**Note:** Due to the limited space within the UFV, the use of continuous, flexible HDPE piping is recommended to avoid interference with equipment foundations and hookup piping/ducting. When using this type of material, compression or electric fusion joints are necessary.
4.2 Solid Floor Void Protection

4.2.1. Void Space Protection

In this case, the floor of the return air plenum is non-perforated so air is returned via Return Air Vents/Dry Coils similar to those in the Sub-fab area. These Return Air Vents are generally of smaller size than those in the Sub-fab. There is no waffle slab and the air is returned horizontally, hence, it is essential to protect the cabling and any equipment with its exhaust venting into this area (Figure 6). Sampling hole orientation should be at an angle of 30º to the direction of airflow.

![Figure 6 - Air sampling in a Fab with a solid UFV.](image)

For a single System Sensor detector, the recommended areas of coverage relative to the average air velocity, measured at the FFU in an UFV with a solid floor void, are shown (Figure 7).

![Figure 7 - Recommended detector coverage, for different average air velocities, in an UFV with a solid floor void space.](image)

The area of coverage per System Sensor detector varies with the average air velocity to ensure the optimum detection performance.

Due to the airflow pattern within the UFV, sampling holes are arranged in a zigzag or alternating manner as shown (Figure 8) to maximize coverage.
4.2.2. Dry Coils/Return Air Vent Protection

Refer to Section 5.2 for the recommendations of System Sensor detector coverage and sampling hole spacing.
5. **Sub-fab Area Protection**

In its simplest form, the Sub-fab area serves as a return air plenum of a Clean Room where perforated floor void presents. Quite commonly, it also houses the support equipment associated with the manufacturing equipment contained above in the Fab area. Sometimes, in the case of LCD manufacture for example, a proportion of the manufacturing process actually takes place in the Sub-fab area. In other instances, automated product transport conveyers and shuttles may also be present. Thus, there is a significant fire risk in this area which makes its protection essential. A typical Sub-fab area is shown below (Figure 9).

![Figure 9 – Illustration of a Sub-fab area.](image)

The next two sections contain recommendations on detection methods suited to the protection of a number of features common to Sub-fab areas.

5.1 **Under Waffle Slab (UWS) Ceiling Protection**

This is a common protection practice in Clean Rooms today. System Sensor systems in this protection provide a high level protection for the Fab area, as well as certain level of protection when the fires are originated from the Sub-fab area.

For a single System Sensor detector, the recommended areas of ceiling detector coverage relative to the average air velocity, measured at the FFU in a Sub-fab area, are shown (Figure 9).

System Sensor pipe networks can be mounted 0.5-0.8 m under the waffle slab ceiling with sampling holes facing up against to air flow.
5.2 Dry Coils/Return Air Vent Protection

NFPA 318\textsuperscript{[8]} considers this a primary area of protection. Since this is the last point at which all air will pass before being filtered, it is a critical location for detection in the Clean Room. Placing sampling pipes across the Dry Coils/Return Air Vent as shown (Figure 11) allows the air to be sampled just prior to entering the air handling and filtering systems. This provides reliable and very early warning smoke detection.

![Figure 11 - Example of Dry Coils/Return Air Vent sampling.](image-url)
The pipe network should be positioned 50 to 200 mm (2 to 8 inches) in front of the Dry Coils/Return Air Vent to minimize the possible adverse effects of the air pressure differences created by turbulent airflow at the surface of the vent. Sampling hole orientation, in cases where the airflow characteristics are likely to vary, should be at an angle of 30º to the direction of airflow.

For a single System Sensor detector, the recommended areas of coverage (i.e. across the face of the Dry Coils/Return Air Vent) relative to the average air velocity, measured 200 mm (8 inches) in front of the Dry Coils/Return Air Vent, are shown (Figure 12).

Figure 12 – Recommended detector coverage, for different average air velocities, at the Dry Coils/Return Air Vent in the Sub-fab area.
5.3 Ancillary High Risk Area Protection

Since the electrical equipment within a Clean Room operates twenty-four hours a day seven days a week, a power failure would be undesirable. Uninterruptible Power Supply (UPS) systems are used to avoid such power outages, however, they also represent a significant fire risk. In-cabinet and on cabinet air sampling, of control cabinets and UPS systems, (Figure 13) offers the most effective detection of incipient fires.

![Figure 13 – Example of in/on cabinet air sampling.](image)

The protection of such areas as UPS systems and Server Rooms is identical to the protection of any other Datacom Facility: refer to the System Sensor’s Telecommunications and Data Processing Facilities Design Guide\(^\text{[10]}\). Ceiling mounted detection, governed by local codes and standards such as NFPA 72\(^\text{[11]}\), together with Return Air Vent and in/on cabinet monitoring provides an effective fire protection solution. Alternatively, using small bore detectors such as the VFT-15 enables in cabinet sampling, whilst also providing addressability to the cabinet level.

**Note:** For duct protection, follow the guidelines in Application Note – System Sensor air sampling in ducts\(^\text{[12]}\).
6. **Air Handling Unit (AHU) Protection**

The Clean Room environment is maintained by either a large powerful AHU or a number of smaller FFUs. Since the air being circulated by this equipment is filtered, fires within it would need to become reasonably large before they could be detected externally in the Fab or Sub-fab areas. For this reason, it is recommended that System Sensor sampling pipe networks be placed above the FFUs or inside individual AHU cabinets as shown (Figure 14).

![Figure 14 – Example of FFU air sampling.](image)

7. **Object Protection**

7.1 **System Sensor OEM Solution**

When designing for object protection with a System Sensor system, the System Sensor detector and sampling pipe network are installed on the process tool to be protected. Some manufacturers install System Sensor detectors as an optional feature on their equipment. Sampling pipe length should be as short as possible to minimize Transport Time, thereby, increasing the speed of detection.

System Sensor OEM solutions are usually explicitly designed, in conjunction with the equipment manufacturer, to provide the best possible detection performance for an individual process tool. Solutions can also be designed to meet specific requirements for a particular type of process tool. For more information contact your local System Sensor representative.
7.2 Utilities and Process Tool Protection

A large number of Clean Room utility and process tools are housed within free-standing cabinets. Either in-cabinet or cabinet exhaust air sampling provides the most effective method for the detection of fire events within these cabinets. Sampling pipes are placed at the cabinet exhaust air duct and at critical positions inside the cabinet as shown (Figure 15). Alternatively, a VFT15 system could be used to sample directly from within the cabinet. This gives the added benefit of providing cabinet addressability.

![Diagram of air sampling inside a process tool cabinet.](image)

**Figure 15 – Example of air sampling inside a process tool cabinet.**

**Note:** The manufacturing processes, taking place within this type of equipment, can result in high background levels of debris and process byproducts.

8. Truss and Ceiling Void Protection

The Truss and Return Air Shaft contain large amounts of electrical equipment. By installing System Sensor detectors in the roof space, the overall protection of the entire facility can be increased. Locating them in the roof space also makes them easy to access.

Area of detector coverage and sampling holes spacing can be designed to comply with local standards, allowing the System Sensor system to form the primary detection system in the place of point (spot) type smoke detectors.
9. Commissioning, Service and Maintenance

Once the System Sensor system has been installed, its performance and sampling pipe network integrity can be verified against the original PipeIQ™ design. A range of environmental parameters can be input to determine Maximum Transport Times for each zone. Calculated Transport Times should be applied conservatively.

Smoke tests may also be conducted, as part of the commissioning process, to test system performance. Refer to System Sensor’s latest revision of “Clean Rooms Smoke Test Method” for further details.

The System Sensor alarm thresholds, for optimum protection, can be determined according to the procedure highlighted in the Appendix.

System maintenance should be performed in accordance with local codes and the Clean Room risk management requirements as well as the procedures outlined in the ‘Maintenance’ section of the System Sensor System Design Manual.\[1\]
References

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