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01852-1124

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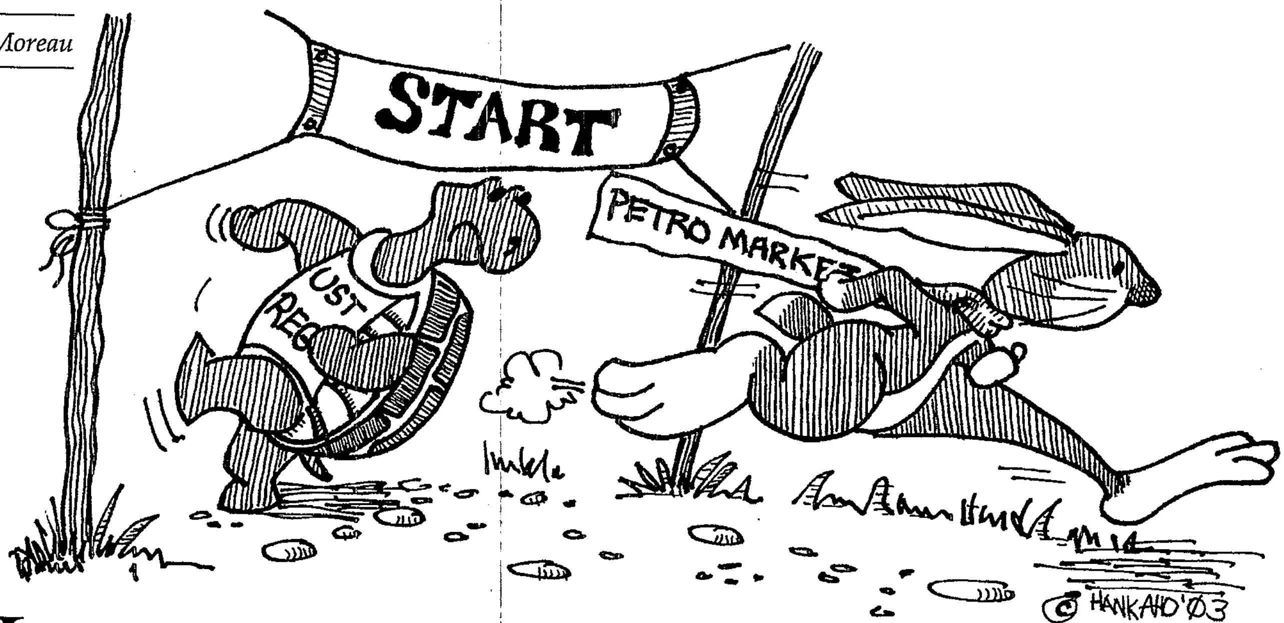
L.U.S.T.LINE

A Report On Federal & State Programs To Control Leaking Underground Storage Tanks

The Tortoise and the Hare Revisited

Reaching the Goal Effectively and Efficiently: The Path Not Yet Taken

by Marcel Moreau



We all know Aesop's fable of the boastful hare and the slow but persistent tortoise. We all know who wins the race and why. For the purposes of this article, I've recast the story and given the characters a more challenging and important goal than simply winning a race. I've morphed the hare into the petroleum marketing industry and the tortoise into the national UST regulatory program. Their goal is to protect human health and the environment, which is defined as reducing the number of petroleum releases from USTs to the absolute minimum. And I've made the story more politically correct by having the tortoise and the hare be part of the same team, struggling to reach the same goal. At issue in this story is how *our players go about reaching their goal—how to keep the team members evenly matched so that they can more effectively and efficiently run the race.*

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The Hare

One of my favorite stories regarding service station construction is in a 1981 American Petroleum Institute publication titled *The Origin and Evolution of Gasoline Marketing*. The story tells how Shell Oil expanded in California in the early 1920s:

> E.H. Sanders, who was assistant division manager of the Central division at the time, loves to tell how they invaded the San Jose-to-Santa Barbara territory, building eight depots (bulk plants) and a hundred service stations all in a matter of six weeks. Sanders and Claude Donaldson, the Central division's traffic manager, first rode the 260-mile stretch of road between the two towns and picked likely sites for depots and stations. They were followed closely by real estate men who, to save time and expense, leased rather than bought most of the desired sites. Then came the construction crews in relays. First, crews to dig holes in the proposed service station lots and bury the underground storage tanks the station would need. Next, crews to pour the concrete foundation for the station, leaving bolt studs sticking out of the concrete. Meanwhile the crates containing the complete "A" station would be delivered. As soon as the concrete had hardened, a crew arrived to install the pumps and bolt the station in place, anchoring it to the foundation by means of the stud bolts protruding from the concrete. Then came the paint crew to apply a coat of red and yellow, and the station, once its storage tanks had been filled from the new depot, was in business "about ten days from start to finish."

This orgy of station construction would continue until World War II. In fact, 1939 was the peak year for the number of retail gasoline outlets in the country, when some 400,000 retail outlets were active. The downside of this huge number of facilities was that the average facility was pumping about 40,000 gallons of gasoline per *year*. By comparison, *National Petroleum News* recently estimated that there were 170,678 retail outlets active in the first quarter of 2002, with the average convenience store selling 1.3 million gallons per year. (Convenience stores represent 73 percent of the retail outlets in the U.S.)

Gasoline marketing continues to be a dynamic industry marked by rapid and continual change. The 1950s saw another construction boom that lasted through the 1960s, only to come to an abrupt halt with the oil embargoes and gasoline allocation and price controls of the 1970s. The 1970s also saw the introduction of unleaded fuel and the rise of self-service fueling. The 1980s saw the transition from the traditional service station, which offered vehicle maintenance and repair, to the convenience store model, which features cigarettes, soda, beer, and snacks along with the fuel.

The 1980s also saw the introduction of federal regulation of underground storage systems, although most of the tank upgrade and replacement activity took place in the 1990s, except for the major oil companies, which got started earlier. The 1990s also saw increasingly high-volume gasoline retailing facilities, culminating in the addition of gasoline to the products offered by "Big Box" retailers, such as Wal Mart. The late 1990s also saw the consolidation of major oil companies and a continued decline in the total number of retail gasoline outlets.

While the pace of change in petroleum marketing is generally rapid, underground storage technology evolves much more slowly. This is easy to understand because petroleum marketing has always been an extremely cost- and customer-conscious industry, and not many customers buy fuel based on the type of storage system a facility has installed.

There have been three major generations of UST systems in the U.S.:

■ First generation: 1910–1985

These storage systems consist of steel tanks with galvanized steel pipe and a suction pump (first manual, then electric) to deliver fuel. The bare-steel tank reigned at petroleum retailing facilities virtually unchanged for 70 years, except for size and the change from riveted to welded construction. Galvanized piping had a similarly long life.

■ Second generation: 1965–Present

These storage systems consist of fiberglass and corrosion-protected steel tanks with fiberglass pipe and submersible pumps. Though fiberglass and factory-engineered corrosion-protected steel tanks have been available since 1965 and 1969, respectively, their market penetration was relatively small until the federal interim prohibition, in effect, forbade the installation of bare-steel tanks after May 1985.

■ Third generation: 1985–Present

The latest system feature is double-walled, corrosion-resistant tanks and double-walled piping (especially flexible pipe after 1990) with containment sumps and submersible pumps. Though double-walled tanks were developed in Europe in the mid 1960s, the technology was slow to cross the Atlantic because of cost.

The dates I cite are approximate, and both second- and third-generation systems are in common use today. Second-generation storage systems, which represent technology

LUSTLine

Ellen Frye, *Editor*
Ricki Pappo, *Layout*
Marcel Moreau, *Technical Advisor*
Patricia Ellis, Ph.D., *Technical Advisor*
Ronald Poltak, *NEIWPCC Executive Director*
Lynn DePont, *EPA Project Officer*

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NEIWPCC
Boott Mills South, 100 Foot of John Street
Lowell, MA 01852-1124
Telephone: (978) 323-7929
Fax: (978) 323-7919
lustline@neiwpcc.org

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that is over 30 years old, are accepted by the federal rules, even for today's installations.

The Tortoise

Storage system regulation is the tortoise in our fable. Environmentally based rules regarding underground storage began at local levels in the late '70s but rose rapidly to the federal level with the signing of the Subtitle I RCRA amendments, establishing a federal underground storage system regulatory program in November 1984. This resulted, after a four-year gestation period, in the promulgation of the federal tank regulations, which in turn established a 10-year program for upgrading the nation's storage systems.

While the introduction and signing of the 1984 RCRA amendment into law happened with lightning speed, the development of the regulations was deliberately slow in an attempt to create a defensible and workable rule. Since publication on September 23, 1988, the rules have remained remarkably stable. Except for a small change to the overfill prevention portion of the regulations in 1991, the federal UST rules have not moved a whisker. This came home to me as I reached for my taped-together, dog-eared copy of the Federal Register and realized that this 14-year old document is still perfectly viable as a reference for technical standards for UST systems today. Is this a good thing?

The Revisit

Consistency has many proponents. "Slow and steady wins the race" is our tortoise's motto. Consistency is touted as a fundamental quality of good parenting. Consistency is important in the workplace so that workers and customers know what to expect. There is something to be said for consistency in regulations, for much the same reason as in parenting and in business. But consistency has its limits. The parenting techniques appropriate for a toddler will not work on a teenager. A company that has consistent policies but is consistently losing money would be wise to assess whether consistency with outmoded policies was contributing to the red ink. A carved-in-stone regulatory program that is operating in a fluid marketplace may find that its effectiveness is eroding.

When the original tank rules were written, the focus was on updating existing UST technology. This was clearly appropriate because the dominant technologies for tanks and piping in use at the time were hopelessly outmoded. In recent years, however, the light has dawned on many in the UST world that technological issues must now take a back seat to operational issues.

It has slowly been recognized that the best of hardware will not function well unless, as Ray Powers of the Pennsylvania Department of Environmental Protection recently stated in an e-mail, it is installed properly, programmed correctly, well maintained, and effectively responded to when an alarm is triggered.

We have upgraded our hardware, but this has not entirely solved the problem because the rules did not look comprehensively at what would happen after the new hardware was installed. By and large, the rules placed the burden of defining the maintenance needs of leak-detection equipment on the equipment manufacturers themselves by requiring that equipment be maintained according to the manufacturers' specifications. Equipment manufacturers have tended to shy away from this responsibility, preferring to imply, if not overtly state, that their equipment is "maintenance free." With few exceptions (e.g., the annual testing of line-leak detectors and the triennial monitoring of CP systems), the original rules adopted the "bury it and forget it" attitude that was a substantial contributor to the UST problem in the first place.

While some technology-based issues are clearly still with us today, the weak link in today's strategy for protecting human health and the environment from leaking underground storage systems seems to be a human one (e.g., ignoring equipment maintenance and the burying of heads in the sand when leak-detection equipment alarms sound). But while the issues have evolved, the regulatory strategy for dealing with the issues has remained solidly chiseled in stone.

A Strategy for the Tortoise

As a result of the different paths taken by our hare and our tortoise, it *is not at all clear to me that our tortoise is doing its share to protect* human health and the environment. Here is my short list of things that could be addressed in rule revisions to help our tortoise meet the challenge:

• **Address maintenance of installed hardware.** A few states have addressed this issue by requiring annual inspections of leak-detection, and in some cases, overfill-prevention hardware. A study that I conducted for the State of Maine a few years ago documented that checking operational status of hardware is a worthwhile endeavor—it was conservatively estimated that some 29 percent of facility inspections discovered significant problems with corrosion-protection, leak-detection, spill-containment, or overfill-prevention hardware.

The Maine study also revealed that merely inspecting the hardware is not enough. It found that 39 percent of tank owners failed to address deficiencies that were pointed out to them in the inspections. The inspection requirement must be accompanied by enforcement measures with sufficient teeth to get the problems fixed. (Maine subsequently enacted regulations to deny product deliveries to tanks with problems that are not corrected.)

• **Increase scrutiny of some UST technologies.** The Iowa tank lining study some years ago indicated that interior tank lining may have a substantially greater failure rate than U.S. EPA believed in 1988. (See "Iowa's Tank Lining Study," *LUSTline* Bulletin #30.) Perhaps the initial lining inspection should be conducted after five years rather than the ten specified in the current rule.

Anecdotal evidence indicates that many retrofitted cathodic-protection systems are also not functioning as they should. Perhaps an annual monitoring frequency, rather than every three years, would be more appropriate. Given the large number of older steel storage systems still in service, should increased attention be focussed on internal corrosion?

California is learning that a very high percentage of installed tank and dispenser sumps, elements that are

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■ **Tortoise and Hare** *from page 3*

critical to the functioning of secondary containment systems, are not tight. It is not clear whether this is due to initial installation problems or the subsequent "aging" of the system. Either way, some periodic evaluation of the integrity of these components would seem to be critical to the effectiveness of secondary containment.

The long-term performance of flexible piping has also recently been called into question. (See "Flexible-Pipe Concerns Drive Home the Need for Tank-Owner Vigilance," *LUSTLine* #42.) It may be time to consider new measures, such as improved performance standards for flexible-piping technology or increased vigilance over existing installations to address these concerns.

• **Plug leak loopholes.** The existing rules do not include leak detection for submersible-pump manifolds or for dispensers. Yet field experience indicates that these components can be frequent sources of release. (See "Field Notes," *LUSTLine* #41.) With the exception of secondary containment, and in some cases statistical inventory reconciliation (SIR), no other commonly used method of leak detection is effective on these components. Another loophole is that the rules never considered the possible impact of vapor leaks from UST systems. California has recently documented that this type of leak is commonplace and will soon be requiring that UST systems be vapor tight. Is this an issue that should be considered nationally?

• **Improve regulatory compliance.** Whether such an effort consists of restructuring state cleanup funds (see "Square Operators, Round Tanks, and Regulatory Hammers: A Petroleum Marketer's Perspective," *LUSTLine* #42), developing some requirements for operator certification, or some other technique, market forces that encourage compliance should be brought to bear on the tank owner. Compliance with tank regulations must be strongly and directly linked to the tank owner's bottom line if the regulations are ever to be effective. It might also be worthwhile to review the rules from a "human engineering" perspective to find ways to simplify compliance so that reliance on fallible humans can be minimized. (See "People and UST Systems" on page 8.)

• **Tighten leak-detection standards.** The present-day rules have petrified leak-detection technology by specifying generous leak-detection standards of 0.2 gallons per hour (gph) (1,752 gallons per year). While the official interpretation of the rule is that no leak is acceptable, the de facto use of the rule is that anything less than 0.2 gph is not a leak. Most volumetric leak-detection methods available today are capable of reaching accuracies of 0.1 gph. While this is still equivalent to 876 gallons per year, it is half the 0.2 gph leak rate that is the standard today.

Test reliability could be improved by calculating the probability of detection (Pd) and probability of false alarm (Pfa) for each volumetric test conducted, which would give a much better indication of the reliability of a specific test result. The limitations of various technologies should also be evaluated and spelled out by manufacturers or regulations. For example, inventory control, automatic tank gauges, statistical inventory reconciliation, and line-leak detectors decline in effectiveness as throughput increases, but the limits of their effectiveness have not been clearly specified. With the proliferation of very high-volume retail facilities, it is important that tank owners know ahead of time which leak-detection options will work for them.

• **Revisit the spill-containment and overfill-prevention issue.** As I have described several times in *LUSTLine* (Bulletins #31, #21, #18), I do not believe that overfill prevention as it is currently practiced is safe, effective, or efficient. (See also "Field Notes" on page 11.) Surely something better can be promoted by redefining the regulatory criteria.

• **Update the rule to reflect knowledge and experience gained in the last 14 years.** Do we still really need groundwater and soil-vapor monitoring as leak-detection options? Should operating guidelines for SIR be specified? Should language regarding the 1998 deadline be changed to reflect that this date has passed? Should issues concerning the appropriate leak rate for testing line-leak detectors be addressed? Can a sensor in a secondary-containment sump take the place of a line-leak detector? Should specific requirements be set for electronic line-leak detectors? These questions must be answered in a process that leads to an improved rule.

Rule revision is not a chore that many relish, but some states find that it is worth the effort. These states have evaluated the effectiveness of their regulations and have made adjustments accordingly numerous times. Florida's rules, originally enacted in 1984, were revised in 1992, 1994, 1996, and 1998. California's first rules went into effect in 1985. Since then, the technical rules have been modified in 1991, 1994, 1998, 2001, and 2002. Maine's first UST rules were adopted in 1986 and modified in 1987, 1990, 1991, 1996, and 2002. Why have these states made changes to their rules? (See "Keeping the Tortoise in Shape" on page 6 for their stories.)

But If It Ain't Broke...

"But wait!" you say. "The data show that the number of new releases is dropping fast nationwide. The current rules are working just fine." (For the latest U.S. EPA data, see "Memo from Cliff Rothenstein to UST Regional Division Directors," December 23, 2002, *FY 2002 End-of-Year Activity Report*.)

OK, let's look at those statistics. (If you want to take a look, go to **www.epa.gov/oust**.) Yes, the data show a significant decline in the absolute number of new releases being reported to U.S. EPA. But you would expect that to be the case because the number of active UST systems has also decreased dramatically since 1988—from 2 million tanks in 1988 to 700,000 active USTs today. If we have truly been making progress in protecting human health and the environment, then there should be a measurable decline in the number of leak incidents *as a percentage of the remaining active UST population.*

Figure 1 is a plot of data taken from U.S. EPA semiannual reports from 1991 through 2002. Though the data are somewhat erratic, there does appear to have been a declining trend (based on the linear regression line) in the number of reported releases as a percentage of the active facility population of from approximately 5 percent to around 2 percent. In other words, in 1991, the number of newly reported releases equaled about 5 percent of the active UST-facility population, while in 2002, the number of newly reported releases equaled about 2 percent of the active UST-facility population.

However, these data don't tell the whole story for two reasons. First, the data have a lot of scatter, and the trend is not a strong one. Second, because historically most leaks have been detected by storage system closure. Because the number of closures has been declining since 1993, the corresponding decline in reported releases may well be an artifact of the way releases are discovered rather than a true estimate of the actual rate of releases at active facilities today. (See Figure 2.) Of course, the ultimate answer would be to go out and test a random sample of the active UST population.

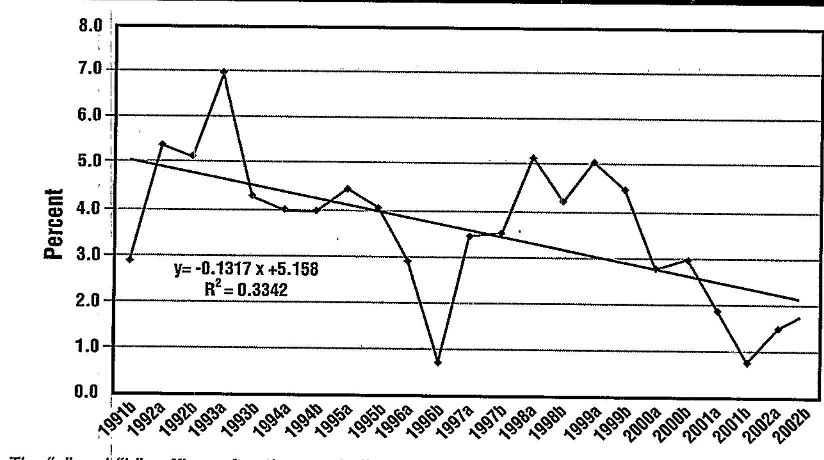
Though not exactly a random test because a large number of tank owners refused to participate in the study, 182 storage systems in California were tested using enhanced leak detection (a version of a Tracer test). (See the report at: **http://www.swrcb.ca.gov/cwphome/ust/docs/fbr/FBR_Final_Report.pdf.**) The study found only one small liquid leak in a piping run but found that 61 percent of the systems tested had released detectable amounts of hydrocarbons along with the tracer compound via vapor releases, primarily from the top of the underground storage tank. But California is a state that requires annual inspections, and only 10 percent of the systems tested were entirely single-walled, so the leak status of California storage systems may not be representative of the national norm.

A Petroleum Equipment Institute (PEI) estimate of UST system performance, though clearly not quantitative, is considerably more pessimistic about UST-system releases. (See "Field Notes," *LUSTLine* #41.). The PEI members estimated that they would find a total of 47 leaking components inside 100 dispensers and 44 leaking components associated with 100 submersible pumps.

The point is we really don't know with any degree of certainty how today's UST systems are performing. Without reliable data on the number of actively leaking UST systems and the nature of the leaks, we cannot know how far from the finish line our hare and tortoise presently are. Perhaps another area for rule revision is to put in place a mechanism that will generate the data we need to chart the team's progress.

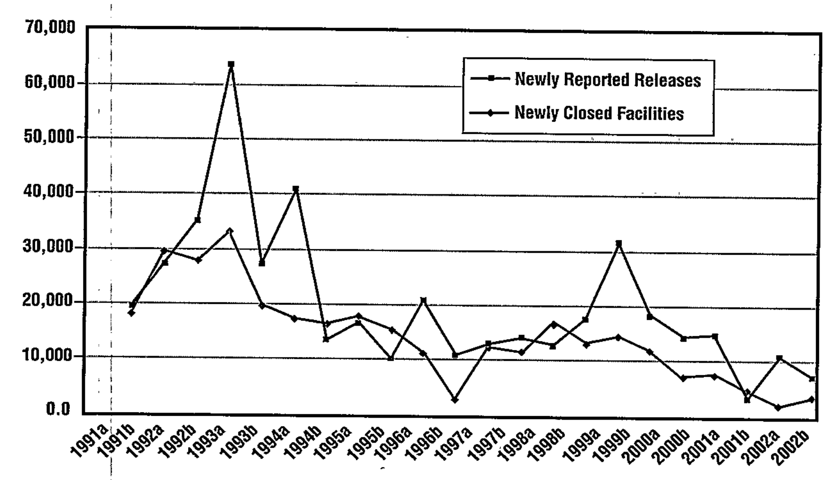
Consistency has much to recommend it. But in a world where the only constant is change, consistency must not be confused with paralysis. Businesses must evolve to survive. Is this not true for regulations as well? I believe that regulations should consistently adapt to the changing circumstances, knowledge, and experiences encountered on the path to achieving the regulatory goal. The tortoise, after all, did not win the race by standing still. ■

Figure 1 — Trend of Newly Reported Releases Over Time



The "a" and "b" suffixes after the year indicate data points for the first and second halves of the federal fiscal year. The original EPA data indicate the number of active tanks. The active tank data were converted to a facility count by dividing by 2.86, the tank/facility ratio used in the preamble to the federal rule. The number of newly reported releases for each six-month interval was divided by the estimated number of active facilities for the same time interval and multiplied by 100 to arrive at each data point.

Figure 2 — Comparison of the Trends of Newly Closed Facilities and Newly Reported Releases Over Time



The "a" and "b" suffixes after the year indicate data points for the first and second halves of the federal fiscal year. The original EPA data indicate the number of newly closed tanks. The newly closed tank data were converted to a newly closed facility count by dividing by 2.86, the tank/facility ratio used in the preamble to the federal rule. Because most new releases are discovered via UST facility closure, the parallel trends in newly closed facilities and newly discovered releases over time may indicate that the reduction in releases discovered is more closely related to the reduction in the number of facility closures than the effectiveness of the UST program in reducing leaks.

Marcel Moreau is a nationally recognized petroleum storage specialist whose column, "Tank-nically Speaking," is a regular feature of LUSTLine. *Marcel would welcome some interactive dialogue on "The Tortoise and the Hare Revisited." He can be reached at* **marcel.moreau@juno.com.**

Keeping the Tortoise in Shape

by Ellen Frye

Several states have revised their UST regulations from time to time since they were originally promulgated. (See "The Tortoise and the Hare Revisited" on page 1.) I asked UST program managers from three such states—Maine, California, and Florida—why they did this, why they feel it is important to continue to do this, and how they evaluate the effectiveness of their rules. For the states that can be no more stringent than the federal rules, this is not meant to rub salt into the wound. Clearly, these three states had the authority to move ahead on what they deemed were necessary changes.

Maine

"The bottom line in this program has got to be preventing discharges and eliminating public exposure," says George Seel, Maine Department of Environmental Protection (MDEP) Director of Technical Services, Bureau of Remediaton and Waste Management. "Unless you've got your head in the sand, you've got to adapt your program to eliminate the problems. To make any necessary revisions to our regulations, we evaluate our program on an ongoing basis, as data becomes available. We try to answer three basic questions: How many new discharges have we had? What were the causes? What were the environmental, public health, and fiscal (insurance program) impacts? It's all about the lessons we learn answering these questions."

Over the years, MDEP has conducted a number of studies instigated by what they have found during routine compliance inspections and release investigations. For example, compliance inspections indicated that many required annual inspections were not being conducted and that defective equipment was not being repaired. MDEP commissioned a study to review the annual inspection reports of a random sample of UST facilities. The study confirmed that a large percentage of owners/operators were not doing what they were supposed to do with respect to annual inspection requirements (e.g., cathodic protection monitoring, leak-detection equipment inspections). Furthermore, when problems were found during annual inspections, about 40 percent of the time they were not corrected.

Based on this information, MDEP got approval from the legislature to institute a third-party inspection program to ensure that annual equipment inspections are conducted, deficiencies are corrected, and a certified report of the inspection is submitted to MDEP.

A review of expenses revealed that about about 40 percent of the agency's annual remediation budget was spent on 1 percent of the discharge sites in the state. This was primarily because the sites located in sensitive geological areas require a high level of long-term groundwater and drinking water remediation.

Seel says they have learned that the primary causes of poor UST facil-

ity performance are equipment failure and human error or negligence by owner/operators. "We've found that even the best-designed facility can still have discharges," says Seel. "Within the first five years of a facility's existence, we have found that it is likely to have at least one discharge—and many have multiple discharges. The problems are often the result of human error, and we've concluded that you can't really correct human error problems." (See "People and UST Systems" on page 8.)

Because some level of UST failure is predictable and seemingly inevitable, MDEP concluded that there are places in Maine that shouldn't have gas stations. The legislature was provided with documentation to this effect, and facility siting standards were adopted. (See "There Ought to Be a Law: Maine's New UST Siting and Inspection Laws," *LUSTLine* #38.)

California

"I believe that in any type of work you do, in order to be successful, you have to evaluate what you are doing to determine if it is effective," says Shahla Farahnak, Chief of Leak Prevention at the California State Water Resources Control Board (SWRCB). "If you need to make the changes, be willing to make the changes—and that is not easy. It is very time-consuming. You have the challenge of coming up with an ideal of what needs to be done and ultimately balancing that with what you want to achieve in terms of environmental protection."

The SWRCB has undertaken various research projects to determine how effective a specific regulatory standard or requirement is when applied in the field. (See these reports at **http://www.swrcb.ca.gov.cwphome/ust/docs/fbr/index**.) Based on the findings of these projects, the SWRCB has moved forward to make changes. "We need numbers and documentation to justify our recommendations," says Farahnak.

For example, in 1998 and 1999, an Advisory Panel evaluated the effectiveness of the state's UST system upgrade requirements in terms of protecting the environment. (See "California's Field-Based Research Project Looks for Answers," *LUSTLine* Bulletin #38.) That effort led to the state's new UST Leak Prevention and Enforcement Provisions, which went into effect on January 1, 2003. (See "News from California," *LUSTLine* #42.)

Florida

"Technology changes. We have to keep up. Reference standards change. We have to keep up," says Marshall Mott-Smith, Administrator of the

Florida Department of Environmental Protection (FLDEP) Bureau of Petroleum Storage. "Plus, state agencies need to be honest with themselves about what they see in the field and make changes that will prevent incidents and discharges."

FLDEP is substantially revising its 1998 UST rules to not only keep up with technology and reference-standard issues but also to make the rules easier to understand. In addition, FLDEP wants to resolve several problem areas in the rules, eliminate tables and deadlines that have passed, and address problems encountered with flexible piping and piping sumps.

Many of the proposed changes were based on the preliminary results from a Cause of Leak Study that FLDEP is conducting in conjunction with the U.S. EPA Office of Underground Storage Tanks. In this study, reports from district and county agency leak investigations have been reviewed with an eye toward gathering data to improve the rules. Early results from the study indicate that in today's UST systems, piping is the major cause of leaks, followed by dispensers. (A future issue of *LUSTLine* will carry the results of the study.)

Mott-Smith says that in many cases, piping sumps are becoming primary containment. These sumps are real headaches for a variety of reasons, including inadequate design, poor installation, bad entry boots, and problems with some types of flexible polyethylene piping. He says that the state's secondary containment requirement (a rule revision instituted in 1992) was a critical departure from the federal rule, which doesn't require UST systems to have that second barrier.

"If you see free product between the walls of a double-walled UST system," says Mott-Smith, "you know that second wall was the only thing that prevented the product from getting into the environment. You have a leak, but you don't have a release, and that makes all the difference in the world." ■

For more information on FLDEP's proposed rule revisions, go to **www.dep.state.fl.us/waste/categories/tanks.**

UL Proposes Changes to Standard on Nonmetallic Underground Piping

On December 6, 2002, a standards technical panel, made up of some 30 state regulators, industry experts, and representatives of nonmetallic piping manufacturers, met in Northbrook, Illinois, to discuss proposed changes to Underwriters Laboratories' (UL) Nonmetallic Underground Piping for Flammable Liquids Standard (UL 971).

The proposed standard addresses two key aspects of the piping: mechanical failure and permeation. UL released the mechanical portion of the proposed standard for comments on February 4 and organized an ad hoc committee to further address permeation. Under discussion is the proposed permeation value of 0.1 $g/m^2/day$, the methodology used to analyze this value, and the proposed new test method for measuring permeability. The committee is considering these issues in conjunction with the California State Water Resources Control Board.

UL expects to publish the standard in early spring (the comment period ended on March 4, 2003). The standard then becomes effective 18 months after publication, giving makers of flexible piping the opportunity to have their products tested to meet the standard. For more information, contact Maggie Carroll at: **marguerite.e.carroll@us.ul.com.** ■

Mississippi and Florida Notify UST Owners and Contractors about Flex-Pipe Concerns

Both the Mississippi Department of Environmental Quality and the Florida Department of Environmental Protection have notified UST owner/operators and installation contractors about concerns with thermoplastic flexible-piping systems. (See "Flexible-Pipe Concerns..." in *LUSTLine* #42.) You can view Mississippi's letter and related photographs at: **www.deq.state.ms.us/newweb/homepages.nsf.** If this link does not work you can go to **www.deq.state.ms.us** and click on the "Underground Storage Tanks" link.

To view the "Special Notice to Storage Tank System Owners and Operators about the Use of Thermoplastic Flexible Piping in Florida," go to: **www.dep.state.fl.us/waste/categories/tanks.**

Check Out EPA's New RFG Web Site

U.S. EPA has posted comprehensive data concerning reformulated gasoline (RFG) fuel properties and emissions performance averages by year/season and RFG area. The tables and graphs at the site are based on EPA's analysis of data generated from surveys conducted by the RFG Survey Association, an association of refiners, importers, and blenders, as a requirement of EPA regulations. The site provides detailed data on all gasoline oxygenates.

To access "Information on Reformulated Gasoline Properties and Emissions Performance by Area and Season," go to: **www.epa.gov/otaq/regs/fuels/rfg/properf/rfgperf.htm.**

People and UST Systems

By Richard S. Bradley, Jr.

Over drinks at business dinners, we discuss industry horror stories with associates. We shake our heads in disbelief at the ignorant, lazy—or worse, unlawful—behavior of people. Together we count the cost to individuals and communities, and occasionally the damage done to the environment, knowing there were opportunities to prevent the incident beforehand.

This is the first installment of a multipart series examining the role of human behavior in the management of UST systems. Human behavior plays a dominant role in our ability to manage those systems for the prevention of contamination and the protection of human health and the environment. One of my favorite dinner and wine stories is germane to this topic. It concerns a major gasoline release from the piping of an UST system caused by the tank owner's failure to search for the root cause behind an ongoing alarm on his automatic tank gauge (ATG) console.

A Story of System Failure via Human Error

This UST owner had a retail location that pumped a high volume of gasoline every month. He attributed years of success to an unwavering focus on his customers, resulting in a very loyal clientele. He understood that interruptions to his business were an inconvenience to his customers. Consequently, interruptions had a clear impact on his bottom line.

So, when it came time to replace his UST system, he was determined to purchase state-of-the-art equipment with the most up-to-date technology. He wanted an UST system that would allow him to operate his facility without the interruptions resulting from product releases and associated contamination.

He installed redundant backups for preventing *and* detecting releases of product. He put in double-walled tanks, double-walled piping, secondary-containment sumps for the submersibles, sensors in the sumps, and high-tech electronic line-leak detectors capable of detecting leak rates smaller than the regulatory requirement.

Unfortunately, this system had one flaw—a flaw that would later reveal how people behave when continually confronted with problems they cannot, or will not, correct.[1]

For all of its high-tech wizardry, this UST system suffered from a common problem—the ubiquitous leaking sump. After investing a significant sum for the "best" money could buy, the owner was surprised and frustrated to discover that these "high-tech" sumps were not watertight. The sensors in the sumps went into alarm shortly after a heavy rain. Rains were frequent at that time of the year, and after several attempts at removing the water from the sumps and resetting the alarm console, the owner and employees became indifferent to the sensor alarms. After all, it was only water.

Trouble

As the early morning rush hour began to wind down during one blustery cold winter's day, several customers entered the store to tell the cashiers on duty that they were unable to pump regular gasoline. The owner looked at his ATG console and discovered that it had shut down the product submersible because the product line failed a gross line test. He called the contractor. Shortly after arriving at the site, the technician tried resetting the ATG system and rerunning the line test. Again, the product line immediately failed the test and the ATG system shutdown the submersible.

He decided to isolate the product line and rerun the line test to determine if the problem was with the submersible. At this time, the technician noticed a substantial amount of water in the submersible sump. The water covered the piping, entry boots, and the submersible. The owner responded that water was always getting into the sumps, but it was just water. Unable to reach the submersible because of the water and seeing that there was no gasoline on the surface, the technician isolated the product line from the dispensers and ran the line test. The product line again failed the gross line test.

The leak was probably somewhere in the product line. However, the absence of gasoline in the submersible sump was bothersome because the UST system had double-walled piping. Had there been a leak in the primary piping it should have drained back to the submersible sump. Fearing the worst, the contractor contacted the tank- and line-testing company, requesting that a tester be sent to the facility to determine whether the secondary piping was tight, and if the testing came back negative, to locate the source of the leak. The testing service supervisor informed the manager that they

1. The topic of human error is fascinating. Two of the more useful and interesting works include: *The Logic of Failure: Recognizing and Avoiding Error in Complex Situations* by Dietrich Dorner, published by Perseus Books, 1996, and; *Inviting Disaster: Lessons From the Edge of Technology* by James R. Chiles, published by HarperCollins, 2001.

would be unable to perform the testing or locate any leak that might be present until the owner removed the water from the submersible sump.

Pumping the Sump

The technician informed the owner of the need to pump the water out of the sump. The owner said that was no problem; he had a sump pump in the back office that he used to pump water out of the car wash during the last heavy rain. He could use that to pump the water out of the sump onto the driveway. The technician politely explained to the owner that that was illegal. The government classified water removed from the sump of an UST system used for storing gasoline as contaminated waste. A licensed waste hauler with the necessary equipment for pumping water from the sump and transporting it to a licensed treatment facility was required.

The owner reluctantly agreed and called the waste contractor recommended by the testing contractor. Shortly afterward, a large tanker truck arrived at the facility and began pumping the water from the sump into the tanker. Water continued entering the sump almost as fast as the tanker could pump it out. A large volume of water had collected in the tank pit during the previous months. After several hours, the tanker truck was filled to its 6,000-gallon capacity. Water no longer continued to enter the submersible sump and the testing technician was able to begin running the necessary tests.

The Helium Test

Performing a helium test at this particular location required injecting helium into the interstitial space of the double-walled piping system through a fitting on the entry boot and waiting an hour to allow movement of the helium through the backfill. Since the helium is lighter than air, it would immediately rise toward the surface upon entering the backfill wherever a hole existed in the secondary piping, causing the detector to alarm.

Using the owner's "as built" drawings as a guide, the technician chose several locations along the piping pathway to drill small-diameter holes through the concrete to get to the backfill material. The technician then placed a sensing device designed for "sniffing" helium over the holes.

The detector alarmed at the hole closest to the dispenser that was nearest the building but well outside the tank pit, confirming that there was a leak in the piping system. Excavation revealed that water from the sumps had filled the interstitial space between the primary and secondary piping. An exceptionally cold winter had caused both the ground and the water in the interstitial space to freeze.

Since freezing water expands, there was nowhere for the water to go; it burst the secondary pipe *and* crushed the primary pipe. Several hundred gallons of gasoline entered the ground because the line-leak detector had been unable to run a test for more than two hours due to the constant running of the submersible pump, which was pumping product to meet customer demand during rush hour.

The Cost

The UST owner's significant investment in technology resulted in an invoice of thousands of dollars to locate a leak, and thousands more to clean up the underground contamination. It would be years before he would recover those costs—all because he had not taken decisive action to properly resolve the problem of the leaking sumps.

This story, almost apocryphal in nature, shows that people play an important role in the management of UST systems. Human behavior, where it concerns the management of technology and equipment to achieve a desired outcome, requires the use of processes in order to assure success—in this case, the prevention of gasoline releases to the underground environment from the UST system. Those processes include daily visual inspection, alarm response and notification, maintenance and repair, and periodic testing. In addition, the management of an UST system requires the investigation of incidents to identify root causes and develop solutions to prevent future problems.

Human Error and Processes

When people use processes, there is always the potential for making mistakes. Regardless of the reasons behind their actions, the consequences can be severe. The actions of the UST owner in this story pushed technology, in this case, fiberglass-reinforced plastic, beyond its performance limits. The resultant equipment failure and malfunction of the UST system had catastrophic consequences.

Numerous studies have revealed that the dominant source of mistakes is human error.[2] There are three common reasons for that error. Mistakes occur when people do the following:

- fail to perform required actions (e.g., removal of the water from the sumps)
- perform prohibited actions (e.g., ignoring the submersible-sump sensor alarms)
- misinterpret information (e.g., performance characteristics of containment sumps) critical for the performance of actions[3]

Reducing and eliminating human error is an age-old problem.

Human error can occur during the design and engineering of the equipment used in UST systems or during the manufacture of that equipment. It can occur during the construction and installation of the UST equipment or during the operation and maintenance of that equipment. It can occur because of human actions during recordkeeping of leak-detection-testing results, inventory reconciliation, or corrosion-protection testing. It can ultimately occur while responding to emergencies associated with the UST equipment or with the remediation and cleanup of releases from UST systems. Clearly, human error is something we cannot afford to ignore, especially when it can lead to the types of defects that create catastrophic results.

Human Error and Complexity

Only in the last 20 years has it become apparent that there is a single common underlying factor linking

■ continued on page 10

2. C. Martin Hinckley, *Make No Mistake! An Outcome-Based Approach to Mistake-Proofing*, Productivity Press, Portland, OR, 2001, pp 10-12

3. Ibid., pg. 10.

■ **People and USTs** *from page 9*

the frequency of human error to defects (in the case of managing petroleum UST systems, the defect would be the release of gasoline to the environment). This discovery was the direct result of attempts by both the Japanese automobile and U.S. electronic industries to improve manufacturing processes in order to reduce defects in their products during the 1980s and 1990s.[4] That single factor was complexity. According to the research, three components comprise complexity:

- objects (i,e., material, equipment, hardware, tools)
- information (i,e., data, communication, training)
- human activity (i.e., the difficulty and number of steps to perform those activities)

When we consider the complexity of UST systems in light of the need to manage human error, it is important to keep in mind the key function of those systems—to store hazardous substances and petroleum products safely, in a way that will prevent the release of product to the environment. Furthermore, if releases do occur, UST systems should be capable of detecting those releases rapidly and effectively, thus enhancing any opportunity to minimize the volume of released product. Soundly engineered, constructed, installed, operated, and maintained UST systems should continue to perform these functions effectively throughout their life cycle.

It should be apparent from my story and the research findings that UST systems are not simply comprised of equipment and technologies. Owners and operators—humans—interact with UST systems at some or all points in their life cycles, developing processes and procedures to manage those systems. Therefore, the core elements of all UST systems are: technology, equipment, people, and processes.

4. C. Martin Hinckley, *Quality By Design – Eliminating Defects Through the Control of Variation, Mistakes, and Complexity, Assured Quality*, 50th Annual ASQC Quality Congress, Chicago, IL, 1996.

The System Can't Do It Alone

Given the complexity of UST systems and the potential for human error, it stands to reason that we must have clearly defined, properly engineered, well-documented, consistently executed, and periodically evaluated processes. If such processes are not present, we should not expect UST systems to deliver years of reliable service, regardless of the capabilities of the technologies or the quality of the equipment.

Given the complexity of UST systems and the potential for human error, it stands to reason that we must have clearly defined, properly engineered, well-documented, consistently executed, and periodically evaluated processes.

Ongoing discoveries of contamination of public drinking water wells and land surrounding UST facilities are causing people to question concepts previously considered inviolate regarding UST technology and equipment. It is not clear whether the sources of contamination are from the upgraded equipment, the result of releases that occurred before the UST systems were upgraded, the mismanagement of UST systems, other factors such as compatibility, or a combination of several of these factors. Unfortunately, it may be several years before we can positively identify the actual root causes or sources of these problems.

Recent court settlements addressing the contamination of entire community drinking water systems with petroleum-based compounds such as MTBE and other chemicals from UST systems illustrate that these problems are immediate. The potential economic and health consequences of these releases to communities can be significant. There are several hundred thousand UST systems in operation throughout North America. Consequently, the immediate need must be to address how to manage the operation and maintenance activities of those UST systems.

How well owners, operators, and the regulatory community understand the factors affecting human error will influence how they approach solving the problems of managing UST systems. This knowledge can guide owners and operators in their selection of technology and equipment for use in new UST systems. More importantly, it can provide a framework for developing the management processes needed to ensure maximum performance from existing UST systems, particularly during their operation and maintenance.

Likewise, this knowledge can guide the regulatory community in determining how best to regulate new and existing UST systems and in their development of any future legislation to address the operation and maintenance of UST systems. Ultimately, understanding the factors affecting human error will determine whether the decisions made by legislators and regulators contribute to the prevention of, or are among the root causes of, the contamination of our water resources.

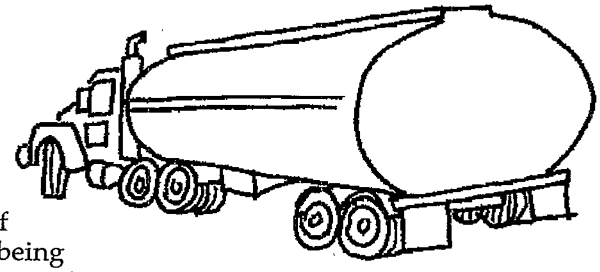
In future issues of *LUSTLine*, I'll take a closer look at this story and other stories like this and examine what went wrong, what should have been done to prevent the problem, and what could be done differently in the future. We will explore such questions as: What happens to people when confronted with something they do not understand? What role does training have with the management of UST systems? How does boredom or inattention affect a person's ability to effectively manage UST systems? Finally, we will review the tools available to UST owners and operators to help them select UST system equipment and design features that will deliver the necessary performance to prevent releases of product at competitive costs throughout the total life cycle of the system. ■

Richard S. Bradley, Jr., LTSA, ASACT, is an Environmental Coordinator and Advanced Safety Auditing (ASA) Trainer for BP Products North America Inc., Marketing Environmental Management Systems, East Coast Retail Business Unit. Richard can be reached at ***bradlers@bp.com****, or at (770) 576-3080.*

Field Notes

from Robert N. Renkes, Executive Vice President, Petroleum Equipment Institute

Overpressurization Problem Baffles Tank Owner
What Do You Think?



A gasoline distributor in the Northeast installed underground petroleum storage systems at one of his stations in September of 1992. The 10,000-gallon-tanks are double-walled fiberglass with a brine solution in the interstitial space that is continuously monitored by an automatic tank gauge (ATG). The station has a two-point Stage I vapor-recovery system and a balance Stage II system. The product piping is a double-walled flexible system.

The unleaded (UL) tank was filled on January 10, 2003, without apparent incident. On January 12, a driver had difficulty dropping his entire load, although the ATG indicated that there was plenty of room in the tank. The driver later remarked that he heard a high-pitched air noise coming from the 18-inch diameter manhole cover over the ATG probe for the tank. During this delivery, a customer also complained that vapors were coming from the nozzle while he was fueling his car. It was decided to carefully observe the next delivery.

Delivery Difficulties

On January 15, a driver arrived at the station at 1:00 a.m. to make a scheduled gasoline delivery. Before dropping his load, he took an ATG reading for the tanks, confirming the load would fit. He dropped 2,800 gallons of UL into the 10,000-gallon tank. He also noticed that vapors were emanating from the same 18-inch manhole cover that had made noises on January 12. Then approximately 40 gallons of gasoline came out from beneath the 18-inch manhole cover. An investigation revealed that the ATG riser cap, which was located under the 18-inch manhole cover, had blown off. The cap was very corroded, and it appeared that there had been sufficient pressure in the tank to force the cap open.

Also, the ATG probe itself was blown up out of the tank. It was being held up out of the tank 26 inches higher than normal by the plastic alignment tabs on the probe that were resting on top of the 4-inch riser pipe. Because the probe was now positioned more than two feet higher than its normal position, it was dramatically underestimating the volume of gasoline in the tank. Because the driver relied upon the ATG reading and did not manually stick the tank before the delivery, the tank had been filled beyond its capacity. The next day the ATG riser caps were replaced on all the tanks and the tank owner thought the problem was solved.

Two Days Later

Another driver, using a different tank trailer, arrived two days later at 1:00 a.m. in 4° weather to drop another load into the UL tank. The driver stuck the tank before making the delivery and confirmed that there was plenty of room in the tank. Halfway through dropping the 2,800-gallon compartment of his tank trailer, the flow seemed to stop, and a small amount of gasoline leaked from the delivery elbow attached to the tank fill pipe.

The driver shut the valve on the trailer and disconnected the delivery elbow. When he did, gasoline shot out from the fill pipe approximately 7 feet in the air, completely covering the driver. He tried unsuccessfully to reattach the delivery elbow to the fill pipe. By the time the flow from the fill pipe stopped, 500 gallons had spilled some 300 feet down the street and into two telephone-company manholes. The fire department responded by spraying the spill with foam and water, which immediately froze as it hit the pavement. The local Fire Marshal closed the station as well as the main road for 12 hours until the spill was cleaned up.

The System Test

The Fire Marshal insisted that a tank-testing company check the tank system before putting it back into service. The initial theory was that the ball of the float-vent valve must have stuck with the ball in the "up," or closed position. To inspect the float vent valve, the testing company had to remove the Stage I vapor fitting.

Unfortunately, they had to beat on the vapor fitting in order to get it off. When they looked down the riser pipe, they could see that the ball of the float-vent valve was in the bottom of its wire basket. There was some suspicion, however, that the blows to the vapor adapter might have dislodged the ball. When removed for examination, the ball of the float-vent valve showed some rust staining, apparently from the steel pipe into which the ball seated when the tank overfill level was reached. The testing company noted that the wire basket for the float-vent valve was not damaged and reinstalled the assembly.

The testing company next checked the Stage I vapor adapter and determined that it was working perfectly. The company did a pressure-decay test on the tank ullage and found a couple of drain valves

■ *continued on page 12*

Field Notes *continued*

■ **Overpressurization Problem Baffles Tank Owner** *from page 11*

leaking on the spill containment fill boxes and one leaking dispenser hose breakaway. Eventually, they were able to get a passing pressure-decay test on the storage system vapor space as well as a liquid-blockage test on the vapor return lines from the dispensers to the tanks.

The testing company assumed that a stuck ball float caused the overpressurization of the tank. The next 7,000-gallon delivery was made with no trouble at all.

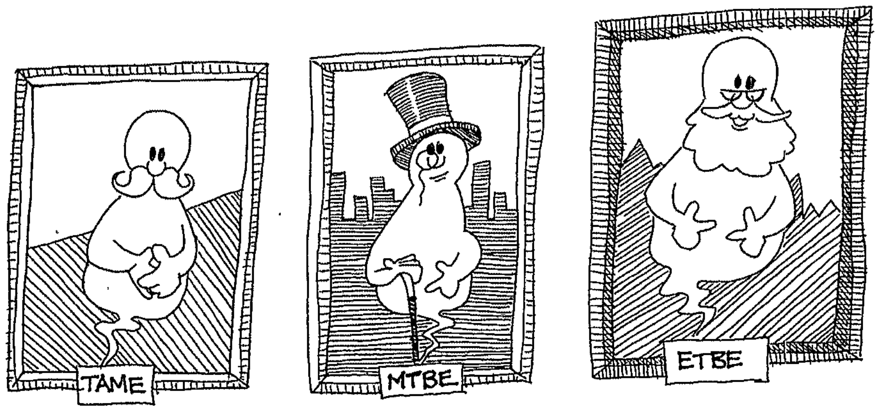
What Do You Think?

The owner's delivery policy is to fill his USTs as close to 90 percent of capacity as possible. The ball-float assembly was measured and found to be the correct length. The tank owner is concerned because if the ball seats at 90 percent and doesn't release before the next fill, the same problem could occur again. The owner wrote me at the Petroleum Equipment Institute and asked if he's the only one to have such an experience and whether there could be other things besides a stuck ball float that could cause the overpressurization. He also wondered if there aren't any other theories or reasons, then what caused the float ball to hang up? A week of really cold weather? Corrosion? Or both?

LUSTLine readers can compare their answers to those of the PEI members who responded to the question by going to the "mystery tank" link at **www.pei.org/frd.** Your comments can be sent to **rrenkes@pei.org.** ■

An Overview of MTBE and Other Oxygenates in Fuel

by Patricia Ellis



Conventional wisdom holds that methyl tertiary-*butyl ether (MTBE) first came into widespread use in the United States in 1979; first as a replacement for alkyl lead compounds, and later (in the 1990s) as a "required" ingredient in oxygenated fuels (oxyfuel) and reformulated gasoline (RFG). But MTBE has a much longer association with automotive fuels, as do many of the other oxygenate fuel additives, whether it's because they were used to increase the oxygen content of the fuel, to enhance the octane content, or because they were part of a proprietary package of additives. Although there are still significant gaps in our knowledge base, let's begin our overview of these oxygenates by piecing together some of the highlights in the history of oxygenates.[1] We'll start with the ethers, with special emphasis on MTBE.*

The Ethers

An English chemist first synthesized MTBE in 1842 (Faulk et al., 2000); however, a U.S. patent wasn't granted until a century later. Literature published by the American Petroleum Institute (API) in the 1950s discusses the applicability of using MTBE in gasoline (Drogos, 2000). In the late 1960s, Chevron field-tested the use of MTBE and *tertiary*-amyl methyl ether (TAME) in taxicab fleets. MTBE was used commercially in Italian gasoline blends in the early 1970s (Hart/IRI Fuels, 2000).

Then in the late 1970s, U.S. EPA issued a waiver under the "substantially similar" rule (see sidebar on page 15) for 7 percent MTBE by volume in motor fuel. MTBE was soon blended into East Coast gasoline for octane enhancement, corresponding with the phaseout of alkyl-lead additives (McKinnon et al., 1984; Garrett et al., 1986; Davidson, 2000).

To achieve the same octane levels as leaded gasoline, MTBE was used at concentrations of from 4 percent to 7 percent by volume. As tetraethyl lead in gasoline was phased out in the early 1980s, the use of MTBE rapidly increased. From 1980 to 1986, the commercial production of MTBE increased at a rate of about 40 percent per year (Suflita and Mormile, 1993). Through the late 1980s, EPA granted waivers for several oxygenated-gasoline blends, some of which used MTBE at increasingly higher levels.

In 1987, the "wintertime oxyfuel program" was first implemented in Denver, Colorado, initially with MTBE, then later with ethanol, due to consumer complaints about MTBE (Harvey, 1998; Drogos, 2000). Report-

1. Much of the information in the history discussion is adapted from Morrison and Associates unless otherwise indicated. (http://www.rmorrison.com/mtbe.htm)

edly in the same year, U.S. EPA issued a waiver for a maximum of 15 percent MTBE by volume in gasoline. At about this time, it is also reported that MTBE was among the top 50 chemicals manufactured in the U.S. (Uhler et al., 2000). By 1989, wintertime-oxyfuel programs were implemented in Phoenix, Las Vegas, Reno, and Albuquerque, initially with MTBE; they later switched to ethanol.

In 1990, the Clean Air Act Amendments (CAAA) were enacted, and the maximum oxygen content of gasoline was raised to 2.7 percent by weight (15 percent by volume for MTBE). Production of MTBE continued to increase, and since 1993, it has become the second most produced organic chemical in the United States (USEPA, 1998)—350 billion liters (92 billion gallons) of MTBE were produced in 1997 (Zogorski et al., 1998). By 1998, more than 10.5 million gallons per day of MTBE were used in the U.S.; 4.2 million gallons per day were being used in California alone (Johnson, et al., 2000). U.S. production of MTBE can meet about two thirds of the country's demand for oxygenates. The remaining demand is met primarily with MTBE from the Middle East and Canada (California, CARB, 1998).

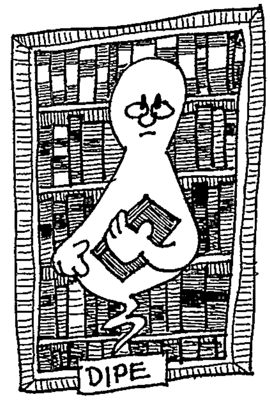
TAME was first produced in 1907, but its first use as an automotive fuel additive wasn't documented until the late 1960s, and then apparently only on a somewhat limited basis. It wasn't until after the Clean Air Act Amendments (CAAA) of 1990 that TAME and ethyl *tertiary*-butyl ether (ETBE) came into general use as oxygenates (Peterson, 2000).

Alcohols

Alcohols have been manufactured for many centuries, and ethanol has been used as an automotive fuel since the 1930s. In 1975, Nebraska began its gasohol (ethanol blend) program. U.S. EPA issued a waiver for 10 percent (by volume) ethanol blends in 1976 (Gibbs, 1998), and in 1978 gasohol (10 percent ethanol by volume to 90 percent gasoline) blends were first used in Nebraska.

ARCO reportedly blended *tertiary*-butyl alcohol (TBA) into gasoline for the first time in 1969 (Harvey, 1998; Peterson, 2000; Drogos, 2000). In 1979 U.S. EPA issued a waiver for methanol and TBA at 2.5 percent by volume. From 1979 through 1988, U.S. EPA granted waivers for methanol/TBA blends at substantially higher levels.

In the 1980s, M85 (methanol at 85 percent to 15 percent gasoline by volume) was introduced and ethanol was tested as an octane booster (Harvey, 1998). Refiners in California began to produce ethanol blends in response to widespread MTBE contamination of groundwater resources because they are considered alternative fuels.



Industry and the CAAA

The CAAA has two basic requirements for automotive fuels, neither of which requires the use of MTBE or any other specific oxygenate. The first requirement is that RFG containing a minimum of 2 percent oxygen by weight be used year-round in severe or extreme ozone nonattainment areas to help reduce vehicle emissions. The second requirement is that gasolines used during the wintertime in carbon monoxide nonattainment areas contain 2.7 percent oxygen by weight.

The choice of which oxygenate to use was, and still is, entirely an industry decision. Primarily for economic and logistical reasons, a majority of the gasolines produced in the U.S. contain MTBE rather than any other oxygenate (e.g., ethanol). The Clean Air Act legislation of 1990 included a number of provisions that would have led to the introduction of alternative (nonpetroleum) fuels, such as methanol. However, the petroleum and oxygenate industries responded to these provisions by offering the RFG program as a substitute.

In fact, industry documents confirm that it was the refining industry that initiated and promoted the use of MTBE in reformulated gasoline (see STPUD references). Their representatives were largely successful in expanding the use of MTBE over ethanol, thereby boosting the profitability of the industry.

The two feedstocks of the primary process from which MTBE is manufactured are methanol and isobutylene. Although the methanol must be purchased, isobutylene is a refinery waste product and its disposal is expensive. The introduction of MTBE into fuel in large quantities turned a liability into a significant asset. MTBE, and ethers in general, have blending properties that are more favorable than alcohols. Ethers can be blended with the bulk fuel at the refinery and then transported through pipelines. Alcohols, on the other hand, cannot be blended with fuel at the refinery and alcohol-blended fuel cannot be transported through pipelines. Alcohols must be blended at the transportation or distribution terminal.

Geographic Distribution of MTBE

Compliance with the CAAA in nonattainment areas requires the use of oxygenated fuel, either RFG or oxyfuel. Beginning in 1992, 36 areas of the country were required to use oxyfuel in the winter. Other areas of the country were allowed to voluntarily opt-in to the RFG program to improve air quality. By the 1998–99 season, however, only 17 areas were still implementing the program, as 19 areas were redesignated as carbon monoxide attainment. This was due, in part, to the implementation of an oxyfuel program along with other control measures. But this is only a small part of the story.

There are estimated to be more than 700,000 regulated gasoline USTs at approximately 400,000 facilities. "Major" oil companies own about 20 percent of the nation's approximately 182,000 retail outlets (Blue Ribbon Panel Report, 1999). In California alone, more than 10,000 sites cur-

■ *continued on page 14*

■ An Overview of Oxygenates
from page 13

rently regulated as leaking tank sites are suspected to have released MTBE to groundwater (Happel, Beckenbach and Halden, 1998). In addition, there are approximately 3 million underground fuel storage tanks nationwide that are exempt from federal regulations (e.g., certain farm and residential gasoline storage tanks and home heating oil tanks), although some states do regulate heating oil tanks.

MTBE and a variety of other ether and alcohol oxygenates have been used for many years as octane enhancers, and therefore, fuel blends containing these oxygenates could potentially have been stored in any UST system anywhere in the U.S. In fact, due to the fungible nature of the fuel supply in the U.S., MTBE has been found in gasoline (and the environment!) in every state at one time or another whether or not an area is or has been subject to RFG or oxyfuel requirements (CRS report for Congress, February 25, 2000).

Industry documents (see STPUD references) reveal that industry was aware in the early 1980s that "exchange agreements" would result in MTBE-laden fuel being delivered to areas where it was not needed. Further complicating the distribution picture is that MTBE has been documented to be present in other fuels (heating oil, diesel fuel, aviation gasoline) for which it was never intended. Again, industry documents (see STPUD references) reveal that industry was also aware of this problem in the early 1980s. More recent studies (Robbins, 1999; Robbins and Henebry, 1999; and Robbins and Zack, 2000) of oxygenates in other fuels have confirmed that this is a widespread phenomenon in the New England states.

Sources of MTBE in the Environment

Given MTBE's widespread use as a gasoline additive and the large volumes of gasoline that are stored, transported, and used in all areas of the country, releases of MTBE to the nation's ground and surface waters occur in a number of ways. But, the largest source of gasoline releases to the environment is leaking underground storage tank (LUST) systems.

Gasoline storage and distribution facilities can release relatively large volumes of gasoline (hundreds to thousands of gallons) that can affect ground and surface water.

MTBE releases can also occur from automobile-related accidents, homeowner spills or misuse, marine engine emissions into lakes and reservoirs, and atmospheric washout. Releases from LUST systems continue to occur, even at upgraded facilities, and releases of MTBE vapors, without a release of liquid, are especially problematic (SCVWD, 2000). Stormwater runoff can also be a source of MTBE contamination. Runoff can be contaminated with MTBE from dissolution of residual from parking lots (such as at service stations and retail businesses) and roadways. MTBE can also enter the environment through atmospheric deposition.

Unprecedented History of Contamination

Perhaps the most remarkable aspect of the history of MTBE contamination is the sheer speed at which MTBE contamination has spread nationwide. Documented cases of groundwater contamination from LUST sites date back to 1980 on the East Coast (see STPUD references). MTBE and other gasoline constituents were detected in private wells in a subdivision in the town of Jacksonville, Maryland, in 1980. Also around this time, several oil companies had documented that MTBE could migrate farther and faster than other fuel constituents.

Furthermore, industry was aware of the low taste and odor threshold of MTBE in water and that carbon adsorption was not effective for removing MTBE from water. For example, an MTBE plume in Rockaway, New Jersey, that contaminated the municipal well was known in 1983 to extend for 1,500 feet, while the hydrocarbon portion of the plume was much shorter. Consumers served by the well had complained of taste and odor problems, which were attributable to MTBE contamination.

Through the 1980s and 1990s the number of MTBE-contamination cases rapidly increased—and they were not limited to RFG or oxyfuel states. For example, Kansas, which may be described as the "buckle of the cornbelt" (where ethanol would presumably be the oxygenate of choice) and where the use of neither RFG nor oxyfuel is or has been required, reported that nearly 90 percent of its LUST cases had documented MTBE contamination (NEIWPCC, 2000).

Today, thousands of private wells from coast to coast have been impacted, as well as numerous public water supply wells. Public wells have been shut down in many states, including California, Rhode Island, Maine, Indiana, and New York. Recent studies of ambient groundwater in California indicate that MTBE is a ubiquitous contaminant (though generally at low concentrations) in

Table 1 Occurrence (%) of oxygenates in conventional versus RFG and regular versus premium gasolines in New Hampshire samples.

	Conventional Gasoline		Reformulated Gasoline	
	Regular	Premium	Regular	Premium
MTBE	100%	100%	100%	100%
TAME	100%	100%	76%	100%
ETBE	45%	85%	18%	52%
DIPE	10%	3%	18%	0%
TBA	0%	0%	0%	14%

Data from Fred McGarry, NH DES.

Table 2 **South Carolina Findings for Releases Sampled for Oxygenates**

Oxygenate	Percent Detected 5/1/01	Percent Detected 5/1/02	Percent Detected 11/1/02	Highest Concentration (µg/L)
Ethyl tert-Butyl Ether (ETBE)	6%	5%	4%	60
Ethyl tert-Butyl Alcohol (ETBA)	14%	27%	31%	7,940
Tert-amyl Methyl Ether (TAME)	28%	35%	38%	1,700
Diisopropyl Ether (DIPE)	36%	38%	43%	8,700
Tert-Butyl Formate (TBF)	0%	3%	7%	20,800
Tert-Butyl Alcohol (TBA)	22%	24%	28%	39,400
Tert-amyl Alcohol (TAA)	33%	26%	47%	76,000
Ethanol	14%	12%	11%	9,800,000

Analytical Method 8260B used to sample for oxygenates and ethanol.

virtually all groundwater that is less than 20 years old (Small, 2002).

The Other Oxygenates

Little data are available on the use of the other oxygenates in gasoline or groundwater, but where states are analyzing for them, they are finding them. In Delaware, we already have domestic wells with TAME and TBA contamination, and ETBE has been detected in at least one public well. I offer some data from two states—New Hampshire and South Carolina—where studies have been done to determine the extent of the use of other oxygenates and related contamination.

In 2000, New Hampshire conducted a study in which samples of regular and premium grades of both RFG and conventional gasoline were collected and analyzed for five of the oxygenates. (See Table 1.) MTBE was found in all samples, while TAME was found in all premium gasoline samples, all regular grade conventional samples, and 76 percent of the regular-grade RFG samples. ETBE was found in all types of samples—the percentage of the samples containing ETBE varied by grade and conventional versus RFG. DIPE was found to a lesser extent, but was identified in at least some of the samples of all types of gasolines except premium-grade RFG. TBA was found in only the premium RFG samples (14 percent of the samples).

Four counties in New Hampshire are RFG counties and six counties use conventional gasoline. Keep in mind that oxygenates can be used to meet octane requirements, not just oxygen requirements for gasoline.

South Carolina, as part of all LUST assessment activities, has been sampling groundwater for MTBE since June 1995. MTBE has been detected at 72 percent of all confirmed releases. Since June 2000, the state has been split sampling all active corrective actions where MTBE is known to be present to see if other oxygenates were present. Sixty-eight samples were collected at 40 different LUST sites since June 2000. In addition to the percentage MTBE detected, Table 2 shows the percentages of other oxygenates that were found.

One thing to keep in mind in considering these figures is that South Carolina is not an RFG state! Yet the data in Table 2 support the fact that not only MTBE but other oxygenates are being found. The figures provided by South Carolina also show that these oxygenates aren't just present in trace amounts.

Art Shrader, Director of the Assessment and Corrective Action Division of the South Carolina UST program, says that the oxygenates aren't just an environmental liability, they are also expensive to remediate. "The bottom line to MTBE from a LUST cleanup perspective, is because of MTBE's higher solubility, its plumes tend to be 20 percent larger than petroleum plumes without MTBE," Shrader says. "Therefore, we've found that the assessment and cleanup costs tend to cost 20 percent more than those of sites without

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Substantially Similar?

All additives for motor-vehicle gasoline are required to be registered by U.S. EPA, pursuant to 40 CFR 79 ("Registration of Fuels and Fuel Additives") before their introduction into commerce. To obtain registration, the additive manufacturer must: (1) provide a chemical description of the additive, (2) provide certain information on the combustion and evaporative emissions of gasoline containing the additive at its maximum treat rate, (3) provide certain technical and marketing information, and (4) comply with the "substantially similar" interpretive rule for gasoline and gasoline additives (56 FR 5352, February 11, 1991) or have received a waiver under section 211(f)(4) of the Clean Air Act.

The basic registration regulations have been in effect since 1970, under authority of the 1967 Air Quality Act/1970 Clean Air Act. They were designed to provide U.S. EPA with information on the health and welfare effects of motor-vehicle emissions. In 1977 the Clean Air Act was amended to require that motor-vehicle fuels and additives be "substantially similar" to the fuels and additives used by the auto makers in emissions certification. This requirement was to prevent the use of additives that might damage emission controls, particularly the catalytic converter. The manufacturer of an additive that was not "substantially similar" could obtain a waiver if it was demonstrated that the additive would not cause vehicles to fail emission standards.

What this means is that when a waiver application is made (e.g., for an ether), U.S. EPA has no choice but to grant the waiver (since, as in our example, ethers have a long history of usage in gasoline). And, because these waivers are issued under regulations that govern the air program, other U.S. EPA programs (e.g., water and USTs) have no legal basis on which to challenge the waivers. ■

An Overview of Oxygenates
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MTBE."

It seems clear to me that sampling and analysis for all of the fuel oxygenates needs to become routine, at least as part of an initial site assessment or as a one-time event for existing LUST sites. A remediation system that is designed to address MTBE may be ineffective for TBA. Remediation technologies designed for one specific oxygenate may be inappropriate or ineffective for other oxygenates. Just as we need to fully investigate the extent of contamination at LUST sites, both laterally and vertically, we need to fully investigate the range of chemicals present, including the complete suite of oxygenates, or we are not being protective of human health, safety, or the environment. ■

Pat Ellis is a hydrologist with the Delaware Department of Natural Resources and Environmental Control, Tank Management Branch, and served as a member of EPA's Blue Ribbon Panel on MTBE. She is a technical advisor and regular contributor to LUSTLine and can be reached at **Patricia.Ellis@state.de.us.**

RFG vs. Oxyfuel

Reformulated gasoline (RFG) was initially developed and promoted by the petroleum industry to forestall the development and use of alternative (nonpetroleum) fuels. In touting the benefits of RFG, the industry claimed that it would serve as a replacement for leaded fuels and help reduce vehicle emissions in severe or extreme ozone nonattainment areas. The final Clean Air Act Amendments of 1990 signed by President George H.W. Bush not only set emission performance requirements for RFG, but also included a mandate for RFG to contain oxygenates (**http://www.epa.gov/otaq/rfgorig.htm**).

By changing the fuel formulation, RFG reduces the formation of ozone precursors with its effectiveness measured relative to a 1990 fuel baseline of NO_x toxics and volatile organic compound (VOC) emissions. RFG also limits the maximum benzene level and requires a minimum 2 percent oxygen by weight (11 percent by volume MTBE, or 5.7 percent by volume ethanol).

In addition to the RFG program, the CAAA of 1990 required the establishment of a wintertime oxyfuel program. Under this program, oxyfuel containing a minimum of 2.7 percent oxygen by weight must be used during the winter in areas that are not in attainment for the National Ambient Air Quality Standards for carbon monoxide The required oxygen content can be achieved by using approximately 15 percent MTBE by volume, or 7.7 percent ethanol by volume. ■

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Plaintiff's exhibit #32; Testimony of Curtis Stanley, Equilon *(032_001.pdf)*

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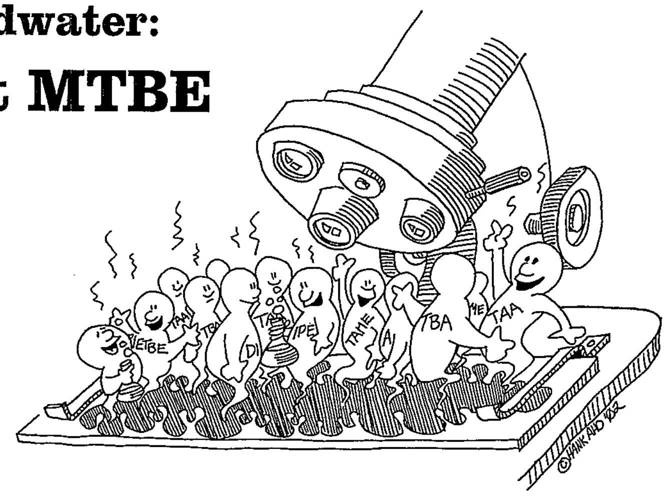
Oxygenate Measurements in Groundwater:

Do We Need to Worry About MTBE Acid Hydrolysis?



by Bruce Bauman

Is there one clearly superior protocol for analyzing oxygenates in water samples? Of course not. Like many aspects of UST release prevention, detection, or corrective action, there is no single "best" way to get the analytical job done. Rather, decision makers must have a good understanding of the general principles and site-specific variables that can influence the performance of the various approaches commonly used to generate data characterizing groundwater quality.

In this article, I'd like to throw in my two cents on the subject of oxygenate analysis—especially with regard to questions surrounding methyl *tertiary*-butyl ether (MTBE) transformations to *tertiary*-butyl alcohol (TBA) via acid hydrolysis. Several articles and conference presentations in the past year, including one in *LUSTLine* #42 (LL#42), "Analytical Methods for Fuel Oxygenates," discuss approaches to sample handling and analysis and how such approaches may influence the accuracy of results for MTBE, TBA (for more about TBA, see *LUSTLine* #36), and other oxygenates in groundwater. You also may have seen a draft copy of the U.S. EPA Office of Underground Storage Tank's widely distributed "Environmental Fact Sheet: Analytical Methods for Fuel Oxygenates."

These discussions have focused on the most popular protocols for oxygenate analysis, EPA SW-846 methods 5030B (purge and trap) and 8260B (gas chromatograph/mass spectrometer [GC-MS]). To somewhat oversimplify those discussions, questions have been raised regarding the ability of these protocols to provide accurate measurements of MTBE, TBA, and other oxygenates in groundwater.

In particular, critics of the protocols question the following: (a) the effectiveness of purge and trap (P&T) techniques for extracting all oxygenates (especially alcohols such as TBA) from water samples, and (b) the potential for transforming MTBE to TBA by acid hydrolysis. As these issues can have profound implications on data quality and interpretations for corrective action decisions at any site, they deserve the considerable discussion surrounding them.

> ***"A tremendous amount of oxygenate data from leaking UST sites have been generated over the past several years, yet there is understandable concern as to whether these data are valid. In general, these concerns are related to two issues: analytical obstacles, and ether hydrolysis (particularly of MTBE to TBA)."***
>
> **LUSTLine *#42***
> ***"Analytical Methods for Fuel Oxygenates"***

Points of Debate

This discussion will focus on the LL#42 article, as many *LUSTLine* readers are familiar with it. That article did a very good job of addressing a broad variety of complex issues associated with chemical analysis of oxygenates, not just purging efficiency and MTBE hydrolysis. The authors provided a good deal of key information about sampling and analyzing gasoline oxygenates in groundwater. They highlighted some obvious problems with certain analytical methods and addressed the important steps associated with sample preservation before analysis.

The authors also provided a "recommended protocol" that "will greatly improve the quality of the data" by avoiding the some of the perceived problems with existing methods. While the overall guidance provided in the LL#42 protocol is excellent, I would like to address two of the recommendations that deserve a little more discussion, and, perhaps, debate:

- To ensure good-quality TBA data, P&T extraction procedures used for oxygenates should preferably be heated to 80°C
- To prevent hydrolysis of oxygenates, field preservation of groundwater samples should use a base (trisodium phosphate dodecahydrate [TSP]) instead of hydrochloric acid.

Let me begin by summarizing a few key "take-home messages" that readers would have extracted from the *LL*#42 article and that will serve as the basis for my discussion.

- It is important to analyze for all oxygenates known to be present in gasoline using methods that provide accurate results.
- Standard P&T at ambient temperature does not adequately extract TBA from water samples, so samples should be heated to 80°C.
- Existing conventional approaches to groundwater sample preservation, extraction, and analysis may be prone to the acid hydrolysis of MTBE, which could lead to underestimates of concentrations of MTBE and overestimates of the TBA concentrations.

Do You Need to Analyze for All Oxygenates?

Yes, indeed. Only a few states currently include TBA as a routine target

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analyte for UST sites—this despite numerous recommendations by a wide variety of authorities over the last five years. (See page 21 for a list of reviews and guidance.) Analyzing for all alkyl ethers (e.g., MTBE, TAME, DIPE, ETBE) and alcohols has been widely recommended ever since the first comprehensive evaluation of oxygenate impacts to water quality was published in the National Science and Technology Council's 1997 report *Interagency Assessment of Oxygenated Fuels*. On an annual basis this recommendation has been reiterated by a series of other EPA reports or pronouncements.

So, obviously, every site should be assessed for the potential presence of all oxygenates at some point, preferably early on, as LL#42 suggests. Does this mean you have to analyze every site, for every oxygenate, every time using GC-MS? Of course not, and LL#42 makes that same point, indicating that there will be situations where simple approaches like Method 8015 will work just fine.

Certainly it makes sense to evaluate every site for all oxygenates at some time to make sure you know what's there. Your data needs may be different for any given sampling event during the life cycle of any site, and a careful decision on the appropriate analytical method to use should made for each round of data collection.

Do You Need to Heat Samples to 80°C to Effectively Extract TBA and Ethers from Water Samples During P&T?

LL#42 states that "if purge and trap is used…it must be modified to increase method sensitivity. One straightforward approach is to heat the sample to 80°C." While it is true that P&T techniques are most effective for nonpolar chemicals like BTEX, there is also good documentation that more polar compounds, such as MTBE and other ethers, can be purged successfully at either ambient room temperature (~25°C) or slightly heated (e.g., <45°C).

EPA's oxygenates method evaluation study (U.S. EPA, 2002) showed good recoveries (>85%) of MTBE and other ethers at ambient temperatures. That same study did show poorer TBA recoveries at ambient temperature and also showed slightly better recoveries of ethers using the 80°C heated purge. It did not evaluate purge recoveries at temperatures between ambient and 80°C.

However, P&T can be an effective TBA extraction method even at ambient temperatures as shown by a Lawrence Livermore National Laboratory study (Halden et al., 2001). These same authors provided similar information several years earlier in a report for California EPA (Happel et al., 1998). Their results showed that gasoline ether oxygenates (i.e., MTBE, TAME, ETBE, and DIPE) and TBA could be effectively measured using P&T/GC-MS at ambient temperatures. They observed that a method detection limit of 35 μg/L could be obtained for TBA but noted that at 40°C, and using a larger sample volume (10 ml versus 5 ml), they were able to reach a detection limit of 4.6 μg/L. So if a heated purge is desirable, a temperature of 45°C should probably be high enough. It should provide acceptable recoveries, and minimize some of the potential problems noted later in this article.

In a very recent paper discussed in more detail later in this article, Evans and Colsman (2003) demonstrate another example of effective MTBE and TBA analysis using ambient temperature P&T. In that study, three California labs using Methods 5030/8260 were able to get good MTBE and TBA recoveries, as well as accurate results at low detection levels (~12 μg/L). While their results don't mean that every lab performs as well, they do document that those methods are capable of delivering satisfactory performance.

Purging effectiveness is clearly more important for TBA than for the ethers, but keep in mind that if proper calibration procedures are performed, good results can be obtained, even with lower recoveries. The relative recovery of TBA from a lab's calibration sample should be similar to that from field samples, and so a correction factor can be applied to determine the "correct" concentration. Higher recoveries (i.e., 75 percent and more) are certainly desirable, but may not always be necessary to document good method performance if recoveries are consistent among all samples.

Finally, there is some anecdotal evidence from lab technicians that when using an 80°C P&T extraction, complicating issues with water management may result in worse recovery of TBA than would be the case at 45°C or lower. The potential problem here is that at this high temperature, some water may also be evaporated, ending up in the instrument's water trap. Some TBA may be in that water and not find its way into the GC, leading to poor recovery. So perhaps 45°C is a good compromise temperature when TBA is a target analyte.

What's Purge and Trap?

Think of the purge and trap technique as a very small-scale air-sparging application in a closed system in which you are capturing the volatilized gases in a carbon canister. In practice, a small volume of water (usually 5 ml, but sometimes larger volumes are used to improve method performance) is purged with a gas (usually helium) to remove the soluble VOCs from that sample. The sample may be heated (e.g., in the 20° to 45°C range) to enhance the removal process, and the purging time may vary, although 11 minutes is very common. The volatilized chemicals are "trapped" on a sorbent column that is then heated slowly to facilitate the sequential separation of chemicals with varying boiling points in the gas chromatograph (GC). The constituents are then identified in the mass spectrometer (MS).

Is Hydrolysis of MTBE to TBA a Concern under Normal Conditions?

The rate of hydrolysis of MTBE to TBA is affected primarily by pH, temperature, concentration, and time. The impact of pH and temperature on the rate of MTBE hydrolysis

"Under normal environmental conditions ethers do not undergo hydrolysis at significant rates without enzyme catalysis; even in acidified (pH < 2) groundwater samples, ethers are generally stable (Church, et al., 1999)."

"Therefore, if water samples are preserved with acid, there is an understandable concern as to whether or not any of these data are valid. . . . If [acidified] groundwater samples are refrigerated before analysis and all the sample preparative methods are carried out at ambient temperature (as opposed to an elevated temperature of 80°C), there is minimal opportunity for hydrolysis of the ether oxygenates."

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"Analytical Metods for Fuel Oxygenates"

has been well documented (O'Reilly et al., 2001). At very low pH (e.g., below 1.5) and at high temperatures (e.g., 80°C) hydrolysis rates will be relatively fast, but those conditions are unusual except perhaps during the heated P&T or heated headspace extractions.

As shown in LL#42, at 4°C, MTBE hydrolysis is negligible under almost any condition. Even at ambient temperature there is insignificant hydrolysis over the standard holding times of VOC samples (14 days) if the sample pH is 2. (Of course, samples should never be stored this way!)

For example, in a recent paper by Douthit et al. (2002), the calculated pseudo-first-order-rate constant for MTBE hydrolysis for a solution containing 900,000 ppb of MTBE at 26°C and pH 2 is 0.0022 per day—that is, 0.2 percent of the MTBE will be transformed into TBA each day. At 100,000 μg/L MTBE and the same temperature and pH, the calculated rate constant is 50 percent slower (0.0011/day). That same study showed no measurable hydrolysis of MTBE to TBA above detection limits as low as 5 μg/L in samples stored at 4°C for 7 to 31 days and analyzed by P&T/GC-MS. Unpreserved control samples were also analyzed. No TBA was detected at 5 to 20 ppb.

The authors state that their results show that "acid hydrolysis of MTBE, in properly handled groundwater samples, does not compromise the integrity of dissolved MTBE and TBA analyses." This is very good evidence that hydrolysis should not be a problem when samples are handled and analyzed according to commonly used standard protocols.

Using the method outlined in O'Reilly et al., it is useful to calculate some possible effects of hydrolysis under a variety of typical analytical conditions. Using an upper range of heated purge conditions (45°C), a sample containing 1,000 μg/L of MTBE theoretically will yield 0.7 μg/L of TBA at pH 1. Under the same conditions, a sample containing 10,000 μg/L MTBE will yield 7 μg/L of TBA, and a sample containing 100 μg/L of MTBE will yield 0.1 μg/L of TBA. So even when pH is extreme, if moderate heating is used, hydrolysis should be insignificant.

To illustrate this point more rigorously, Figure 1 shows the calculated amount of TBA that can theoretically result from the hydrolysis of a sample containing 500 μg/L MTBE *at pH 1.5 at temperatures* ranging from 20 to 80°C. Inspecting Figure 1 at the typical purge time of 11 minutes, reportable TBA (> 5 μg/L) can occur at temperatures above 65°C. In practice, samples with concentrations above 500 to 1,000 μg/L are diluted prior to analysis. This practice both dilutes the acid, raising the pH, and reduces the MTBE concentration to a point where any resulting TBA concentration is below reporting limits.

To see that temperature effects are of greatest concern above 40°C, look at Figure 2. As temperature increases, the rate constant for hydrolysis increases by nearly an order of magnitude between 45°C and 80°C. Keeping purge temperatures below this range should greatly reduce potential rates of hydrolysis.

Figure 1 Theoretical TBA Production from a 500 μg/L Solution of MTBE at pH 1.5

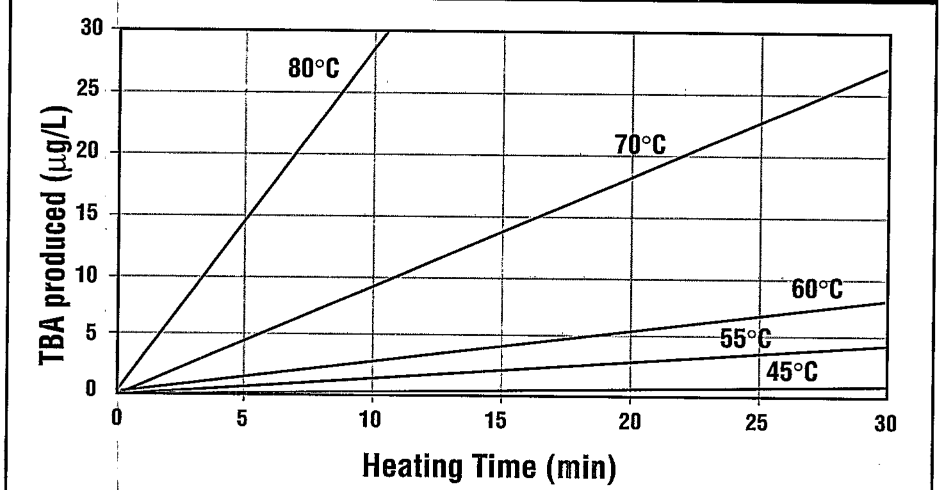
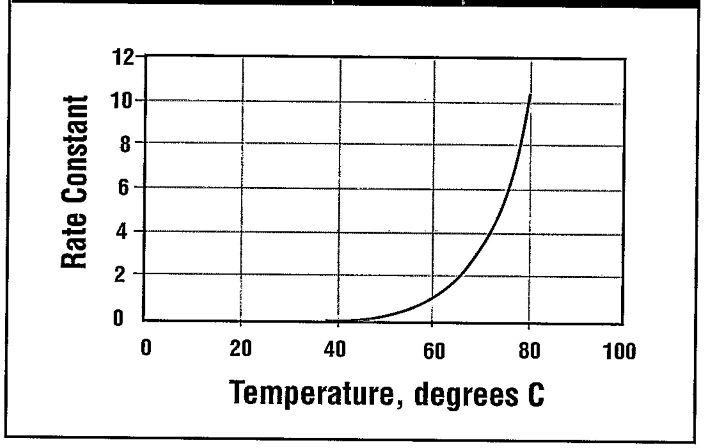


Figure 2 Changes in Hydrolysis Rate Constant with Temperature



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■ **MTBE Acid Hydrolysis**
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A Multi-Lab Performance Study Validation of Methods 5030/8260

As mentioned earlier, the recent article by Evans and Colsman (2003) provides an excellent summary of a study that addresses many of the issues raised about the data quality provided by P&T/GC-MS analysis. The authors note that the U.S. EPA Office of Solid Waste is a strong advocate of performance-based analytical methodology, which is a requirement for several RCRA programs. Briefly defined, "the performance-based approach requires that methods be selected and approved based upon their ability to meet the data quality goals of a given project in the actual matrix to be sampled." (Readers looking for more information this topic are referred to EPA's site at: **http://www.epa.gov/epaoswer/hazwaste/test/pbms.htm.**

The authors compared the performance of three different California commercial labs for MTBE and TBA that use routine P&T/GC-MS analysis. They wanted to make sure that the data they were collecting for their site (the world-famous Port Hueneme) would be adequate to quantify MTBE at 5 μg/L and TBA at 12 μg/L (2-propanol and acetone were two other target analytes).

The authors do not indicate that they had concerns regarding possible hydrolysis of MTBE to TBA, but they do note that some critics question the purging efficiency of these methods for nonpolar compounds like MTBE and especially TBA.

They submitted a variety of Port Hueneme groundwater samples to the three labs (concentrations ranged from 1 μg/L to about 3,000 μg/L in the samples submitted to each lab) and asked them to run their standard method. Two labs used EPA 5030 / 8260 and one used EPA 5242, a similar P&T/GC-MS method. All three labs used a purge cycle of 11 minutes. Two labs purged at ambient temperature, and the other used 40°C. A variety of quality assurance and quality control procedures were also employed to confirm method performance.

To very briefly summarize their results, using the standards of U.S. EPA's performance evaluation protocol criteria, all three labs performed within acceptable limits of accuracy and precision for all four compounds for the entire range of concentrations studies (i.e., 1 to 3,000 μg/L). MTBE and TBA recoveries were almost always within the acceptable range (i.e., between 75 and 125 percent recovery). In all cases, the desired low ppb detection limits were reached.

The authors conclude that the results reflect a successful demonstration of method applicability (P&T/GC-MS) for the compounds studied. This single study of three labs does not, of course, mean that each and every one of the almost 1,000 environmental labs nationwide routinely performs as well. However, the authors conclude, "The results...appear to be a successful demonstration...that...purge-and-trap GC-MS is an acceptable technology for the analysis of MTBE and its oxygenated breakdown products."

There is a lot of other good information and discussion in that well-written article, and I strongly encourage you to take a closer look for yourself. It provides a good template for the kind of information you should be able to obtain from your laboratory regarding the quality of its analytical performance.

With Good Data and Attention to Protocol...

We know a lot more today than we did a few years back about the proper approaches for oxygenate analysis. We also know a lot about MTBE acid hydrolysis and its potential effects on groundwater analysis, but that's not to say we know it all. I suspect that this topic will continue to be of high interest and that we will learn a lot more in the coming year.

The studies cited in this article and in LL#42 collectively provide a lot of interesting information, but more information will be required to conclusively document the performance of the analytical methods currently in common use. To be sure, following the recommended protocol provided in LL#42 would help you become more aware of the quality of the data for the sites you manage, and any potential limitations to that data. That information should serve you well, and your corrective action decision-making should improve.

However, at most sites you probably do not need to use a heated P&T extraction to generate good data for MTBE and TBA. If heating is shown to improve method performance, then temperatures of 40° to 45°C are likely to be sufficient, and at these temperatures, MTBE hydrolysis should not compromise data quality. Purge-and-trap extraction of water samples at ambient or slightly elevated temperatures (combined with good calibration procedures) should adequately recover any TBA present in samples.

Furthermore, it is probably unnecessary in most situations to use TSP as your field preservative, instead of acid. While both low acidity (pH) and high temperature are known to enhance the rates of MTBE hydrolysis, an evaluation of these factors and a review of the standard analytical procedures employed at many commercial laboratories indicate that it is unlikely that significant MTBE hydrolysis occurs. For conditions used at most UST release sites—using standard acid preservation of samples, followed by P&T/GC-MS extraction and analysis—hydrolysis of MTBE to TBA will be very limited and will not significantly influence data quality. Hydrolysis of MTBE to TBA should not be a concern during storage and analysis of acid-preserved samples.

Data users should have a good understanding of the basic performance of the sampling and analytical procedures they use to generate oxygenate data. If they have concerns about data quality for ongoing evaluations of corrective action at UST sites where gasoline oxygenates are present in groundwater, they should review the protocols in use, the list of target oxygenate analytes, and their performance criteria (e.g., recoveries and detection limits) to determine if any changes might improve performance. I would also recommend that you talk about these issues with some of the commercial labs in your area to determine what they think are the best approaches to maintaining or improving data quality. ■

Bruce Bauman is the Soil and Groundwater Research Program Coordinator at the American Petroleum Institute. He has been involved with UST and groundwater issues at API since 1985, and is an occasional LUSTLine *contributor.*

[Note from Bruce: Everything I've needed to know about oxygenate analysis I've learned from: Ileana Rhodes (Shell Global Solutions); Mike Miller (ExxonMobil); and Kirk O'Reilly, Michael Moir, and Al Verstuyft (ChevronTexaco). Their substantial contributions to this article are most gratefully acknowledged. I assume sole responsibility for any errors and misstatements.]

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Analyze for All Oxygenates, Got It?

As shown by the following quotes from authoritative oxygenate reviews and guidance during the last six years, there is no excuse for not knowing what other oxygenates besides MTBE may be present at your UST sites.

- **1997 National Science and Technology Council report, *Interagency Assessment of Oxygenated Fuels:***
  "Add the alkyl ether oxygenates MTBE, ETBE, TAME, and DIPE to existing VOC analytical schedules and as U.S. EPA routine target analytes for drinking water, wastewater, surface water, groundwater, and remediation studies." This report noted that at that time, there were no validated methods for TBA analysis in groundwater, and so it did not recommend TBA analysis.

- **1998 EPA Office of Research & Development report *Oxygenates in Water: Critical Information and Research Needs* (EPA/600/R-98/048): Section 5.2 (p.18):**
  "Oxygenates should be added to existing VOC analyte schedules and included as routine target analytes for VOCs in drinking water, waste water, surface water, groundwater, and remediation sites. ... Given the existence of TBA as a primary oxygenate, as a contaminant of MTBE, and as a degradation product of MTBE, the inclusion of TBA in ambient groundwater quality monitoring programs is advisable. It also would be useful to monitor for TBA at specific sites where MTBE contamination is known or suspected to have occurred."

- **August 1999 EPA Blue Ribbon Panel Report Recommendations:**
  "Establish routine systems to collect and publish, at least annually, all available monitoring data on: use of MTBE, other ethers, and Ethanol; levels of MTBE, Ethanol, and petroleum hydrocarbons found in ground; surface, and drinking water; trends in detections and levels of MTBE, Ethanol, and petroleum hydrocarbons in ground and drinking water. Identify and begin to collect additional data necessary to adequately assist the current and potential future state of contamination."

- **EPA OUST letter, January 2000, "Monitoring and Reporting of MTBE and Other Oxygenates at UST Release Sites":**
  "While MTBE has received most of the publicity recently, it is by no means the only chemical of concern for which you should be monitoring and reporting. For example, the oxygenate TBA is both a degradation product of MTBE and a fuel additive in its own right; it is also potentially more toxic than MTBE. You should also carefully consider assessing for other oxygenates (that include, but are not limited to, TAME, DIPE, ETBE, ethanol, and methanol)."

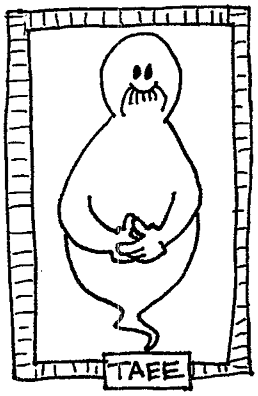
- **Halden et al.: 2001, "Evaluation of Standard Methods for the Analysis of Methyl *tert*-Butyl Ether and Related Oxygenates in Gasoline-Contaminated Groundwater":**
  "The results of this study indicate that project managers of LUST sites and chemists working with gasoline-containing groundwater samples may turn to EPA Method 8260B and ASTM Method D4815 in their search for a robust, accurate, precise, and widely applicable monitoring tool for ether oxygenate and TBA analysis."

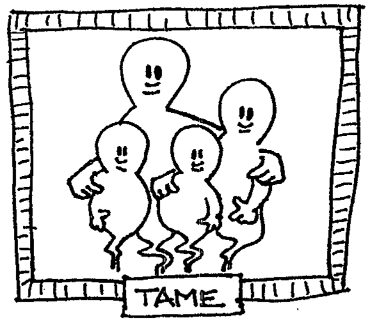
- **NEIWPCC 2001: "A Survey of State Experiences with MTBE Contamination at LUST Sites":**
  "States were asked if they analyze for any of the following oxygenates: ethanol, TBA, TAME, ETBE, DIPE, or any others. The overwhelming majority of states indicated that they never analyze for any of these substances."

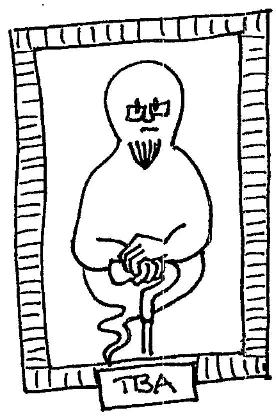
The Other Fuel Oxygenates

A Summary of the ASTSWMO Fuel Oxygenate Symposium

by Jeff Kuhn and Bob Haslam







When the topic of fuel oxygenates comes up, most people probably think of methyl tertiary-*butyl ether (MTBE). MTBE has played so prominently in the news the past few years that most people probably use "MTBE" and "oxygenate" interchangeably. But those of us who are more involved with fuels, fuel storage, and fuel contamination know that MTBE is but one of several oxygenates that are commonly used in fuel. Other oxygenates include* tertiary-*amyl methyl ether (TAME), ethyl* tertiary-*butyl ether (ETBE), di-isopropyl ether (DIPE),* tertiary-*amyl ethyl ether (TAEE),* tertiary-*butyl alcohol (TBA),* tertiary-*amyl alcohol (TAA), ethanol, and methanol.*

Despite our best efforts at keeping fuel in fuel storage tanks where it belongs, fuel components (including MTBE and other oxygenates) frequently escape the confines of tank systems and find their way into the environment. MTBE has also been found in many types of fuels, such as home heating oil, in which its presence was never intended. Because of the nature of the nation's fuel production and distribution system, it is likely that other oxygenates are also present in fuels other than gasoline. It is becoming increasingly evident that MTBE as well as other oxygenates are quite often discovered in fuel releases, if one dares to look for them; all that's needed is the appropriate analytical method.

Over the years, we've become relatively familiar (and hence comfortable) with the behavior, cleanup approaches, and toxic properties of the hydrocarbon constituents in fuel, and we're now getting somewhat familiar with MTBE. But what about the other oxygenates? What do we know about them? Are these oxygenates going to be as widespread and difficult to address as MTBE?

These questions (and undoubtedly many others) prompted the Association of State and Territorial Solid Waste Management Officials (ASTSWMO) to hold a one-and-a-half-day symposium on fuel oxygenates other than MTBE. The symposium, entitled: "State Symposium on Fuel Oxygenates: Analysis, Assessment, and Remediation" was held October 22 and 23, 2002, in Arlington, Virginia. Representatives from 25 states, two territories, and the District of Columbia were represented, as well as six U.S. EPA regional offices and U.S. EPA's Office of Underground Storage Tanks (OUST), Office of Research and Development (ORD), Office of Solid Waste (OSW), and Technology Innovation Office. Also represented were the U.S. Geological Survey (USGS), the American Petroleum Institute, two consulting firms, and NEIWPCC. This article briefly summarizes the main issues identified by participants of the symposium.

Symposium Highlights

The symposium offered all participants the opportunity to provide their perspectives on the issue of fuel oxygenates as contaminants in soil and groundwater. The first day of the event featured presentations on a variety of issues, including physical and chemical properties of oxygenates and methods for detecting them in soil and groundwater, occurrence of oxygenates in fuel and at LUST sites, site characterization, remediation, regulatory trends, and industry perspectives. The second day was devoted largely to breakout sessions for small-group discussions of state experiences with oxygenate occurrence, remediation strategies, the effect of ethanol on hydrocarbon plumes, and the effect of state and/or federal regulatory levels for various oxygenates. The outcome of all of this information exchange is summarized as follows:

- **TBA is an emerging problem and is anticipated to be a large problem.** Little is known about the health effects of TBA and whether current treatment/remediation technologies can adequately address soil and groundwater contamination. Also, common analytical practice is yielding inaccurate data on the occurrence and magnitude of TBA in environmental samples. This complicates decision making on treatment and remediation and can lead to unnecessary expenditure of scarce resources.

- **States generally feel that there is a need for U.S. EPA and others, such as USGS, to be proactive (rather than reactive) in regard to the other oxygenates in fuel.** States expressed a desire to be notified of changes in fuel composition so that they can adjust their site assessments to look for any new fuel additives. A key component of this issue is the need for a comprehensive, multimedia life-cycle analysis of the various oxygenates being considered as a replacement for MTBE. States are concerned about what other compounds may be added to fuel that can end up in the groundwater and are fearful of another *60 Minutes*-style debacle, this time regarding (most immediately) TBA.

• There is uncertainty and some anxiety in the states regarding analytical methods for fuel oxygenates. While the recent U.S. EPA study on analytical methods and sample preservation answered some questions regarding these issues (see "Analytical Methods for Fuel Oxygenates," *LUSTLine* Bulletin #42), states expressed a strong desire for U.S. EPA to release formal guidance on these and other issues.

• A major issue states face with regard to oxygenates, including MTBE, is the lack of federal drinking water standards for these contaminants. While some states are testing for a broad range of oxygenates, others are only looking for MTBE. Several states that have started to focus their attention on TBA are concerned about the frequency of discovery of the compound in drinking water. Many are frustrated by the absence of any federal mandate to consider the impacts of oxygenates other than MTBE.

• Recent product analysis studies performed in nine states show that the presence of other oxygenates is widespread—oxygenates were detected in virtually all the gasoline sampled. These data suggest that if MTBE is present in gasoline, then other oxygenates will also be present.

• States need training and guidance on how to put together planning documents to generate useable data for site characterization and remediation options (e.g., site-specific sampling and analysis plans [SAPs]). This need for guidance also extends to the issue of whether sites should be resampled for TBA (and in some states for MTBE where resampling has not yet been initiated). Some states suggested that OUST develop guidance with specific criteria for resampling sites contaminated with MTBE and/or TBA.

• Nationally, there is an increasing concern over vapor migration and indoor air issues.

• To date, there have been no advances in release detection, specifically in the lowering of the leak detection threshold. This necessitates greater reliance on containment and cleanup strategies, which are much more expensive than prevention. States suggested that gas stations could be better designed to prevent releases of oxygenates into the environment.

• States would like to have U.S. EPA better coordinate the development of strategies to more effectively deal with oxygenate issues as a whole. This coordination should be in the form of both intra- and interagency workgroups that hold regular meetings and report findings.

The Three Most Significant Issues

ASTSWMO representatives compiled and evaluated the issues raised during the symposium and selected three that were of such significance that they were detailed in a letter to OUST Director Cliff Rothenstein requesting "further discussion and support from OUST." The three issues identified and discussed in the letter are as follows:

• States need to look for TBA and the other common fuel oxygenates. Sampling for TBA and other oxygenates should be completed routinely as part of an initial scan. ASTSWMO urged OUST to provide guidance on TBA and the other oxygenates so that states can have a better understanding of these compounds (e.g., toxicology, appropriate remediation alternatives) when they find them in groundwater and drinking water. Some remediation technologies that are effective for MTBE may be inappropriate, ineffective, or may exacerbate contamination from some of the other oxygenates.

ASTSWMO suggested that an OUST memo issued by Sammy Ng in 2000 (**http://www.epa.gov/swerust1/mtbe/jan1800.pdf**), which recommended that states test LUST sites for MTBE and the other oxygenates, be updated to more strongly emphasize the concern for TBA and the importance of using appropriate sampling methodologies during sample preservation and analysis.

• Finalize and release the "Analytical Methods for Fuel Oxygenates" fact sheet prepared by OUST, OSW, and ORD. This is timely and critical information. In fact, some states are already using the draft fact sheet methodologies. This work complements the efforts of many researchers and the recommendations of the EPA Blue Ribbon Panel on MTBE—efforts that occurred in response to the discovery of a national MTBE problem. States need this guidance to help verify that they are using the most appropriate analytical methodologies to detect groundwater impacts from the various oxygenates. As many states are already finding these compounds in groundwater and drinking water, the research under way by OUST will provide a welcome level of assurance that state analytical approaches are either valid or in need of change.

The issue of testing for oxygenates other than MTBE was previously highlighted in technical presentations made at the last two National UST/LUST Conferences, presentations made in ASTSWMO MTBE and Fuel Oxygenates Workgroup meetings, and discussions between federal and state managers. While state concerns about testing for the list of common oxygenates are not new, the level of knowledge regarding these contaminants has greatly advanced. TBA is now recognized as a significant contaminant of concern by a number of states. Therefore, knowledge of analytical methods that have the potential to provide a more accurate analysis is more important than ever.

• Form an interagency work group consisting of USGS and the U.S. EPA Offices of Solid Waste and Emergency Response, Research and Development, Air and Radiation, and Ground Water and Drinking Water that meets quarterly to discuss fuel oxygenates and additives that have the potential to impact groundwater and drinking water. This work group would also address life cycle considerations for these compounds.

Symposium participants agreed that a federal interagency workgroup would be an important component of future discussions on fuel oxygenates and additives. Interagency coordination and communication between U.S. EPA, USGS, the Departments of Agriculture and Energy, industry, and water suppliers was also put forth in the final recommendations of the Blue Ribbon Panel on MTBE

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■ **Symposium Summary** *from page 23*

(final recommendations dated July 27, 1999).

ASTSWMO envisions that the focus of this new work group would be to enhance interagency communication to prevent future incidents similar to that caused by the unanticipated impacts of the federal Reformulated Gasoline (RFG) program. With this in mind, the Blue Ribbon Panel had called for a multimedia life cycle analysis of any proposed fuel additives. In light of the anticipated increase in the use of ethanol nationwide, ASTSWMO recommends that life cycle analyses be completed on new formulations of gasoline.

Future Outlook

The ASTWMO Fuel Oxygenates Symposium underscored the continued high level of state concern over the long-term implications of monitoring for, and detecting, fuel oxygenates in groundwater and drinking water. Oxygenates clearly should not be ignored; but time and resource constraints will influence what is realistically achievable within a reasonable period of time. For example, the promulgation of federal drinking water standards is a lengthy process that could conceivably span more than a decade. And there are other factors that may come into play over which neither U.S. EPA nor state agencies have any control. In particular, any of the various bills relating to fuels and energy that are floating in Congress could affect federal and state UST/LUST programs in ways that we cannot now anticipate.

If you've ever hiked on a talus slope in the western U.S., you know the "two steps forward, one step back" feeling that many of us have experienced in the battle to keep oxygenates out of the environment. The good news is that we're now above the timberline—prior to MTBE, we couldn't see the forest for the trees. ■

Jeff Kuhn is a hydrogeologist and manages the Petroleum Release Section for the Montana Department of Environmental Quality. He can be reached at **jkuhn@state.mt.us.** *Jeff chairs the ASTSWMO MTBE and Fuel Oxygenate Workgroup. The workgroup includes representatives from state LUST Programs, U.S. EPA, American Petroleum Institute, U.S. Geological Survey, Association of California Water Agencies, Academic Network for Contaminated Lands Research in Europe (ANCORE), Montana State University Center for Biofilm Engineering, and several private consulting firms. The workgroup is open to all interested parties.*

Bob Haslam is a hydrologist with the Vermont Department of Environmental Conservation, Underground Storage Tank Program.

UST Bill S.195 Set for Action in Senate

Senate Bill S.195, which is nearly identical to last year's S.1850, sponsored by Senators Chafee, Inhofe, Carper, Warner, and Jeffords, was adopted by the Environment and Public Works Committee in February and is ready for action in front of the full chamber. (The full Senate never voted on S.1850.) Under S.195, states would be required to ensure that UST facilities are inspected every two years and that they implement a strategy for training UST operators. It provides states with the authority to prohibit gasoline deliveries to noncompliant tanks.

The bill also requires that EPA distribute to the states at least 80 percent of the corrective action funds appropriated each year from the Leaking Underground Storage Tank Trust Fund. Substantial funding is authorized for MTBE cleanup, enforcement, inspection, and corrective action. While much of the intent of the bill has the support of state UST regulators, program managers caution that the added workload associated with certain requirements in the bill could only be accomplished with additional federal resources. The House is expected to introduce a similar bill soon. ■

Northeast States Powwow on Compliance with Marketers

On January 22, EPA Region 1 and New England Interstate Water Pollution Control Commission (NEIWPCC) hosted a meeting with UST program managers from the New England states and New York and representatives from six major petroleum marketers in the region. Discussion focused on the possibility of building partnerships to improve compliance with tank regulations.

Petroleum marketing trends of greater consolidation, centralized data collection, use of outside contracted maintenance services, and electronically monitored systems have fostered low significant operational compliance rates and a move away from on-site facility management. UST inspectors are frustrated by the lack of required on-site documentation; disconnects between corporate headquarters, contract service personnel, and facility operators; the lack of on-site system knowledge; and confusion about compliance responsibility.

At the meeting, regulators asked industry representatives how they could work together to improve compliance. Regulators offered to provide inspection forms to the companies to let them know what they are looking for in the field, to let corporate headquarters know about problems inspectors are finding, and to work together to find solutions. The corporate participants were interested in doing this and in continuing the dialogue. NEIWPCC has mailed out state inspection checklists and plans to hold another meeting this spring. ■

Pay for Performance: California's Cleanup Goal Metric

When RBCA is not RBCA

by Robert S. Cohen, David Charter, George Cook, and Kevin Graves

California's Pay for Performance (PFP)[1] implementation process yielded a substantial tool for state trust funds, in general. In California, as in many states, the regulators have a strict standard of cleanup for site remediation. This standard is not always obtainable, yet much effort and money can be spent in the chase. The U.S. EPA and the California Underground Storage Tank Cleanup Fund (The Fund) worked together to find a way to satisfy the regulators' environmental agenda and simultaneously achieve fiscal control. The solution was found in implementing a Preliminary Active Remediation Goal as a means for concluding PFP contracts—a cleanup target goal that is something short of full closure. The PARG tool combines elements of RBCA with PFP—bringing peace and satisfaction to regulators and trust fund administrators alike.

The Problem

Cleanup authority in California lies with nine Regional Water Quality Control Boards and 20 local agencies that are under contract to the state. Each regional board determines the cleanup standards required for closure of UST sites in its jurisdiction, based on the present and future beneficial use of groundwater in the area. Standards vary from board to board and tend to be very protective of groundwater quality.

Meanwhile, back in Sacramento, The Fund pays the bills for petroleum cleanups—up to $1.5 million per incident. The Fund pays reimbursement claims, some of which are preapproved. It is well financed with an annual income of over $150 million and has paid over one $1 billion in claims. Nevertheless, the lack of progress on many sites is straining its resources.

Remedial projects tend to drag on for various reasons, with many cleanups taking in excess of 10 years to complete. Some regional boards have stringent cleanup standards that are not practically obtainable at some sites. Nevertheless, many cleanups continue until The Fund limit is approached, even at sites that do not warrant a high level of effort.

Without firm and reachable targets, consultants cannot be held responsible for their engineering efforts, and many remediation systems are not optimized. In a nutshell, the regional boards are reluctant to reduce standards, The Fund is not agreeable to paying for endless cleanups, the consultants are not accountable, and the owner has a contaminated site!

An associated problem is that property owners and their consultants often don't want to begin remediation on a site where there are not clearly defined and achievable goals. As a result, the investigation and monitoring phases are drawn out at hundreds of sites. Because they have little confidence that they can achieve the regulatory goals, owners and consultants adopt the delaying tactic of proposing additional monitoring wells, long-term monitoring, endless pilot tests, and feasibility studies. In looking for a means of introducing a PFP approach to California's cleanup conundrum, our challenge was to find a solution that would implement site cleanup without the dawdle factor.

The Solution

The solution was found in the Preliminary Active Remediation Goal (PARG), a remediation goal that the consultant, owner, and regulator agree is obtainable by active remediation. It is not necessarily the regulatory cleanup goal, or MCL, though it could be. (See Table 1.) The PARG is simply the concluding goal of the PFP agreement. Upon reaching and maintaining the PARG, the PFP agreement is concluded and one of three events may occur:

- The site is issued closure (no further action)
- Natural attenuation monitoring begins
- The site continues with active remediation, and a new PARG is negotiated

PFP is impossible without realistic goals. With a defined and obtainable interim goal, a remediation system can be efficiently designed and operated. Without the PARG, consultants design systems for unobtainable goals (i.e., systems that are doomed to fail). Systems that are designed without a defined goal such as a PARG operate with the tenacity of the EverReady Bunny, yet the sites never close. For the less-than-scrupulous consultant, this creates a long-term annuity; for the scrupulous consultant, this creates the frustration of not satisfying the clients' desire for a no-further-action status.

Table 1 — EXAMPLES OF MCLS VERSUS PARGS

Constituent	Cleanup goal	PARG
Benzene	1.0 ppb	100 ppb
MTBE	13.0 ppb	200 ppb

The LUST Paradox

The goal of LUST regulators and fund administrators, nationwide, is to use available resources to protect the environment from the impact of leaking underground storage tanks. Yet our enthusiasm to achieve the

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1. Pay for Performance is a contractual mechanism by which the cleanup consultant is paid upon achieving agreed-upon environmental milestones. The cleanups are typically faster and cheaper than the ordinary time and materials approach. More information is available at the EPA Web site: **http://www.epa.gov/swerust1/ pfp/index.htm.**

■ When RBCA is not RBCA

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fullest protection may result in less protection! Let us explain this paradox in terms of programs in which the regulator is separate from the fund administrator; although the argument also applies to instances when the regulator and fund administrator are not separate.

The regulator is primarily concerned with protecting water resources and restoring contaminated resources to a legislatively defined standard of acceptability. State fund administrators are universally concerned with using their limited financial resources to achieve the regulatory goals for as many sites as possible. The separation of a fund from a regulatory authority is intended to assure that the financial resources do not determine regulatory standards. In this arrangement the regulator may demand restoration to the strictest standard and only allow less stringency when "best efforts" have failed to achieve the results.

The operative words here are "best efforts." If the consultant is not working toward an obtainable goal, the engineering design cannot be optimized and "best efforts" will remain elusive. Best efforts become the longest and most expensive efforts. In the PARG scenario, the goal is one that the stakeholders have agreed is obtainable and, therefore, metrics can be established to track progress. These metrics become the payment milestones of PFP.

Contract Goal versus Cleanup Goal

Some stakeholders in California have argued that the PARG reduces cleanup standards and, by doing so, is simply a back door to RBCA, overriding what the local regulations have specified. This is not true; the PARG does not obligate the regulator to close the site. Rather it directs resources toward achieving obtainable goals while leaving full regulatory structure and authority in place. The PARG is a contract goal, not a cleanup goal. This approach leads to faster, more efficient cleanups and provides the regulator with a greater level of satisfaction.

Consider a hypothetical example of how a PARG might work. Let's say Joe's U-Pump suffers a loss of 100 gallons from a pipe-connection failure. The released gasoline migrates 50 feet through the vadose zone to the surficial aquifer (water table). There are no sensitive receptors, such as potable wells or surface water, within five miles of the discharge. The subsurface is composed of interfingered sands and clays.

The MCLs for benzene and MTBE are 1.0 ppb and 13 ppb, respectively. Due to the clays it is quite difficult to achieve these levels. With clays under the building having absorbed product, the only way to fully achieve the MCLs would be to remove the building and excavate the soil or install vapor laterals under the building. The structural engineer is opposed to laterals. Similar facilities in the same town have had vapor extraction and air-sparging systems operating for years, without appreciable success.

Using the traditional approach, a consultant would continue "best efforts" until reaching the funding limit, and then the regulatory agency would consider a petition for no-further-action with contamination still present, though at reduced levels. In the PARG scenario, the regulator, consultant, owner/operator, and fund administrator meet upon completion of the assessment. They agree upon obtainable and practical interim cleanup goals that will protect receptors and minimize off-site migration. These goals are the PARGs.

From Process to Results

A PFP agreement motivates the consultant to install effective and efficient technology and motivates the consultant to operate diligently. PFP encourages and allows the regulator to refocus resources from process to results. The fund administrator preapproves the PFP agreement payment terms and no longer needs to review complex time and materials invoices. Payments are based upon milestone contamination reductions within agreed-upon time parameters.

As in all PFP agreements, there are termination clauses for unforeseen events, such as a new discharge. Upon reaching the PARG, the PFP agreement is terminated. At this point, the regulator will most likely either issue a site closure or require additional active remediation, or natural attenuation monitoring.

In the example above, the regulatory authority was not reduced under a PARG scenario, yet effective contamination reduction was achieved. Most importantly, the reduction was greater and faster than the neighboring facilities' attempts to reach the MCL without the PARG and PFP.

Elements for Success

Many sites in California are proceeding according to the PFP method and satisfying all concerned. Through the simple combination of the PARG and PFP, cleanups can proceed without the tension between the fund administrator and the regulators. The key elements for success are:

- Accurate and complete assessment, at least at the source area
- Early post-assessment agreement of practical interim goals
- A PFP agreement to reach the PARG
- Project review once the PARG is achieved

The PARG may be a site-specific goal or a regional goal. The Santa Clara Valley Water District (SCVWD) promulgated a regional PARG for PFP sites that do not have an impact on sensitive receptors. This is notable since the district is considered stringent. It took up the PARG to break the gridlock of endless and inefficient remediations. Let's look at two SCVWD cases studies.

Santa Clara County

There are currently two PFP sites in Santa Clara County that have active remediation systems and two sites that are in the process of installing their remediation system. The first site began remediation in December 2001 and has reduced contamination levels by 70 percent. The second site began remediation in May 2002 and has achieved a 75 percent reduction in contamination levels. Both of these cases were in the program for over 10 years with little or no progress made towards achieving closure prior to entry into the PFP program.

The SCVWD has developed a standard set of PARGs for total petroleum hydrocarbons as gas (1,000 ppb), benzene (100 ppb), toluene (200 ppb), ethylbenzene (500 ppb), xylenes (300 ppb), and MTBE (200 ppb). These PARGs are applicable for all PFP sites in Santa Clara County. The district believes that they are achievable and will likely allow the majority of sites to be closed, if achieved. The SCVWD does not guarantee closure upon reaching the PARG but does guarantee that the site will be reviewed for closure when the PARGs are achieved.

■ Case Example #1

Fuel leak site #1 was first opened as an active case in January 1990, following the discovery of petroleum hydrocarbons in soil during the removal of two 8,000-gallon fuel USTs and a 550-gallon waste oil UST. Soil and groundwater investigations and quarterly monitoring events conducted between 1993 and 2000 detected total petroleum hydrocarbons as gasoline (TPHG) and benzene in groundwater at concentrations up to 140,000 and 34,000 parts per billion (ppb), respectively. Additionally, free product was detected at thicknesses up to 1.65 feet. No site remediation was completed in the 12 years following the initial report of a release at the site. The reasons for this delay in site remediation are not clear, but the PFP initiative gave the cleanup its jump-start.

A PFP cleanup agreement for the site was reached in June 2001 and was modified in April 2002 to take into consideration additional contamination discovered in December 2001. The consultant proposed the use of groundwater extraction (GWE) in combination with soil vapor extraction (SVE) and air sparging (AS).

The SVE and AS systems are being conducted with the use of a mobile unit that allows considerable flexibility in selecting the wells to be used for extraction. After six months of GWE and two months of SVE and AS, total BTEX concentrations in key monitoring wells at the site have been reduced by 77 percent. Current maximum concentrations at the site are 19,430 ppb benzene (a 43 percent reduction) and 38,000 ppb TPHG (a 73 percent reduction).

The site consultant feels the PFP approach resulted in faster payment from the cleanup fund, eliminated much of the administrative hassles that were involved with the standard cleanup fund process, and provided him an opportunity to increase profits. We believe this is a win-win situation for all parties.

■ Case Example #2

Fuel leak site #2 was first opened as a leak site in February 1992 following the discovery of petroleum hydrocarbons in soil during an UST removal. Maximum concentrations at the site were 31,000 ppb benzene, 10,000 ppb MTBE, and 200,000 ppb TPHG. Remediation activities performed at the site between 1991 and 2001 included additional excavation of contaminated soil in 1991 and 1993 and the installation and operation of SVE and GWE systems from 1996 to 2001.

Following the initial period of remediation, benzene, MTBE, and TPHG concentrations were reduced by 72 percent, 97 percent, and 73 percent, respectively. Although the total reduction of contaminants was positive, most of this progress was made between 1996 and 1998, and the concentrations remained stable from 1998 to 2001.

The responsible party and the consultant entered into a PFP contract in November 2001. The consultant proposed to continue to use the existing systems but to upgrade the equipment to provide increased flow rates and to increase the number of extraction wells. The upgraded system was started up in December 2001. After eight months of operation, total BTEX concentrations were reduced by 70 percent. Benzene, MTBE, and TPHG concentrations were reduced by 78 percent, 46 percent, and 37 percent, respectively.

These case studies show that the PFP program is effective in moving stagnant sites into successful remediation. Setting realistic PARGs—goals that are achievable and will provide protection to the groundwater basin—is a critical component of the PFP program. Without realistic PARGs, it would be difficult, at best, for any consultant to agree on a PFP contract.

Progress Without Angst

Introducing the PARG in combination with PFP can lead to faster, less expensive, and, most importantly, more efficient cleanups. Setting obtainable goals is a powerful tool for avoiding regulatory tension with the trust fund and for getting all sides to focus on what we all want—maximum protection of receptors by efficient use of resources. Pay for Performance has produced remarkable results in many states by promoting faster and less expensive cleanups. (See *LUSTLine* #42, "Pay for Performance: Does It Work? The Data.") The PARG combines elements of RBCA with PFP to accelerate cleanups through efficient operations. ■

Robert S. Cohen is a professional geologist specializing in LUST cost containment and risk management issues. He is a consultant to both the public and private sectors. He has conducted over 30 PFP workshops and studies on behalf of the EPA and various states. For more information, contact Bob at **bobcohen@ivs.edu** *or (352) 337-2600*

David F. Charter is a Senior Engineering Geologist in the California Underground Storage Tank Cleanup Fund. He has been involved in UST removal, assessment, and remediation since 1990. He can be reached at **dcharter@cwp.swrcb.ca.gov**.

George E. Cook Jr., R.G., is an Assistant Engineering Geologist with the Santa Clara Valley Water District. He is responsible for oversight of 100 active fuel leak sites in Santa Clara County, California. He can be reached at (408) 265-2607 ext. 2665 or **gcook@valleywater.org**.

Kevin Graves is Chief of the UST Cleanup Unit at the State Water Resources Control Board in California. He has worked in the environmental remediation field for the past 10 years as a regulator, researcher, and consultant. He can be reached at **gravesk@swrcb.ca.gov**.

At the 11th Annual State Fund Administrators Conference, June 2003, in Boise, Idaho, there was much discussion concerning LUST cleanup reimbursement, Pay for Performance (PFP) style. We've selected some of the questions asked and some of the answers provided that we felt might be of interest to state fund administrators considering implementing PFP.

PAY FOR PERFORMANCE

Q. ***When you negotiate a PFP agreement, how do you know when you get a good price?***

A. Experience, experience, experience! The more experience state officials and contractors have in PFP, the more confident all the parties will be with the negotiated price. For example, Florida program personnel, with over 250 agreements, have gained considerable experience at knowing what things cost. For each project, three state project managers independently review the cleanup plan developed by the negotiating contractor and then develop an estimate of the price of the cleanup. These three estimates are then compared to the price proposed by the contractor. "If the contractor had a very high price and then suddenly comes down to meet your estimate, you know there was a lot of fat in the proposal to begin with," said Florida DEP's Brian Dougherty.

Oklahoma, on the other hand, uses the Tank Racer costing program as a basis for negotiations. "Tank Racer removes any question of arbitrariness and has proven useful in court," said Dave Kelley, Oklahoma Corporate Commission, PST Division.

Q. ***What were some of the most unexpected benefits of PFP?***

A. One state representative noted that contractors make their systems work better without contacting agency staff. He said the back and forth calls between state staff and contractor, the change orders, and the cost overruns all go away under PFP.

Art Shrader, South Carolina DHEC, recalled one occasion when a hurricane was approaching. The PFP contractor notified his office that he was shutting down the systems. Six systems were under water, and the state didn't have to pay to replace any of them.

"PFP helped whittle out all the bad consultants. Now, the technical people that we work with are more knowledgeable. The good consultants rise to the top and stand behind their work," said Dave Kelley.

Q. ***How has PFP changed the way you approach site characterization?***

A. "You need more thorough site characterization for consultants to feel comfortable about entering a PFP agreement," said Chuck Schwer, Vermont DEC. "Our fund pays a bit more for a better characterization, but it's worth it."

Art Shrader noted that if you don't have a good site assessment, you're gonna find out about it in the price tag.

Q. ***Do you allow for real-time sampling after the contract is awarded?***

A. In South Carolina, baseline levels are established before entering a PFP agreement. If site conditions change significantly between the time of the baseline sampling and the implementation of the agreement (e.g., free product levels double), the contractor can be released from the agreement and the project can be rebid.

Q. ***Does state lead on a cleanup seem to work more smoothly?***

A. Florida experience says get as much state lead as you can. You have more problems when owners choose the contractor. Vermont, on the other hand, has not done any state-lead PFP work; however, they've found that if they work very closely with the owner/operator, a better agreement can be developed. VTDEC staff have helped owners/operators conduct bidding and routinely meet with contractors during the development of the agreement. "Working as a team, owners/operators and the state can be each other's best ally," said Chuck Schwer.

Q. ***How do you justify which contractor is chosen?***

A. To have an objective way to evaluate bids, Utah uses a Proposal Evaluation Form that consists of a list of the criteria required for each bidder's proposal and a scoring system for evaluating the proposals according to the criteria. Six people score the proposals using the same rating scale. Higher ratings are assigned to bidders that clearly define the work to be performed. Higher ratings are also assigned to realistic assumptions of equipment performance, flexible cleanup plans that cover a range of potentially unknown conditions, and offers that provide adequate equipment and backup in the event of breakdown, that adequately address all environmental and health and safety concerns, and that minimize the risk of not completing work on schedule. (For a copy of Utah's Request for Bid Form, contact Randy Taylor at **rtaylor@deq.state.ut.us**.)

Q. ***What techniques do states use to control contractors?***

A. Since the stakes are high under PFP, you need to ensure that your agreements have some stiff consequences if the contractor walks away from the project. For example, in Vermont, if the contractor doesn't fulfill his obligations, he risks losing work under the fund for three years. In Oklahoma, if a contractor fails to fulfill his contract, he cannot perform any remediation work for two years, by legislation. "If you don't have such legislation, you should put it into the contract," remarked Kelley.

Q. ***Does the ability to encumber funds through PFP help prevent raids on state funds?***

A. In 2002, the Vermont fund was raided by the legislature. If not for PFP and monies encumbered for the cleanups, the amount taken by the legislature would have been much larger. In Oklahoma, because of PFP, they were able to encumber funds. Florida has found that if you encumber funds, money is saved. ■

Tank Systems in a Jam

Contaminated Gasoline from a Kentucky Refinery Spurs a Flurry of Tank Cleanups and Lingering Concerns

by Ellen Frye

In summer 2002, incidents at several retail gasoline facilities in West Virginia caught the attention of inspectors from the state's Department of Environmental Protection (WVDEP) and Division of Labor Weights and Measures Section (W&M). "In June, we were hearing from tank owners who were doing inventory control and statistical inventory reconciliation (SIR) and getting inconclusives and faulty meter readings," says Gil Sattler, WVDEP's UST program manager.

In August, Dennis Harrison, a supervisor with W&M, was contacted by a major jobber who said he was being overcharged for his 87-blend gasoline and suspected that there was a calibration problem at the bulk storage loading racks. "We quickly discovered that the turbine meters at the loading rack were out of calibration," says Harrison. "We suspected there was something amiss at the marine terminals.

"The first physical evidence I saw was at an Exxon station, where a submersible pump was plugged with particulates. One of the pumps had already been replaced," says Harrison.

Harrison contacted Marathon Ashland Petroleum LCC (MAP), the refiner/distributor, and told them of his finding. A MAP representative instructed him to remove the filters and empty them into a pan. Upon doing this, Harrison found that the filters were filled with particulates that had been sucked up by the pumps. Marathon immediately sent teams of investigators to its refineries and barges.

About two weeks later, Harrison started hearing from other station owners, complaining of meters breaking, filters clogging prematurely, and some pumps failing. "Jobbers aren't big on talking to each and comparing these kinds of notes," says Harrison. "So unfortunately it can sometimes take them awhile to realize that it is not just their problem."

MAP inspected more than 2,100 retail stations that often had as many as 20 meters per site. The company replaced 26 broken meters, less than one tenth of one percent of the meters inspected.

The Problem

Fuel contamination was soon traced to MAP's refinery in Catlettsburg, Kentucky, the source of about 70 percent of West Virginia's fuel. The refinery, according to MAP, had been "distributing gasoline containing foreign material." The company took immediate steps to stop the contamination at the source and clean all affected points along the distribution system. Ultimately, the problem was identified at facilities receiving product from this refinery in West Virginia, Kentucky, Ohio, and Indiana.

According to a brochure, *Fuel Quality: Everybody's Business*, prepared by MAP and distributed to the jobber and service station network in the affected area, the company performed analytical sampling on more than 200 terminal and bulk plant tanks in the Catlettsburg distribution system.

MAP identified the following three types of contaminants that could be traced to the Catlettsburg fuel quality issue.

- **Excessive spent sodium hydroxide (NaOH) water** (caustic, high pH) that is normally recovered from gasoline before it leaves the refinery. NaOH is used in conjunction with air and a catalyst to react with mercaptan and ultimately remove sulfur compounds. Mercaptan is a sulfur-containing organic compound that is a byproduct of the gasoline refining process.

- **Excessive rust particulate** generated from within the refinery and the barges that was carried downstream. According to MAP, the *particulate itself was not generated* from UST corrosion. MAP says that other scavengers used to remove mercaptan kept particulate from bulk tanks and barges in suspension and carried it downstream to retail facilities.

- **Thick sludge** resulting from a reaction of chemical additives with finished product. The use of these additives has now been discontinued.

More than 70 of the tanks at the terminal and bulk plants were cleaned. All Catlettsburg-sourced barges were inspected—of 124 barges, 43 required cleaning. More than 220 company-owned, commercial, and private transports delivering product to the four-state area were inspected, and 90 were cleaned. Of the more than 2,100 retail sites in the four-state area that were inspected, approximately 1,300 of those sites underwent tank cleanings. MAP has also addressed claims by car owners concerning problems with fuel systems, primarily fuel injectors.

State inspectors also found signs of microbial blooms at the product/tank system interface during and after cleaning. "The truth is, I don't understand it all," says Dennis Harrison. "We routinely check the water bottoms. In some of these tanks we've seen a noticeable amount of jet black water...after they'd been cleaned."

"MAP's efforts to look at underground tank bottoms have been unprecedented," says MAP spokesman Shawn Lyon. "The dark liquid found at the bottom of tanks is a normal occurrence. Using various sampling methods, field tests conducted outside of the impacted Catlettsburg area further prove this point. With that understanding, MAP's cleaning efforts focused on removing particulates."

Long-Term Concerns

Based on what inspectors were seeing in affected tanks, WVDEP's UST Advisory Committee discussed some long-term concerns they had about the potential for corrosion or other adverse impacts to the linings of USTs.

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■ **Tanks in a Jam** *from page 29*

"During the tank-cleaning process, we noticed that the water in the tank bottoms looked different at different locations," says WVDEP UST inspector Michael Young. "In steel tanks (those that are bare steel on the inside) the water was a rusty brown color. In lined and fiberglass tanks we noticed that it was a dark red/purple/ black color. It was also more viscous and some places it was sticky.

"The results from some tank-bottom sampling that we conducted indicated that there were significant metals and some odd organics in the watery tank bottoms," says Young. "Some of these constituents are the same as the binder material that is used in the tank linings; however, they can also be found in parking lot runoff and soil. We realized that these samples were of little use because they were not definitive. Even if we looked into some of the lined tanks and measured the thickness of the liners, we have no baseline data indicating what the lining thickness was when it was first installed. Without this data it would impossible to determine if any liner loss had occurred."

Responding to WVDEP's concerns about long-term tank integrity and microbial growth, MAP's Lyon explains that of all the samples taken at the retail station level, the pH readings were normal (in the 6 to 8 range) with only a nominal number of samples slightly elevated to 10. Further analysis by a third-party testing lab noted that NaOH water found in the system is no more corrosive than normal water.

"Essentially, what we have occurring is normal corrosion, and, as a result, we implemented a plan to remove the NaOH water and the solids in the system," says Lyon. "In addition, industry standards for station equipment such as UL-listed storage tanks and piping include testing to withstand exposure to high pH solutions, which should further validate tank integrity."

With regard to microbial growth, Lyon contends that this is not a Catlettsburg issue but that "it is becoming more common in today's environment of [EPA-regulated] cleaner burning fuels. Therefore, there is an increasing need for education and awareness of this topic." Lyon notes that "microbial-induced corrosion is typically much more aggressive than normal corrosion associated with the presence of water." (See "Does Your Tank System Have Bugs?" below.)

In the meantime, WVDEP inspectors remain somewhat puzzled about the goings on in so many tank systems. "While Marathon has been very responsive to this problem," says Gil Sattler, "we still have some concerns about the long-term effects of all of this."

What Should Tank Owners Do to Ensure Product Quality?

In its brochure to affected jobbers and station owners, MAP describes what it is doing to ensure product quality throughout its distribution system. The company also notes that jobbers and dealers have a "responsibility to continue efforts to assure product quality after product leaves the terminal." Jobbers and dealers can help achieve this by

- regularly monitoring and minimizing water levels in underground and aboveground storage tanks,
- scheduling regular changing of dispenser filters, and
- developing a plan to proactively monitor for microbial growth at all tank locations. ■

Does Your Tank System Have Bugs?

We've heard from several UST inspectors who are concerned that they are seeing internal corrosion associated with microbial contamination in USTs. In *LUSTLine* Bulletins #39 and #40, industrial microbial ecologist Fred Passman provided our readers with extensive information on this subject.

If you are wondering whether microbes are likely to be causing problems with your UST or dispenser systems, here are a few quick checks that Fred has provided us that will help put you on the right track.

■ **What does your bottom sample look like?** Is there a third layer in the sample that looks like mousse and tends to cling to the sides of a gently tilted glass jar? If you see this in your bottom sample, you can be better than 90 percent certain that you have enough microbial contamination to be causing problems.

■ **Do you have a flow-rate restriction**? Note the totalizer reading when you change dispenser filters. If your flow rate falls below 7 gpm in less than 50,000 gallons through the filter, there's a better than 75 percent chance that microbes are a major, if not the major, cause.

■ **Have you replaced dispenser flow-control valves more than once in the past year?** If so, there's a better than 75 percent chance that microbes are causing the fuel to become corrosive.

■ **Have you experienced more than one of these problems at a retail site?** If so, there is a 95 percent chance that you have a microbe problem in your UST.

Also, ASTM Manual 47: *Microbial Contamination of Fuels and Fuel Systems* is scheduled for publication in spring 2003. This manual will contain three original chapters plus all of the nonvolume 5 ASTM and IP standards to which ASTM's D6469 *Standard Guide to Microbial Contamination in Fuels and Fuel Systems* refers (See LL#38). The three original chapters in Manual 47 are:

- Fuel Microbiology Basics
- Fuel Sampling for Microbiological Examination
- Fuel System Contamination Control

The manual also includes a glossary of microbiological and filtration terms with which petroleum industry people might not be familiar.

For more information, contact Dr. Fred Passman, President, BCA, Inc. **bca-fjp@ix.netcom.com** or (609) 716-0200. ■

UST-Related Explosions in Kentucky and Pennsylvania Are Unfortunate Reminders of What Not to Do

by Ellen Frye

"A RIVER OF GAS" AND BOOM

On the morning of December 12, 2002, Virgil Burgan, the operator of the Mount Eden Country Store in Shelby County, Kentucky, was on his way out of the store to fill a customer's kerosene can. He'd noticed that a gasoline delivery truck was making a drop but that it was parked in a different direction than usual. As Burgan walked to the kerosene pump, he saw what he said looked like a "river of gas" flowing along the left side of the store to the back of the building.

Burgan yelled to the driver and went back inside, where he found the smell of gas was already strong. He asked everyone inside to put out any smoking materials and turn off the stove burners. But as folks started to get up and leave, they heard—and felt—an explosion. They ran from the building just before the store caught fire and burned to the ground. No one was injured.

Several factors caused this delivery incident, according to Dale Mancuso, Senior Deputy State Fire Marshal. "First and foremost, a liquid-tight connection was not established before filling the tank," says Mancuso. A bulk delivery nozzle used to fill *aboveground* tanks had been placed inside the opening of the fill riser pipe, and the product was *pumped* into the tank.

Underground tanks are equipped with an adapter on the fill riser pipe that allows the delivery truck to hook up without the possibility of the hose disengaging. Once this connection is established, the valve to the storage compartment of the truck is opened and the product flows by *gravity* into the tank. "Even if a liquid-tight connection had been used, the delivery would still have gone against code requirements," says Mancuso, "since overfill-prevention devices used in underground tanks are not listed for pump-fed deliveries."

According to Mancuso, another factor that contributed to the release was that the nozzle being used to fill the tank did not have an automatic shut-off device. Although state codes don't require this safety feature in bulk-fuel nozzles, Mancuso says that such a device could have prevented the release and the subsequent fire.

The driver had also parked his truck so that the rear of the truck was in the front of the store. The UST fill connection was on the side of the store, so the driver could not have seen it from the rear of the truck since the store blocked the line of sight. The driver explained to investigators that he had been going back and forth between watching the meter at the back of the truck and his nozzle at the fill connection.

"The amount of product ordered played a role too, in that the Burgans only ordered 400 gallons of gasoline. The proper way to make this delivery into a UST would have been to meter 400 gallons of gasoline into a compartment of the tank truck and then deliver it. Instead, the driver chose to fill up the compartment," explains Mancuso.

Mancuso says the driver had to be at the rear of the truck to make sure that only 400 gallons went into the tank. The tank didn't have a meter with a preset cutoff, a device that shuts off the flow of product when a preset amount is reached.

As for the gasoline spill, at this point investigators do not know what caused it. Mancuso suggests a few possibilities: The nozzle could have been kicked out when the driver was going back and forth from the meter to the fill. The restriction in pipe size from the UST overfill-prevention device could have caused excessive turbulence in the tube and created backpressure. A restriction in the vent line to the UST could have caused the problem.

"One fact still remains,' says Mancuso, "had a tight fill connection been used along with a gravity fill, this release would never have happened."

TANKS BLAST OUT OF DORMANCY AT MTBE CONTAMINATION SITE

On January 7, 2003, two underground tanks at a former Mobil station at the Pool's Corner area of Doylestown, Pennsylvania, exploded, injuring two workers, rocking the neighborhood, and sending a shower of rocks and tank debris onto passing cars and residential properties. The station had been closed for over two years because of a gasoline release that contaminated a dozen nearby wells with MTBE. Both the Mobil station and a nearby Exxon station had voluntarily closed to clean up the sites.

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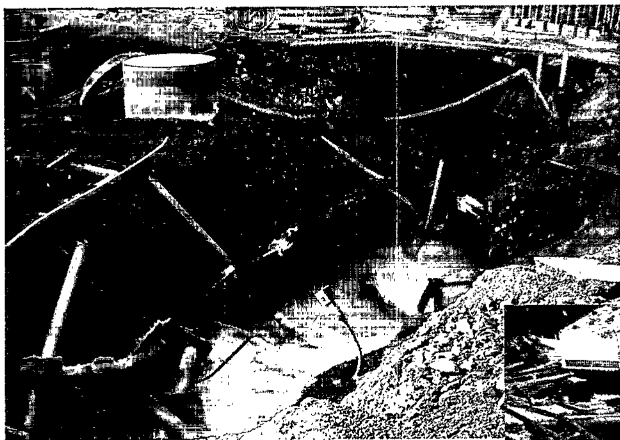
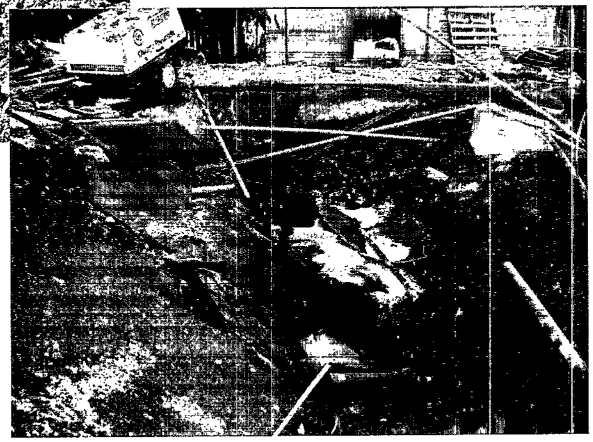
Recommendations for Preventing a Similar Fuel Delivery Situation

In the wake of the Mount Eden fire, Senior Dputy State Fire Marshall Dale Mancuso made the following recommendations.

- ✔ Provide better training for drivers/operators.
- ✔ Use tight fill connections.
- ✔ Fill USTs by gravity, not by pump.
- ✔ Follow the manufacturer's recommendations on product usage. Specifically, do not use a pump in conjunction with an overfill-prevention device listed for USTs.
- ✔ Make deliveries to USTs with premetered amounts of fuel.
- ✔ Make sure that the driver/operator can always see the tank-fill connection as well as the truck.

■ UST-Related Explosions *from page 31*





Left: *Exploded tank closest to the road at Pool's Corner Mobil Station. The foam in the tank area is fire-fighting foam. At upper left are the two containment sumps for the middle two tanks in the field.*

Bottom: *The tank at the opposite end of the tank field blew out enough of the gravel back fill to cause the macadam to collapse.*

On the day of the explosions, contractors were in the process of upgrading the tops of the four 10,000-gallon tanks at the site, replacing the lines and dispensers, and installing a remediation system. New owner Conoco Inc. was doing this in preparation for a reopening of the station. When the station was closed, the tanks had been emptied of product but not cleaned—about an inch of sludge remained at the bottom. At the time, the tanks were filled with water, as ballast.

"There seemed to be an assumption that the water would negate the need to monitor the tanks inside and out for vapors," says Kathy Nagle, Pennsylvania Department of Environmental Protection Water Quality Specialist Supervisor. "We haven't identified the ignition source, but the vapors from the tanks were clearly at levels high enough to trigger the explosions, first in one tank and then in the other."

Well users in the area have relied on bottled water since the MTBE was discovered. Some of them have sued Tosco Refining Co., former owner of the Mobil station, and Exxon-Mobil Corporation, owner of the Exxon station. The explosions have raised new concerns about well contamination. ConocoPhillips and Exxon-Mobil have stepped up well sampling schedules to assess possible impacts on contaminant levels. Ongoing sampling is under review by PA DEP. The MTBE-impacted homes (i.e., MTBE levels above the cleanup standard of 20 ppb) have had point-of-entry filters installed. ■

Building a Better Internet Presence

Ten Things You Can Do to Improve the Performance of Your UST Web Site

by Ben Thomas

Technology can be a blessing and a curse when it comes to delivering technical assistance on underground storage tanks via the Internet. It's a blessing when you can provide UST operators with perpetual access to a plethora of rules, forms, lists, and documents to help them achieve operational compliance. But it's a curse when operators can't find what they want on your Web site.

Chances are the stuff they seek is there, but it's buried somewhere on your Web site. The good news is that you can fix this. All it takes is some analysis, design work, some coding, the nod of the boss, and violà! You improve your Web site, increase accessibility, and have a happier, more educated operator.

So, at that juncture of your next Web page update, consider the making following improvements:

1. Know your audience.

For a Web page to meet its goal of increased access to useful information, it must be tailored to its intended audiences. Who uses your Web page the most? Owners? Contractors? Consultants? Other government employees? Knowing your audience will help you organize your information so that it is as eye-catching and intuitive as possible. The most effective UST Web pages out there today are the ones intentionally designed to greet the target audiences the moment they show up at the front door.

Idea: Analyze your audience by percentage of user types, and see if your Web page is designed for those audiences. Redevelop the page as necessary, based on user type.

2. Realize that users don't read, they surf.

Internet users don't navigate through your Web page like you might think they do. Studies show that users don't really read introductory statements. They don't study any particular Web page at length. They don't read it like a book. Basically, they surf. They surf and surf and surf until they find what they want, and then they bail out. Users roam a Web page like a driver in a bustling city scanning for street signs. If a user wants an UST installation form, then the glowing "form" button is all they see; all else is blurrily irrelevant. If you understand better how a user typically navigates through your page, you can arrange the layout for optimal performance.

Idea: Study your Web page, and look for wordy distractions that could be culled. As Strunk and White suggest in their little book, *The Elements of Style*: "Omit needless words!" I would add to this:

- Relocate lengthy introductory statements with links or buttons that say something intuitive like "Mission" or "About Us."
- Remove or relocate esoteric topics.
- Use bullets to organize topics whenever possible by deleting accompanying text that doesn't help navigation.

Think of the sum of your Web pages as a series of traffic signs that are designed to get drivers to their destination as simply and clearly as possible.

3. Prioritize information.

If a user comes to your Web page looking for something basic like a form or a list of service providers, they shouldn't have to spend any time looking for the link. It should be obviously and immediately located right there at the top of the home page. Organize the links to these types of common items by making them abundantly apparent the second a user hits your page. Steve Krug's excellent book, *Don't Make Me Think*, says users who are scanning your Web page should need take only a few milliseconds to decide where to go next in search of their objective.

Idea: Write down what you think is the most popular information on your Web page, and see if you can find it at first glance on entering your Web page. Think of the top half of the first page as waterfront property—prime real estate. Use that space for all your mission-critical elements. The less common items should be relegated to the lower half of your page.

4. Keep your home page short.

Your home page, where your user presumably starts, should be short. Users generally avoid scrolling downward (and never, ever across) and with a well-designed home page, you have all the basics laid out in an intuitive fashion.

Idea: If you have a lengthy introductory page, chop it down to a one-pager. For example, shrink all text fonts (8 point is fine) except for topic headers. Shrink the banner (your logo). Summarize and hyperlink the common things people look for (e.g., news, forms, regs, documents, lists). Consolidate banners, navigation bars, and links to reduce the amount of empty space.

5. Avoid jargon.

While jargon helps streamline the language among regulators, it is a primary barrier to communication with the general public. Jargon only increases barriers to user comprehension. Nearly all UST Web pages out there could do with a little bit of jargon reduction. Even if you think your audience knows your particular flavor of acronyms, make your Web page super-intuitive by saying, for example, "Installation Form" instead of "State Form 27B-6."

Idea: Review your pages for acronyms, jargon, and shop talk. Remove this language that is not common or useful to the audience. The acronym "UST" is probably okay to keep. Use common language to highlight concepts.

6. Keep a uniform look to all pages.

This may seem obvious, but the more your Web pages all look the same, the more comfortable your user will be navigating through your site on the way to technical nirvana. Navigational bars, banners, fonts, and general layout should all be as similar as possible.

Idea: Scan your pages and look for thematic similarities among your pages. Correct the odd-duck sites and strive for a uniform look.

7. Use/fix navigation bars.

Navigation bars are common tools on Web pages these days, and every single one of your Web pages should have them. This lends itself to the uniform look mentioned above. Navigation bars should contain foundation-type links, such as "Contact Information," "Search," and "Index." Today's Web user has come to expect this navigational system and will look for these features on your pages.

Idea: Survey your pages and evaluate whether you have effective navigational bars, or whether you have them at all. Strive for simple, compact, consistent bars.

8. Avoid gadgets.

An ambitious and creative Web designer can easily get carried away with the arsenal of tools available to enhance a Web page—features such as animated graphics, scrolling banners, and snazzy background designs. Often, these gimmicks, if not tightly controlled, distract rather than enhance the content. We all know that the poor content of a speaker's message cannot hide behind the appeal of a nice-looking PowerPoint presentation. The same is true for a Web page. If the enhancement doesn't enhance, don't bother.

Idea: Review your page to determine whether your enhancements help or hinder. Have someone outside the program perform the assessment. When in doubt, go basic.

9. Provide a visually pleasing layout.

Users should get subliminally warm and fuzzy when they enter the realm of your Web site. They should feel a certain amount of ease and comfort because the information is laid out intuitively, and certain categories of information are smartly lumped together and compartmentalized. White space allows users to scan the page and zero in on what they want. Any white space should have the subliminal ability to guide users along. Poorly designed white space can confuse users in the matter of a split second.

Idea: Study highly successful Web pages such as **www.ebay.com** or **www.amazon.com**. See how they lay out a page. Study the use of white space, the lumping together of topics, the hierarchy of information, and the overall appeal, including font, colors, and background design. Then evaluate your page.

10. Have searchable databases.

A number of government Web pages have searchable UST and LUST databases. In these lucky states, operators, prospective property buyers,

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■ Web Pages *from page 33*

tank workers, and environmental consultants all have access to either thumbnail or exhaustive UST database files. Even mildly savvy Web users are coming to expect this sort of service. Plus, it will save you tons of time and money rooting though your database files.

Idea: Convince your database staff and your program manager that your Web page will be infinitely more effective if it has a searchable UST and LUST database. While your state may have database platform constraints and money issues, keep beating this drum. Like digitizing other UST services, it is a new thing and will only save you money in the end.

So What Makes a Great Web Page?

Layout, color scheme, organization, content? Obviously there are lots of things that make a Web page functional and attractive. Some things are apparent, but much has to do with what goes on in the subliminal realm. If users can surf effortlessly through your site, grab what they want, and leave, you've done your deed.

If I had to choose the most important element of having an effective Web page, it would probably be ease of navigation. All of the 10 elements listed here can be tied back to how easily a surfer surfs your site.

If you are one of those UST regulators who feels there aren't enough UST operators online to warrant a full-blown Web page analysis, don't despair. Web usage is increasing daily. By the time you finish your assessment, the numbers will have grown—and along with them the expectation for better, stronger, faster service. ■

Ben Thomas is a former UST regulator in Alaska. He created one of the first state UST Web pages to deliver in-depth technical assistance online. In 1997, he urged program managers at the national UST/LUST conference to seriously invest in the Web as a primary outreach tool. Today as an UST consultant, Ben is always looking for ways to improve access to information about tanks. His Web page is **http://www.bentanks.com**.

EPA HQ UPDATE

The United States Sues New York City Over UST Violations

The U.S. has filed a civil lawsuit in Manhattan federal court against the City of New York (NYC) alleging that since at least 1997 and continuing until today, the city has been violating RCRA in connection with its UST systems. NYC owns at least 1,600 federally regulated USTs in at least 400 locations throughout the NYC metropolitan area. The tanks are operated by at least 16 agencies or departments of the city.

The complaint charges that NYC has for many years and continuing until today committed numerous violations of RCRA and the UST regulations, including the failure to upgrade UST systems in a timely manner; and properly provide, operate, maintain, and/or monitor release-detection methods in a timely manner; maintain and furnish records concerning compliance with release-detection requirements; report, investigate, and confirm suspected releases of regulated substances; comply with performance standards for new UST systems; comply with requirements for closure of certain UST systems; and maintain and furnish records concerning closure of tank systems. The complaint seeks civil penalties and injunctive relief from the city.

EPA Issues a Unilateral Order to Chevron USA for a LUST Site in Chillum, MD

On November 26, 2002, U.S. EPA issued a Unilateral Order to Chevron USA, Inc., requiring it to investigate the release of petroleum products from a former Chevron service station on Riggs Road in Chillum, Maryland. The order also requires Chevron to develop a cleanup plan to address contamination associated with the release. The order became effective December 11.

A release of gasoline of unknown quantity was discovered in 1989 in response to an investigation of a traffic accident that damaged a premium unleaded gasoline dispensing line. The release was initially addressed by the Maryland Department of the Environment (MDE); however, after many years of pump-and-treat and monitoring, MDE notified the District of Columbia Department of Health in April 2001 that a gasoline plume had migrated into a residential area in D.C. Current data indicate that the plume has migrated approximately 1,600 feet into D.C.

In October 2001, due to the jurisdictional issues of cross-state contamination and at the request of D.C. elected officials and citizens, U.S. EPA Region 3 assumed responsibility for the site. When Chevron has completed its investigation and recommends a cleanup plan, EPA will evaluate the plan and make it available for public comment.

16 States Pilot Test Significant Operational Compliance

Sixteen states, including at least one from each Region, have volunteered to take part in pilot testing EPA OUST's draft revised significant operational compliance (SOC) performance measures. These revised measures are the product of an EPA/state work group that first met in June 2002. Each state conducted a minimum of 20 inspections of UST facilities, checking for compliance with regulations contained on two matrices, one for release prevention and the other for release detection. The results from these pilot tests have been analyzed and were presented at the annual UST/LUST National Conference in March 2003. OUST expects that when these measures become final, the agency will be able to obtain from the states more accurate and nationally consistent data regarding compliance with regulations designed to prevent and quickly detect releases. For more information, contact Jerry Parker at (703) 603-7167. ■

Your Vote is Needed!
Should L.U.S.T.LINE Go Electronic?

Dear Readers,

These are extraordinarily tough times for state UST/LUST programs. In such times, a publication such as *LUSTLine* can play a critical role. Ever since our first issue in 1985, we have worked hard to keep our readers up-to-date on UST/LUST issues. We promise to continue to stay on top of these issues and to address your concerns. This is, after all, *your* publication.

Like so many of your state and federal programs, we are not immune to budget concerns. In the interest of cutting costs, EPA's Office of Underground Storage Tanks, the grantor of this publication, has asked us to look into having *LUSTLine* go electronic. This would mean dropping the current print version and instead delivering *LUSTLine* to you as a PDF file via e-mail.

We know that *LUSTLine* is a valuable source of UST/LUST/state fund information for many readers and that some of you save your issues for reference purposes. This is why we instituted the index. On one hand, such archiving of a hard copy isn't so simple with a PDF file. On the other hand, an electronic *LUSTLine* would enable you to read it via computer or print it out and read it at your leisure.

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Should L.U.S.T.LINE go totally ELECTRONIC?

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See page 35.

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