

VERY EARLY WARNING FIRE AND GAS DETECTION IN MANUFACTURING ENVIRONMENTS

By Scott Wilson

Scott Wilson is the Director of Market Development for Xtralis. Xtralis is a leading provider of advance knowledge solutions that detect threats and critical events before they endanger business continuity, life safety and critical infrastructure.

Mr. Wilson's role encompasses fire detection (VESDA & ICAM brands), surveillance, intrusion detection, premise access control (ADPRO & Xtralis Security Solutions) and traffic management solutions (ASIM), designed to protect facilities in a wide range of industries and enterprises.

Manufacturing environments present a number of unique risks of fire. Air-sampling smoke detection (ASD) is the preferred method for detection of smoke and fire in manufacturing environments because of its proven reliability and maintenance profile.

Increasingly, the need to safeguard against the risks of leaked gas or unsafe levels of gas in manufacturing and industrial environments has been driven by increased awareness and emerging legislation.

In this article, we will explore ASD and the emerging application of environmental gas detection in manufacturing environments.

THE INDUSTRY FIRE PROBLEM

The risks and causes of fire within manufacturing environments are numerous:

High voltage. Many processes within manufacturing require high power systems that increase the possibility of fire in the event of poor or damaged circuitry.

High power electromechanical devices. Use of systems or processes that generate significant amounts of heat, such as belts for conveyors, drills, or mills create major accident potential.



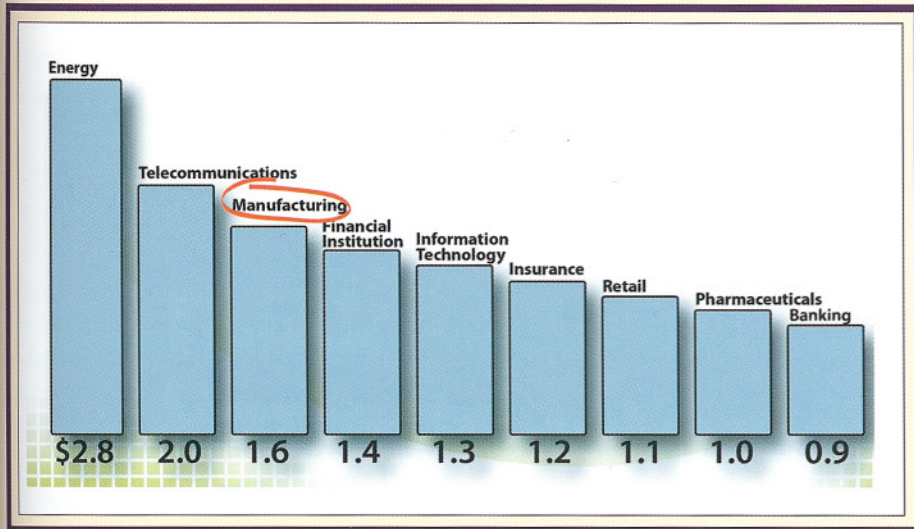


Figure 1. Average cost of hourly downtime for manufacturing ranks as one of the highest [5]

High temperatures. High temperature equipment or processes such as ovens or welding pose a real danger of fire if not properly contained.

Flammable gases and liquids. Flammable gases and liquids used during the manufacturing process can increase the likelihood of fire and speed the growth of a fire.

Fume and contaminant extraction systems. Industrial exhaust systems are renowned to cause fires within their dust and particulate collection systems, especially if used near hot work. If not monitored and/or suppressed, fires can grow to large fires through a steady supply of air.

Manufacturing facilities are expensive, difficult to replace and clean and expensive to have lying idle. The extreme value concentration and financial consequences of business interruption have led to the view that better systems are needed for fire detection. The problem, however, is that early or even reliable detection of fire in these environments is challenging. Traditional fire detection systems are particularly taxed by certain features of manufacturing environments that overwhelm their capacity to detect fire. Here are some examples:

Tall ceilings and large open spaces cause smoke dilution – even quite large fires can be hard to detect fast or reliably.

High air movement, often with open doors and windows, carry smoke away from detectors high velocity air dilutes smoke very quickly.

Electrical noise may affect detector performance where detection is required near manufacturing equipment.

Common return air paths and filtration – the source of the fire may be difficult to determine due to rapid mixing of airflows at an air return - early detection close to the source is essential.

Crowded floor spaces make access to the ceiling and routine system maintenance difficult getting access to detection systems above manufacturing hall tools with a scissor lift is often impossible. In addition, systems testing should not introduce contaminants in sensitive environments.

Cost, complexity and dangers of evacuation – many facilities like steel works and pharmaceutical plants have complex processes before evacuation can be commenced, require security processes to be

followed and the act of evacuation creates enormous process interruption costs.

EARLY WARNING CONCEPTS

Improved detection speed increases the opportunity to investigate risks, intercede early, and avoid an escalating fire, protect property, and ensure safe egress. If fire is detected and managed during the incipient phase, the opportunities for simple and low-cost management of the risk are significantly enhanced. Quelling a small fire might simply involve turning off a piece of production equipment. Having multiple levels of alarm spread across the life of a fire enables early detection and response to arrest the propagation of the accident sequence. The trend of consequences from early to late detection is illustrated in Figure 2.

A better awareness of even potential fire risks also reduces the costs of any nuisance alarms. Instead of the response procedure necessarily involving an immediate down-tools and evacuation, a trained facility manager can respond with appropriate, perhaps reduced haste (and reduced cost) to prudently investigate. Even if the first level of alarm indicates a spurious and benign cause, and no fire, the nuisance alarm has caused little more than a slight inconvenience to the facility manager, no interruption to operations and costs little to the manufacturer. Reduction of down time and business interruptions are valuable benefits of very early detection. Of course, detection that avoids the total loss of a facility is of enormous value.

AIR-SAMPLING SMOKE DETECTION DESCRIBED

Air-sampling Smoke Detection (ASD) involves a fixed system which draws air from an area, via a pipe network, back to a central detector which continually monitors for very small amounts of smoke.

The systems typically use forward

light scattering principles with high quality optical designs to achieve sensitivities hundreds of times greater than those of a commercial spot-type smoke detector. Good product designs also allow reporting of very high levels of smoke with multiple, software configurable, alarm levels. Products designed with a clean-air barrier to protect their sensitive optics are also tolerant to continued and reliable use in relatively high levels of contaminants. The ability to place the detector remote from the protected environment or outside of a large piece of equipment enables sampling for smoke from within very harsh temperature, humidity, dust-prone, or high vibration environments. The flexibility of using pipes and ancillary filtration to "condition" the air sample is one of the unique aspects of ASD that has allowed its successful use in a broad range of hazardous applications.

MANUFACTURING APPLICATIONS FOR AIR-SAMPLING SMOKE DETECTION

ASD is the most popular technology

for very early warning smoke detection. ASD now accounts for a significant proportion of the commercial smoke detection installed around the globe in a range of sterile and hazardous manufacturing environments [1]. ASD has been proven to provide reliable detection in a very wide range of enclosed manufacturing spaces. It is not suitable for outdoor applications.

ASD is widely used in high value manufacturing to monitor for smoke in processes that depend upon cleanliness such as those found in pharmaceutical, food and semiconductor manufacturing. The detection technique is also used in general manufacturing environments for its low cost of installation and centralized maintenance with reduced impact on process continuity. ASD is selected in harsh manufacturing facilities like steel mills due to its superior tolerance to contamination and reliability. Some emerging ASD technologies can also be used to distinguish and detect smoke in an environment heavily

laden with dust, however, this has not yet been reliably demonstrated with all dust types and sizes of smokes and dusts.

THE NEED FOR ENVIRONMENTAL GAS DETECTION

Efficiency, productivity, and a good working atmosphere are interused in a competitive world. The requirement to ensure a safe manufacturing environment for staff runs parallel to the need to ensure manufacturing equipment and processes also continue to run optimally. Detection of a gas leak from a manufacturing process into the occupied environment serves to identify risks to man and machine, and the safety of all dependent processes. In general terms, the sources of fire and gas hazards can be categorized as one of three types:

Toxic Gases. A toxic gas is defined as a chemical compound that, when inhaled, ingested, or absorbed through the skin provokes a wide range of damage, from minor irritations to death. Exposure limits to toxic gases have been established by occupational safety agencies and may vary according to local directives.

Oxygen Deprivation. Oxygen is one of the top 4 gases that are measured in industrial environments. Oxygen is also used to notify personnel that an area has been or is being flooded by an "inerting" gas such as nitrogen.

Flammable Gases. A flammable (combustible) gas is defined as the chemical compound, which will ignite (or explode) on contact with an ignition source.

Multi-criteria Fire Detection. Gas detection can be used to detect the products of combustion. It can be combined with smoke detection for confirmation of fire detection for faster response or to verify a genuine fire event and eliminate unwanted and costly nuisance alarms.

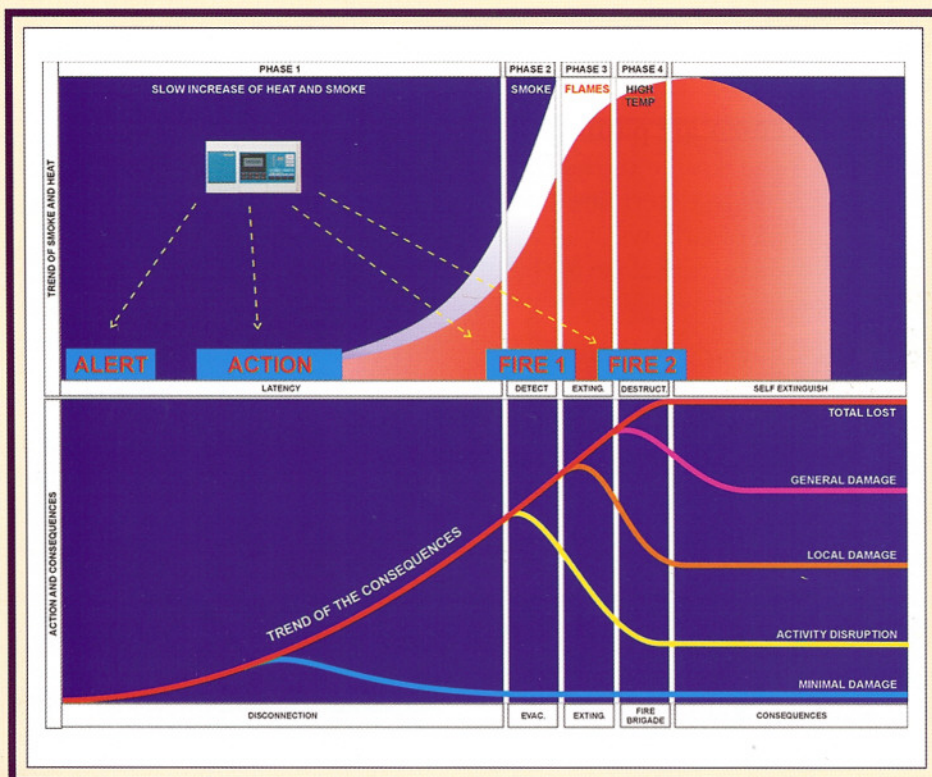


Figure 2. Early detection and multiple levels of alarm allow reduced risk through the life of a fire

Smoke detection is well suited in locations where steam is present, in dusty or dirty environments, or where there is a high risk of a slowly developing or smoldering fire where toxic gases may evolve before smoke particles.

APPLICATION OF ASD SAMPLING TECHNIQUES TO ENVIRONMENTAL GAS DETECTION

Drawing a gas sample for analysis is common in the process industry. Representative samples must be clean, dry, moderate in temperature, and safe to enter the instrument. The active sampling helps compensate for adverse air movement in the sample zone, assures a known sample volume, and provides for an accurate sample composition. But in the environmental and building automation fields, use of aspiration techniques is the exception. Monitors for CO, CO₂, combustibles, refrigerants and VOCs tend to be fixed discrete sensors mounted in the area of detection, relying upon passive delivery of the sample to the sensor.

The opportunity to leverage the installed and growing base of ASD and add new gas sensor types to the centralized and networked detectors realizes new user benefits, especially for occupied areas in manufacturing environments. The concept and efficiencies of using a distributed pipe network in a facility to actively deliver a sample of gas to a centralized detector for analysis and reporting deserves some analysis.

ASD overcomes a very specific problem - the impedance to smoke particles entering a passive detector. In the case of a traditional photoelectric point ("spot") smoke detector, the impedance presented by the external mesh and the labyrinth to the chamber, designed to keep insects and light out, is quite significant. This impedance is suspected to be a major contributor to these



devices performing below their nominal and factory calibrated levels [2] and providing only 20% certainty of operation [3]. Aspiration not only moves the sample into the collection system, but also delivers it to the detector at a known and monitored rate. Within design limits this same ASD collection system can be used to actively monitor for the presence of gas, overcome any impedance or specific gas density issues, provide a means to condition the sample before analysis, and measure and monitor the flow to ensure reliable detection.

Expected advantages of using the method compared with existing passive gas detection methods include:

Active sampling in and around dangerous equipment - The ability to sample in and around the immediate environment of a manufacturing process from a safe distance has been a common market

requirement. For example, if entry to a production environment first requires verification of safety, then the mounting of the detector on the outside of that environment provides obvious benefits.

High cost efficiency - Compared to wiring and placement of multiple sensors, each with its own communication and mounting requirements, it is anticipated that common use of existing ASD sampling pipes will provide significant initial capital savings and lower total cost of ownership.

Elimination of sources of sensor poisoning - Through filtration and active sample treatment it is possible to eliminate the majority of interfering gases and poisons. For instance, sampling for a gas in a humid place with a sensor that is sensitive to humidity can be solved by first drying the sample by passing it through a desiccant. Likewise, with sensors that are sensitive to chlorine or other

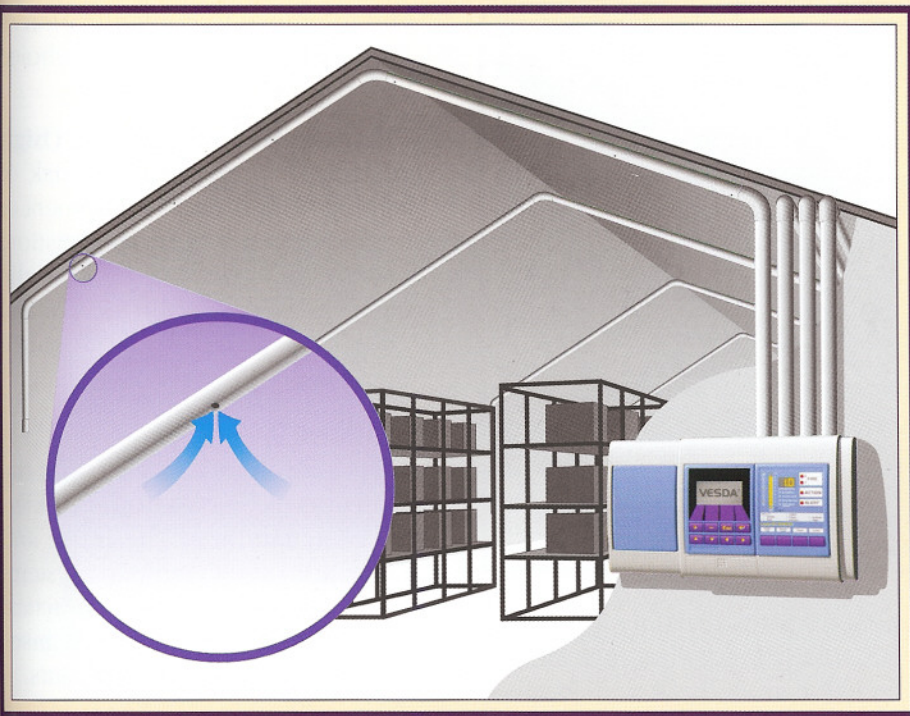


Figure 3. ASD consists of a centralised highly intelligent detector that draws air samples to it through a series of pipes

aggressive gases, it is possible to first condition the sample to remove the compounds expected to cause poisoning. Common filtration of dust and other particles can also be achieved by using airflow to overcome the impedances such filters cause.

Easy access for maintenance and service - Centralized placement of a single sensor (or reduced sensor count) naturally reduces the effort of maintenance, service, and testing. For example, if sampling is required within an electrical room in which technicians must circumvent electrical hazards to perform routine maintenance, it is possible to have the pipe network inside and the detector outside, allowing fire and environmental staff to service the equipment from outside.

Management of environmental extremes - Conditioning of the sample in the pipe before sampling at the detector is a common tactic in ASD. Similar practices such as pipe warming could be adopted.

Improved aesthetics and tamper-proofing - Where gas de-

tection is required to be out of sight or made with improved aesthetics, then the sampling point can be disguised or hidden within other equipment of facility features.

Convenient and cost-effective integration centralized monitoring and communication - Power systems, and monitoring and reporting networks for ASD already exist, in many cases with interfaces to building management systems ("BMS") and process and control systems. Leveraging existing

common infrastructure reduces the cost of implementation and ongoing system support.

APPLICATION OF THE ASD TECHNIQUE FOR COMBINED FIRE AND GAS DETECTION

Fire Alarm Confirmation

Various types of fires produce different gases, as illustrated in Table 1. The possibility for augmentation of fire-detection performance for improved responsiveness and reduced nuisance alarm rates through the use of multi-criteria analysis has been much lauded [4]. Typically, one of the challenges of relying upon multi-criteria systems in domestic environments is the fact that you are less aware of, or in control of, the possible fuel types that might cause different ratios of the coincident gases. To some extent, the manufacturing environment could be said to be more controlled and knowledge of the particular fuel present and likely fire products could allow better discrimination.

Multi-criteria discrimination in a manufacturing environment could reduce nuisance alarms from dust particulates of sizes resembling smoke particulates. It could allow the possibility of very early smoke detection, where a relatively high percentage of particulates is present, but a selected gas is known to be produced as a product of combustion. Naturally the coincidence of

TABLE 1. GASES PRODUCED FROM COMMON FIRE TYPES				
Measurement of fire produced gases [5]				
BS5445				
Fire Type	CO (ppm)	H ₂ (ppm)	H ₂ O (%)	O ₂ (ppm)
Cellulose	38	3	0	1300
Smouldering (cellulosic)	105	0	0	0
Smouldering (cotton)	230	245	0	0
Open polyurethane fire	45	0	8	2200
Liquid (n-heptane)	23	0	28	8000
Liquid (methylated spirits)	18	0	39	9000



the smoke and gas sampling in the one pipe network provides a good basis for multi-criteria analysis.

Common Gas Detection Applications Leveraged by ASD

ASD is today applied in a number of manufacturing and building automation situations that are targets for innovative gas detection. Here are examples of common applications and their target gases:

Ventilation systems – CBRNE (Chemical, Biological, Radiological, Nuclear, Explosive) for detection of terrorist threats, CO₂ for demand control ventilation (DCV) to reduce capital expenditure and ongoing energy costs. ASD is already the preferred choice for duct and HVAC monitoring because of its tolerance to high airflow and high sensitivity to diluted smoke.

Warehouse and cold storage – refrigerants such as NH₃, CO to ensure equipment reliability, avoid stock contamination and compliance with OSHA and FDA require-

ments. ASD is the only approved technology for cold storage smoke detection and is most widely specified for high value storage applications.

Utility rooms, electrical control and switching equipment – light hydrocarbons, H₂, CO, other gases to avoid explosions and ensure tenability for staff and ensuring equipment and service continuity. The very early warning and remote active sampling capabilities of ASD make it the preferred choice for remote sensing inside small rooms and cabinets.

Habitation in adverse climates – CO, O₂, CO₂ for indoor air quality (IAQ) and compliance with OSHA requirements. ASD is ideal for detecting, recording and audit reporting of such life safety risks.

Tunnels and enclosed spaces – light hydrocarbons, H₂, CO and argon to avoid explosions, detect incipient cable fires and ensure tenability for staff. The very early warning, pipe network flexibility

and tolerance to contamination of ASD make it the preferred choice for protecting tunnels.

The manufacturing floor (high ceilings) – any gases at risk of leaking from process equipment or the likely product of combustion. ASD is selected to overcome the dilution in large open spaces and reduce the cost of maintenance above busy workspaces.

SUMMARY

ASD is a reliable method for the detection of, smoke from smoldering or active fires. The reuse and adaptation of ASD sampling systems can be applied to provide practical detection of environmental gases in manufacturing environments.

This paper has outlined the challenges for smoke detection in the manufacturing environment and the mechanisms that ASD employs to overcome those challenges. The same strategies used to provide good smoke detection can ensure detection of a representative sample of gas in a set volume, overcome ventilation and sample entry impedance, and condition the air sample before detection. The combined “Aspirating Smoke and Gas Detection” (ASGD) solutions offer flexibility for the solution designer for the range of toxic gas detection, flammable gas detection, and multi-criteria fire detection.

ASD, as the preferred technology for reliable and very early warning fire detection, now also provides solution designers with a gas detection scheme that offers the manufacturer a more productive and safer working environment.

• • •

References

1. *The Americas Market for Fire Detection & Suppression Products 2008 Edition*, IMS Research USA, pp. [58-59].
2. Milke, J.A. and Gandbi P., “Guidelines for Estimating Smoke Detector Response”, SUPDET 2009. Results are for the 80th percentile for unventilated non-flaming fires using UL-approved commercial photoelectric spot detectors.
3. Geiman J.A., and Gottuk D.T., “Alarm Thresholds for Smoke Detector Modeling,” *Fire Safety Science Proceedings of the Seventh International Symposium, 2002*, pp. [197-208].
4. University of Duisburg AUBE Conferences on Automatic Fire Detection proceedings for '99, '01, and '04. Specifically, Conforti, F., “Multi-Sensor, Multi-Criteria Detectors are Better”, *Proceedings AUBE 99, 1999*, pp. [247-249].
5. *Gas sensing for fire detection: measurements of CO, CO₂, H₂, O₂, and smoke density in European standard fire tests.* JACKSON M. A.; ROBINS I.; *Fire Safety Journal* 0379-7112, 17248, Elsevier Science, 1994, vol.22, no2, pp. [181-205].