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EYE On Environment

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Environmental Research Helps to Restore Tallgrass Prairie Ecosystem, Pawhuska, Oklahoma

by Rebecca Myers, Environmental Engineer, BDM Petroleum Technologies

Tallgrass prairie once covered about 142 million acres of land in 14 states across the Midwest, making it a major North American ecosystem. However, the tallgrass prairie, as a functioning ecosystem, became extinct with the increase in population and conversion of large tracts of prairie to farmland.

Recreating a Tallgrass Prairie

The Tallgrass Prairie Preserve is a 37,000-acre nature preserve in Northeast Oklahoma which was formed by the Nature Conservancy in 1989 in order to recreate a tallgrass prairie ecosystem. The Conservancy is using the natural environmental pressures of prescribed burning and grazing by bison, both prime factors in shaping the presettlement prairie ecosystem, to return the Preserve to its native state.

Watching the prairie's signature tallgrass sway in the wind, visitors will understand why early settlers referred to the prairies as "oceans of grass." Photo courtesy of Harvey Payne, Director, Tallgrass Prairie Preserve

Oil & Gas Impacts

Oil and gas production have been a part of the history of the Midwest prairie for the past 100 years. Past and present activities from oil and gas production have impacted numerous sites in this natural ecosystem.

Accidental release of production fluids such as crude oil and/or produced water into the prairie ecosystem may cause immediate changes in the ecosystem at the impacted site, including changes in species diversity or replacement of species. After such events, the ecosystem begins a natural remediation process to return to its native state. However, it is not well understood what long-term effect these impacts have on the ecosystem.

Remediation Studies

With support from the Department of Energy's National Petroleum Technology Office, BDM

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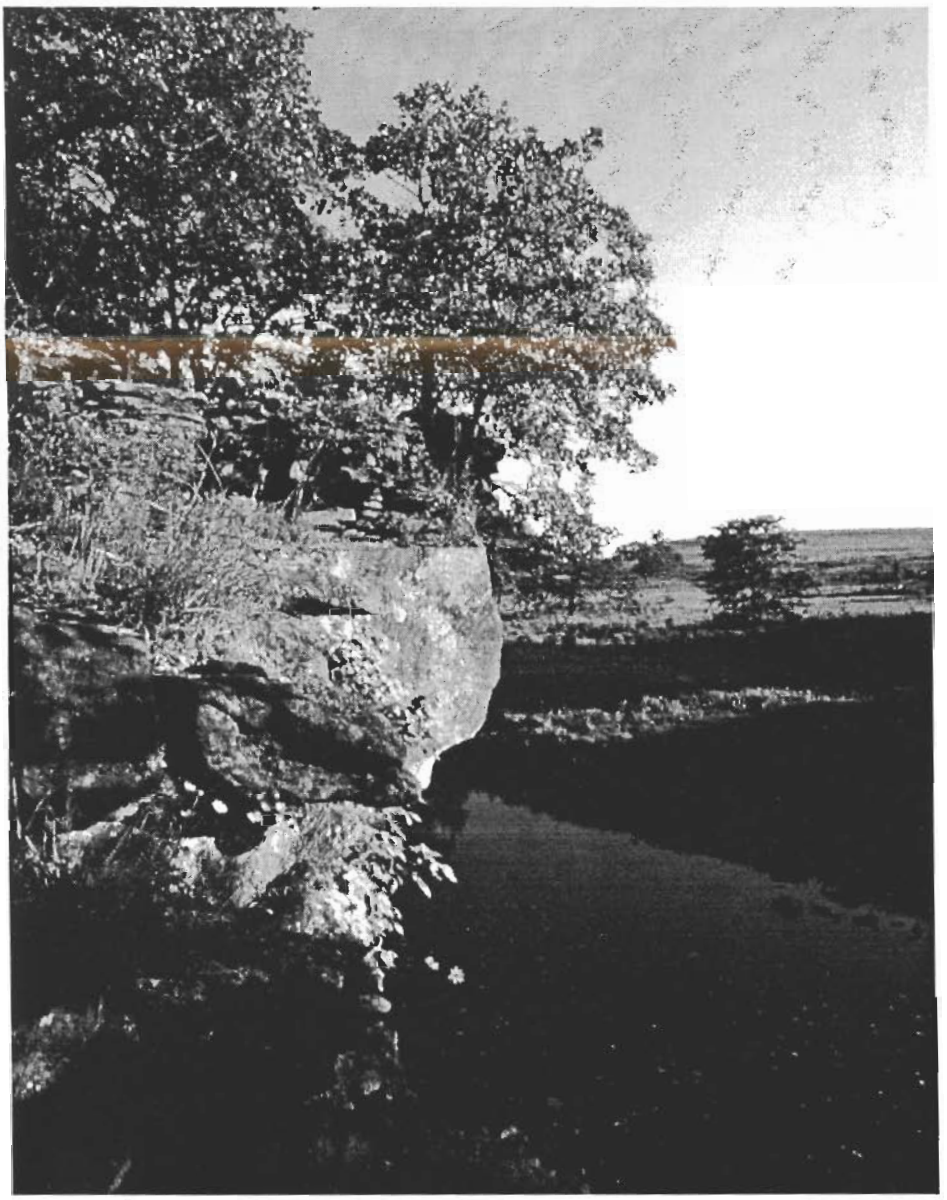
Petroleum Technologies is conducting research in the Tallgrass Prairie Preserve to study the remediation process and help understand the restoration of this important ecosystem. The Preserve contains approximately 120 active oil wells and has a number of sites contaminated by crude oil and brine releases occurring over the production history.

BDM Petroleum Technologies is studying the long-term effects of oil field contamination on the prairie ecosystem, and researching the development of new technologies to minimize the negative impact of crude oil and salt water contamination from oil production activities.



A view of the Tallgrass prairie Preserve shows the beauty of the landscape.
Photo courtesy of Harvey Payne, Director, Tallgrass Prairie Preserve

Information gained in this study is important for providing a scientific basis for evaluating spill impact to the environment and subsequent remediation strategies.

Characterizing Soil Ecosystems

Ecological studies are being conducted at historical crude oil and produced water spill sites to better understand the recovery process, or how nature "restores itself." At one location, a ruptured crude oil pipeline released an unknown amount of crude oil in a path down the side of a hill. The site has been remediated and is fully vegetated. However, the site has not fully returned to its native state.

Ongoing research at this site involves characterizing the ecology at the spill site to document the continued restoration. By comparing the soil ecosystem dynamics across the span of the spill area, theories can be formed about the natural restoration process.

Microbial Studies

At another site previously contaminated by crude oil and process water, the role of different groups of soil microorganisms in the bioremediation process is being examined. This research shows how microbial populations change over time and how distinct groups of microorganism contribute to the natural remediation process.

Information gained in this study contributes to a better understanding of the ecological impact of crude oil spills in the environment.

Containment Research

In addition to the research just described, BDM Petroleum Technologies is developing technologies to aid in the containment and remediation of subsurface contamination. The primary technology being researched is the feasibility of microbial gel barriers–pumping a nutrient-enriched bacterial solution into the subsurface, around or down-gradient of the contaminated site. The microbes used are nontoxic to humans and the environment, and have been selected for their ability to produce polymer (see Fig. 1).

This technology is being tested at a historical produced water spill site on the Tallgrass Prairie Preserve. The solution will travel through the most porous subsurface areas, and as the microbes produce polymer they will form a barrier wall or zone in which the hydraulic conductivity has been significantly reduced. This will prevent migration of the production water or other subsurface contaminants and protect downstream environmental receptors from further damage resulting from the release.

Gaining Ground on Spills

Through this collaborative research program, the Nature Conservancy, the Department of Energy, BDM Petroleum Technologies, and other research groups are not only helping to recreate a functioning tallgrass prairie ecosystem, but are also gaining valuable information on the impact of oil-related spills on the environment and developing innovative remedial strategies.

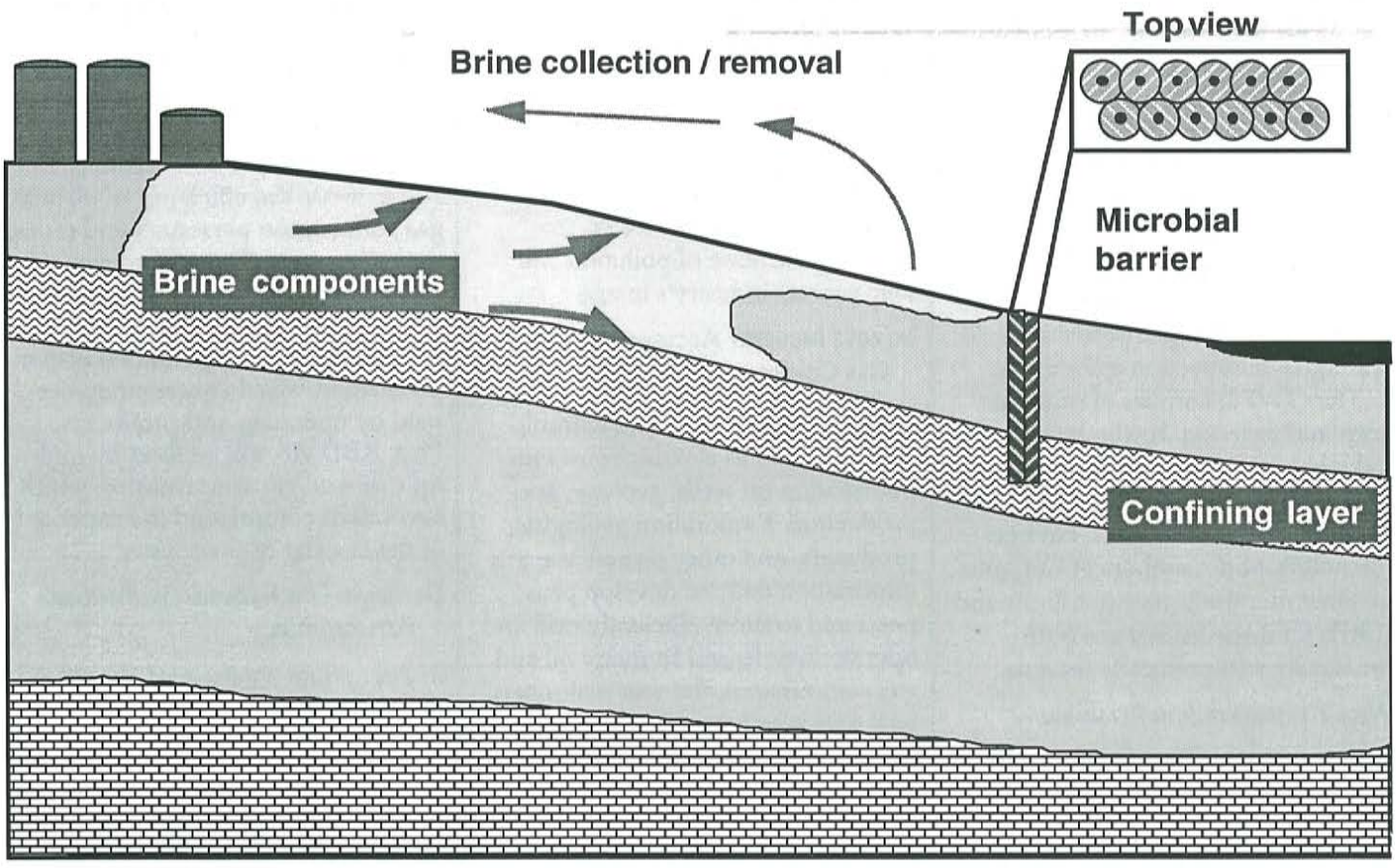


Figure 1 Cross-section of microbial gel barrier wall applied for containment of brine release

Risk-Based Data Management System Project Summary

by Mike Paque, Executive Director, Ground Water Protection Council

Design Considerations

Long-term design considerations were used for the Underground Injection Practices Research Foundation's (UIPRF's) Risk Based Data Management System (RBDMS). The system was designed to be a comprehensive database with the ability to expand into multiple areas, including oil and gas production. During system design, applications such as geographic information system (GIS) were anticipated so that adapting RBDMS to such applications could easily be initiated.

Mission

UIPRF is the research arm of the Ground Water Protection Goals Council (GWPC). GWPC is a national, not-for-profit organization whose members are interested in protecting the nation's ground water supplies. The mission of GWPC is to promote the safest methods and most effective regulations for comprehensive ground water protection and underground injection techniques.

The GWPC consists of organizations and individuals who have a stake in ground water protection–citizens, industry, federal, state, and local government officials, environmentalists, and members of Congress. Council members pose questions and search for answers that are both practically and politically feasible.

Wide Participation in Planning

The RBDMS system also was designed for general application nationally. This critical objective prompted selecting Alaska, Mississippi, Montana, and Nebraska for initial participation in database development (see Fig. 1).

Benefits of RBDMS to the Oil & Gas Industry

Enhance Protection of the Nation's Ground Water

The RBDMS will provide regulators with information to help focus attention and resources, both governmental and industry, on those wells that pose the greatest environmental risks. The ability to target human and financial resources toward the wells with the greatest risks will result in more effective and efficient use of those resources and improved environmental protection.

In addition to the tangible public benefits from enhanced protection of the nation's ground water, the resulting decrease of pollution will help protect industry's image.

Improve Industry Access to Oil and Gas Commission Data

Oil and gas boards and commissions function as clearinghouses for information on wells, geology, and production. Exploration geologists, producers, and other players use this information daily to develop prospects and to more efficiently drill and operate their leases. In many oil and gas commissions, the vast majority of well data is only available via laborious searches through voluminous paper files on wells.

In addition, the RBDMS is a comprehensive data management system that will answer most oil and gas information requests quickly and easily from a computer terminal. More readily available data on active, idle, and past plugged and abandoned (P&A'd) wells will decrease the cost of new discoveries and facilitate the development of enhanced recovery projects.

Reduced Cost to Industry of Oil & Gas Commission Operations

Many state oil and gas boards and commissions operate without the benefit of well-designed computer systems. As a result, many operations that could be automated are performed manually at much greater cost.

The RBDMS is an efficient and comprehensive data management system designed to meet the needs of state oil and gas commissions. It will increase the efficiency of oil and gas commission personnel and reduce operating costs. The oil and gas industry will directly benefit from any cost savings, as most oil and gas commissions are cash funded with a production-based conservation tax paid by operators and producers. Plus, RBDMS will be used by multiple oil and gas commissions, which saves each commission the expense of developing its own system.

Decrease Time Required to Process Applications

An on-line database of oil and gas commission data will decrease the amount of time commission staff require to research and process Applications for Permission to Drill and other applications involving reentry and recompletion. Also, the

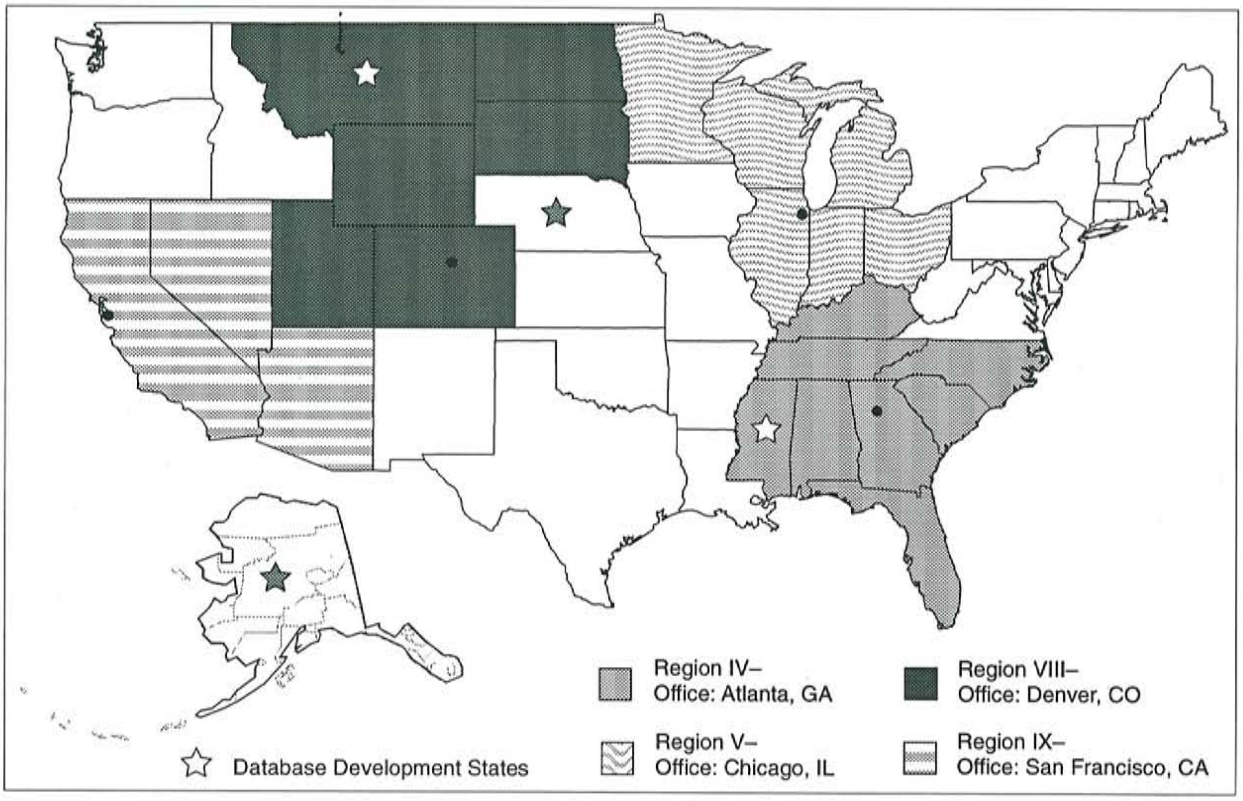


Figure 1 Database development states and Environmental Protection Agency Regions receiving presentations on UIPRF's RBDMS

ability to evaluate environmental risk will result in construction and testing requirements matching the level of risk.

Facilitate Uniform Reporting Requirements Among States

Operators who work in more than one state are often frustrated by the variety of applications and reporting forms used by different states. The RBDMS was designed for use in multiple states. During the design of the system, all participants shared the goal of developing a common database, program screens, and reports that would work for all participating states.

Implementing RBDMS in multiple state oil and gas commissions will further progress toward the goal of uniform application and reporting requirements among states. This will decrease costs to operators with wells in multiple states.

Preserve Shut-in and Idle Wells

Many oil wells are inactive, as they cannot economically produce at today's market prices. Such wells may pose potential threats to underground sources of drinking water (USDW), and pressure exists to plug inactive wells before they pollute and/or become orphans. Although the future for increased oil prices is not bright, such wells may have value as candidates for enhanced oil recovery projects.

The Department of Energy is currently sponsoring research into cost-effective enhanced oil recovery technology. Yet such technology will be viable only if wellbores exist were the new technology can be applied.

Some inactive wells do pose a threat to USDWs and should be plugged, and the RBDMS will assist in pointing out such wells. However, the system also will assist in objectively evaluating inactive wells that pose a relatively low risk of endangering USDWs. Such analysis will minimize errors of omission and commission: not plugging wells that should be plugged, and plugging wells that should not.

The RBDMS will maintain an online list of all inactive wells together with historical mechanical integrity tests, static fluid level tests, and idle well reports. Computer programs will ensure that required tests are run and reports received.

Inactive wells will not become lost and forgotten in a mass of paper files. Such a system will improve public confidence in the regulatory process and reduce pressure to plug inactive wells with future value.

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RBDMS Features

The system offers the following features for versatility, compatibility, and efficiency:

- National standards usage for many fields, including API well number, DOE operator number, AAPG field and formation codes, geologic naming conventions, well status and types, cement/casing descriptions, well location descriptions, and others
- Two types of environmental risk analysis (risk probability and levels of protection)
- Comprehensive well information for both producing and injection wells
- Normalized and fully relational database–Access version 2.0 for Windows environment has been selected for its user friendliness and quick learning curve. Users can self-customize and expand the system. Access also uses Rushmore Technology–for example, optimized queries–to facilitate high performance.
- Automated functions for performing tasks related to Area-of-Review (AOR) analyses, environmental risk analyses, well evaluation, permit evaluation, compliance monitoring, operator bonding assessments, operational monitoring/tracking, and more
- More than 600 data fields, 40+ database tables, and 60+ standard reports (including fully automated EPA 7520 reports, reports directed toward state field personnel, and form letter reports for permit approvals, mechanical integrity test notifications, etc.)
- On-line help in a typical Windows format to facilitate quick response to users' questions

  Referential integrity to minimize errors in data entry and full security features so that only individuals with proper authorization can modify the database. The system also contains a host of update and edit criteria, which help data entry personnel to avoid errors.
- Customized menu system allowing users to quickly and intuitively jump from one screen to any other in the database
- Network compatibility and the ability to upgrade to a client/server platform
- Data conversion from existing state and industry databases to provide near instantaneous results

Development Status

Development of RBDMS in the first group of states (Alaska, Mississippi, Montana, and Nebraska) has been completed. Participating states were provided with a final version of the UIPRF's RBDMS in early 1995. Also, states which had provided standards for common terms and well construction details received a comprehensive list of codes. Assistance has been provided to states in regards to data conversion from existing databases, as well as training, both of which will be ongoing through mid-1998.

Technology Transfer Efforts

A significant part of the RBDMS effort is technology transfer. Over the last year, several meetings and presentations were made to various groups and organizations on RBDMS, including:

- EPA in Region IV (KY, TN, NC, SC, MS, AL, GA, FL), Region V (WI, MI, IL, IN, OH, MN), Region VIII (CO, MT, ND, SD, UT, WY), and Region IX (AZ, CA, NV) (see Fig. 1)
- Various state departments which oversee natural resources, including those in Indiana, Oklahoma, Michigan, New Mexico, Kansas, Colorado, Alaska, Mississippi, Montana, and Nebraska
- Texas Railroad Commission (TXRRC)
- Multiple Ground Water Protection Council meetings
- Various oil and gas producing companies, including Shell Oil Company/Shell Western E&P, Phillips Petroleum, BP Exploration, Texaco, Exxon, and Amoco

Because of the complex and comprehensive nature of the UIPRF's RBDMS, it is not possible to list all of the system features and attributes here. This summary provides just a brief overview. If any readers would like more information, please contact either Ben Grunewald or Mike Paque at 405-848-0690 or by e-mail at ben@gwpc.site.net.

This newsletter features oil-and gas-related projects implemented through the U.S. Department of Energy's (DOE's) oil and gas environmental research program. BDM-Oklahoma, Inc., as management and operating contractor of the National Oil Program, assists DOE in achieving its objectives.

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Infrared Gas Imaging for Detecting Fugitive Emissions Rapidly

by Thomas J. Kulp, Optical Remote Sensing Group, Sandia National Laboratories

The rapid detection and location of fugitive gas emissions are important industrial activities for a variety of applications including hazards control, reduction of product loss, and compliance with environmental regulations. This project, which is jointly funded by the DOE National Petroleum Technology Office (NPTO) and the Gas Research Institute (GRI), addresses the need for faster survey tools by developing technology to allow fugitive emissions to be imaged in a real-time video format.

Annual Costs for Compliance

The U.S. natural gas industry spends $1.6 billion annually to carry out Environmental Protection Agency (EPA) -mandated leak surveys in its production, transportation, and distribution sectors. Similarly, the EPA requires the U.S. petroleum industry to maintain leak detection and repair (LDAR) programs to minimize emissions from oil refineries. Annual costs to accomplish LDAR using the required EPA Method 21 protocol range from $800,000 to $3.3 million per refinery for large facilities.

Labor-Intensive Sniffers

In both the gas and petroleum industries, leak surveys are accomplished using hand-held flame-ionization detector (FID) sniffers. While quite sensitive, detection and location of leaks with hand-held point sensors can be tedious and inefficient. Thus, costs associated with surveys are mainly determined by the labor needed to operate the sniffers. Methods that accelerate leak surveys would reduce manpower requirements and, thus, reduce the cost of regulatory compliance.

Sighting Plumes

In the technology developed by this project, a video camera is used to "see" gas plumes streamlines leak surveying by instantaneously covering a wide area and by simplifying the leak recognition process. Figure 1 shows possible implementations of gas imaging including hand-held, vehicle-mounted, autonomous, and airborne operation.

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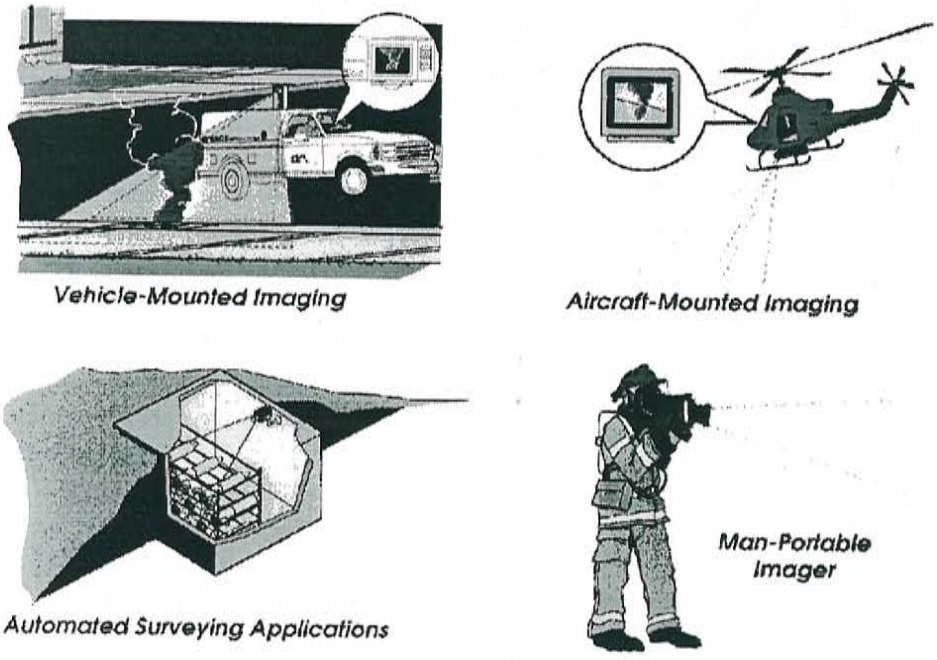

Figure 1 Illustrations showing potential uses of gas imaging systems

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How It Works

The method used to visualize gases is called backscatter absorption gas imaging (BAGI). It operates by illuminating a scene with infrared (IR) laser radiation as it is being viewed with an IR video camera. An image is created when laser light is backscattered toward the camera by surfaces in the imaged region. The laser is tuned to a wavelength that is absorbed by the gas to be detected.

If a gas plume is present in the imaged scene, it absorbs the backscattered laser radiation and appears as a dark cloud in the video image. Figure 2 shows a sample BAGI image of a 0.1 standard cubic foot per hour (scfh) methane leak taken at a range of 20 m.

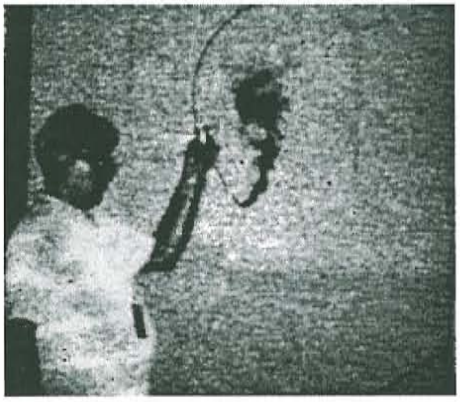

Figure 2 BAGI image of a 0.1 standard cubic foot per hour (scfh) methane leak taken at a range of 20 m

Suitable Ranges & Wavelengths

Work in this project has focused on developing gas imaging instruments suitable for visualizing hydrocarbon vapor at standoff ranges (> 30 m) of interest to the natural gas and petroleum industries for vehicle-mounted operation.

Instrumental requirements to achieve this include operation at laser wavelengths that are efficiently absorbed by hydrocarbon vapors (and transmitted by the atmosphere), tunability of the laser to allow the absorption by different hydrocarbons to be optimized, and sufficient laser power and backscatter collection efficiency to achieve the range goal. The wavelength span between 3.0 and 3.7 μm was selected as an optimal tuning range because it overlaps the C-H stretch vibrational absorptions of most hydrocarbons.

Pulsed & Continuous Wave Laser Options

Two types of BAGI instruments have been developed that meet these requirements. In both systems, a laser source generates IR light using optical mixing in a nonlinear crystal.

The first type of instrument uses a pulsed laser to "flood-illuminate" the target with light pulses while making an image with a focal-plane array camera. The second uses a continuous-wave (cw) laser in conjunction with a scanning IR camera. The cw laser was developed in collaboration with Laser Imaging Systems (Punta Gorda, FL), which is commercializing BAGI technology. In that system the laser is rapidly scanned across the target in a raster-pattern to make an image.

The pulsed system uses difference frequency mixing in a bulk lithium niobate crystal. The cw system uses an optical parametric oscillator (OPO–a type of laser) containing a new kind of crystal called periodically poled lithium niobate (PPLN). The use of PPLN allows cw IR powers on the order of 1W to be generated. This is a factor of 30 higher than that (30 mW) of the IR HeNe laser, the most powerful previously available cw mid-IR light source.

New System Capabilities

Both systems are capable of generating recognizable methane plume images at concentrations as low as approximately 20 ppm-m and standoff ranges as high as 40 m (scanned system) and 70 m (pulsed system).

Detectable levels are specified as a product of gas concentration and plume thickness because IR absorption is a path-integrated process. Thus, 20 ppm methane is detectable at a plume thickness of 1 m; 200 ppm is the detection limit at a 0.1 m thickness, etc. It also has been demonstrated to image pure methane leaks at a rate of approximately 0.02 scfh.

Viewing Complex Scenes

Detection limits for ordinary gas imaging can degrade when viewing a complex scene (i.e., combinations of highly reflective and nonreflective surfaces). This can be remedied, however, by operating in a differential mode, as shown in Figure 3. There, images are alternately collected at wavelengths that are and are not absorbed by the gas to be detected, and these images are subsequently digitally processed to remove the interfering background

scene. This allows the specified detection limit to be maintained.

Field Testing

The scanned approach using the PPLN OPO is currently the most likely technology to be commercialized because of its lower cost and greater ruggedness. The scanned imager has been field tested successfully in a few different applications that include leak imaging at natural gas compressor stations, in a natural gas distribution system located in Atlanta, Georgia, in controlled leak tests carried out for the EPA, and in a field campaign at an oil refinery.

Plans are now being made for an additional refinery test to take place during October 1998. This work is being done in collaboration with the American Petroleum Institute and the EPA, under the Common Sense Initiative (CSI). The CSI Subcommittee is considering BAGI as a more effective LDAR technology for refinery fugitives screening.

Other ongoing efforts are directed toward improving the sensitivity of BAGI, ruggedizing the PPLN light source, and developing a compact imager that is capable of man-portable operation.

For more information, please call 925-294-3676, fax questions to 925- 294-2276, or send e-mail to tjkulp@sandia.gov.

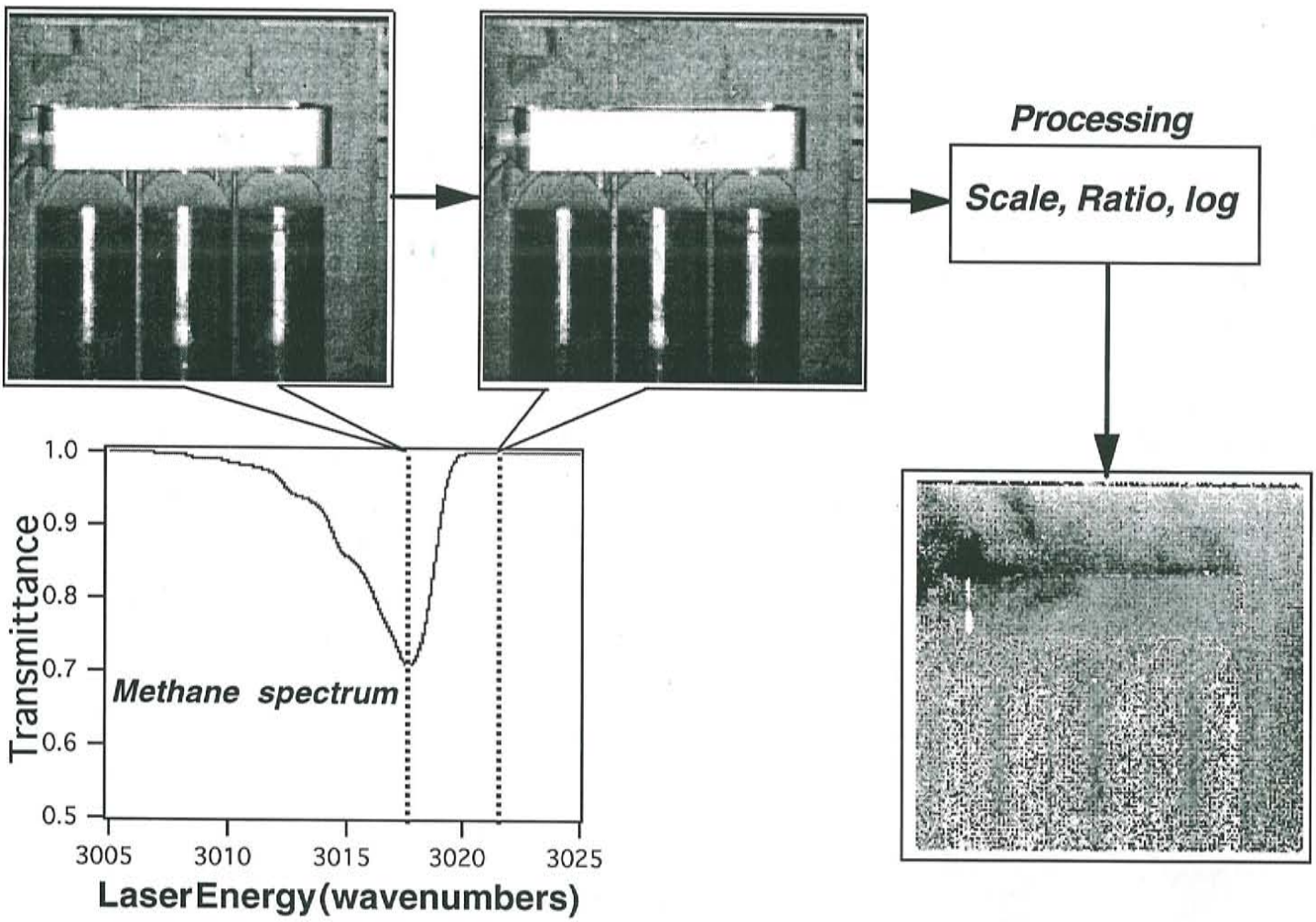

Figure 3 The results of differential imaging: Upper left, image taken at a wavelength absorbed by methane (as indicated on the absorption spectrum). Upper right, image taken at a nonabsorbing wavelength. Lower right, image showing the result of differential processing of the two images, where the background has been removed, and the gas plume is now clearly visible.

CALENDAR

OCTOBER 20–23, 1998

5th International Petroleum Environmental Conference, Issues and Solutions in Exploration, Production, and Refining, Albuquerque Hilton, Albuquerque, NM. Cosponsored by South-Central Environmental Resource Alliance (SERA), University of Tulsa & DOE NPTO; K. Sublette, conference chair. Contact Pat Hall, 918-631-3003, fax 918-631-2154, patricia-hall@utulsa.edu, or visit http://hpserv.keh.utulsa.edu/~ipec98.

Impact of Fuel Oxygenates in the Environment, Oct. 23 symposium, J. Suflita, University of Oklahoma, & J. Salanitro, Shell Development.

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