Control Instruments®
Corporation

Application Note

Area Monitoring of Hazardous Gases and Vapors Using the SmartMax®II Gas Detection System

Wherever hazardous gases or vapor-producing liquids are used, transported or stored, there exists the possibility that they could accidentally leak into the surrounding area. Continuous monitoring of such hazards is therefore an essential part of any safety program.

The SmartMaxII gas detection system is specifically designed for use in area monitoring applications. SmartMaxII can be used with the several different types of sensors used in area monitoring, plus it offers advanced communication and reporting features.

This Application Note guides you through the basic steps to take when monitoring hazardous gases and vapors, and illustrates how the SmartMaxII can be used to manage gas hazards in the most effective and efficient way.

The Four Steps
The important considerations to make when establishing a hazardous gas detection system are:

- Select the proper sensor.
- Understand what will happen when a gas leak occurs.
- Install the sensor correctly.
- Connect sensors to an alarm system.

Properly following these four steps will result in a dependable detection system.

Step 1. Selecting the Proper Sensor
The sensors used in area monitoring applications are typically "diffusion" in design. This means that the sensor does not employ an active sampling system that draws the sample to the sensor, but instead relies on diffusion and convection to obtain the sample. That is, the gas will mix with ambient air and diffuse through the sensor's flame arrestor without the use of a pump or aspirator.

The appropriate sensor to use in any application depends upon the gas or gases to be measured, the background gases present, and the conditions around the sensor location. Flammable hazards are measured in the 0-100% Lower Flammable Limit (LFL or LEL) range. Toxic hazards are measured in the low Parts Per Million range. Several sensor technologies are available in diffusion designs: catalytic and infrared (IR) sensors for LFL range monitoring of flammable gases; and electrochemical and solid state sensors for PPM monitoring.

Catalytic sensors
Catalytic sensors are appropriate for detecting flammable gases and vapors in the LFL range. When a flammable gas enters the sensor, it reacts with a catalyst-coated electrical coil. The resulting resistance change offsets the balance of a Wheatstone Bridge circuit. The output signal is proportional to the concentration of flammable gas. Catalytic sensors have numerous strengths, including low cost, long-life, and simplicity of design. But they can be affected by "catalytic poisons" which coat or corrode the sensor's catalyst, such as silicones, plasticizers and sulfur compounds.

Infrared sensors
The infrared sensor (point IR) has proven useful in monitoring methane in the LFL range. The point IR sensor's chief advantage over the catalytic sensor is that it is not subject to catalytic poisons such as hydrogen sulfide. Because it is an optical device, however, care must be taken to prevent fouling of the optics. Its usefulness in LFL monitoring of gases other than methane is limited to applications where gas mixtures and background interference are not issues.

Control Instruments® Corporation
25 Law Drive
Fairfield, NJ 07004-3295
973-575-9114
Fax 973-575-0013
sales@controlinstruments.com

Document H7APP017
Created 1/98
Revision A
Rev Date 4/05

Electrochemical sensors
Electrochemical sensors are excellent for detecting low parts-per-million concentrations of a select gas. The electrochemical sensor contains an electrolyte that reacts with a specific gas. The reaction produces an output signal that is proportional to the amount of gas present. Electrochemical sensors exist for gases such as chlorine, carbon monoxide, ethylene oxide, hydrogen sulfide, and hydrogen. The number of gases that can be detected using this technology is relatively small, but is increasing from year to year. These sensors cannot be used to measure hydrocarbons.

Solid State sensors
Solid State sensors, typically a tin oxide semiconductor, respond to gases by changing resistance. Solid state sensors are used to measure numerous gases in the parts per million range. They are relatively low in cost and have a long operating life. However, solid state sensors have low selectivity: background gases can create inaccurate readings. Also, the sensor's output signal is non-linear, which makes calibration more complicated.

Step 2. Understanding What Happens During A Gas Leak

Dispersion Characteristics of Gases
When a gas leak occurs, the gas tends to disperse into the atmosphere based on its physical characteristics—most importantly, its vapor density.
The diffusion rate of a gas into air is proportional to their respective densities. Hydrogen, for example, which has a much lighter density than air, will diffuse very rapidly into the air. The resulting hydrogen in air mixture has a density lighter than the surrounding air; therefore convection currents lift the mixture in a manner similar to smoke rising from a cigarette in an ashtray (see figure 1).

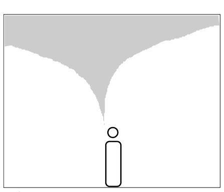


Figure 1

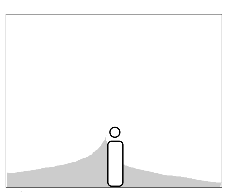


Figure 2

For gases denser than air, the inverse is true. Most of the gases heavier than air are generated by liquids and are referred to as vapors. Gases with a density greater than air (figure 2) tend to settle along the ground or into a pit. Gases with densities very close to air do not diffuse much and tend to follow local air currents.

Understanding Air Movement
In many cases, the movement of air is the greatest force in the dispersion of gas. When locating sensors, careful thought must be given not just to the density of the gas but also to prevailing air flow. In some cases, it may be necessary to locate sensors counter-intuitively.

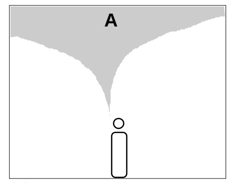


Figure 3

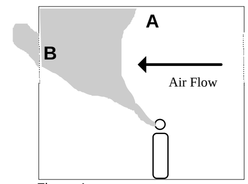


Figure 4

In figure 3 above, a sensor placed on the ceiling at A will detect a lighter-than-air gas leak. But if the air flow in the room is as shown in figure 4, the sensor at A will not detect the leak. Once the air flow in the room is understood, correct detector placement at B can be made.

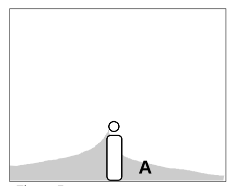


Figure 5

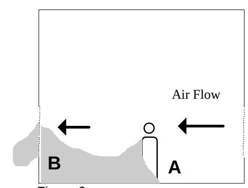


Figure 6

The same logic applies to a heavier-than-air gas leak in a similar situation. Locating the detector at B in figure 6 will result in earlier detection and warning.

Understanding Temperature Effects
In addition to density and air flow, temperature can also affect the dispersion of leaking gas. Most importantly, it can change the way a gas might normally behave. If the temperature of the air at the ceiling is much hotter than the room air, the ceiling air will have a lighter density (hot air rises). This "thermal barrier" may slow down the diffusion of the leaking gas enough to delay or prevent detection at the sensor (figure 7).

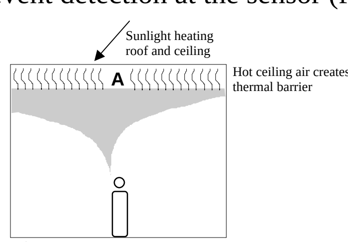


Figure 7

Also, many lighter-than-air gases are stored as compressed liquids. When these gases escape into the atmosphere, their density may at first be heavier-than-air (figure 8) until they are warmed by the ambient temperature and become lighter-than-air (figure 9).

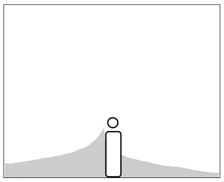


Figure 8.

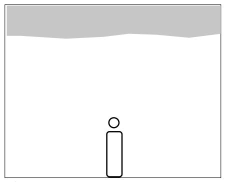


Figure 9.

Understanding Dilution Effects

Figure 10 illustrates the dilution effect that occurs when several rooms are monitored by a single sensor placed in the ventilation system. If the air volume moving through each room is roughly the same, a hazardous concentration in one room would be diluted to one-third of its true value (at A) because of the air movement from the other two rooms.

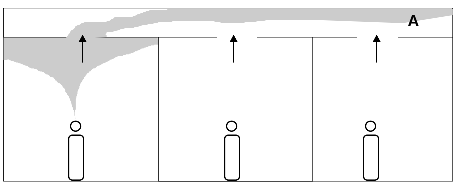


Figure 10.

Outdoor Monitoring Concerns

When locating sensors in outdoor applications, careful consideration must be given to prevailing wind conditions. It may be necessary to monitor a single hazard (such as a storage tank) using several sensors (figure 11) so that an accidental leak can be detected regardless of wind direction at the time of the leak (figure 12).

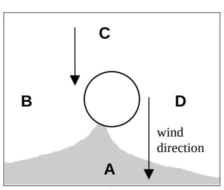


Figure 11. Arial view

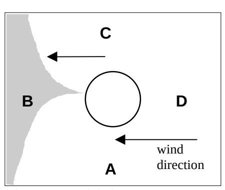


Figure 12. Arial view

When monitoring gases and vapors in outdoor applications, wind and weather become of particular concern. The equipment may be subjected to very hot and very cold temperatures in the course of the year, and may even experience large shifts in temperature from daytime to nighttime. Equipment will be exposed to rain, snow, ice, dust and dirt. For outdoor applications, a rugged, robust instrument and sensor are essential. Also, it is important that the sensor always points down or at least never points above horizontal, to prevent rain from entering the cell. When monitoring pump seals, pressure vessels, flanges, etc., it is possible to use hoods, tubing, or small ducts to direct the escaping vapor toward the sensor.

Step 3. Installing the Sensor Properly

Proper installation is the key to success

Installation is the most important aspect of the gas detection system. Just as an improperly-installed seat belt will not protect a driver, an improperly-installed gas detection system will not protect people and property from harm.

Calibration

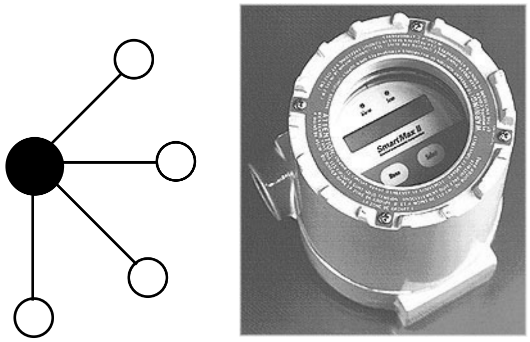
All of the sensors mentioned in this Application Note require routine calibration in order to function properly. Installation is not complete until the system has been installed, allowed to warm up and stabilize, and been calibrated. Both the Zero and Span response of the sensor must be checked before putting the system into operation. Typically, clean bottled air (or, in some cases, room air) is used to set the Zero. A known concentration of test gas must be used to set the Span.

Sensor Quantity

There are no published guidelines or standards indicating the volume or area effectively protected by a diffusion gas leak sensor. In fire protection, where diffusion smoke detectors are used, Underwriters Laboratories suggest a 900 square foot ceiling space or less per detector. While this smoke detector guideline is helpful, it does not directly apply to gas detectors. Lacking set rules based on area or volume, the total number of sensors required must be determined by considering actual conditions, especially those highlighted in Step 2 – Dispersion Characteristics of Gases.

Once the approximate sensor location is defined, final placement should consider the concept of early warning. Early warning is accomplished by placing the sensor near the most probable gas leak point while at the same time maintaining overall coverage of the entire area. Early warning means that a gas leak will reach the sensor and cause an alarm before the gas disperses into the entire protected volume.

In many instances, more than one sensor may be needed to monitor a single hazard. Each SmartMaxII continuously monitors the readings from as many as four independent sensors. Sharing the SmartMaxII with more than one sensor allows you to dramatically lower the cost of your gas detection system three ways: there is less equipment to buy, less equipment to install, and less equipment to maintain. In many applications, costs can be cut as much as fifty percent.



The SmartMaxII monitors up to four independent sensors.

Step 4. Connecting to an Alarm System

Alarm action

The sensors must be connected to a controller that is capable of producing alarms. All gas detection systems require three levels of alarm. The first alarm level should provide early warning of a developing hazard and notify supervisory personnel to initiate corrective actions. The second alarm level must warn personnel and automatically stop the process or the flow of gas. If stopping the process is not feasible, then some action must be taken to control the hazard (for example, a water deluge or curtain to confine the flow of vapor).

The third type of alarm will warn operators of malfunctions, loss of signal, loss of power to the system, or communication errors. Malfunction alarms should be connected to either the Warning or Danger alarms so that corrective actions are taken as soon as possible.

Relays

The SmartMaxII includes three internal relays that can be programmed to activate external horns and lights—and to indicate when the system is undergoing calibration. Built-in relays provide maximum safety and ensure that critical alarms are initiated directly by the sensor. Direct action is more reliable than the use of a secondary device or an intermediary connection.

Output Signals

The SmartMaxII is equipped with both a 4-20mA analog output and an RS-485 Modbus digital I/O port. This means that you can easily transfer readings to your PLC, plant-wide data acquisition system or process control system. The digital port also allows you to access and control many sensors from any PC or laptop, either directly or through a modem.

* * *

For more information, please contact us at

Control Instruments Corporation

25 Law Drive, Fairfield, NJ 07004-3295

973-575-9114
Fax 973-575-0013
sales@controlinstruments.com
www.controlinstruments.com