Celebrating more than 25 years in the data center industry, AFCOM is the only association dedicated to providing education and resources for data center managers. Our mission is to enable data center management professionals to share industry best practices by providing a forum for dissemination of critical information; to provide education on key data center management issues; to provide the industry's most comprehensive insight and analysis in key areas affecting all data-intensive organizations; and to be the most comprehensive and effective resource available to the overall data center community.

The Effects of High Air Velocity and Complex Airflow Patterns on Smoke Detector Performance…

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  - – Southeast US
  - Member NFPA, SFPE, 7x24, AFCOM

Outline / Direction

- Identification of Applications/Industries where potential problems may exist
- Overview of commercially available smoke detection technologies
  - (Features & Limitations)
- Application Specific Performance Limitations
  - (Including how Automatic Suppression Systems may suffer)
- Presentation of Tested Solutions

The importance of and dependence on NFPA building and life-safety codes….

- NFPA codes are widely adopted and accepted as the benchmark for facilities protection.
  - The codes are developed by technical committees comprising of:
    - End-Users
    - Manufacturers
    - AHJ's
    - Consultants
    - Risk Insurers
  - However, it is important to note that:
    - **The codes are only updated every few years, and often at a rate slower than industry/technology evolution**
    - **& While a system may be designed for "Code-Compliance", it may provide for only a base level of life safety, with very little consideration for business continuity or equipment damage**
    - **In fact, in areas with high air-velocity and complex air patterns, systems designed to a "code-minimum" level may not be listed by third party testing agencies (UL/FM) or perform to a level to meet the original intent of the code.**

At risk industries/applications…

- Data Centers
- Computer Rooms
- Telecommunications Sites
- Clean Rooms
- Control Rooms
- Warehouse/Manufacturing/Industrial with Ventilation and HVLS Fans
- Other unique environments…

Smoke Detection Technologies

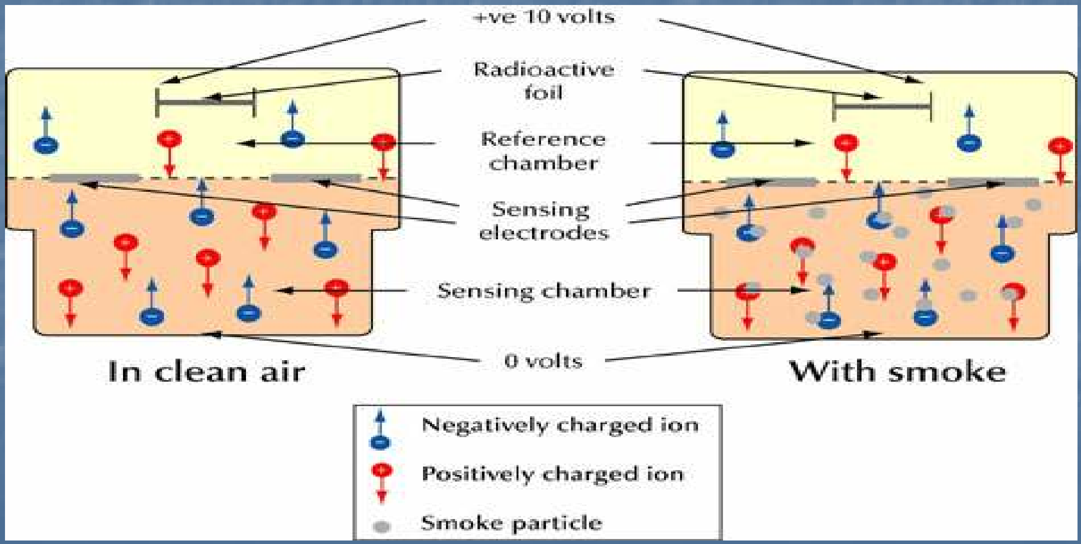
- Spot-type Ionization Detectors
- Spot-type "Optical" Photo-Electric Detectors
- Projected-Beam Smoke Detectors
- Aspirating Smoke Detection Systems

% Obscuration per foot?

Spot-type Ionization Smoke Detectors

The sensing part of the detector consists of two chambers - an open, outer chamber and a semi-sealed reference chamber within. Mounted in the reference chamber is a low activity radioactive foil of Americium 241 which enables current to flow between the inner and outer chambers when the detector is powered up. As smoke enters the detector, particles become attached to the ions, causing a reduction in current flow in the outer chamber and hence an increase in voltage measured at the junction between the two chambers. The voltage increase is monitored by the electronic circuitry which triggers the detector into the alarm state at a preset threshold.

Ionization smoke detectors are good general-purpose detectors which respond well to fast-burning (flaming) fires and are widely used for property protection. MORE SENSITIVE THAN SPOT-TYPE "OPTICAL" PHOTO-ELECTRIC DETECTORS (1.0-2.0 % OBSCURATION PER FOOT)



- **Not suggested for use above 300 fpm (3.8 mph) per NFPA-72**
- **High false alarm rate, particularly in high air-velocities**
- **Passive detection requires smoke to enter the detection chamber by air-current or heat (thermal lift)**

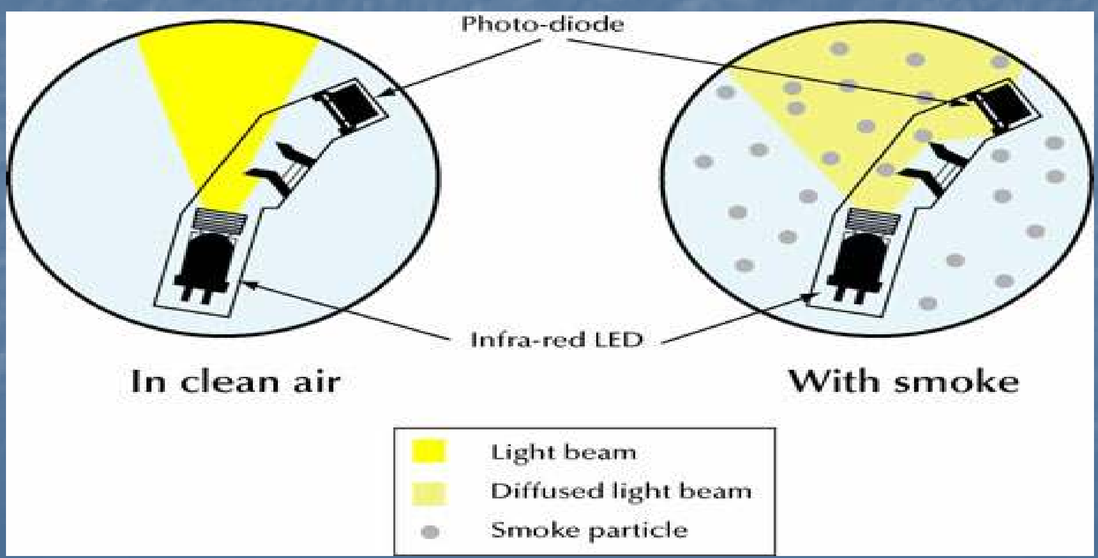
Common Ionization Detectors

Model #	Sensitivity	Rated Airflow
System Sensor 1251B	1.0-1.5% obs/ft	1200 fpm
Hochiki AIE-EA	1.0-1.5% obs/ft	300 fpm
Fenwal CPD 7052	0.8 – 1.0% obs/ft	2000 fpm

Spot-type "Optical" Photo-electric Smoke Detectors

Optical smoke detectors incorporate a pulsing infra-red LED located in a chamber within the housing of the detector. The chamber is designed to exclude light from any external source. At an angle to the LED is a photo-diode which normally does not register the column of light emitted by the LED. In the event of smoke from a fire entering the chamber, the light pulse from the LED will be scattered and hence registered by the photo-diode. If the photo-diode "sees" smoke on the two following pulses, the detector changes into alarm state and the indicator LED lights up.

Optical smoke detectors respond particularly well to slow-burning (smoldering) fires. They are widely used for life protection.
LESS SENSITIVE THAN SPOT-TYPE IONIZATION DETECTORS (2.0-4.0 % OBSCURATION PER FOOT)



- **High Sensitivity versions NOT listed for use above 300 fpm UL**
- **Low Sensitivity versions listed up to 4,000 fpm but do NOT respond until very late in the fire 4.0% obs/ft**
- **Often will not detect fires in high airflow environments**
- **Passive detection requires smoke to enter the detection chamber by air-current or heat (thermal lift)**

Common Photoelectric Detectors






Model #	Sensitivity	Rated Airflow
SimplexGrinnell – TrueAlarm	0.2-4.0% obs/ft	2000 fpm
System Sensor – 2251B	2.0-4.0% obs/ft	4000 fpm
GE/EST Signature	2.0-4.0% obs/ft	4000 fpm
Siemens Fire Print – FP-11	2.0-4.0% obs/ft	4000 fpm
Hochiki – ALG-V	2.0-4.0% obs/ft	4000 fpm
Fenwal PSD 7152	2.0-4.0% obs/ft	4000 fpm

Projected-Beam Smoke Detectors

A beam detector is made up of three main parts: the transmitter, which projects a beam of infra-red light; the receiver which registers the light and produces an electrical signal; and the interface, which processes the signal and generates alarm or fault signals. When a fire develops, smoke particles obstruct the beam of light and, once a pre-set threshold has been exceeded, the detector will go into alarm.

The Intelligent Reflective Beam Detector is a single unit comprising a transmitter, a receiver and control electronics. The transmitter projects a cone-shaped beam of modulated infra-red light to a reflector (prism). The reflector returns the beam to the detector where the receiver measures the amount of light received and converts it to a signal for processing in the control electronics.

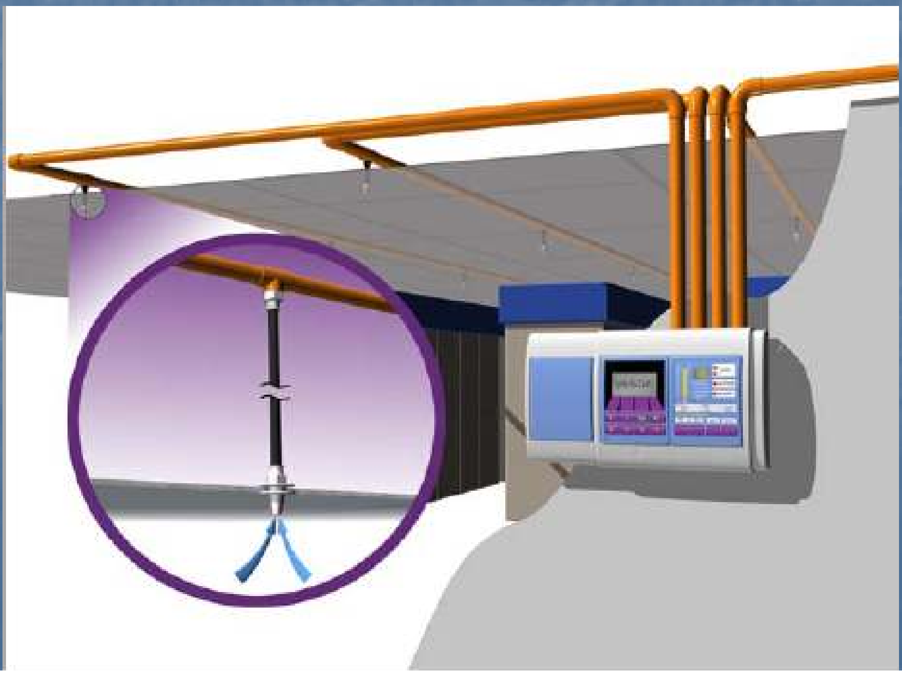
Beam detectors are designed to protect large open spaces such as atria, museums, churches and warehouses.

- **Limited Sensitivity**
- **Maintenance Intensive (Beam Alignment/Obstruction)**
- **Often will not detect fires in high airflow environments**
- **Passive detection requires smoke to enter the beam-path by air-current or heat (thermal lift)**

Aspirating Smoke Detection (ASD) Systems

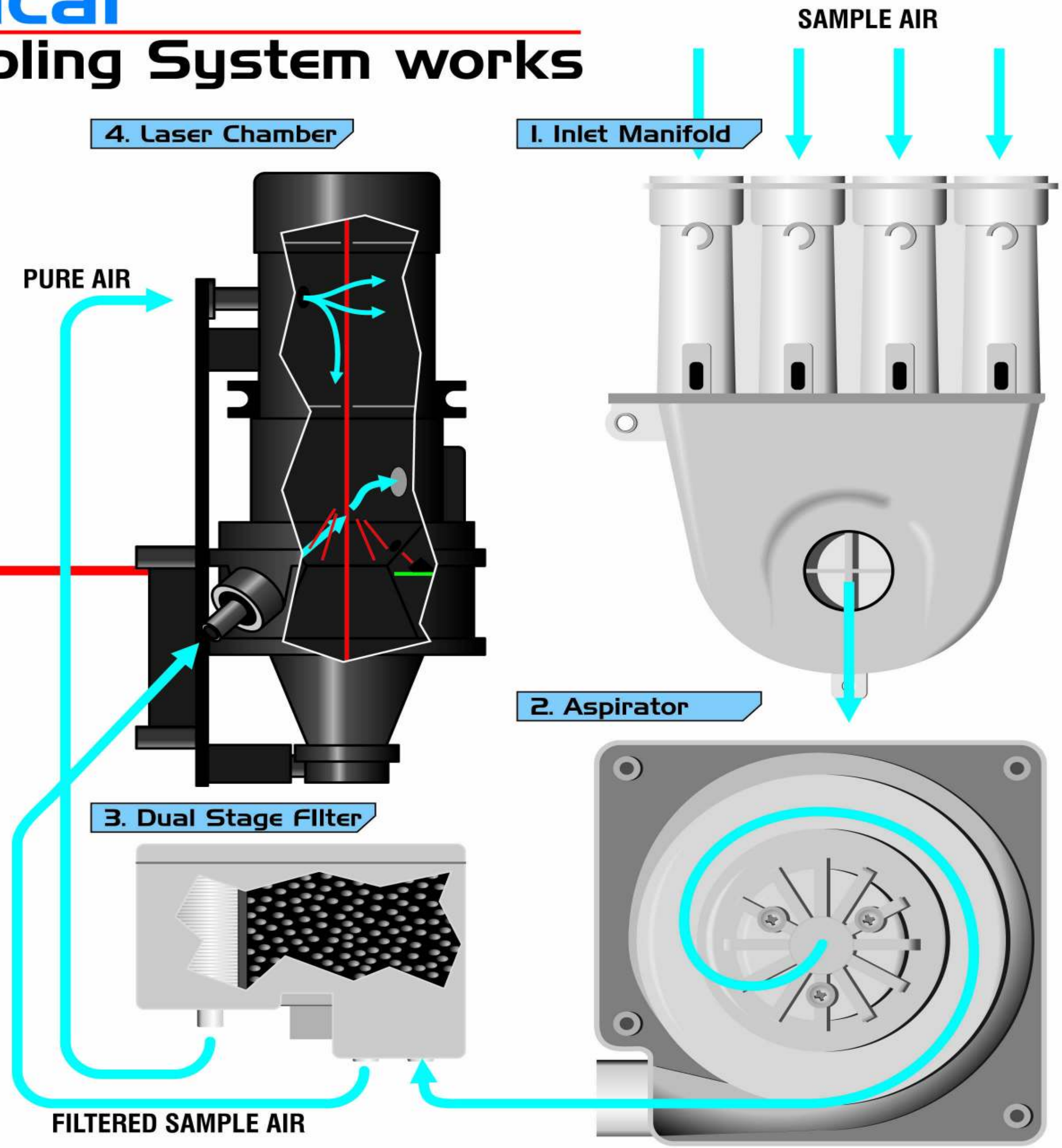
ASD provides proactive detection in high airflow environments by actively sampling air from a protected zone via multiple sampling holes in a pipe network. The air sample is transported to a calibrated laser detector for accurate analysis. ASD reliably detects fire at the earliest possible stage; providing a series of customized warning alarms to allow a controlled, early response to prevent fire progression. Smoke changes can be reliably detected by ASD's laser technology at a minimum level of 0.0015% obs/ft - a level invisible to the human eye. The advanced technology allows alarm thresholds to activate outputs at specific smoke levels—in any environment. This smart feature combined with ASD's filtration technology and advanced learning capabilities, provides the earliest possible detection of fire and eliminates nuisance alarms.

ASD Detectors were specifically designed to protect high-airflow mission critical electronic equipment and IT facilities from fire and fire related business disruption and downtime. There have been over 500,000 successful installations over 20 years.

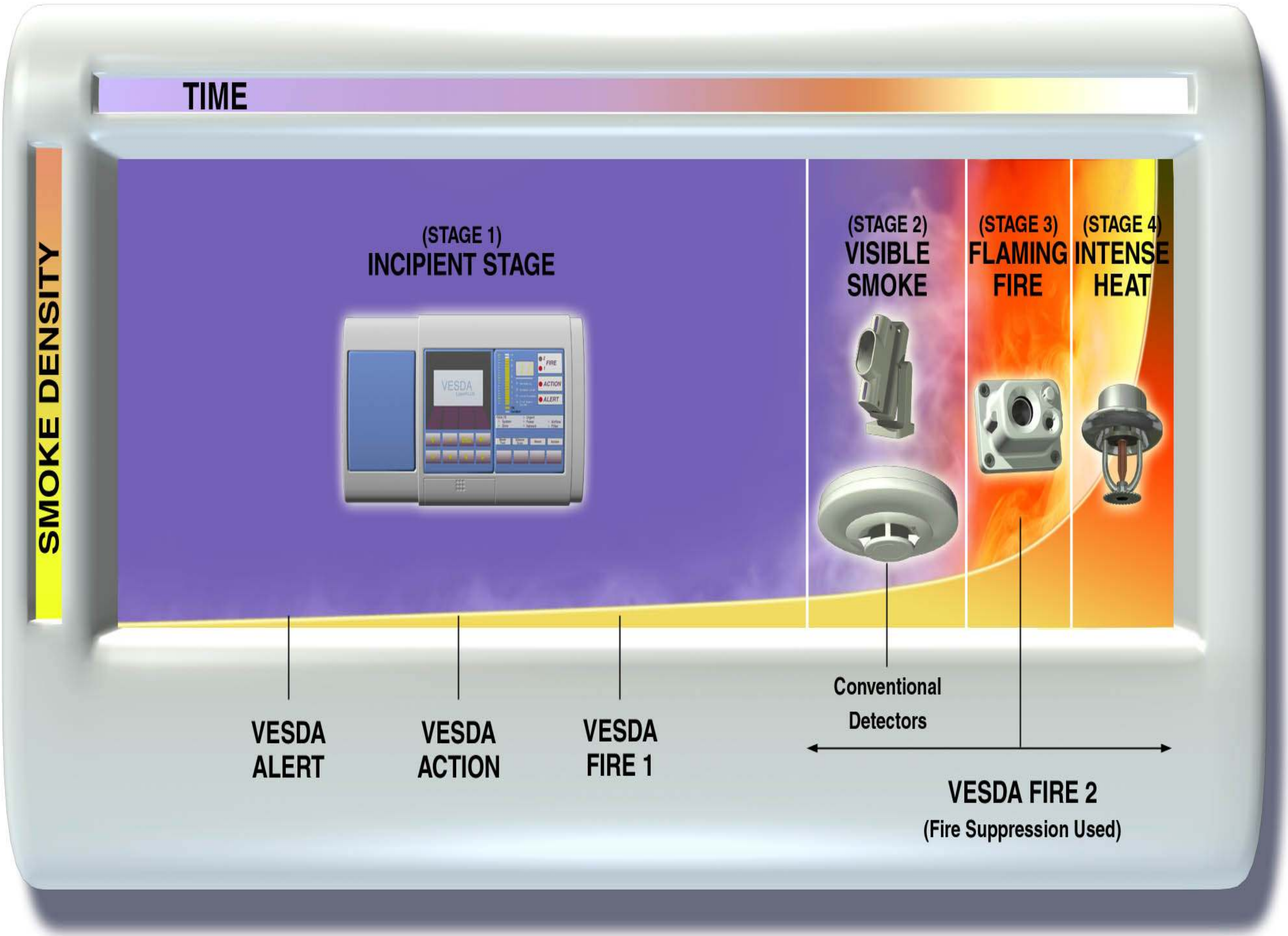


- **Wide Sensitivity Range (0.0015% – 6.25% Obs/ft)**
- **Active sampling detects smoke and invisible smoke particulate in air velocities exceeding 4,000 fpm. (UL Listed and recommended by NFPA for high air-velocity environments)**
- **Single point of maintenance**
- **No false alarms or recalibration requirements**

How an optical Air Sampling System works



1. Air is collected by a network of pipes and funnelled in the Inlet Manifold.
2. Air sample is moved through the laser chamber via the Aspirator.
3. The Dual Stage Filters has two parts. The first stage of the filter removes dust from the air sample. The second stage removes all particles for ultra pure air to keep the optical surfaces clean.
4. Air sample is fed into the Laser Chamber and exposed to a highly stable laser light source with a 3.5mm diameter laser beam. Smoke particle scatter the beam and sensors pick up on these scatters.
5. Light signal is passed to the processor card for processing into a bargraph representation of the smoke level.



TIME
SMOKE DENSITY
(STAGE 1)
INCIPIENT STAGE
VESDA
FIRE
ACTION
ALERT
(STAGE 2)
VISIBLE SMOKE
(STAGE 3)
FLAMING FIRE
(STAGE 4)
INTENSE HEAT
VESDA ALERT
VESDA ACTION
VESDA FIRE 1
Conventional Detectors
VESDA FIRE 2
(Fire Suppression Used)

Smoke Detector Spacing for High Airflow

- 5.7.5.3.3* Spacing. Smoke detector spacing shall be in accordance with Table 5.7.5.3.3 and Figure 5.7.5.3.3.
- Table 5.7.5.3.3 Smoke Detector Spacing Based on Air Movement

Minutes per Change	Changes per Hour	m2 spacing	ft2 spacing
1	60	11.61	125
2	30	23.23	250
3	20	34.84	375
4	15	46.45	500
5	12	58.06	625
6	10	69.68	750
7	8.6	81.29	875
8	7.5	83.61	900
9	6.7	83.61	900
10	6	83.61	900

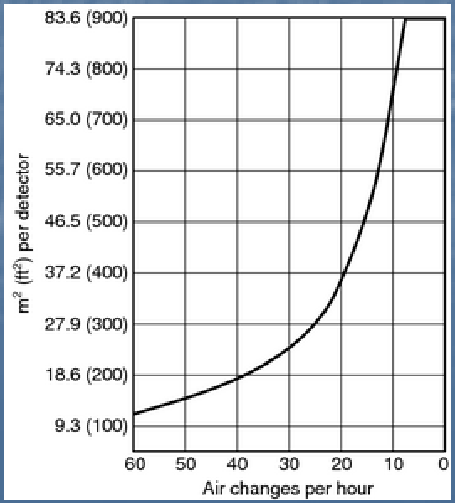
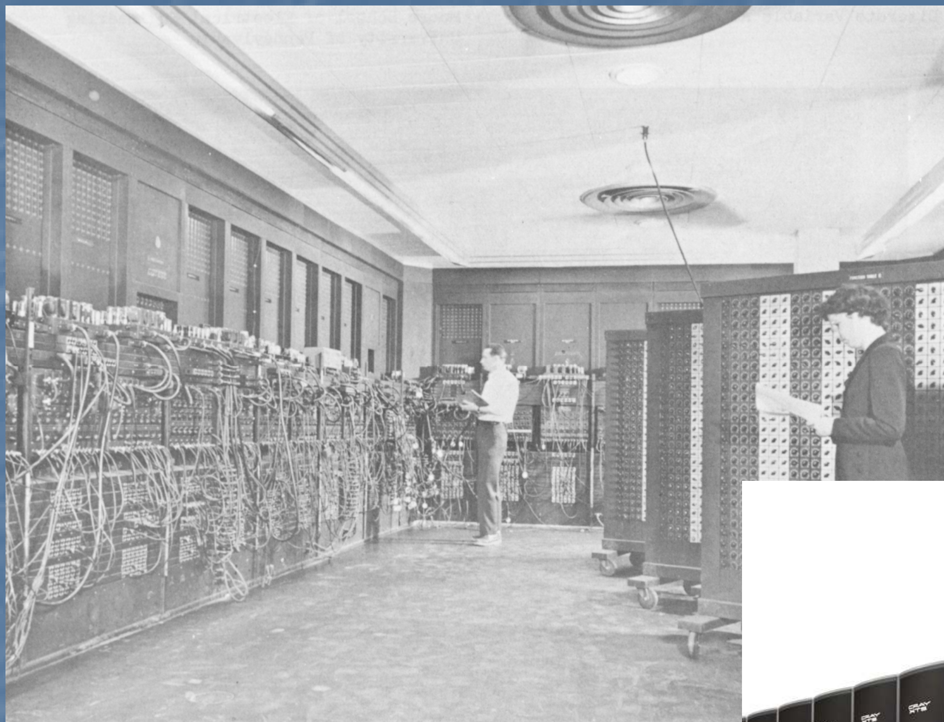


FIGURE 5.7.5.3.3 High Air Movement Areas Exception: Air-sampling or projected beam smoke detectors installed in accordance with the manufacturer’s published instructions.

Evolution of the data center…



Evolution of the smoke detector…

What's happening in the market?

- According to a report conducted by the Aperture Research Institute (ARI), 38% of those surveyed in their study noted that their newest data center is over four years old and that they are **"ill-equipped to cope with the intense power and cooling demands of modern hardware."**

- According to the ARI report, **36% of respondents noted that they were currently building or planning new data centers**. These new facilities are likely to be built with huge electrical capacity. The same report noted that **55% of the respondents who are planning to build a new data center are building it with an electrical capacity of 1-5 megawatts of power and 41% will design to 6 or more megawatts.**

- A typical corporate data center can have several hundred cabinets. For example, a legacy computer room designed for 400 2.0-kW racks has an equipment-cooling load of 800 kW of cooling. If the legacy servers in the 400 racks are replaced with 200 racks at say 12 kW each, the equipment load increases from less than 250 tons to over 680 tons with half as many racks. If all 400 racks are upgraded to 12 kW, the cooling system capacity climbs to 1,365 tons! (2005)

- legacy data centers were typically designed to accommodate a power consumption of about 100 to 150 watts per square foot. Today, data centers are being built with 300 to 400 watts per square foot in mind and by 2011, the number could rise to more than 600 watts. (2007)

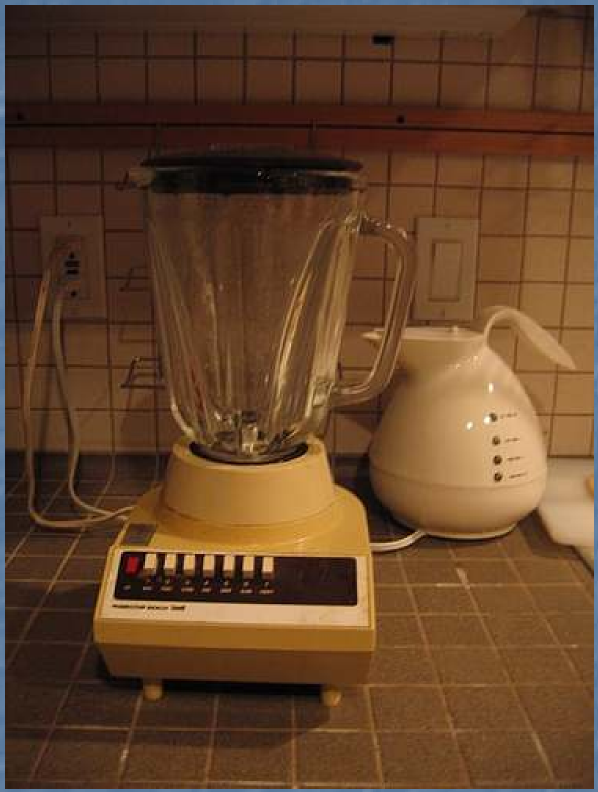
Relevant Codes

- NFPA 72
  - National Fire Alarm Code
- NFPA 75
  - Standard for the Protection of Information Technology Equipment

NFPA 75 - Detection

- 8.2* Automatic Detection Systems.
- Automatic detection equipment shall be installed to provide early warning of fire. The equipment used shall be a listed smoke detection–type system and shall be installed and maintained in accordance with NFPA 72®, National Fire Alarm Code®.
  - 8.2.1* Automatic detection systems shall be installed in the following locations:
  - (1) At the ceiling level throughout the information technology equipment area
  - (2) Below the raised floor of the information technology equipment area containing cables
  - (3) Above the suspended ceiling and below the raised floor in the information technology equipment area where these spaces are used to recirculate air to other parts of the building
  - 8.2.2 Where interlock and shutdown devices are provided, the electrical power to the interlocks and shutdown devices shall be supervised by the fire alarm control panel.
  - 8.2.3 The alarms and trouble signals of automatic detection or extinguishing systems shall be arranged to annunciate at a constantly attended location.
  - A.8.2 Fire detection and extinguishing systems should be selected after a complete evaluation of the exposures. The amount of protection provided should be related to the building construction and contents, equipment construction, business interruption, exposure, and security need. For amplification of the important need of fire protection, see Chapter 4.
  - A.8.2.1 The detection system selection process should evaluate the ambient environmental conditions in determining the appropriate device, location, and sensitivity. **In high airflow environments, air-sampling detection devices should be considered.**

The "Blender Effect"

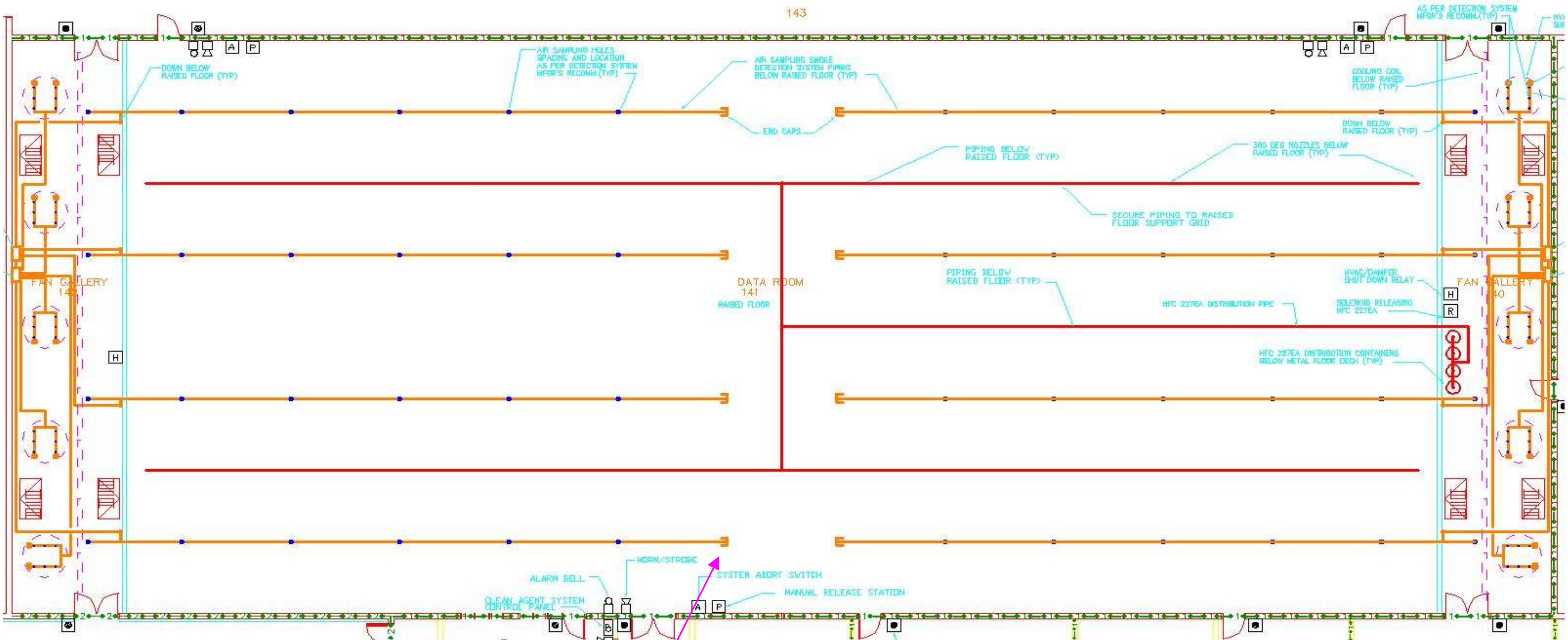


80's Data Center

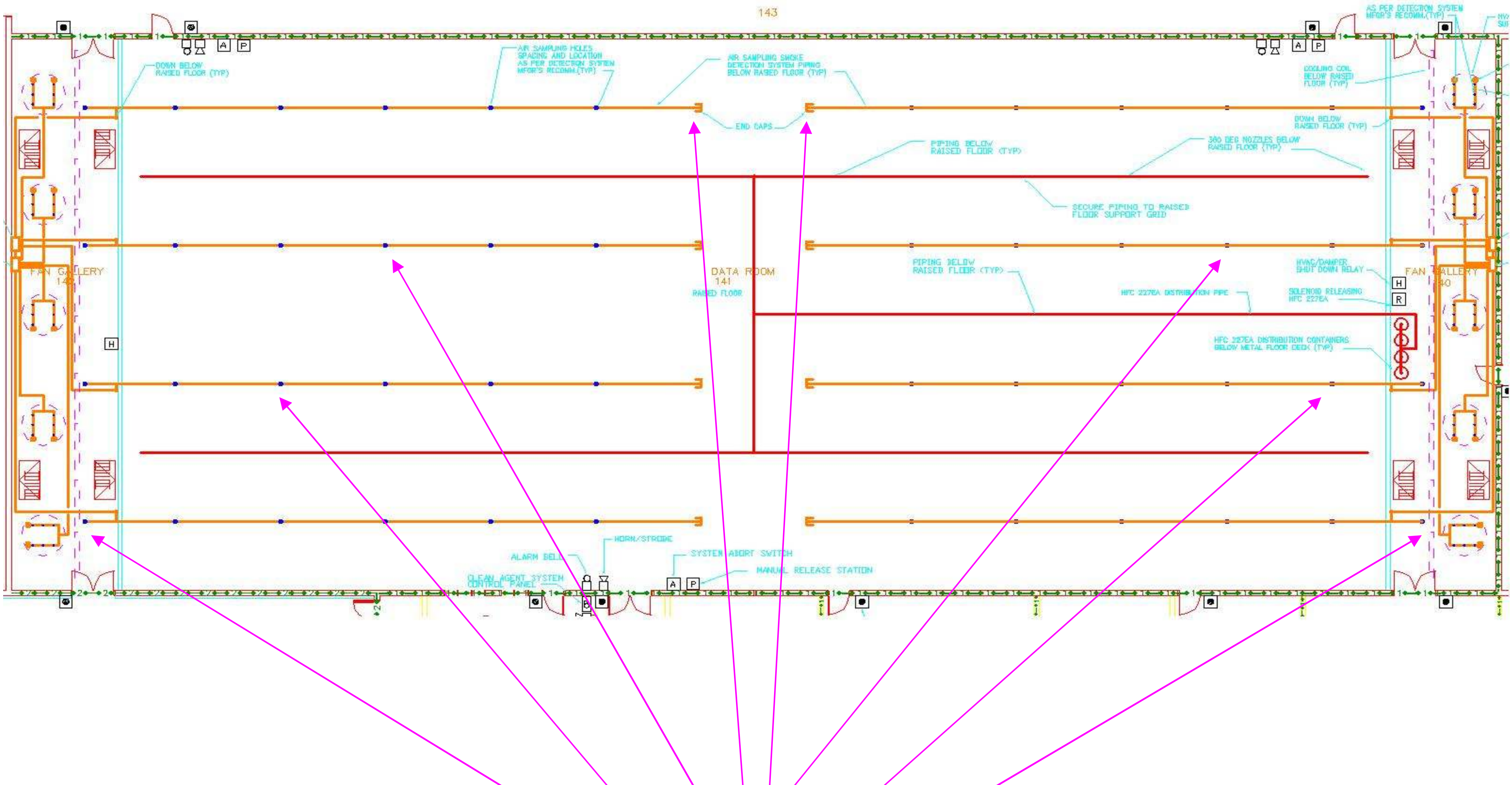
90's Data Center

Today's Data Center

Data Center Case Study



2% obs/ft here means…

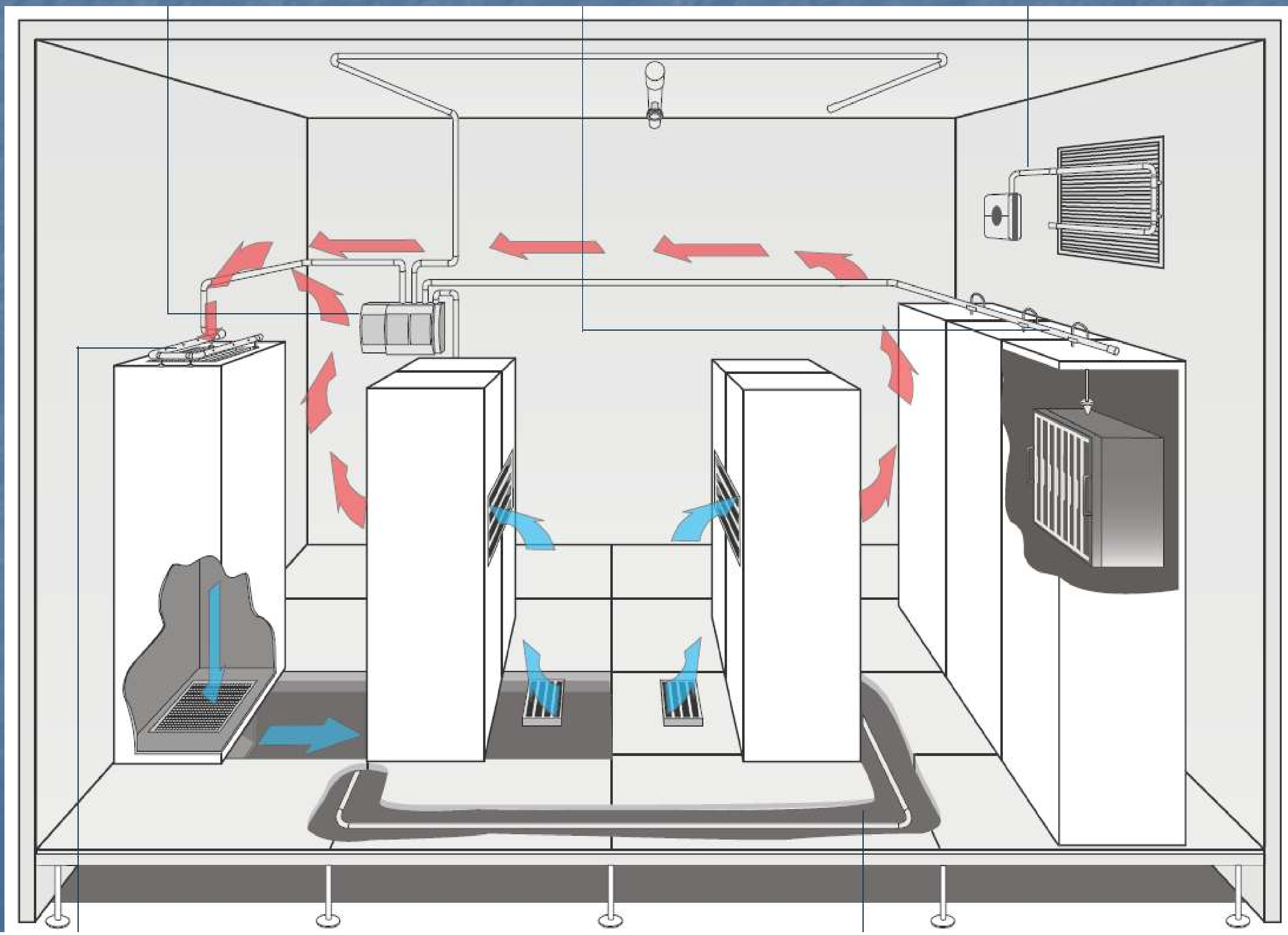


2% obs/ft everywhere!

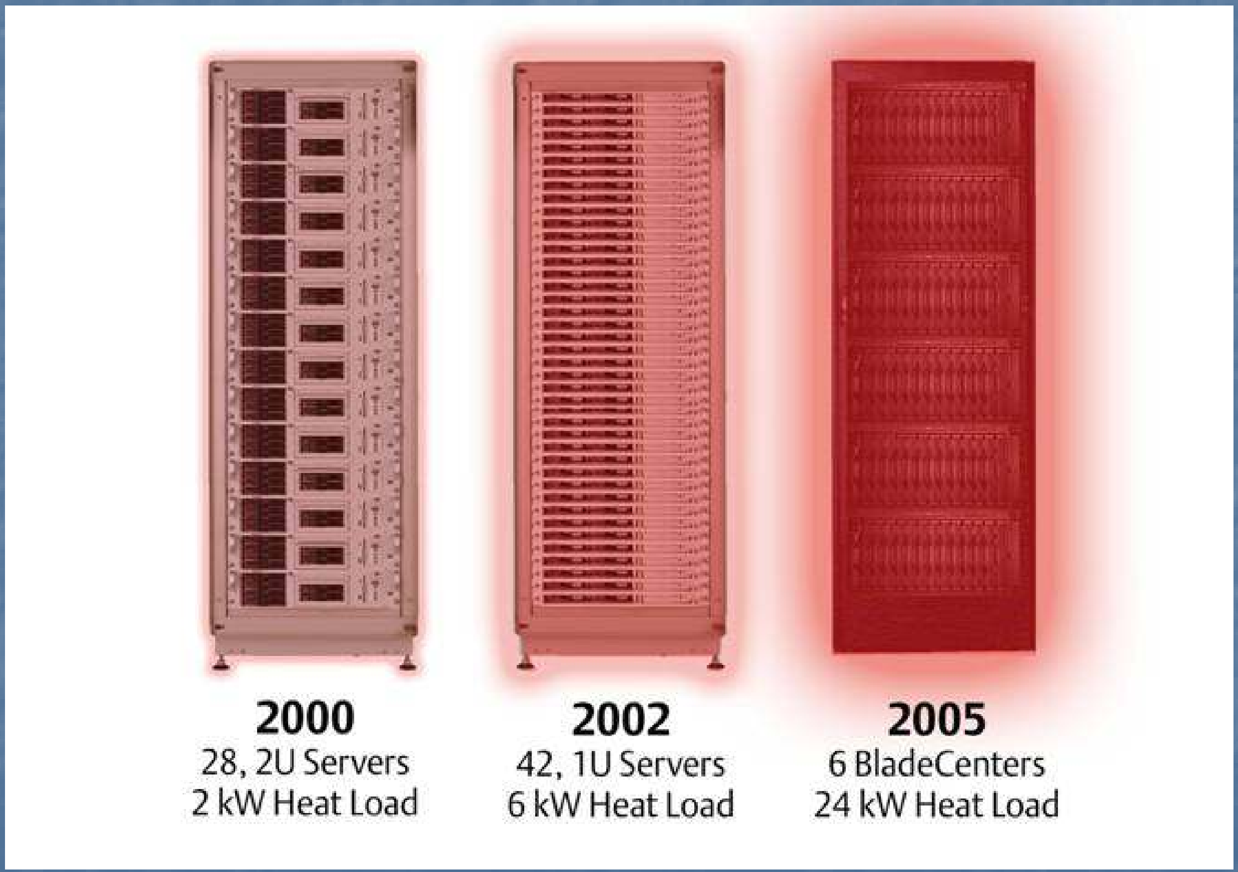
NFPA 75 – Gaseous Suppression

- 8.4 Gaseous Total Flooding Extinguishing Systems.
  - 8.4.1* Where there is a critical need to protect data in process, reduce equipment damage, and facilitate return to service, consideration shall be given to the use of a gaseous agent inside units or total flooding systems in sprinklered or non-sprinklered information technology equipment areas.
  - 8.4.2* Where gaseous agent or inert gas agent total flooding systems are used, they shall be designed, installed, and maintained in accordance with the requirements of NFPA 12A, Standard on Halon 1301 Fire Extinguishing Systems; NFPA 12, Standard on Carbon Dioxide Extinguishing Systems; or NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems. The agent selected shall not cause damage to the information technology equipment and media.
  - 8.4.2.1 The power to all electronic equipment shall be disconnected upon activation of a gaseous agent total flooding system, unless the risk considerations outlined in Chapter 4 indicate the need for continuous power.
  - 8.4.3* Gaseous agent systems shall be automatically actuated by an approved method of detection meeting the requirements of NFPA 72®, National Fire Alarm Code®, and a listed releasing device compatible with the system.
  - 8.4.4* Where operation of the air-handling system would exhaust the agent supply, it shall be interlocked to shut down when the extinguishing system is actuated.
  - 8.4.5* Alarms shall be provided to give positive warning of a pending discharge and an actual discharge.

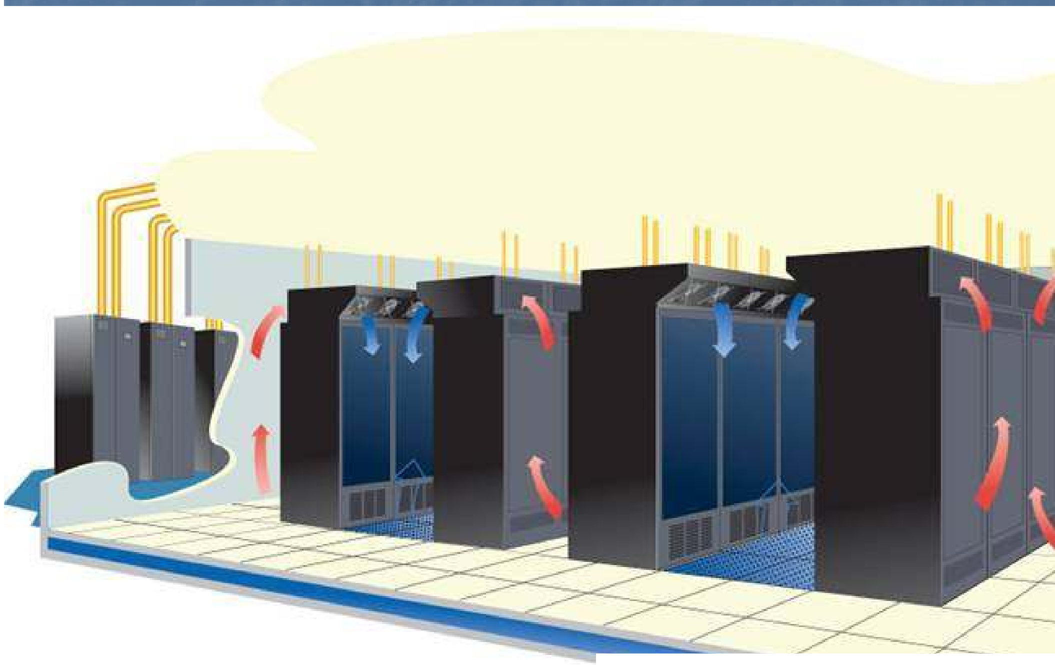
Data Center Cooling / effects on smoke detection…

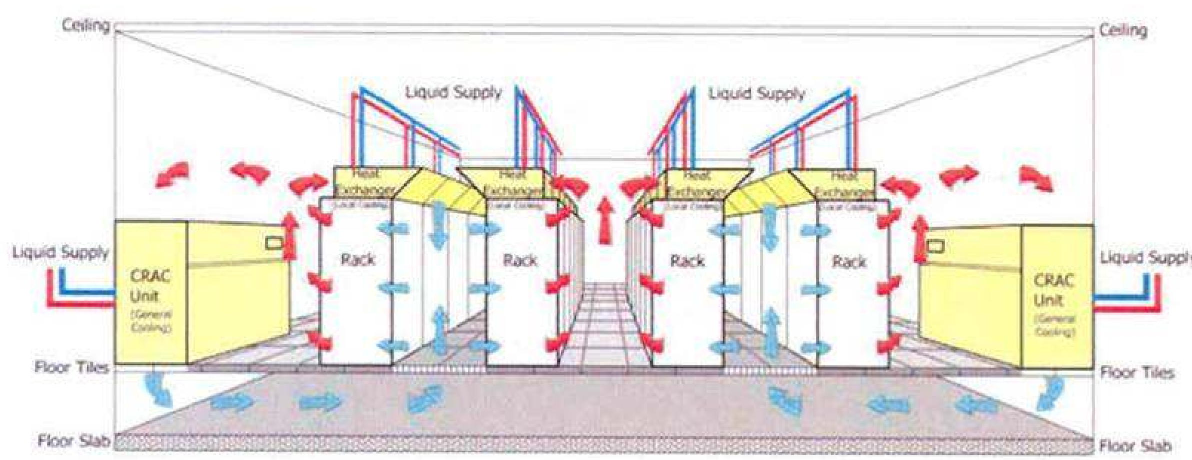


Server Heat load

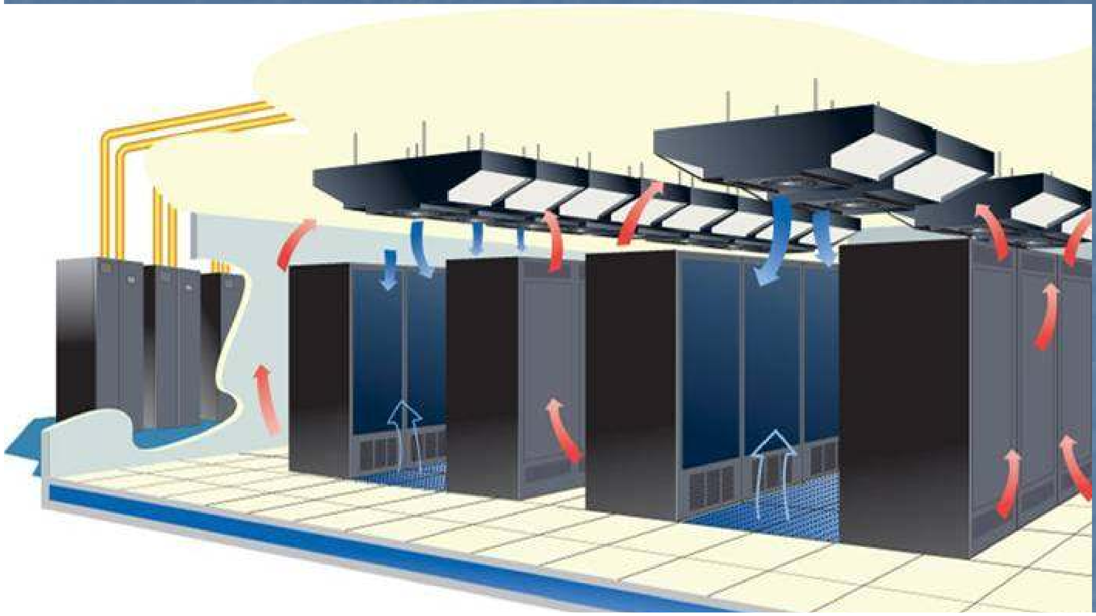


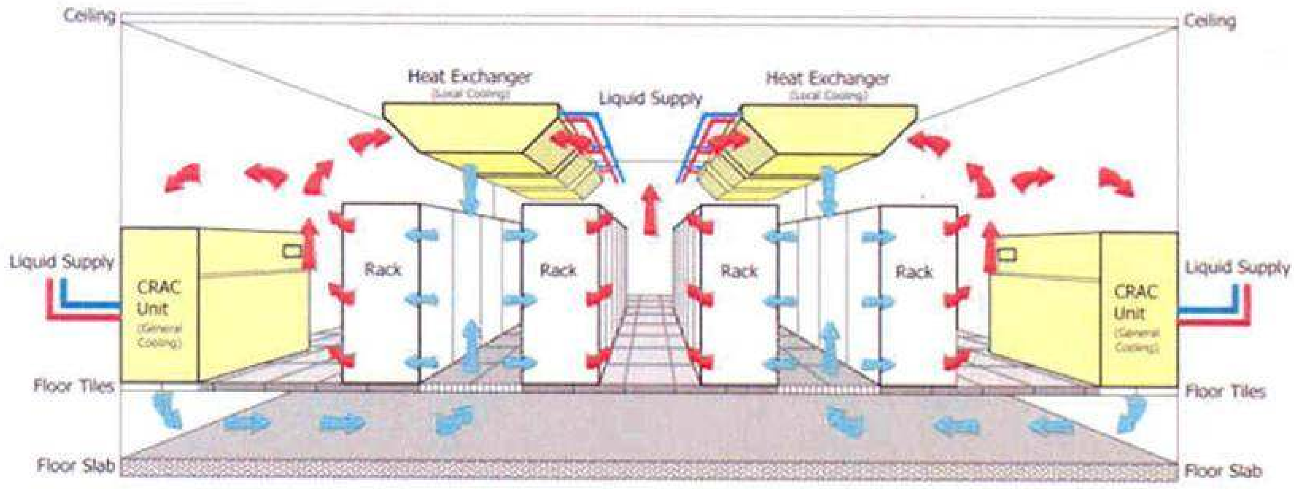
Data Center Cooling / Evolution



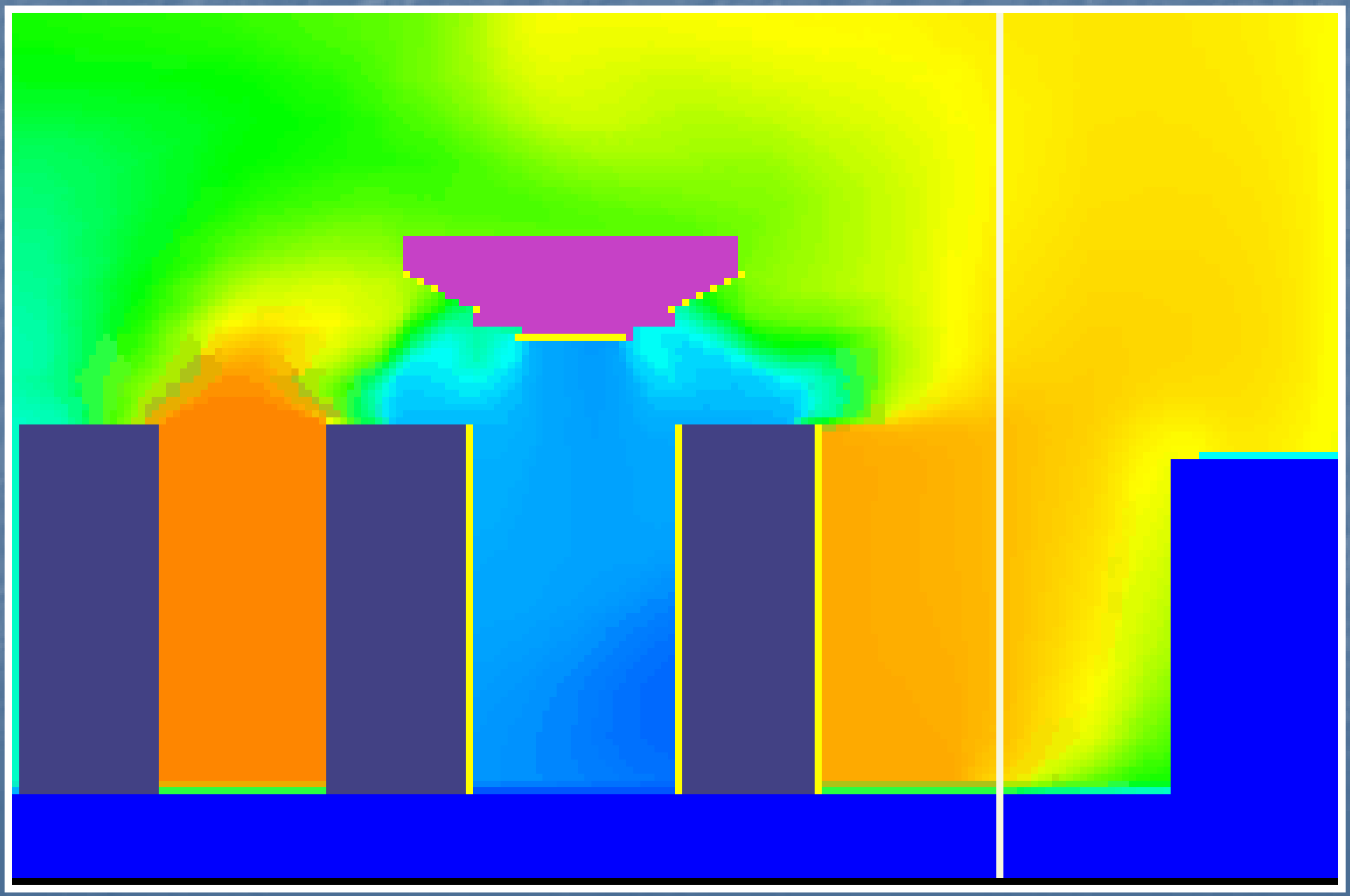


Data Center Cooling / Evolution

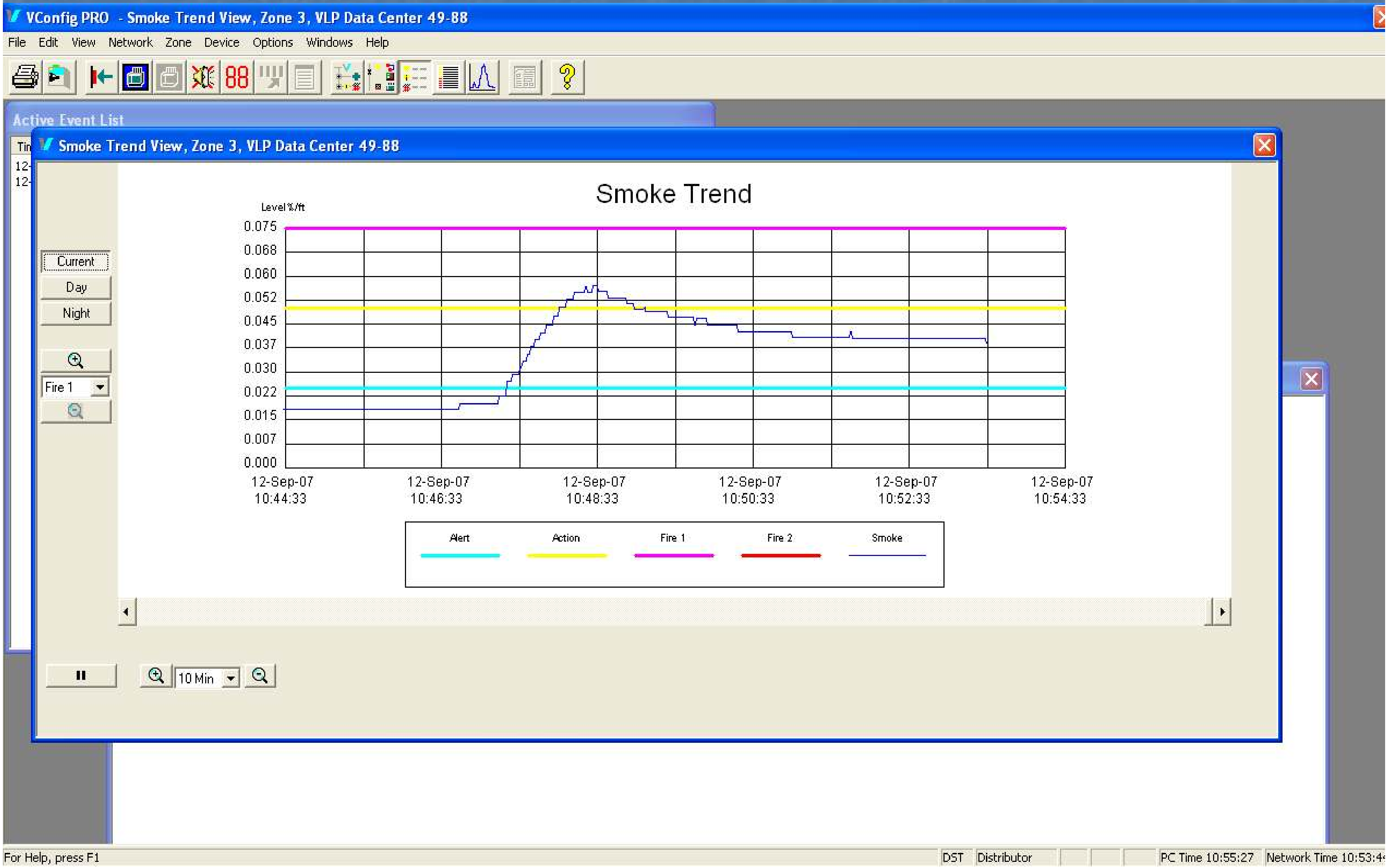




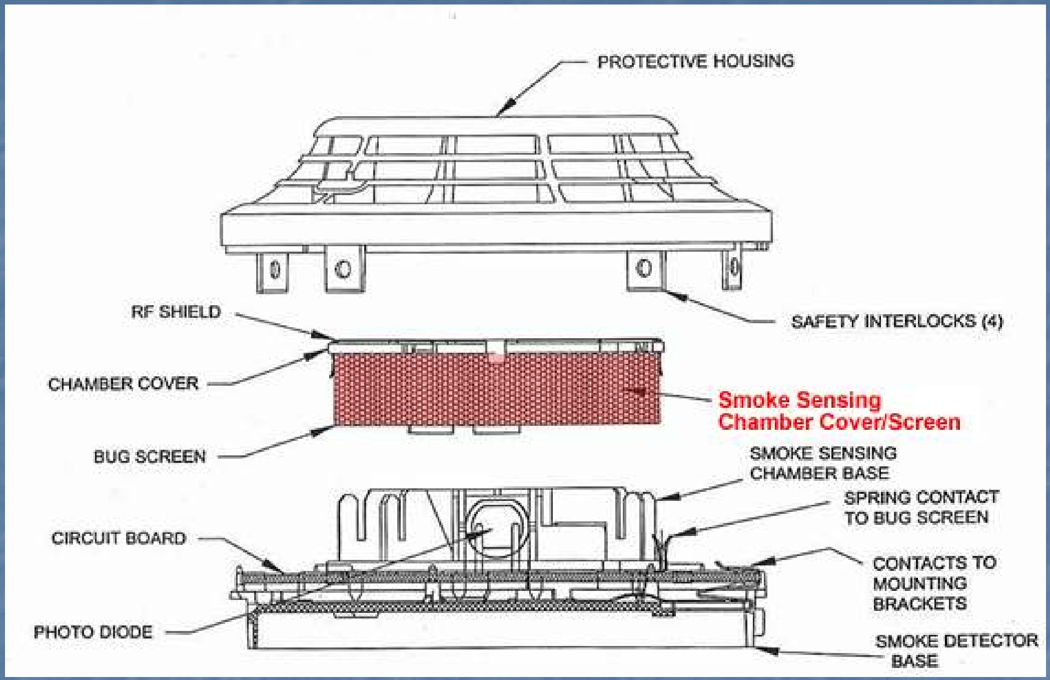
CFD Heat model



5’ Wire Burn Results (above floor)



Detection Challenges



5.7.1.8* Unless specifically designed and listed for the expected conditions, smoke detectors shall not be installed if any of the following ambient conditions exist:

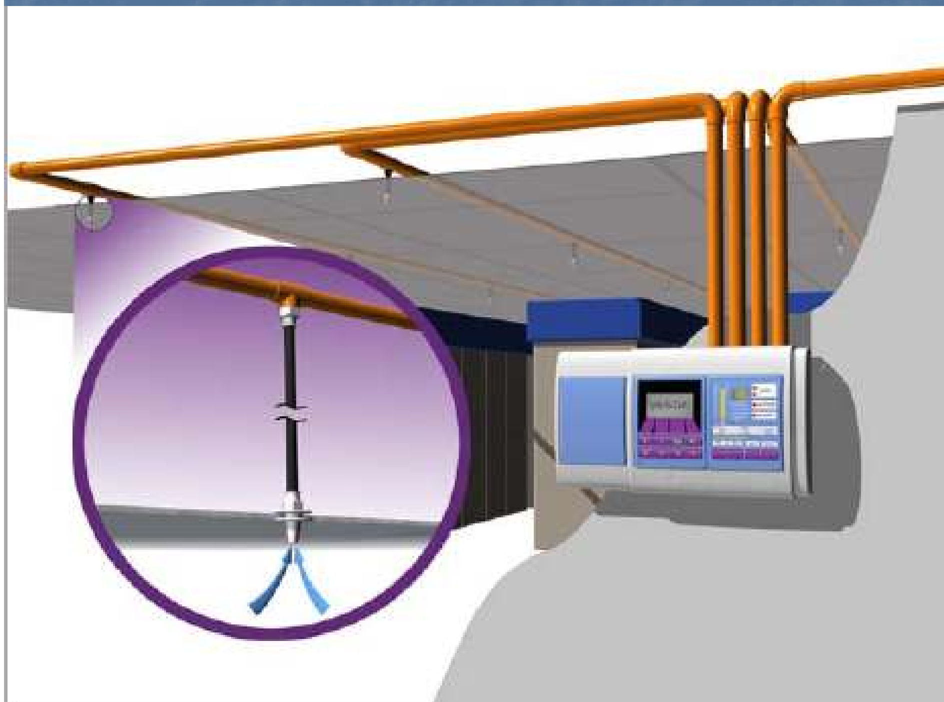
(1) Temperature below 0°C (32°F)

(2) Temperature above 38°C (100°F)

(3) Relative humidity above 93 percent

(4) Air velocity greater than 1.5 m/sec (300 ft/min)

"Spot Type" Smoke Detector Equivalency



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NFPA 72

Sampling points of an Air Sampling type detection system are placed where conventional spot detection would be placed*

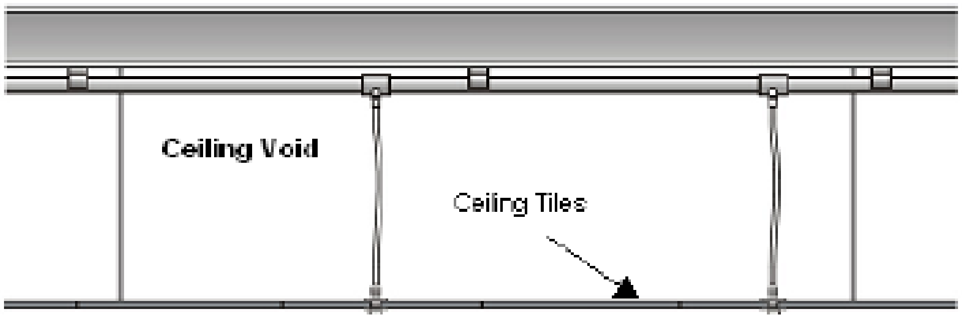
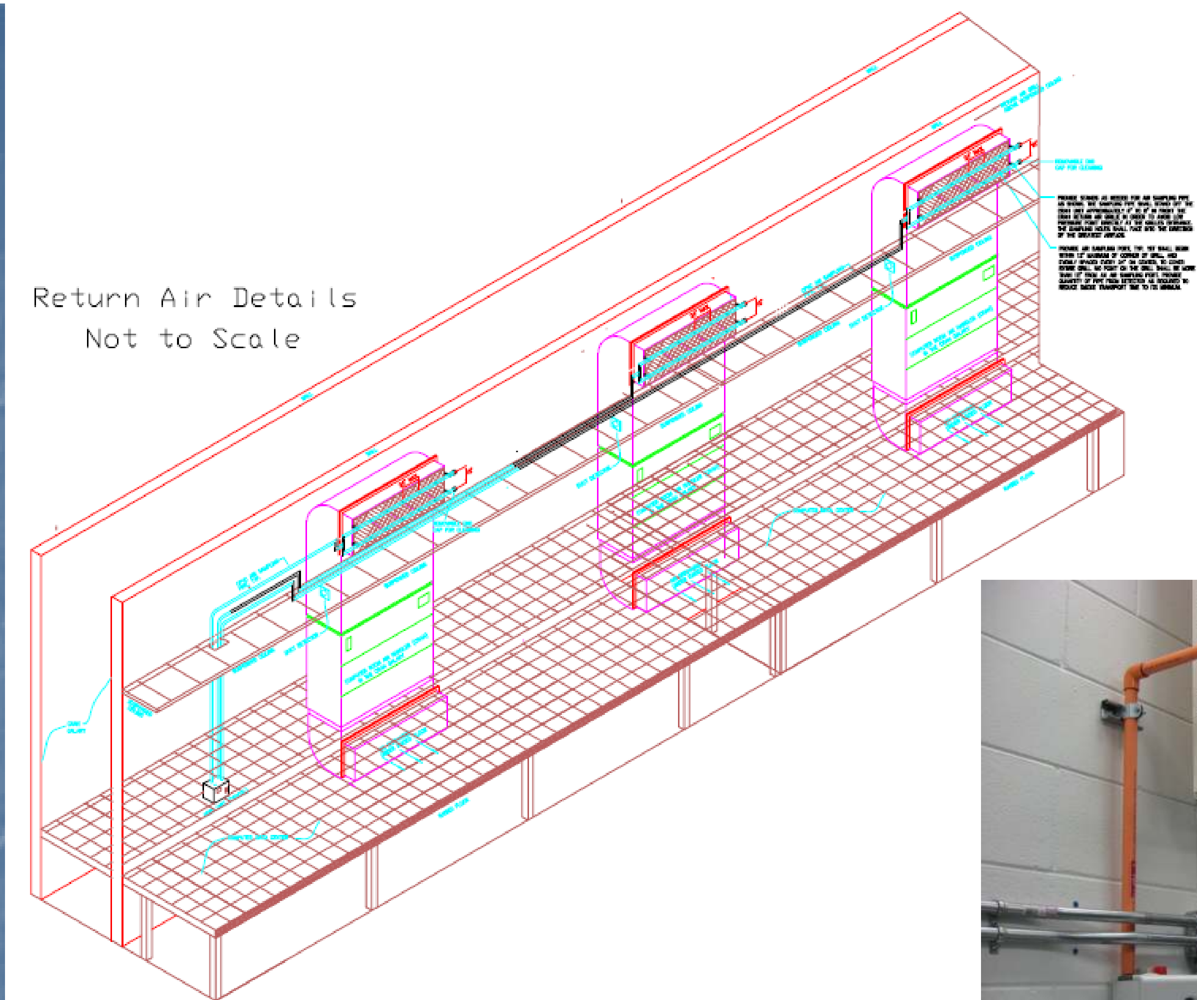


Figure 2 – Example of capillary air sampling through the ceiling.



5.5.2.1.4 Detectors shall not be required in concealed, accessible spaces above suspended ceilings that are used as a return air plenum meeting the requirements of NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems, where equipped with smoke detection at each connection from the plenum to the central air-handling system.

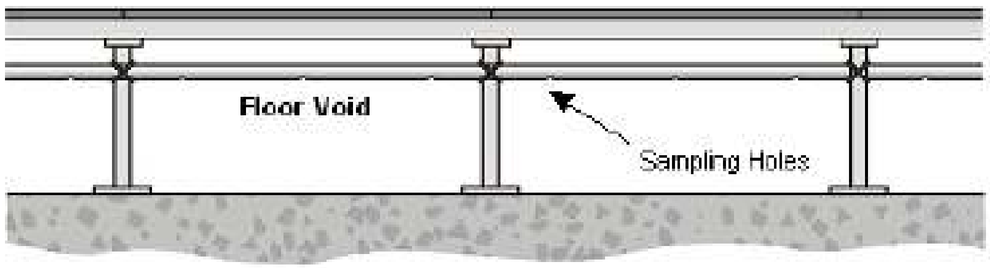


Figure 3 – Example of floor void protection.

Q & A…