# Relative Sensitivity based Fire Detection Systems used in High Density Computer Rooms with In-Row Air Conditioning Units

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***Experts for Your Always Available Data Center***

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## EXECUTIVE SUMMARY

**Preventing fire in mission critical facilities by detecting them at a very early stage is arguably the most proactive step in maintaining a suitable environment for the IT equipment. Fire detection has become a challenge in today's high-end, mission critical, facilities having high-density cooling requirements. This is due primarily to the varying levels of effectiveness of competing detection systems in high velocity airflow computer room environments. The purpose of this white paper is to identify and analyze the effectiveness of relative sensitivity based fire detection systems in a computer room utilizing a high-density, high-velocity, and high volume cooling system.**

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## Introduction

Fire detection and fire suppression have become integral parts of the computer room environmental control infrastructure. Companies run the risk of losing their businesses in the event of a computer room fire.  Fire detection has typically been accomplished using thermal rate-of-rise detectors and smoke detectors. Thermal rate-of-rise detectors depend upon a rapid increase of the temperature in the space that they protect. This rise in temperature requires a substantial amount of fire.  Smoke detectors are designed to sense the presence of smoke particles which are generally referred to as products of combustion.

Fire and smoke detection devices must be utilized in accordance with the equipment manufacturers' recommendations, as well as national, state and local fire protection codes which are usually based upon the publications from the National Fire Protection Association, and the International Building Codes. The NFPA codes: NFPA 72 (fire alarms) and NFPA 75 (fire protection for computer rooms) are a common standard for fire alarm systems, in general and smoke detection, in particular. However, some state and local building codes do not reference these codes directly.

In its simplest form, a smoke alarm in a computer room environment initiates when a smoke detection device senses some form of products-of-combustion, and signals a fire alarm control panel to issue an alarm to alert personnel of a potential fire. This simple operation is normally expanded in a data center to include control of a sprinkler pre-action valve and a gaseous fire suppression system.

Traditionally, spot type smoke detectors are positioned throughout the data center at various locations including the ceiling, within the access floor space, on walls near the ceiling, in the return air, and sometimes the supply air streams of the computer room A/C equipment. These locations were chosen because smoke will normally accumulate near the ceiling, the underside of the access floor, and rise along the wall as well as travel with the airflow associated with the computer room A/C equipment. Note that the use of supply air, smoke detection is linked to the airflow volume of each individual piece of A/C equipment. This design approach was effective as long as the spacing of the spot detectors was based upon the total air change rate for the entire room, and the airflow velocities were low enough to allow air to flow through the sensing chamber of the smoke detector. The two most common smoke detection methods employed in smoke detectors are optical-detection, which is employed in photoelectric smoke detectors, and chemical-reactions, which are used in ionization type smoke detectors. There are detectors available that use both methods to increase sensitivity to smoke. Smoke detectors may operate alone or be cross-zoned. Most data center fire alarm systems do not utilize individual smoke detectors for fire alarm initiation. Where suppression system initiation and/or fan shut down is to occur as part of the alarm matrix, common practice is to cross-zone fire detection devices to ensure more than one device is in alarm, reducing the occurrence of false alarms.

Smoke detectors in the data center are powered from the fire alarm control panel, (FACP). The FACP is normally powered from an emergency electrical power distribution system. PTS recommends connecting the computer room FACP to the computer room's standby power system if available. This will ensure an emergency power source should the normal utility service to the computer room, or the output of the UPS be interrupted. Additionally, the fire alarm system is usually connected to a building-wide fire alarm and/or security system.

Smoke detection is dependent on three variables; the sensitivity of the detector, how clear the smoke path is leading to the detector and how diluted the smoke will be once it reaches the detector. In an area such as a computer room, where the airflows are rapid, it becomes difficult to detect smoke with conventional spot-type detectors. In contrast, an aspirating system's design allows it to detect a fire condition in the incipient stages, before visible smoke is present; this includes particles released from PVC, a common fire load in these types of environments. An aspirating fan and pipe network draws air from the hazard area back to a centrally located detector. Further, a Class1 laser beam analyzes the air to determine the smoke obscuration levels within the protected space via a method of light scattering. The aspirating smoke detection systems process can be up to 1000 times more sensitive than a photoelectric or ionization smoke detector. These systems are capable of detecting byproducts of combustion in concentration as low as 0.00046% obstruction per foot.

## Smoke Detection Methodology

Most of the smoke detectors available in the market are based on the methodology of fixed sensitivity. Smoke detectors based on fixed sensitivity produce an alarm when the ambient smoke level rises above a predetermined and fixed threshold. These systems typically compare the ambient smoke density against predefined alarm levels. The performance of fixed sensitivity detectors is significantly affected by the background smoke levels which vary over time, typically seen in normal working environments.

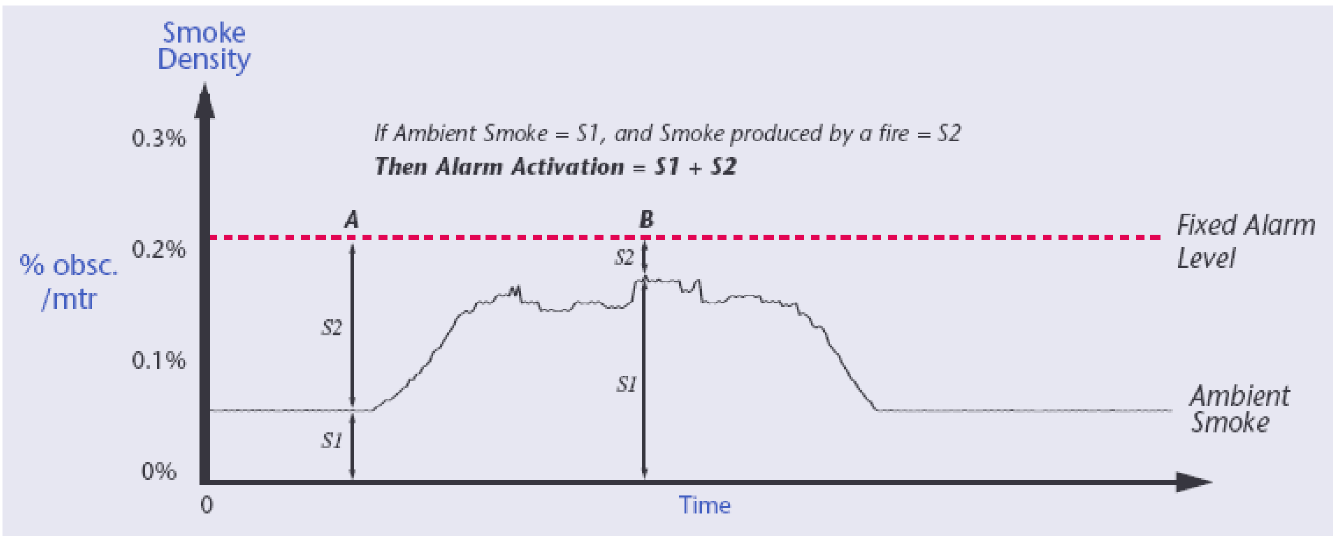


*Figure 1: Fixed Sensitivity (Source: AirSense Technology Limited)*

The above figure shows that, a fixed sensitivity based smoke detection system raises an alarm when the combined smoke density of background smoke and fire smoke reaches the predefined level (can be changed by the user). Initially, ambient smoke density is low and therefore, a relatively large amount of fire smoke is required to generate an alarm. The predefined level doesn't vary with respect to the background smoke. At point 'B' the background smoke level is closer to the predefined level. Due to this point, setting low predefined levels may lead to false alarms. Therefore, it is clear that fixed sensitivity detectors do not have accurate prediction of fire, meaning they have variable sensitivity to fire smoke.

## Relative Sensitivity Aspirating Smoke Detectors

Smoke detectors which do not have a fixed threshold but continuously maintain an appropriate level of sensitivity are said to be based on the methodology of relative sensitivity. These smoke detection systems continuously adapt their sensitivity such that the alarm level is relative to the background smoke levels. At any time, the detector's sensitivity remains constant, regardless of fluctuations in the normal background smoke level. In the figure below, initially the alarm level is at a point with respect to the ambient smoke level. As the ambient smoke level changes, the alarm level is also changed relatively. They constantly trace the ambient smoke level and thus, when there is an increase in fire smoke, they produce an alarm.

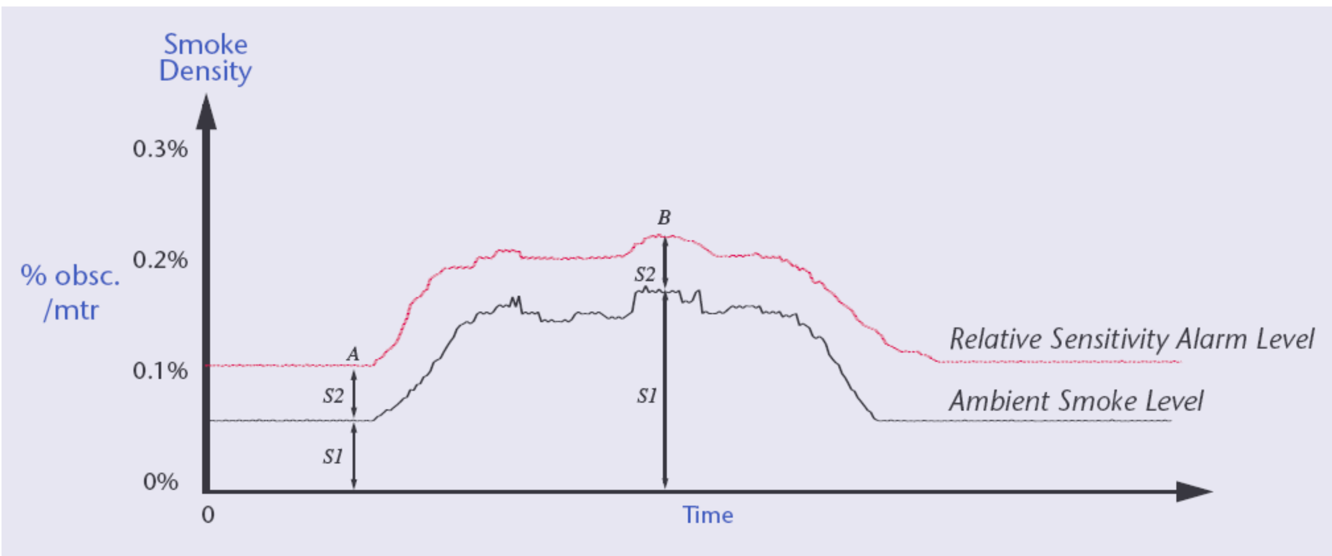


*Figure 2: Relative Sensitivity (Source: AirSense Technology Limited)*

## The Test Setup

**The high sensitivity aspirating smoke detector used for this test was AirSense Technology's Stratos- Micra 25 ® smoke detection system. The facility for testing was PTS' operational computer room and demo center. The PTS computer room site is comprised of one (1) network cabinet, one (1) UPS/Battery cabinet, one (1) PDU cabinet, two (2) server cabinets, an in-row computer room air conditioning (CRAC) unit, and a self contained air conditioning unit as backup.**

AirSense Technology describes the Stratos-Micra 25 ® system as providing the very earliest warning of incipient fire with a minimal rate of nuisance alarms for up to 2,500 square feet (other systems not tested can cover up to 20,000 square feet). It utilizes laser based forward light scatter mass detection with particle evaluation for reliable very early warning and high sensitivity. It can accommodate a single sampling pipe, up to 164 feet (50 meters) in length. Furthermore, it incorporates an artificial intelligence system that dynamically adjusts the detector's operating parameters, allowing for allowing for optimum sensitivity, regardless of changing ambient conditions.

**Picture 1: AirSense Stratos-Micra 25 installed**

PTS' computer room design allows for high-density cooling. It utilizes a single APC, RC-series, in-row, air conditioning unit to provide approximately 5-tons of cooling to the critical load. The hot aisle/cold aisle arrangement of the in-row computer room air conditioner (CRAC) and the equipment cabinets housing the critical load offer increased cooling effectiveness. This arrangement greatly reduces the mixing of the hot and cold air streams, thereby promoting greater cooling system effectiveness, and therefore allowing greater cabinet power density deployment. The in-row system incorporate a horizontal, supply airflow pattern, specifically designed for hot aisle/cold aisle configurations and is capable of providing airflows exceeding 9,000 CFM at full load.

**Picture 2: Stratos-Micra 25 with air sampling pipe installed in the return air stream of the CRAC unit**

The mounting of The Stratos smoke detection system was as shown in Picture 2, on the back wall of the computer room with its sample pipe run adjacent to the rear of the in-row CRAC. This ensured the air sample was drawn directly from the return air stream on the CRAC unit.

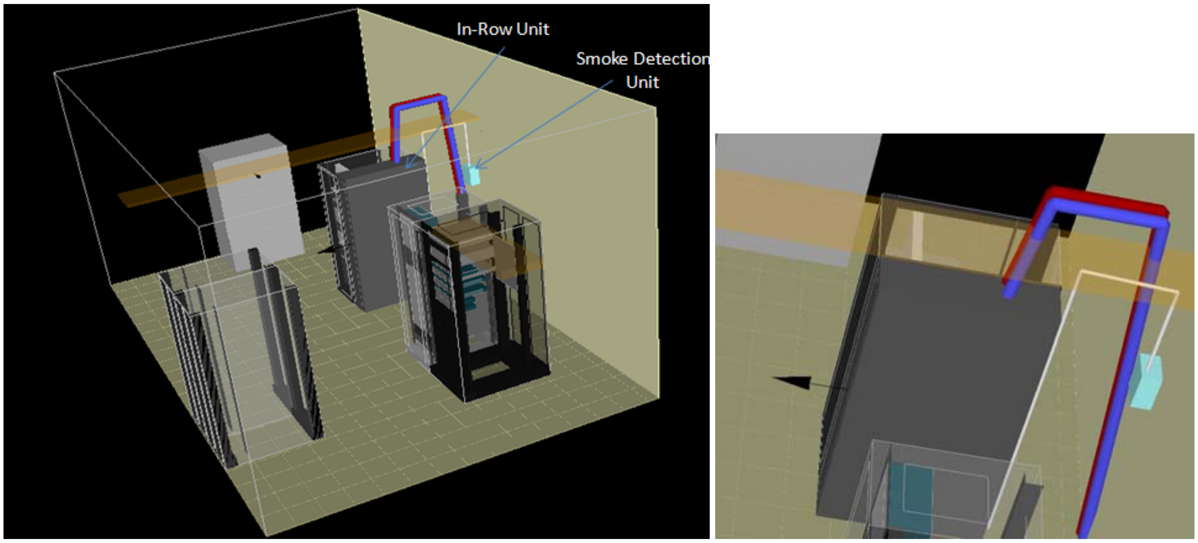


Figure 3: PTS' Computer Room Model

## Tests Performed & Results

The aspirating smoke detection system was tested utilizing a low concentration of canned smoke (UL listed for testing a smoke detectors' functionality per NFPA 72). The test was conducted at each row (read distance from the in-row cooling unit) to simulate an incipient fire condition both inside the cabinet as well as away from the cabinet. The smoke aerosol time was less than 3 seconds. Additionally, the smoke aerosol test was conducted at varying airflow rates of the CRAC equipment to verify the effectiveness of the smoke detector in a high-velocity, high-volume environment. Finally, the smoke level was monitored using the manufacturer's real-time viewer software with predefined alarm thresholds for different smoke density classes.

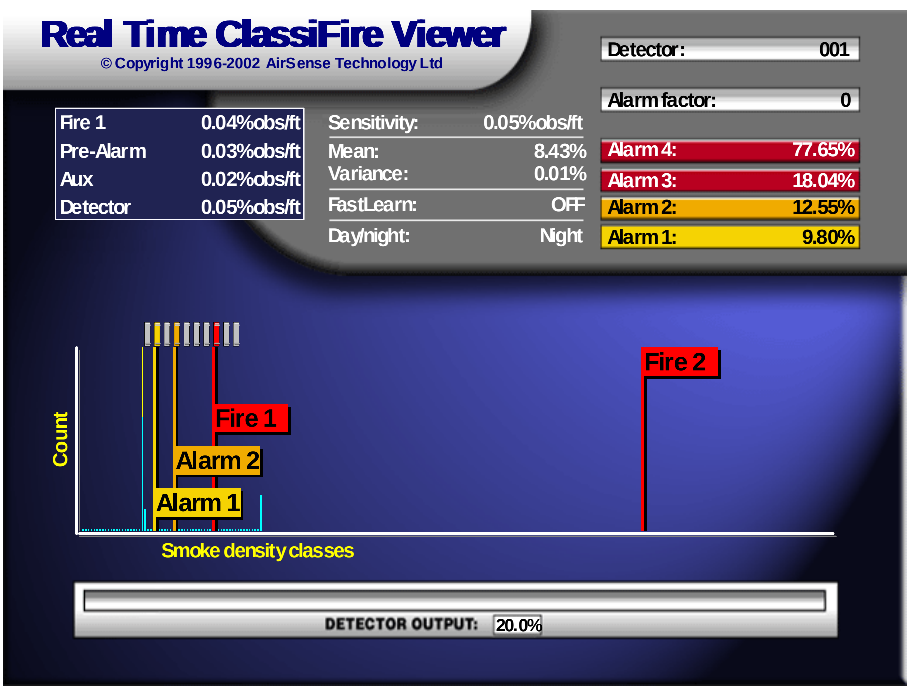


Figure 4: Alarm level viewer (Source: AirSense Technology Limited)

| Distance | CRAC Air Supply | Response Time |
|---|---|---|
| (ft) | (cfm) | (s) |
| | | |
| 3 | 1250 | 2.1 |
| | | |
| 6 | 1250 | 5.8 |
| | | |
| 10 | 1250 | 11.9 |

Table 1: Smoke detector's response time (at constant cfm of 1250)

Table 1 shows the result of testing the smoke detector and smoke aerosol at varying distances from the in-row CRAC unit in the cold aisle (3 feet & 6 feet along the face of the row of cabinets and in the corner of the room for at a distance of 10 feet). Test results indicate, the closer the smoke was to the in-row CRAC unit, the faster the smoke detector system responded. In any case, the detector was clearly and quickly able to sense the smoke in all instances.

| Distance | CRAC Air Supply | Response Time |
|---|---|---|
| (ft) | (cfm) | (s) |
| | | |
| 3 | 1450 | 2 |
| | | |
| 6 | 1450 | 5.2 |
| | | |
| 10 | 1450 | 10.1 |

Table 2: Smoke detector's response time (at constant cfm of 1450)

The results of the Table 2 indicate, increasing the supply airflow rate of the in-row unit by 200 cfm resulted in an improved response time. It is clear airflow directly affects the smoke flow pattern. Therefore, the best possible detection point is at the return air source. Analysis of the results indicates the response time of the detector would be less than 10 second for any IT device caused fire source inside the computer room, regardless of the high airflow generated by the in-row cooling system. Furthermore, a fire source located at the furthest extents of the computer room (farthest from the detector) would be detected in less than 12 seconds. Finally, it should be noted that for the 2 months the smoke detector has been installed, the unit has remained stable and has not produced any nuisance or false alarms.

It is quite clear that for In-cabinet fire condition, detection at the return air stream provides the earliest possible warning of a thermal event or fire as compared to traditional smoke detection systems located in the suspended ceiling or over the top of the room.

## Conclusion

**In conclusion, it is clear that aspirating smoke detection systems, based on relative sensitivity, are well suited, if not preferred, for computer rooms utilizing high-density, high-velocity, high-volume cooling systems. Additionally, since airflow directly affects the smoke pattern in the computer room, PTS recommends installing the air sampling pipes directly in the return air stream of the cooling system. Finally, whereas a fixed sensitivity based smoke detection systems has a variable sensitivity to fire smoke, a relative sensitivity based detection systems continuously adapt to the fluctuating background smoke levels. Thus, the thresholds only take into account the increase in smoke caused by a fire.**

## References

www.nfpa.org
www.airsense.us

## About the Authors:

Suresh Soundararaj is a Mechanical Engineer and CFD modeling expert for PTS Data Center Solutions, Inc. Suresh is a member of ASHRAE and the American Society of Mechanical Engineers

Dave Admirand is professional engineer with twenty-five (25) plus years of electrical design & engineering experience in the data center and computer room industries. He has extensive experience in designing facility service entrance & grounding schemes, power protection & distribution schemes, computer room air conditioner systems, fire alarm & protection systems, and security & access control systems.

## About PTS Data Center Solutions

PTS Data Center Solutions is a computer room consulting, design, and engineering services firm, as well as turnkey solutions provider.

We offer a broad range of project expertise. We specialize in planning, designing, constructing, monitoring, and maintaining computer rooms that integrate 'best-of-breed', critical infrastructure technologies. The result is an always available, scalable, redundant, fault-tolerant, manageable, and maintainable computer room environment.

In today's hyper-competitive markets, where you measure network downtime in lost profits, PTS protects against some of the leading causes of downtime, hardware damage, data loss, and decreased productivity. PTS sets the standard for 'always available' solutions for computer rooms, computer rooms, server rooms, network closets, telecommunications rooms, network operations centers, and other mission critical facilities.

From our corporate headquarters in Franklin Lakes, New Jersey, and our office in Orange County, California, PTS works to fulfill our mission of creating satisfied customers by emphasizing pre-design & planning services to provide the optimal solution to meet our clients' needs. This results in an early & accurate alignment between scope, schedule, and budget.

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