

Application Brief AB-084

Multiple Gas and Vapor Analysis on a Single Platform Using the HGVI™

Introduction

Air monitoring is a critical part of any hazmat response protocol. Numerous technologies, including combustible gas indicators, four gas meters, and PIDs, are employed for detecting flammables and toxics at appropriately low levels¹. Recently, infrared (IR) spectroscopy has emerged as a technology for identifying many gases and vapors for complementary qualitative information. However, IR instruments lack the sensitivity and portability of true front-line detection tools, whereas hand-held single and multi-gas detectors require the proper sensing elements to be chosen prior to their deployment.



Figure 1. HGVI system developed by Smiths Detection

What is HGVI?

The Hazardous Gas and Vapor Identifier (HGVI) (Figure 1) provides detection, identification *and* quantification capability for a large group of high priority gases and vapors on one instrument. Having complementary sensor types integrated on a single platform affords greater accuracy than any one sensor alone. With HGVI, there is no need to select or change out sensors for specific gases or to switch manually between operational modes for certain classes. Toxic industrial chemicals (TICs), flammables, and chemical warfare agents (CWAs) alike are measured simultaneously with a novel integration of multiple sensing technologies. Most substances are detected and identified at or below their IDLH levels, making the HGVI well-suited for low level monitoring. The instrument is also designed to resist saturating at higher concentrations above IDLH, so it is useful in a variety of atmospheres. This Application Note describes the technology inside the HGVI and some examples which highlight its suitability for hazmat air monitoring.

Sensing Technologies

At the heart of the HGVI are three different and orthogonal gas sensing technologies which operate in parallel to analyze an unknown gas. An internal pump draws in ambient air toward the sensor suite, which includes twin Ion Mobility Spectrometers (IMS), a Photoionization Detector (PID) and an array of tin dioxide Taguchi Gas Sensors (TGS) (Figure 2).

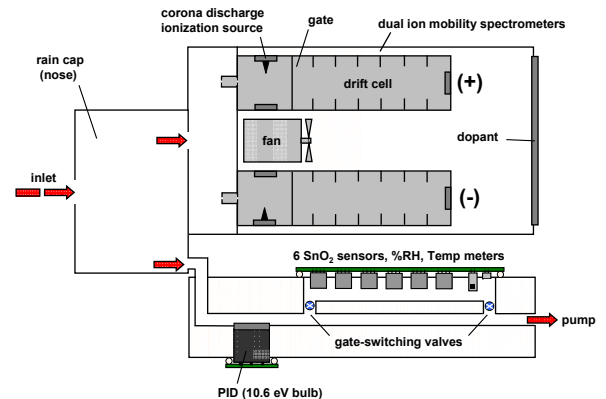


Figure 2. HGVI Sample Flow Path

In the IMS region, gaseous molecules enter an ionization zone where they interact with dopant molecules and are subjected to a non-radioactive electrical spark called a corona discharge. Depending on their resulting ionic charges, the sample ions travel through an electric field along either the positive (+) or negative (-) IMS channel and are detected based on their drift times. The measured response of detector signal versus drift time is characteristic of a sample. IMS provides a semi-specific and highly-sensitive method for detecting many organic and inorganic gases and vapors.

Each of the sensors in the TGS array is a non-specific element for detecting the presence of a low-level gas. However, the TGS array in the HGVI is operated in such a way to produce a pattern of signals that is semi-specific to each of the TICs of interest. When the instrument is sampling, the valves to the TGS cavity are open and the array is actively sensing. When a gas is detected, the valves close and the sensor array pattern is analyzed. Following identification, the valves re-open allowing the array to clear down for the next sample.

The PID is similar to those widely used by first responders for air monitoring. Operating at 10.6 eV, the PID continuously detects the presence of TICs whose ionization potentials (IP) are less than the bulb energy. Since the PID response is well characterized and highly linear, it can also be used to quantify the level of the sample gas after initial identification for continuous air monitoring. Even for samples whose IP exceeds 10.6 eV and are not picked up by the PID, the IMS and/or TGS responses provide detection capability.

The signals obtained from the HGVI sensor suite are analyzed by advanced H-Fusion™ software which evaluates qualitative and quantitative information from the sensors to identify the sample. If the sample is one of the TICs or CWAs programmed into the HGVI memory, it will be reported with its identity.

If the TIC is PID-active, meaning its IP is less than 10.6 eV, its absolute concentration will also be reported (in parts-per-million, ppm). In addition, the identified TIC will be continuously quantified until the user chooses to stop the analysis and clear down the unit. A series of screens from the HGVI interface is shown in (Figure 3).



Figure 3. Screen Shot Sequence of Chemical Identification: Sampling, Detection and Identification

Toxics

Some of the toxic gases and vapors programmed into the HGVI are chlorine, ammonia, hydrogen cyanide, hydrogen sulfide, sulfur dioxide and phosgene. Hydrogen cyanide (HCN, or AC) is used in industrial processes including chemical synthesis, metallurgy and electroplating. It is also considered a CWA since being deployed as such in World War I. During structural fires, HCN is liberated through combustion of nitrogen-containing polymers used in fabrics, upholstery and padding and is a secondary hazard to emergency personnel². HCN is considered flammable with an LEL of 5.6% (56,000 ppm), but its IDLH of 50 ppm indicates that toxicity is the greater hazard. Because of its high ionization potential (13.6 eV), HCN is not picked up by the PIDs typically used for general TIC detection. Therefore, first responders must rely on colorimetric tubes or electrochemical cell sensors. With the HGVI, HCN is already programmed as a detectable substance. The TGS array and (-) IMS channel exhibit strong responses to HCN at single ppm levels. Although the PID sensor cannot quantify HCN (because of its high IP), an estimate of the concentration can be reported based on signal from the other sensors.

Two other high priority TICs available on the HGVI are chlorine and ammonia. Chlorine (Cl₂) is widely used for industrial processes such as sulfurous emission scrubbing, water treatment, and chemical synthesis. Unfortunately, chlorine gas (IDLH 10 ppm) is as deadly as it is useful.

Like HCN, Cl₂ has been employed as a CWA, and the EPA and OSHA strictly regulate chlorine for industrial processes³. Ammonia (NH₃) is widely used as a coolant in large industrial refrigeration systems, but has an IDLH of only 300 ppm and is even flammable at high concentrations. Both of these gases are typical culprits in Sick Building Syndrome (SBS) incidents, as they are common ingredients in cleaning supplies. Again, the standard techniques for detecting them involve colorimetric tubes or electrochemical cells which require suspicion of the gas for choosing the appropriate sensor before entering the scene. With HGVI, these gases are already programmed and are readily detected, identified and quantified. The TGS array and (-) IMS channel respond to Cl₂ down to 2 ppm, while the TGS array and PID are sensitive to NH₃ down to approximately 50 ppm.

Flammables

Some of the flammable substances measurable with the HGVI include industrial solvents like acetone, ethanol, and hydrocarbons. In addition, many toxic flammables such as carbon disulfide, formaldehyde, and ethylene oxide are also handled by the instrument. Ethylene oxide (EtO) is widely used as a precursor to many industrial chemicals and pharmaceuticals. EtO is also the most common agent for sterilizing medical devices without autoclaving. EtO (IDLH 800 ppm) is toxic and carcinogenic to humans but its odor cannot be detected below 700 ppm. With its widespread use in many different industries, EtO is a problem for emergency responders when storage leaks or building damages occur. Electrochemical cells and metal oxide semiconductor (MOS) sensors, like those in the HGVI TGS array, are commonly used for generically detecting elevated EtO levels. Unlike the standard MOS "smoke detector," the HGVI uses an array of TGS sensors which collectively produce a characteristic response. In addition, the PID and both (+) and (-) IMS channels produce EtO signals. This redundancy of sensors makes HGVI very well-suited to detecting and identifying EtO in a way that each sensor could not do on its own.

Chemical Warfare Agents

In addition to dual-use toxic industrial chemicals such as chlorine, phosgene and hydrogen cyanide, the HGVI detects and identifies many nerve and blister chemical agents. The twin IMS channels permit simultaneous detection of the G-series agents, VX, and mustards at physiologically relevant levels. In addition, the PID and TGS sensors allow the HGVI to properly detect many of the common CWA interferents that pose challenges for many IMS-only based detectors.

Footnotes and References

* The number and type of TICs programmed into the HGVI may vary with the software version number or release date.

¹ *Hazardous Materials Air Monitoring and Detection Devices*, Chris Hawley, Albany, NY: Delmar/Thompson Learning, 2002.

² "CBRNE - Cyanides, Hydrogen," Erik D. Schraga, MD, <http://www.emedicine.com/emerg/topic909.htm>, 2007.

³ "Toxic Gas Detectors," General Monitors, Inc., http://www.gmtoxics.com/chlorine_article.html, 2004.

⁴ "Ethylene Oxide Monitoring in Hospitals," Interscan Corporation, http://www.gasdetection.com/TECH/tn_eth_hosp.html, 2007