Industrial Strength
Fire and Smoke Protection

Providing very early warning smoke detection for mission critical industrial facilities and equipment

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Mission-critical facilities and equipment

"Mission-critical" facilities are those that are critical to a facility's operation. Such equipment provides a “guarantee” that it will continue to operate, regardless of external conditions. A cabinet containing process control equipment providing services to a steel refinery is one example. A minor interruption in services from the cabinet could seriously impact the operational continuity resulting in economic loss. This article discusses smoke detection systems and their role in prevention of fire and smoke contamination within a mission-critical facility and industrial equipment.

Very early warning

Within the fire industry, detectors are categorized as Early Warning Smoke Detection (EWS) and Very Early Warning Smoke Detection (VEWSD). In fact some people use these terms very loosely and do not differentiate the two correctly. An EWS system provides detection of a fire condition prior to the time that it becomes threatening to the occupants of a building or equipment within it. Generally this is the time that smoke is visible. Let’s use the example of a low voltage switch cabinet with a fault within the electronics resulting in a thermal event; it may smolder for hours before a flame ignites. We refer to the smoldering stage as the incipient stage of a fire. During this incipient stage the human eye will not see the particles but the human nose may smell them. EWSD are not sensitive enough to detect smoke at the incipient stage of an electrical-type fire. Only a VEWSD will detect an incipient fire and thus the term “VERY EARLY WARNING”. This stage of a fire could last for hours or even days and it could cause significant damage.

Smoke contamination

So why is the detection of smoke at the earliest possible stage important? Because the biggest risk to the continuous operation within an industrial facility is the smoke damage to electrical equipment, not the fire. In fact according to the USA Federal Commission of Communications, 95% of all damage within telecoms facilities is non-thermal. The by-products of smoke from PVC and digital circuit boards are gases such as HCL and these gases will cause corrosion of IT equipment. Even at 16 micrograms/cm² there is moderate corrosion with long-term effects on electronics, at 30 micrograms/cm² the corrosion is active and the effects are short term. Above this the damage to equipment is detrimental to ongoing performance.
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The shortcomings of conventional fire detection solutions

There are several types of common smoke detection technologies often deployed to protect equipment and facilities – spot detectors, beam detectors and rate of rise heat detectors. While these technologies are adequate in some scenarios, each has a shortfall that prevents it from being appropriate for a VEWS approach.

Spot detectors, also called point detectors, are one of the most common types of smoke detectors used today. Spot detectors are “passive” in that they wait for smoke to enter a detection chamber where an optical sensor identifies the presence of smoke. A key problem with spot detectors is that dust, insects and other airborne debris can impede the flow of air and smoke into the detection chamber. This can lower sensitivity and also cause them to become prone to nuisance or false alarms in some environments.

Beam detectors monitor a beam of light between two elements to detect the presence of smoke. When a significant level of smoke disrupts the beam, an alarm is activated. Unfortunately, beam detectors are prone to nuisance alarms from obstructions or building movement. These false alarms reduce confidence in the effectiveness of beam detectors and often lead to disqualification. In addition, beam detectors require regular cleaning and maintenance of reflectors and beams surfaces due to dirt and contaminants in the air.

As indicated by their name, Rate of Rise Heat Detectors measure the rapid rise of ambient room temperature to identify the imminent threat of a fire. Rate of Rise Heat detectors are often integrated with fire suppression systems and are typically mounted on ceilings where heat from a fire collects. Unfortunately, a smoldering fire typically produces only low initial levels of heat, making these detectors ineffective for early detection.

Aspirating smoke detection solutions

A new breed of Aspirating Smoke Detector (ASD) solutions is gaining rapid adoption within industrial facilities. ASD solutions are designed to detect the earliest presence of a fire while it is still in the first stage of development, before smoke may be visible to the human eye. The most effective ASD solutions address reliability issues found in conventional smoke detectors through an alternative approach to capturing and analyzing air samples called aspiration. Aspirating smoke detection solutions use multiple air sampling tubes, spread out across large open facilities, to capture and condition air samples. These samples may be conditioned to remove dust and other contaminants that can cause false alarms with conventional smoke detectors. Finally, air samples pass through a highly sensitive centralized laser detection unit. If the presence of smoke is detected, alarm signals are processed and transmitted to centralized monitoring stations, fire alarm panels, as well as to integrated systems such as building management, equipment control or fire suppression systems. The entire process takes only seconds. Because aspirating detectors are actively sampling the air in a facility, they are tolerant of smoke dilution and are reliable in high airflow environments. Because they monitor the flow into the pipe network and indicate a flow fault if the flow is too high (broken/open pipe) or too low (blockage) they provide an additional layer of supervision that passive point (spot) type smoke detectors cannot provide.

Active and ready for extremes

Spot type smoke detectors are ‘passive’ detectors in that they wait for smoke and rely on the airflow to transport the smoke to the detector. Therefore their performance is affected by high airflow. Since the rate of smoke generation in a smoldering fire is relatively small, and the airflow velocity around the equipment or in the facility may be relatively high, the movement of smoke is dominated by the airflow of the mechanical systems. Furthermore the smoke generated during the incipient stage is not hot therefore there is very little thermal lift. The smoke dissipates more widely and is diluted. This often prevents smoke from moving directly to the ceiling of an industrial facility, where spot type detectors might be located according to fire codes. An ASD
system is ‘active’, constantly sampling the air from multiple points throughout the environment of a piece of equipment or the broader facility. It is not totally dependent on thermal energy to transport the smoke to the detector. The active nature of ASD systems overcomes the uncertainties of smoke ingress through insect screens and the other components of a spot detector that are designed to keep insects and smoke out. The passive nature of spot detectors is the cause of their reported poor response, well outside of manufacturer’s quoted figures. It is also the principle cause of many spot detectors remaining in service despite their contamination and risk of failure in a real fire event.

The active detection method used by ASD allows the use of clever methods to keep the detector optics clean, such as the use of a clean air barrier within the laser chamber. This allows ASD to operate in harsh industrial environments with high levels of pollutants such as dust and dirt, without risk of detector contamination. ASD are frequently used in the most harsh environments such as coal bunkers of power plants or heavy manufacturing environments. The use of a pipe network and filtration of the air sample allows contaminants such as dust and lint and even harmful gases such as HCl to be removed before being sampled at the sensitive detector.

**Sensitivity in large open industrial spaces**

Cumulative air sampling refers to the way the ASD sample smoke over the network of sampling points, allowing each to contribute to the smoke being sampled at the detector. Within a large open space or high airflow environment this phenomena becomes very useful as particles of smoke are spread through the facility allowing the cumulative sampling effect to take place.

Take the example of a 20,000 square foot industrial facility room with 20 sample points on the ceiling. If the detector alarm sensitivity for the first level of alarm is set to 0.03% obscuration/ft this effectively makes each sample point’s sensitivity 0.03 x 20 = 0.6% obscuration/ft. That is, if only one sample point was exposed to smoke it would require 0.6% obscuration/ft to trigger an alarm. This is because the fluid mechanics of the model takes into account dilution caused by the other holes. Using the same example, if smoke enters three holes the effective sensitivity required to trigger an alarm is 0.03 x 20 divided by 3 = 0.2% obscuration/ft. Clearly, cumulative sampling allows much lower levels of smoke to be detected and therefore, allows very early warning.

If the same room was designed with WESD and each spot type detector was rated at 2.5% detection is, therefore, fire prevention. Figure 2 illustrates the stage at which a VESDA smoke detector can detect smoke.

One of the most exciting features of the VESDA System is its flexibility in the setting of its sensitivity. The detector alarm thresholds can be set up to 6% obscuration/ft. Obscuration is the effect that smoke has on reducing visibility. Higher concentrations of smoke result in higher obscuration levels, lowering visibility. The first three thresholds would typically be set with Alert 0.009% obscuration/ft, Action at 0.018% obscuration/ft and Fire1 at 0.036% obscuration/ft, in a relatively clean environment. Then there is the opportunity to set Fire2 threshold at 3% obscuration/ft, for example, acting as confirmation of a serious fire event, with the option to activate a suppression system at that point. The provision of these alarm thresholds allows for activating an early and controlled response. For example, the Alert Alarm (the first alarm) condition may be used to call local staff to investigate an abnormal condition. Should the smoke condition continue to increase the Action threshold may be used to initiate smoke control, begin a warning sequence via the evacuation system and alert further staff members via paging or SMS to mobile phones. The FIRE1 Alarm (the third threshold) indicates that a fire condition is very close or has started. At this stage the building is evacuated, the zone on the fire alarm control panel is activated and the signal transmitted to the local monitoring company and fire department. The FIRE2 Alarm threshold will activate once the level of smoke is significant enough to calculate that a fire has started and therefore suppression systems can be activated. For the first time, one product can provide very early warning as well as initiate suppression at a much later stage. Of course, if building fire systems and procedures have operated correctly, then early intervention should preclude operation of the FIRE2 threshold – but it’s a safety net providing control of the last line of defense.
Figure 3 The new VESDA VFT-15 brings high sensitivity ASD to 15 zones of flexible sampling

obscuration VFT, the alarm would only trigger once the smoke density has reached this point throughout the room or at one detector. Many mission critical environments have large areas and tall ceilings which often results in dilution. In addition, the areas may be subject to air flow to cool equipment, processes or workers. The high airflow mixes any smoke quickly in the large space. Under this scenario ASD really shine, as all the sample holes in the system, would see the same smoke level (although at an extremely low level) and would immediately cause an alarm condition at the ASD detector. This is an example of the benefit of the cumulative detection.

Ease of maintenance
Because the sampling pipe can be placed remote from the actual ASD it is possible to have a system protect one environment, such as a busy manufacturing assembly hall, and have the detector placed nearby in a service closet where it is secure and easily serviced. There is no need to service the sample holes regularly and the system can be tested by placing smoke in the last hole.

In-cabinet and integrated-equipment detection
Interest is developing regarding the application of ASD within industrial control equipment cabinets and to provide integrated protection for specific equipment or assets. It is desirable to fit ASD within these cabinets because in some circumstances it would not be acceptable for smoke from a fire within the cabinet to 'breech' the cabinet, enter the mission-critical facility, contaminate other systems or processes and possibly activate main alarms and suppression systems.

In-cabinet smoke detection and action enables an excellent very early warning solution because:
- The sampling is performed closest to the source of the fire, before dilution, which allows earliest detection
- Sampling within the enclosure allows clear identification of the source of the problem. This “addressability” reduces time, effort and error in identifying and remediating the problem.
- The detection occurs before any spread of the risk; loss can be minimized: Smoke is not allowed to contaminate or otherwise affect other systems in the facility.
- Compartmentalization ensures that in worst cases the estimated and possible maximum loss and business interruption estimates are minimized (for insurance assessment)

- The background dust and smoke levels within sealed enclosures are relatively consistent. Also, the airflow dynamics within a sealed enclosure can be predicted with relative confidence by computational fluid dynamic models. This ensures that detection systems can be designed, built and commissioned with confidence of their efficiency and performance.
- Fire responses can be more automated and cost and downtime from fire responses, such as use of suppression, is reduced.
- Better control of the issue management and escalation processes is possible—an alarm can be routed to the data center manager as an “environmental alarm”, rather than reporting via the main fire alarm system. This staged response to a fire threat allows facility staff investigation and possible intervention, an ability to move processes from problem equipment, action such as power-down of problem equipment and, if necessary, suppression of an escalated fire. Such a staged response will often negate the need for suppression to be fitted or, if fitted, will negate the need for expensive suppressant to be released.

Achieving very early warning with ASD while also having fire source location is now possible. With the release of the VESDA VFT-15, up to 15 cabinets, small rooms or pieces of industrial equipment can be protected with independent indication of the location of the incipient fire risk. The use of flexible capillary tubing also makes addition of protection to existing equipment simple.

Solving problems in the industrial world
Due to the huge financial loss and potential business risk, a mission-critical industrial facility cannot risk downtime especially of the size and duration potentially caused by fire and smoke contamination. The most important system that contributes to the prevention of fire is a very early warning smoke detection system such as a VESDA system that meets the performance objective to detect smoke at the very early stages of a fire.

The VESDA Air Sampling Smoke Detection System features provide the designer flexibility by meeting design requirements of prescriptive codes as well as facilitating use of today’s performance-based fire engineering methodologies. These enabling features include:
- Detection of both small incipient smoldering fires and large flaming fires in large open spaces and in high airflow
- Flexibility to design on ceiling, in cable ducts, in exhaust systems and across return air intakes, as well as in cabinets and in targeted equipment
- Reduced nuisance alarms and tolerance to contamination through protected optics and the ability to pre-condition the air sample to remove contaminants
- Multiple alarm levels that can be used to provide:
  - Reduced cost of any nuisance alarms
  - Initiation of orderly shutdown of industrial systems and related processes
  - Removal of contaminated air (via activation of exhaust systems)
  - Communication of reliable early warning (to fire wardens, brigades, etc.)
  - Initiation of staged evacuation
  - Initiation of automatic suppression