Chapter 17

Fire & Gas Detection and Alarm Systems

Various simple and sophisticated fire and gas detection systems are available to provide early detection and warnings of a hydrocarbon release which supplement process instrumentation and alarms. The overall objective of fire and gas detection systems are to warn of possible impending events that may be threatening to life, property of continued business operations that are external to the process operation.

Process controls and instrumentation only provide feedback for conditions within the process system. They do not report or control conditions outside the assumed process integrity limits. Fire and gas detection systems supplement process information systems with instrumentation that is located external to the process to warn of conditions that could be considered harmful if found outside the normal process environment. Fire and gas detection systems may be used to confirm the readings of major process releases or to report conditions that process instrumentation may not adequately report or be unable to report (i.e., minor process releases).

Fire and Smoke Detection Methods

Hydrocarbon vapors immediately burn with flame temperatures that are considerably higher than that of ordinary combustibles. For this reason damage from a hydrocarbon fire is much more severe than an ordinary combustible fire. The objective of a fire detection for the petroleum industry is to rapidly detect a fire where personnel, high value, and critical equipment may be involved. Once detected executive action is initiated to alert personnel for evacuation and while simultaneously controlling and suppressing the fire incident.

Human Surveillance

Human beings provide the first line of observation and defense for any facility. Periodic or constant first hand operator on site surveillance of the process provides careful observation and reporting of all activities within the facility. Humans have keen senses that have yet to be expertly duplicated by instrumentation devices or sophisticated technical surveillance mechanisms. In this fashion they are more valuable in the observation of system performance than ordinary process control systems may be.

It should be remembered that humans are also prone to panic and confusion at the time of an emergency and so may also be unreliable in some instances. Where proper training and selection of personnel occurs situations of panic and confusion may be overcome.
Manual Activation Callpoint (MAC)/Manual Pull Station (MPS)

Simple switches that can be manually activated can be considered a fire alarm device. Models are used which normally require the use of positive force, i.e., to avoid accident and fraudulent trips. Fire alarm switches normally can only be reset by special tools in order to trace the source of the alarm, however sophisticated data reporting systems with addressable data collection may make this requirement obsolete.

Manual activation devices are normally placed in the main egress routes from the facility or location. Usually placement in the immediate high hazard location egress route and at the periphery evacuation routes or muster location of the installation is accomplished.

Telephone Reporting

All telephone points can be considered a method of notification. Telephones can be easily placed in a facility but may be susceptible to ambient noise impacts and the effects of a fire or explosion. Additionally information from verbal sources can be easily misunderstood spoken during an emergency. Simultaneous use of the phone system during emergency situations may also cause it to be overloaded and connections difficult to achieve.

Portable Radios

Operations personnel are normally provided with portable radios in large facilities. They have similar deficiencies to telephones but offer the advantage on onsite portability with continuous communication access.

Smoke Detectors

Smoke detectors are employed where the type of fire anticipated and equipment protection needs a faster response time than heat detectors. A smoke detector will detect the generation of the invisible and visible products of combustion before temperature changes are sufficient to activate heat detectors. The ability of a smoke detector to sense a fire is dependent on the rise, spread, rate-of-burn, coagulation and air movement of the smoke itself. Where the safety of personnel is a concern, it is crucial to detect a fire incident at its early stages because of the toxic gases, lack of oxygen that may develop, and obscuration of escape routes. Smoke detection systems should be considered when these factors are present.

Ionization

Ionization and condensation nuclei detectors alarm at the presence of invisible combustion products. Most industrial ionization smoke detectors are of the dual chamber type. One chamber is a sample chamber the other is a reference chamber. Combustion products enter an outer chamber of an ionization detector and disturb the balance between the ionization chambers and trigger a highly sensitive cold cathode tube that causes the alarm. The ionization of the air in the chambers is caused by a radioactive source. Smoke particles impede the ionization process and trigger the alarm. Condensation nuclei detectors operate on the cloud chamber principle, which allows invisible particles to be detected by optical techniques. They are most effective on Class A fires (ordinary combustibles) and Class C fires (electrical).

Photoelectric

Photoelectric detectors are of the spot type or light-scattering type. In each, visible products of combustion partially obscure or reflect a beam of light between its source and a photoelectric receiving element. The disruption of the light source is detected by the receiving unit and as a result
an alarm is actuated. Photoelectric detectors are best used where it is expected that visible smoke products will be produced. They are sometimes used where other types of smoke detection is too sensitive to the invisible products of combustion that are produced in the area as part of normal operations such as garages, furnace rooms, welding operations, etc.

**Dual Chamber**

Combinations of photoelectric and ionization detectors are available that operate as describe above. They are used to detect either smoldering or rapidly spreading fires.

**Very Early Smoke Detection and Alarm (VESDA)**

High sensitivity sampling smoke detector systems provide the best form of rapid smoke detection for highly critical equipment or in high air flow situations. The VESDA system is basically a suction pump with collection tubes or pipes that use an optical smoke detection device to test for evidence of smoke particles. Since it gathers air samples from the desired protected area they are much faster in detection than ordinary detection that has to wait for the smoke to arrive to it. Care must be taken that the sampling tubes are protected from mechanical damage and the initial effects of an incident. In the petroleum industry, VESDA systems are typically provided for the interior of electrical or electronic cabinets or racks that control critical oil or gas processing activities.

**Thermal or Heat Detectors**

Thermal or heat detectors respond to the energy emission from a fire in the form or heat. The normal means by which the detector is activated is by convention currents of heated air or combustion products or by radiation effects. Because this means of activation takes some time to achieve thermal detectors are slower to respond to a fire when compared to some other detection devices.

There are two common types of heat detectors - fixed temperature and rate of rise. Both rely on the heat of a fire incident to activate a signal device. Fixed temperature detectors signal when the detection element is heated to a predetermined temperature point. Rate of rise detectors signal when the temperature rises at a rate exceeding a pre-determined amount. Rate of rise devices can be set to operate rapidly, are effective across a wide range of ambient temperatures, usually recycle rapidly and can tolerate a slow increase in ambient temperatures without providing an alarm. Combination fixed temperature detectors and rate of rise will respond directly to a rapid rise in ambient temperatures caused by fire, will tolerate a slow increase in ambient temperatures without effecting an alarm, and recycle automatically on a drop in ambient temperature.

Heat detectors normally have a higher reliability factor than other types of fire detectors. This tends to lead to fewer false alarms. Overall they are slower to activate than other detecting devices. They should be considered for installation only where speed of activation is not considered critical or as a backup fire detection device to other fire detection devices. They have an advantage of suitability for outdoor applications but the disadvantage of not sensing smoke particles or visible flame from a fire.

Some of the systems can be strung as a line device and offers detection over a long path alternatively they can be used as spot detectors. A common deficiency after installation is they tend to become painted over, susceptible to damage, or the fusible element may suffer a change in activation temperature over a long installation period.

Heat detectors are activated by either melting a fusible material, changes in electrical current induced by heat loads on bi-metallic metals, destruction of the device itself by the heat, or by sensing a rate of ambient temperature rise.
The following are some of the most common heat detection devices that are commercially available and used in the hydrocarbon industries.

- Flexible plastic tubing (pneumatic)
- Fusible optical fiber
- Bi-metallic wire or strip
- Fusible plug (pneumatic pressure release)
- Quartzoid bulb (pneumatic pressure release)
- Fusible link (under spring tension)
- Fixed temperature detector
- Rate of rise detector
- Rate compensated
- Combination rate of rise and fixed temperature

(On a rare occasion a tensioned string tied to pressure switch has been provided as detection over the vapor seal area of a floating roof crude storage tank. Although this method may be considered primitive and cheap, it is effective and beneficial versus the option of no detection).

**Optical (Flame) Detectors**

Flame detectors alarm at the presence of light from flames usually in the ultraviolet or infrared range. The detectors are set to detect the typical light flicker of a flame. They may be equipped with a time delay features to eliminate false alarms from transient flickering light sources.

There are six types of optical detector commonly used in the oil and gas industry.

1. Ultraviolet (UV).
2. Single frequency infrared (IR).
3. Dual frequency infrared (IR/IR).
4. Ultraviolet/infrared - simple voting (UV/IR).
5. Ultraviolet/infrared - ratio measurement (UV/IR).

Each of the five types of detectors listed has advantages and limitations, making each more or less suitable for an application or a specific risk. There is not a uniform performance standard for flame detectors such as their is with smoke detectors. Flame detection for a particular model has to be analyzed by evaluation of its technical specification to expected fire development.

**Ultraviolet (UV) Detector**

Responds to the relatively low energy levels produced at wavelengths between 0.185 and 0.245 microns. This wavelength is outside the range of normal human visibility and outside that of sunlight.

Advantages

The ultraviolet detector is general all purpose detector. It responds to most burning materials but at different rates. The detector can be extremely fast, i.e., less than 12 milliseconds for special applications (e.g., explosive handling). It is generally indifferent to the physical characteristics of flames and does not require a "flicker" to meet signal input functions. It is not greatly affected by deposits of ice on the lens. Special modules are available that can be used in high temperature applications up to 125 °C (257 °F). Hot black body sources, (stationary or vibrating) are not normally a problem. It is blind to
solar radiation and most forms of artificial light. An automatic self testing facility can be specified or it can be tested with a hand held source at distances more than 10 meters (3 ft.) from the detector. Most models can be field adjusted for either the flame sensitivity or the time delay function.

Limitations

It responds to electric arcs from welding operations. It can be affected by deposits of grease and oil on the lens. This reduces its ability to "see" a fire. Lightning with long duration strikes can cause false alarm problems. Some vapors typically those with unsaturated bonds may cause signal attenuation. Smoke will cause a reduction in signal level seen during a fire. It may produce a false alarm response when subject to other forms of radiation such as from NDT operations.

Single Frequency InfraRed (IR) Detectors

This detector responds to infrared emissions from the narrow CO₂ band at 4.4. microns. It requires the satisfaction of a flicker frequency discrimination at between 2 and 10 Hz.

Advantages

It responds well to a wide range of hydrocarbon fires and is blind to welding arcs except when very close to the detector. It can see through smoke and other contaminants that could blind a UV detector. It generally ignores lightning, electrical arcs and other forms of radiation. It is blind to solar radiation and resistant to most forms of artificial lighting.

Limitations

There are few models with automatic test capability. Testing is usually limited to hand held devices only 2 meters (7 ft.) from the detector or directly on the lens test unit. It can be ineffective if ice forms on the lens. It is sensitive to modulated emissions from hot black body sources. Most of the detectors have fixed sensitivities. The standard being under five seconds to a petroleum fire of 0.1 square meter (1.08 sq. ft.) located 20 meters (66 ft.) from the device. Response times increase as the distance increases. It cannot be used in locations where the ambient temperatures could reach up to 75 °C (167 °F). It is resistant to contaminants that could affect a UV detector. Its response is dependent on fires possessing a flicker characteristic so that detection of high pressure gas flames may be difficult.

Dual or Multiple Frequency InfraRed (IR/IR) Detectors

This detector responds to infrared emissions in at least two wavelengths. Typically a CO₂ reference at 4.45 microns is established and a second reference channel that is away from the CO₂ and H₂O wavelengths is made. It requires that the two signals received are confirmed as are synchronous and that the ratio between both signals is correct.

Advantages

It responds well to a wide range of hydrocarbon fires and is blind to welding arcs. It can detect fires through smoke and other contaminants, although the signal pickup will be reduced. It generally ignores lightning and electrical arcs. It has minimal problems with solar radiation and artificial radiation. It is also insensitive to steady or modulated black body radiation. There is a high level of false alarm rejection with this model of detector.
Limitations

Detectors with complete black body rejection capability are usually less sensitive to fires than a single frequency infrared optical detector. Because it's discrimination of fire and non-fire sources depend upon an analysis of the ratio between fire and reference frequencies, there is a variation in the amount of black body rejection achieved. A detector's degree of black body radiation rejection is in inversely proportion to its ability to sense a fire. The detectors are limited to applications that involve hydrocarbon materials.

Ultraviolet/Infrared (UV/IR) Detectors

There are two types of detectors under UV/IR classifications. Both of the types respond to frequencies in the UV wavelength and IR in the CO₂ wavelength. In both types simultaneous presence of the UV and IR signals must be available for alarm conditions. In the simple voting device an alarm is generated once both conditions are met. In the ratio device, satisfaction of the ratio between the level of UV signal received and IR signal received must also be achieved before an alarm condition is confirmed.

Advantages

These detectors respond well to a wide range of hydrocarbon fires and are indifferent to arc welding or electric arcs. There are minimal problems with other forms of radiation. They are blind to solar radiation and artificial lighting. They ignore black body radiation. Its fairly fast response is slightly better than a single frequency IR detector but not as fast as a UV detector. The simple voting type will respond to fire in the presence of an arc welding operation. It is not desensitized by the presence of a high background IR source. The flame sensitivities of the simple voting detector can be field adjusted.

Limitations

The sensitivity to a flame can be affected by deposits of IR and UV absorbing materials on the lens if not frequently maintained. The IR channel can be blinded by ice particles on the lens. While the UV channel can be blinded by oil and grease on the lens. Smoke and some chemical vapors will cause reduced sensitivity to flames. UV/IR detectors require a flickering flame to achieve an IR signal input. The ratio type will lock out when an intense signal source such as arc welding or high steady state IR source is very nearby. Flame response for a ratio type is affected by attenuators, while in the voting type there is negligible effect. The detectors are limited to applications involving hydrocarbon materials.

Multi-band Detectors

Multi-band fire detector monitors monitor several wavelengths of predominate fire radiation frequencies by photocells. They compare these measurements to normal ambient frequencies through micro processing. Where these are found be above certain levels an alarm is indicated. False alarms may even be "recognized”

Advantages

These detectors have a very high sensitivity and very encouraging stability. The microprocessor has the capability to be programmed to recognize certain fire types.
Disadvantages

May be inadvertently mis-programmed. The detector is relatively new on the market and needs further industry experience for wide acceptance.

<table>
<thead>
<tr>
<th>Type of Detection</th>
<th>Detector Type</th>
<th>Speed</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>Human</td>
<td>Moderate</td>
<td>Expensive</td>
</tr>
<tr>
<td></td>
<td>Telephone</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Portable Radios</td>
<td>Moderate</td>
<td>Moderate to Expensive</td>
</tr>
<tr>
<td></td>
<td>MPS/MAC</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Smoke</td>
<td>Ionization</td>
<td>Fast</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Photo-Electric</td>
<td>Fast</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>VESDA</td>
<td>Very Fast</td>
<td>High</td>
</tr>
<tr>
<td>Heat</td>
<td>Fusible Link</td>
<td>Low to Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Plastic Tube</td>
<td>Low to Moderate</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Fusible Plug</td>
<td>Low to Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Quartzoid Bulb</td>
<td>Low to Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Optical Fiber</td>
<td>Low to Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Bi-metallic Wire</td>
<td>Low to Moderate</td>
<td>Low to Moderate</td>
</tr>
<tr>
<td></td>
<td>Heat Act/ROR</td>
<td>Low to Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Optical</td>
<td>IR</td>
<td>Very Fast</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>UV</td>
<td>Very Fast</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>IR/IR</td>
<td>Very Fast</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>UV/IR</td>
<td>Very Fast</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Multi Band</td>
<td>Very Fast</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Video Camera</td>
<td>Fast</td>
<td>Expensive</td>
</tr>
</tbody>
</table>

Table 19

Comparison of Fire Detectors
<table>
<thead>
<tr>
<th>Location or Facility</th>
<th>Hazard</th>
<th>Fixed Detector Type Options</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>Ordinary Combustibles Electrical Fire</td>
<td>MPS Heat Smoke</td>
<td>NFPA 101, Section 26-3.4.1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accommodation</td>
<td>Ordinary Combustibles Electrical Fire</td>
<td>MPS Smoke</td>
<td>NFPA 101, Section 18-3.4.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&amp; Section 20-3.4.1</td>
</tr>
<tr>
<td>Kitchens and Cafeterias</td>
<td>Cooking Electrical Fire</td>
<td>MPS Heat</td>
<td>NFPA 101, Section 8-3.4.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NFPA 96, Section 7-3.1.4</td>
</tr>
<tr>
<td>Control Rooms</td>
<td>Electrical Fire</td>
<td>MPS Smoke</td>
<td>NFPA 75, Section 6.2</td>
</tr>
<tr>
<td>Switchgear Rooms</td>
<td>Electrical Fire</td>
<td>MPS Smoke</td>
<td>NFPA 850, Section 6.3</td>
</tr>
<tr>
<td>Turbine Package</td>
<td>Electrical Fire</td>
<td>Heat Optical</td>
<td>NFPA 30, Section 5-5.5.1.</td>
</tr>
<tr>
<td></td>
<td>Hydrocarbon Fire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process Units</td>
<td>Hydrocarbon Fire</td>
<td>MPS Heat Optical</td>
<td>NFPA 30, Section 5-5.5.1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump Stations</td>
<td>Hydrocarbon Fire</td>
<td>MPS Heat Optical</td>
<td>NFPA 30, Section 5-5.5.1.</td>
</tr>
<tr>
<td>Loading Facilities</td>
<td>Hydrocarbon Fire</td>
<td>MPS Heat Optical</td>
<td>NFPA 30, Section 5-5.5.1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tank or Vessel Storage</td>
<td>Hydrocarbon Fire</td>
<td>MPS Heat Optical</td>
<td>NFPA 30, Section 5-5.5.1.</td>
</tr>
<tr>
<td>Offshore Drilling or Production Facility</td>
<td>Hydrocarbon Fire</td>
<td>MPS Smoke Heat Optical</td>
<td>API RP 14 G</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NFPA 30, Section 5-5.5.1.</td>
</tr>
<tr>
<td>Laboratories</td>
<td>Hydrocarbon Fire</td>
<td>MPS Heat</td>
<td>NFPA 45, Section 4-1.1 &amp; 4.5</td>
</tr>
</tbody>
</table>

Table 20
Application of Fixed Fire Detection Devices
Gas Detection

Gas detection is provided in the petroleum industry to warn of and possibly prevent the formation of a combustible gas or vapor mixture that could cause an explosive overpressure blast of damaging proportions. There are two types of gas detectors used in the oil and gas industry. The most common and widely used is the catalytic detector. More recently, infrared (IR) beam detectors have been employed for special "line of sight" applications, such as perimeter, boundary or offsite monitoring, pump alleys, etc.

A gas detection system monitors the most likely sources of releases and activates alarms or protective devices to prevent the ignition of a gas release and possibly mitigate the effects of a flash fire or explosion.

Most hydrocarbon processes contain gases in a mixture. Therefore the gas detection vapor selected for detection must be chosen carefully. The most prudent approach in such cases to chose to detect the gas that is considered the highest risk for the area under examination.

The basis of the highest risk should account for:

1. The gas with the widest flammable range of the gasses that are present.
2. The largest percent volume of a particular gas in the stream.
3. The gas with the lowest ignition temperature.
4. The gas with the highest vapor density.
5. Spark energy to necessary for ignition (i.e., Group A, B, C or D).

Since no specific property can define the entire risk for a particular commodity, the consequence for each material should be examined when deciding upon the optimum gas detection philosophy for a particular area.

The following table is a brief comparison of the characteristics of the most common gases that may be encountered in a hydrocarbon facility.

<table>
<thead>
<tr>
<th>Material</th>
<th>LEL/UEL %</th>
<th>AIT (°C)</th>
<th>VD</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>4.0 to 75.6</td>
<td>500</td>
<td>0.07</td>
<td>B</td>
</tr>
<tr>
<td>Ethane</td>
<td>3.0 to 15.5</td>
<td>472</td>
<td>1.04</td>
<td>D</td>
</tr>
<tr>
<td>Methane</td>
<td>5.0 to 15.0</td>
<td>537</td>
<td>0.55</td>
<td>D</td>
</tr>
<tr>
<td>Propane</td>
<td>2.0 to 9.5</td>
<td>450</td>
<td>1.56</td>
<td>D</td>
</tr>
<tr>
<td>Butane</td>
<td>1.5 to 8.5</td>
<td>287</td>
<td>2.01</td>
<td>D</td>
</tr>
<tr>
<td>Pentane</td>
<td>1.4 to 8.0</td>
<td>260</td>
<td>2.48</td>
<td>D</td>
</tr>
<tr>
<td>Hexane</td>
<td>1.7 to 7.4</td>
<td>225</td>
<td>2.97</td>
<td>D</td>
</tr>
<tr>
<td>Heptane</td>
<td>1.1 to 6.7</td>
<td>204</td>
<td>3.45</td>
<td>D</td>
</tr>
</tbody>
</table>

Table 21

Comparison of Common Hydrocarbon Vapor Hazards

By an analysis of the composition of gas or liquid stream and the arrangement or conditions at the particular facility one can prudently arrive at the optimum detection philosophy.
Application

Assuming the main objective of combustible gas detection is to warn of the formation of vapor clouds that if ignited would produce harmful explosion aftereffects, then the threshold of 5.5 meters (18 ft.), as proposed by the Christian Michelsen Institute, Norway, should be the limiting case for the spacing of combustible gas detectors. A three dimensional triangular spatial arrangement of 5 meters (16.4 ft.), 10% for adjustment and contingency factor, would provide a satisfactory arrangement for area gas detection in confined areas. The first step is to define all possible leakage sources and then narrow the possibilities by selecting equipment that has the highest probability of leakage. This can be accomplished by first referring to the electrical hazardous area classification drawings for each facility. Equipment that handles low flash point materials should be given the highest priority, with materials of a high vapor density of most concern, since these vapors are easiest to collect and less likely to disperse.

Pump and compressor seal areas are by far the most common areas where vapor releases may occur. This is followed by instrumentation sources, valve seals, gaskets and sample points and the most rare but usually catastrophic erosion and corrosion failures of process piping.

The nature of the release needs to be analyzed to determine the path of the vapors, i.e., high or low. This will determine whether the detectors need to be sited above or below the risk. Detectors should also be sited with due regard to the normal natural air flow patterns. High and low points where gas may settle should also be considered.

Enclosed spaces that may subject to a gas leak that have intrinsic production valve or are high capital items should be provided with gas detection. Typically these locations are compressor and metering houses.

As a preventive measure, gas detectors are normally placed at the air intakes of manned facilities, critical switchgear shelters and internal combustion engines subject to vapor exposures, i.e., near process areas handling gases and vapor. The facility air intakes themselves should be positioned to prevent the intake of combustible gases from these areas, even during accident scenarios.

Normally point source detectors are positioned with their detector head downwards for better capture of the ambient gases.

No gas detector should be located where it would be constantly affected by ambient conditions such as surface drainage runoff, sand, ice, or snow accumulation. Special consideration should be given near open sewer grates and oily water drain funnels were frequent alarms may appear due to vapor emissions.

Where overall large area coverage is necessary or desired, such as the monitoring of facility borders, pump alleys, entire onshore units or offshore modules, "line of sight" IR beam detectors are used, otherwise "point source", catalytic detectors are provided. The point source locations should be at least on either side of the leak point, which at least one of the detectors downstream ventilation pattern.
Typical Hydrocarbon Facility Applications

The following locations are typical applications where combustible gas detection devices are provided or should be considered in the hydrocarbon industry:

- All hydrocarbon process areas containing materials with gaseous materials that are not adequately ventilated (i.e., would not achieve a minimum of six air changes per hour or would allow the build up of flammable gas due to noncirculating air space). Typically applications include compressor enclosures, process modules in offshore platforms and enclosed arctic facilities.

For enclosed areas, they can be considered adequately ventilated if they meet one of the following. Where artificial mechanisms are employed for ventilation assistance high reliability must be assured.

1. The ventilation rate provided is at least four times the ventilation rate required to dilute the anticipated fugitive emissions to below 25 percent LEL as determined by detailed calculations for the enclosed area.
2. The enclosed area is provided with six air changes per hour by artificial (mechanical) means.
3. If natural ventilation is used, 12 air changes per hour are obtained throughout the enclosed area.
4. The area is not defined as "enclosed" per the definition of API RP 500, Section 4.6.2.2.4.

- All gas compressors should be provided with point gas detection at sealage points and especially if enclosed in a packaged module - interior area detection and at the air intake and exhaust of the driver and compressor.

- Pumps handling high vapor pressure hydrocarbon liquids (detector sited close to the pump seals).

- At all intakes for fresh air or HVAC systems to buildings in an electrically classified area according to the National Electrical Code (NEC) or subject to ingestion of combustible vapors. Especially if they are considered inhabited, critical or of a high value. Typically control rooms, critical electrical switchgear, or main process area power sources are provided with gas detection.

- At all critical internal combustion prime movers subject to the possible ingestion of combustible vapors.

- In all battery or UPS rooms in which hydrogen vapors may be vented or released from battery charging operations.

- Entrances and air intakes to the accommodation module or continuously manned enclosed locations located offshore.

- Drilling areas such as the mud room, drilling platform, and areas around enclosed wellheads.

- Possible hydrocarbon leaks points at process cooling towers.

- Sensitive (critical or high value) processing areas where immediate activation of incident and vapor mitigation mechanisms are vital to prevent the occurrence of a vapor cloud
explosion.

- Enclosed water treating facilities that can release entrained combustible gases or vapors, especially a concern at produced water treating operations.

- Monitoring the purge gas from cold boxes and double walled insulated cryogenic storage tanks.

- Process locations containing large volumes or high pressure hydrocarbon gases which might be susceptible to extreme effects of erosion or corrosion from the process activity.

Catalytic Detectors

Description

The catalytic gas detector was originally developed in 1958 for the mining industry. It has become the standard means of detection worldwide in virtually all oil and gas operations. It is also used extensively in coal extraction and the chemical process industry.

Catalytic gas detection is based on the principal that oxidation of a combustible gas in air is promoted at the surface of a heated catalyst such as a precious metal. The oxidation reaction results in the generation of heat that provides a direct measure of the concentration of the gas that has been reacted. The sensing element embodying the catalyst is a small bead that is supported with the sensor.

They are sensitive to all flammable gases, and they give approximately the same response to the presence of the lower explosive limit (LEL) concentrations of all the common hydrocarbon gases and vapors. However it should be remembered that gas detectors do not respond equally to different combustible gases. The milli-volt signal output of a typical catalytic detector for hexane or xylene is roughly one half the signal output for methane.

They have two disadvantages. First they are only capable of sensing a flammable gas at a single point. If the position of the sensor is unfavorable in relation to the origin of the flammable gas release and the pattern of air flow and ventilation in the hazardous area, then the gas detector will not detect a dangerous release of gas until it is too late to take effective action. Generally point gas detectors can only provide adequate protection at a facility if deployed in large numbers.

Secondly small quantities of airborne pollutants may poison the catalyst in the detector. This severely reduces its sensitivity. The detector becomes less reliable and often makes duplication, voting logic and frequent maintenance necessary.

The following substances have been known to poison catalytic gas sensors:

- Tetraethyllead (at present being phased out as a gasoline additive in most countries).
- Sulfur compounds (particularly hydrogen sulfide in oil production refining operations).
- Phosphate esters (used in corrosion inhibitors in lubricating oils and hydraulic fluids).
- Carbon tetrachloride and trichloroethylene (found in degreasing agents and dry cleaning fluids).
- Flame inhibitors in plastic materials.
- Thermal decomposition products of neoprene and PVC plastics.
- Glycols.
- Dirt or fiber particles.
Fire and Gas Detection and Alarm Systems

- Silicon vapors.

**Infra-Red (IR) Beam Gas Detection**

Conventional gas detectors are only capable of detecting gas at point locations. If the position of the detector is unfavorable in relation to the origin of a gas release, it may not detect the gas release before a dangerous accumulation of gas has occurred. To provide improved detection capability, an infra-red beam gas detector has been developed which is capable of detecting gas anywhere along an open path of several hundred meters in length. These devices have been available to the industry for approximately ten years and their quality has improved as field experience was gained. The sensor is based on the differential absorption technique and has a reasonably even response to a range of light hydrocarbons. A microprocessor controller is commonly used for signal processing that produces the alarm and trouble indications.

Many frequency lines of infrared radiation are absorbed by hydrocarbon gases. By selection of a particular frequency, a detector can be made which is either specific to a particular gas or if the frequency is common to several gases, a particular group of gases may be detected.

**Application (IR Beam)**

IR beams are typically provided as a special gas detection applications. They offer a direct view and surveillance over a large area rather than a point source origination of gas. The most frequent use of these is verifying whether a gas release would be carried offsite from the facility. Other possible applications would be overall monitoring in area of several possible leak sources but within a line of sight arrangement such as a pump alley or an offshore module.

**Pump Alleys** - Where a number of pumps are used, they are usually arranged in parallel to each other facilitating the use of an IR beam over the line of pumps.

**Perimeter Monitoring** - The perimeter of a hazardous area or process unit can be effectively monitored for vapor release by IR beam arrangements on the edges. Theoretically they could be used to warn of open air combustible vapors approaching ignition sources in a reverse role, e.g., to the flare from the process area.

**Boundary and Offsite** - Especially critical for locations near to public exposures, an IR beam detector can be used to signal if vapors or gases may be released to offsite locations.

**Alarm Setting**

To achieve early and reliable warnings of leakages, the sensitivity of detectors should be at the highest level commensurate with the level of false alarm rates.

Alarm panels are normally set to give two levels of warning: a first alarm at low level and a second alarm at high level. Typical practice is to set these at 25% and 50% of the LEL, for the low and "high" levels respectively. A recent trend is to provide lower levels such as 10 and 25% LEL. Although there is no statutory requirement for the exact levels of alarms settings, NFPA 15, Appendix A, section A-8-2, suggest levels of 10-20% of the LEL as the first alarm point and 25-50% LEL as the second alarm point at which executive action should occur. Alternatively API RP 14C, Section C 1.4 (b), suggest settings no greater than 25 and 60% of the LEL.

From a safety viewpoint the lower the alarm levels are set the better. However the lower the level of alarm the greater the possibility of false alarms and disruption to operations. On the other hand
some practical experience has shown that with the lower levels of sensitivity, more minor leakages are at first detected. As these leakage sources are corrected, less and less real alarms are received than if the gas detectors were set at the higher LEL levels (i.e., 25 and 60% LEL). It should also be realized that for immediate leaks the concentration of the vapor in an area will immediately rise directly into the LEL range (or past it) so the relative settings below the LEL may not be significant. The most important feature is to have detection capability for the gases that may be encountered at the installation.

In general practice, the gas detection alarm set points are the settings recommended by the manufacturer of the equipment or by requirements of an operating company to effect an acceptable compromise on any given field of operation. The lower the set points the higher the sensitivity to possible leakage emissions.

**Calibration**

Operation of detectors with their associated alarm panels should be checked and calibrated after installation. Detector performance can be impaired in a hostile environment by blockages to the detector (i.e., ice, salt crystals, wind blown particles, water or even fire fighting foam, or by inhibition of the catalysts by airborne contaminants such as compounds of silicon, phosphorus, chlorine or lead. It is essential that detectors and alarm panels be checked and re-calibrated on a routine basis.

It is also possible for detectors to be calibrated using one gas (e.g., methane) for use thereafter in detecting a second gas (e.g., propane or butane) provided the relative sensitivity of the detector to each of the gases is known. A procedure for calibration of the detector for a different gas than that which is being used is normally available from the manufacturer of the detector.

Detectors should be calibrated after installation as recommended by the manufacture, typically this is every 90 days. However if experience indicates that the detectors are either in calibration or out of calibration the period of re-examination should be lengthen or shorten accordingly.

**Hazardous Area Classification Rating**

Since detectors are by definition exposed to combustible gases they should be rated for electrically classified areas, such as Class I, Division 1 or 2, the specific gas groups (normally groups C and D), and temperature ratings. It should be noted the UL presently does not specifically test combustible gas detector sensor heads for use in classified areas, although they do tests enclosures for control and data acquisition circuits. Several other international standards do evaluate combustible gas detectors for use in classified areas (e.g., BS 6020).

**Fire and Gas Detection Control Panels**

Stand alone fire or gas detection and alarm panels are normally provided in the main control facility for the installation. Recent trends also incorporate the transmittal of fire and gas alarms through the DCS into the main process alarm real time control panel. When alarm panels are located within a protected building, they should be located for easy access for emergency response personnel and proximity to manual electrical power shut off facilities.
Graphic Annunciation

Alarms should be displayed on a conventional dedicated window annunciator panel or if control room based on a dedicated CRT display for fire and gas detection systems. Each detector location should be highlighted with indications for trouble, alarm low, and alarm high. Where annunciator panel window alarms the alarm indication lights should be provided with specific labels indicating the exact alarm locations.

Power Supplies

Commercially available combustible gas detection systems generally use 24 VDC as the power supply for field devices. 24 VDC is inherently safer and corresponds the voltages increasing used by most instrument systems in process areas. A main supply voltage converter can be used to step down or convert from AC to DC power supplies.

Emergency Backup Power

The power for combustible gas detection system should be supplied from the facility’s UPS or if this is unavailable normal power with a reliable battery backup source of at least 30 minute duration.

Time Delay

Where instantaneous reaction is not imperative, susceptibility to false alarms can be reduced by requiring the fire signal to be present for a predetermined period of time. However, the time delay reduces the advantages of high speed early detection. In most applications, the tradeoffs between false alarms and the damage incurred in the first few seconds of a fire have been inconsequential.

Voting Logic

Activation of a single fire or gas detectors should not be trusted to provide executive action for hydrocarbon facilities. The present technology suggests they are too vulnerable to false alarms. They should also be arranged for a voting logic for alarms and executive actions. Voting is the requirement for more than one sensor to detect a fire or gas presence before the confirmation of the alarm. This method would prevent a false alarm cause by a single spurious source or by electronic failure of a single component. Usually a one out or two or a two out of three (2003) voting network of detectors is used to offer a confirmed alarm reception.

Cross Zoning

The use of two separate electrical or mechanical zones of detectors, both of which must be actuated before the confirmation of a fire or gas detection. For example, the detectors in one zone could all be placed on the north side of a protected area, and positioned to view the protected area looking south, while the detectors in the second zone would be located on the south side and positioned to view the northern area. Requiring both zones to be actuated reduces the probability of a false alarm activated by a false alarm source such as welding operations, from either the north or the south outside the protected area. However this method is not effective if the zone facing away from the source, sees the radiation. Another method of cross zoning is to have one set of detectors cover the area to be protected and another set located to face away from the protected area to intercept external sources of nuisance UV. If welding or lighting should occur outside the protected area, activation of the alarm for the protected area would be inhibited by second
detection activation. Although this method is quite effective a fire outside the protected area would inhibit the activation for the protected area.

Executive Action

Once an alarm has been confirmed, actions should be taken to prevent or reduce the impact from the event. Depending on the priority of the alarms the following actions should be taken at the point of activation:

1. The facility evacuation and warning alarms should be activated, and personnel evacuation or muster should commence.
2. Activate fixed fire extinguishing systems or vapor dispersion mechanisms (i.e., water sprays).
3. Start fire water and foam solution (if applicable) pumps.
5. Shutdown HVAC fans (unless arranged for automatic smoke control and management).
6. Activate the process ESD systems (i.e., Isolation, Power Shutdowns, Blowdown and Depressurization).
7. On confirmed gas detection sources of ignition such as welding or small power circuits should be immediately shut down in the affected area (immediately shut down is applied to equipment not rated for use where hazardous gases are present).
8. Messages should be sent alerting outside agencies of the event and current situation.

Circuit Supervision

The detection and alarm circuits of fire and gas detection systems should be continuously supervised to determine if the system is operable. Normal mechanisms provide for a limited current flow through the circuits for normal operation. During alarm conditions current flow is increased while during failure modes the current level is nonexistence. By measuring levels at a control point the health of the circuit or monitoring devices can be continuously determined. End-of-line-resistors (EOLR) are commonly provided in each circuit to provide supervisory signal levels to the control location.
<table>
<thead>
<tr>
<th>Type</th>
<th>Speed</th>
<th>Cost</th>
<th>Test Std.</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Applications</th>
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<tbody>
<tr>
<td>Catalytic Point Detection</td>
<td>Moderate</td>
<td>Moderate</td>
<td>ISA CSA (API)</td>
<td>Easily Positioned Industry Standard Detection Device</td>
<td>Poisoning Limited to Spot Detection Costly Maintenance Expert Judgment Required for Placement</td>
<td>Point Sources (Pumps, Compressors, Seals, etc.)</td>
</tr>
<tr>
<td>IR Beam</td>
<td>High</td>
<td>High</td>
<td>None</td>
<td>High Reliability Wide Area Coverage Less Dependent on Specific Location Placement</td>
<td>Requires clear view</td>
<td>Boundaries</td>
</tr>
</tbody>
</table>

Table 22
Comparison of Gas Detection Systems
Bibliography

**Fire Detection**


**Gas Detection**


