Applications for RAE Systems Gas Detection Products in Chemical Warfare and Anti-Terrorist Response

Contents:

Purpose of this document

The tragic events of September 11, 2001 have shown that terrorist armaments and tools are not limited to traditional explosives and chemical warfare agents. The most prudent approach to discovering, identifying and neutralizing explosives and chemical warfare agents, as well as toxic industrial chemicals which might be used in terrorist attacks, is to use an integrated approach which includes both broadly-responding, as well as substance-specific gas detection technology.

RAE Systems' technology and instruments are uniquely suited for use in the detection, identification and response to chemicals and vapors associated with weapons of mass destruction (WMD), chemical warfare agents (CWAs), and toxic industrial chemicals (TICs).

This paper provides a brief overview of the applications and capabilities of current RAE Systems products for use in WMD and other military and government gas detection programs. This paper also includes a proposal for the development of an enhanced, field-deployable, wide area grid of monitors equipped with radio frequency (RF) modems which allow real-time, wireless transmission of monitoring data, position, video, and other information to local control and command centers, or via cellular telephone or Internet connection, to designated oversight agencies or command centers located literally anywhere in the world.

Overview of RAE Systems

RAE Systems manufactures a wide array of technologically advanced single and multiple sensor atmospheric monitors, photo-ionization detectors, gas detection tubes, and sampling pumps. Based in the heart of California's "Silicon Valley", RAE Systems is a progressive, high-tech company with manufacturing and distribution networks spanning the entire globe.

The Company's proprietary, patent protected technology has made it the

World's Leading Manufacturer of portable photoionization detector equipped instruments. The Company's products are used in WMD, environmental, safety, HAZMAT, petrochemical, semiconductor, and confined space entry monitoring programs all over the world.

RAE Systems' monitors are used in civilian and government atmospheric monitoring programs in over 50 countries. The Company's products are used in all major United States manufacturing industries, as well by numerous city, state and federal agencies and departments. A substantial number of municipal agencies and city departments have standardized their programs on RAE Systems' products for confined space and HAZMAT incident response. RAE Systems is also the leading supplier of gas detectors used for jet fuel vapor monitoring programs. Commercial aviation customers with sizable numbers of RAE Systems' instruments include American Airlines, United Airlines and US Airways. RAE Systems' customers include many of the World's Leading corporations, such as General Motors, Honda, Exxon, IBM, Mobil, Dow, Texaco, DuPont, Chevron, Hewlett-Packard, British Petroleum, Amoco, Motorola, Boeing and Intel.

RAE Systems' commitment to quality can be seen in every aspect of the Company's business. RAE Systems has been ISO 9001 Certified since 1998. The Company's Quality Systems constantly reinforce our customer focused culture of continuous improvement.

Military, WMD and other United States government programs currently using RAE Systems products

RAE Systems has significant numbers of instruments currently in service with the United States Navy, Marine Corps, Army, Air Force, Canadian Department of Defense, Environmental Protection Agency, Occupational Safety and Health Administration, and the Department of Justice (including the FBI, Treasury Department, Secret Service, and Drug Enforcement Agency). RAE Systems instruments are used in a wide variety of programs for the detection of vapors associated with explosives, nerve agents, CWAs, TICs, and as part of the personal protective equipment issued to bomb-disposal, hostage-rescue, clandestine crime lab, hazardous material (HAZMAT), and other high-risk response teams throughout the country. To date, RAE Systems has over 3,000 instruments fielded with these various United States government departments, agencies and programs.

Specific RAE Systems Products and Applications

- **MultiRAE Plus**

The MultiRAE Plus is the Company's most widely used product in government service. The MultiRAE Plus is an extremely versatile instrument capable of being configured for a wide variety of specific atmospheric monitoring missions.

Figure 1. MultiRAE Plus Multi-Gas Monitor with PID

Weighing only 16 ounces, the instrument is excellent for basic confined space entry, as well as advanced WMD, HAZMAT, TIC, aviation, hygiene, and many other special purpose monitoring applications. The MultiRAE Plus monitors up to five atmospheric hazards simultaneously: oxygen, combustible gas, and a choice of sensors and detection technologies for toxic gas measurement.

The MultiRAE Plus is the only instrument available to offer a choice of both substance-specific TIC sensors, as well as true, broad-range, toxic gas detection by means of a built-in photoionization detector – all in the same, compact , multi-sensor instrument package.

The MultiRAE Plus can be equipped with up to two substance specific sensors for toxic gas measurement. RAE Systems' sensors provide accurate, dependable, direct readings for the detection of chlorine (Cl2), hydrogen cyanide, (HCN), carbon monoxide (CO), carbon dioxide (CO2), hydrogen sulfide (H2S), sulfur dioxide (SO2), and other commonly encountered TICs.

The MultiRAE Plus may also be equipped with RAE Systems' unique, miniaturized, photoionization detector for the broad range detection of a wide variety of volatile organic compounds (or VOCs) in 0.1 – 2,000 parts-per-million (PPM) range concentrations.

Photoionization detectors, or PIDs, use ultraviolet light to break up the molecules of the substances being detected into charged fragments or "ions". This produces a flow of electrical current proportional to the concentration of contaminant. A lamp located within the photoionization detector housing is used to provide the UV light. RAE Systems' patented photoionization detector technology allows dependable, linear, part-per-million range readings for many toxic gases and vapors that are effectively undetectable by any other means. Photoionization detection is particularly suited to the detection of the highly toxic, long-chain, low vapor-pressure VOCs associated with many explosives, TICs, nerve agents and CWAs.

The MultiRAE Plus is housed in a rugged, weatherproof, housing designed to stand up to the toughest environmental conditions. The instrument is highly resistant to radio frequency and other electromagnetic interference, showing no effect when exposed to a 5 watt transmitter held at 12 inches (or 30 cm) from the detector.

The MultiRAE Plus is used by the FBI, Treasury Department, Secret Service, DEA, Navy, USMC, Army, and various national guard programs as a first line surveying, or personal protective gas

Figure 2. ppbRAE (PGM-7240) Parts-Per-Billion Photoionization Detector for VOC Measurement

detector for confined space entry, jet fuel vapor detection, general explosive gas detection, as well as for CWA and TIC response. The MultiRAE Plus is deployed in WMD, bomb-disposal, hostage rescue, clandestine drug lab investigation, and general HAZMAT response programs throughout the country.

Most importantly, the instrument is inexpensive, and extremely easy to use. The personnel who routinely use MultiRAE Plus detectors are not always experts in the use of complex analytical equipment. With the MultiRAE Plus design, they don't have to be.

- **ppbRAE**

The ppbRAE is RAE Systems' most accurate and sensitive photoionization detector. The ppbRAE is designed to provide real-time, broad-range detection of a wide variety of volatile organic compounds. Weighing only 19.5 ounces (553 grams), the ppbRAE is the most advanced and versatile hand-held photoionization detector on the market today. The ppbRAE offers unparalleled sensitivity and resolution over a wide dynamic measurement range, with maximum resolution of plus or minus 1 part-per-billion, and a full dynamic range of 0 – 200 PPM. The instrument automatically displays readings in the correct measurement units as a function of concentration. The easily accessible lamp and sensor, reduced humidity interference, and user friendly operating software make the ppbRAE the World's Most Advanced Photoionization Detector.

The ppbRAE is excellent for the detection of highly toxic industrial chemicals, as well as indoor air quality investigations, leak detection, industrial hygiene, environmental remediation, and many other special purpose monitoring applications. The exceptional sensitivity of the ppbRAE detector makes it especially

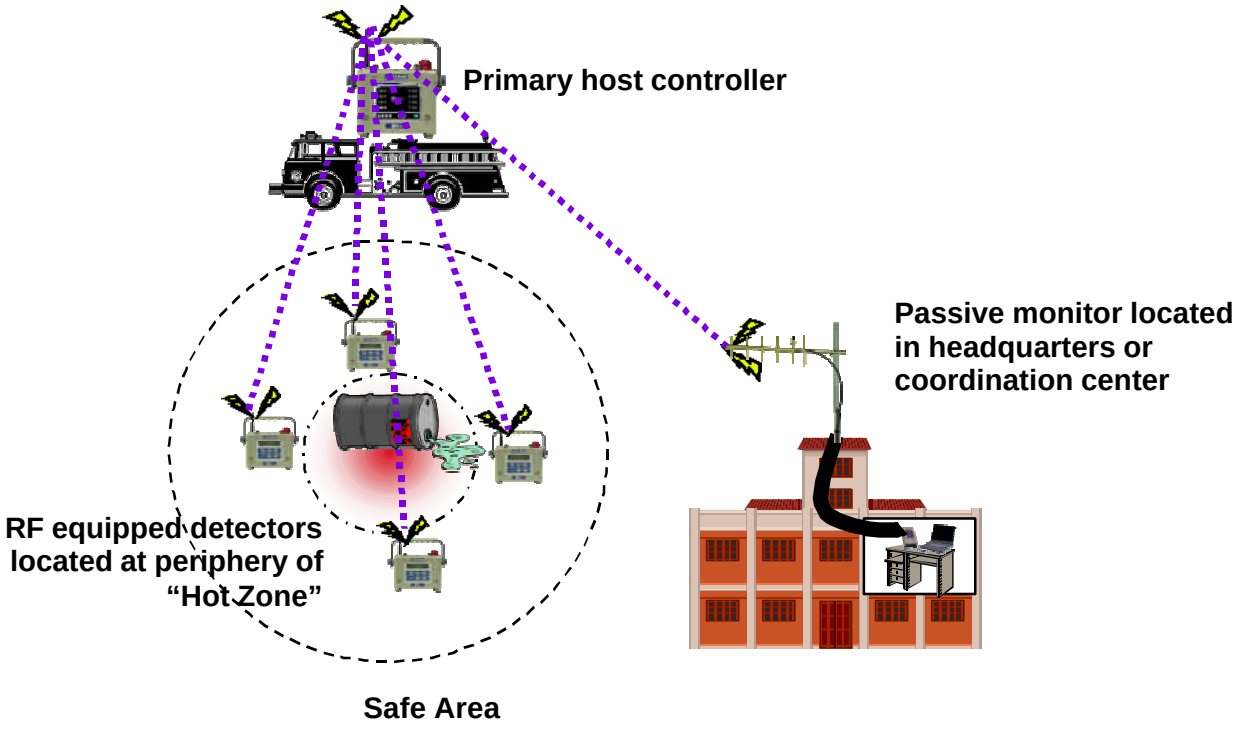

Figure 3 RF equipped portable AreaRAE monitors used to establish used to establish a monitoring perimeter during a hazardous material response[1]

useful for the detection of low vapor pressure and highly toxic VOCs such as nerve agents and other CWAs, vapors associated with a wide variety of explosives, pesticide residues, and in low level permeation breakthrough detection.

- **AreaRAE**

The AreaRAE is a one-to-five sensor gas detector which can be optionally equipped with a wireless, RF (radio frequency) modem which allows the unit to communicate and transmit readings and other information on a real-time basis with a remotely located base controller.

In its simplest form, the AreaRAE is a rugged, weatherproof, one-to-five sensor portable monitor that can run over 24-hours on either rechargeable lithium-ion, or alkaline batteries. The AreaRAE includes a photoionization detector (PID) for parts-per-million measurement of volatile organic compounds (VOCs), as well as a combustible gas sensor, an oxygen sensor, and up to two electrochemical toxic sensors for measurement of specific toxic contaminants.

A built-in RF modem allows real-time data transmission with a base controller located up to two-miles away from the AreaRAE detector. Any personal computer can be used as the base station for an AreaRAE system. The standard ProRAE Remote software used to control AreaRAE systems is capable of monitoring the input of up to 16 remotely-located monitors.

AreaRAE options include the ability to track and display readings from remotely

[1] Figure 3 diagram courtesy of Chris Wrenn, RAE Systems Inc., Sunnyvale, CA

Figure 4 RF equipped multi-sensor gas detector, and wirelessly integrated AreaRAE gas detection system. (Courtesy RAE Systems Inc., Sunnyvale, CA)

located detectors on a GPS map, using the wireless communications link for two-way voice communication, and even video image transmission between AreaRAE detectors and the base controller.

The AreaRAE is ideal for WMD, CWA, HAZMAT and other emergency response monitoring programs. AreaRAE detectors can be used to quickly establish an emergency perimeter by setting out multiple monitors at strategic locations, then backing off to a position of safety to monitor readings over the wireless link. The AreaRAE can also be used to provide readings from a moving vehicle, or "dropped off" in especially hazardous locations by means of self-mobile robots. Readings can be displayed directly on a GPS grid, on a PC, on a ruggedized laptop, or by means of one of RAE Systems' integrated touch panel controller systems.

Using photoionization detectors in integrated WMD and TIC response

In a terrorist chemical attack, responders cannot rely on their senses for decision-making. Many chemical warfare agents, as well as many highly toxic industrial chemicals, have very poor warning properties, and are effectively undetectable by means of human senses. Without readily available, field-portable, real-time, CWA and TIC detection techniques, responders are unable to respond appropriately to the true level of threat. Minus real-time information, the only option is to assume the highest level of threat, and respond accordingly. Inappropriate over-response can be almost as damaging as under-response. The greater the understanding of the hazards which are potentially present, the more feasible it is to implement a risk-based response at the lowest level necessary to prevent undue risk to the responder, while

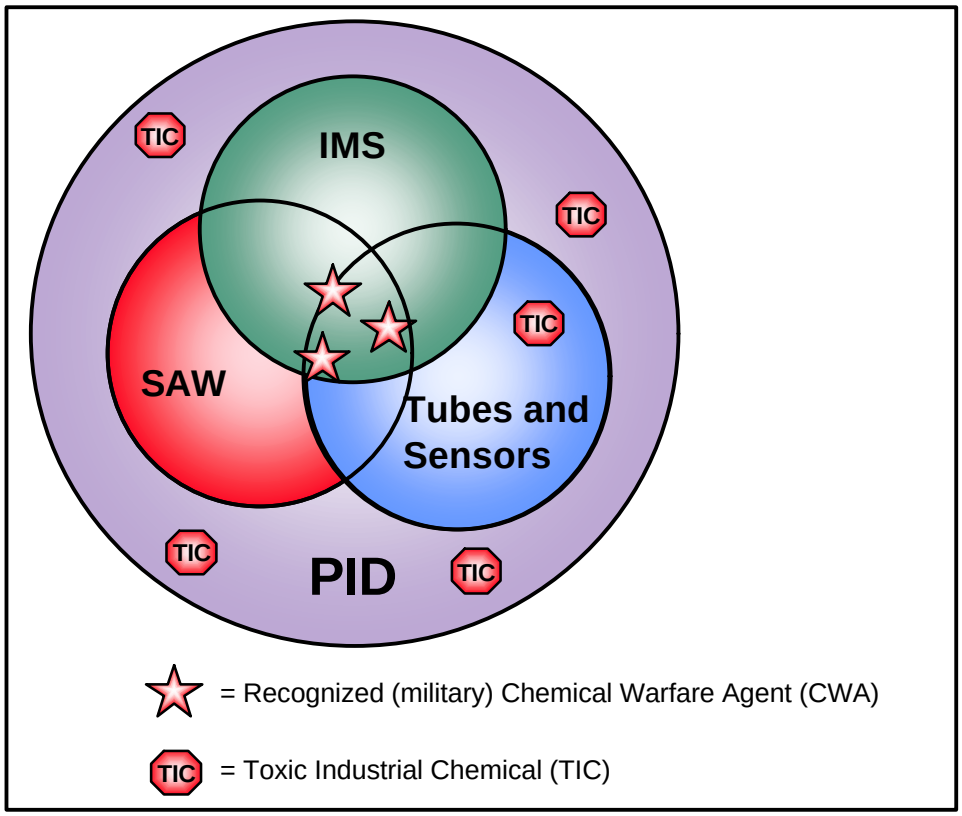

Figure 5. Role of PID in screening for broadest range of hazards

still protecting the public. Over-responding can easily lead to erosion of community confidence, as well as loss of public support for the responding agency as a consequence of ordering what are perceived as unnecessary, expensive and time-consuming evacuations, business shut-downs, highway closures, and other protective measures which affect the community.

WMD preparedness programs initially focused only on military CWAs. Ironically, many chemical compounds designed to either kill or debilitate opposing military forces were originally developed from civilian toxic industrial chemicals (TICs). It is clear today that WMD and CWA response programs must include the many other, potentially equally deadly, types of toxic chemicals that are used widely in many industries. As an example, one of the earliest and most effective chemical warfare agents used in World War I was chlorine gas. A tanker truck carrying a full load of chlorine, or ammonia, or phosgene, or any of a long list of other dangerous toxic industrial chemicals, can be a formidable delivery device for a chemical terrorist attack. For that matter, the only difference between a serious traffic accident involving the transportation of hazardous materials, and a deliberate chemical terrorist attack, is one of intent. An integrated response to WMD chemical threats must encompass both CWA and TIC detection capabilities.

CWA detection techniques which were designed for the battlefield environment tend to be highly focused on a limited number of recognized chemical warfare agents. CWA specific detection techniques such as ion-mobility

spectroscopy (IMS), and surface acoustic wave (SAW) may not measure TICs, and when used alone, can be fooled by common chemicals such as brake fluid, and the glycol ethers and vinyl esters in cleaning products.

Broad-range chemical detectors like PIDs are very useful in a risk based WMD response. PIDs are already one of the primary tools that HAZMAT responders use to measure toxic chemicals at PPM and PPB concentrations. PIDs are used both as a screening tool to identify the presence of chemical contaminants, as well as tools for the accurate measurement and quantification of contaminants once they have been identified.

The role of PIDs as a primary screening tool for risk-based response to chemical hazards is illustrated in Figure 5. Each circle represents the range of chemicals seen by a specific chemical detection technique. No one technique by itself is adequate to identify and measure all types of CWAs and TICs. By overlaying multiple detection techniques, however, we can provide the balance between broad-range and substance-specific detection necessary to develop the most prudent response.

Anhydrous ammonia presents an excellent example of the efficacy of this overlapping detection strategy. Physical clues include appearance of the gas (white cloud), and ammonia odor. While typical CWA detectors based on IMS or SAW technology, show no response, PID shows a strong response. Follow-up testing with substance-specific ammonia detector tubes, or substance-specific electrochemical sensors for ammonia provides confirmation.

Carbon disulfide (CS2), is a highly toxic, explosive, and common TIC. Physical clues include a sweet, ether-like odor. Once again, typical CWA detectors show no response, while PID again shows a strong response. Follow-up testing with substance-specific CS2 detector tubes provides confirmation.

Chlorine gas provides yet another good example. Physical clues include the presence of a greenish/yellowish cloud with a pungent odor. Typical CWA detectors show no response, while once again PID shows a strong response. Follow-up testing with substance-specific chlorine detector tubes, or a substance-specific electrochemical sensor provide confirmation.

At the same time that PIDs are able to detect many substances that traditional CWA detectors are unable to measure, PIDs ***are*** able to detect a wide variety of recognized military CWAs and nerve agents such as Lewisite, Mustard Gas (HD), phosgene, Sarin (GB), Soman (GD), Tabun, VX and GF, as well as vapors associated with many common explosives such as ammonium nitrate/fuel oil (ANFO), nitroglycerin, blasting caps, blasting cord, Semtex, C4 and dynamite. In this case, use of IMS or SAW based CWA detectors can be used to provide confirmation of the specific agent.

Conclusion

RAE Systems products are particularly well suited to use in WMD screening programs for gases and vapors associated with many toxic industrial chemicals, chemical warfare agents, and vapors associated with a variety of explosive substances. Using photoionization detectors in conjunction with other WMD detection and monitoring techniques ensures the ability to detect and resolve the widest possible spectrum of WMD agents.