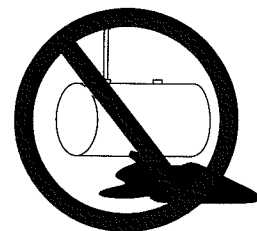


L.U.S.T.LINE



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

Where Do We Go From Here?

UST Program Direction for 1999 and Beyond

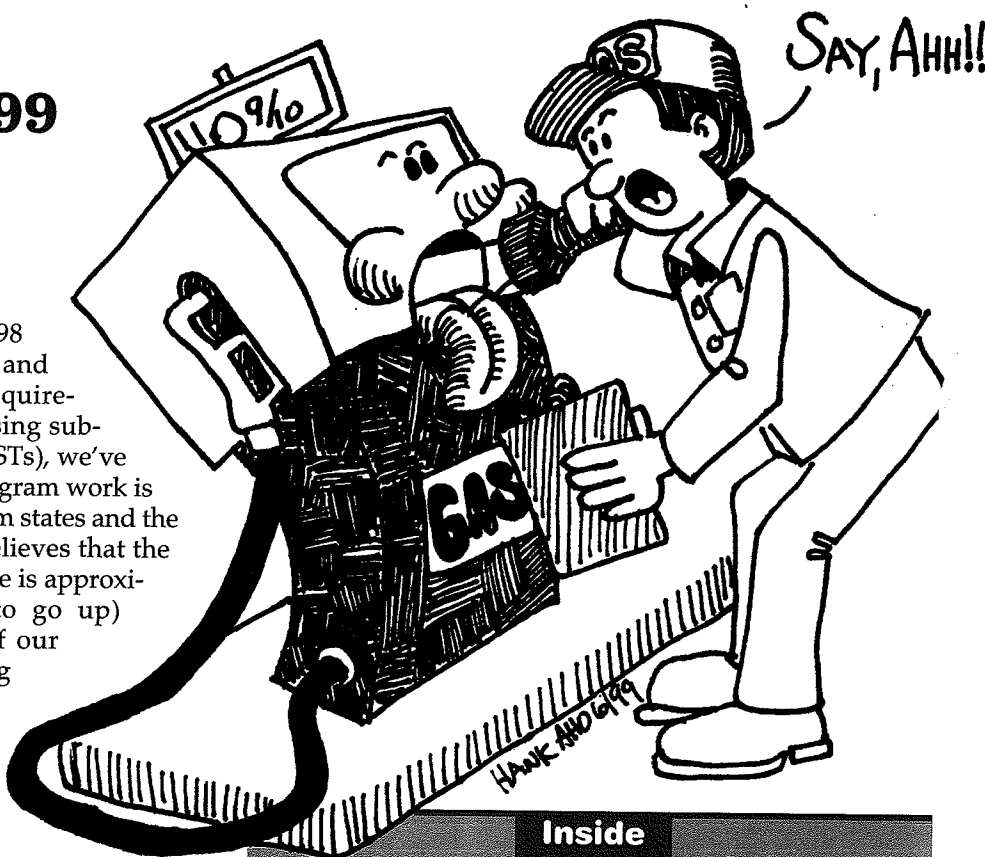
by Sammy Ng

With the passing of the 1998 deadline for tank owners and operators to comply with requirements for upgrading, replacing, or closing substandard underground storage tanks (USTs), we've heard some people suggest that UST program work is now complete. Based on information from states and the Petroleum Equipment Institute, EPA believes that the rate of compliance with the 1998 deadline is approximately 80 percent (and continuing to go up) nationwide. So, it is true that some of our work is done—but the job of ensuring that all owners comply with the technical requirements, including leak detection requirements, is far from over.

We are concerned, for example, that although owners may have installed leak detection equipment on their tanks, a significant percentage of these systems may not be operated or maintained properly. EPA and states need to work with owners to raise leak detection compliance awareness and, in doing that, ensure a higher level of compliance. In short, we need to ensure that we prevent the next generation of leaking tank systems.

We do not, however, plan to promulgate new regulations as a means to make progress on the remaining work. Instead, EPA will work closely with states to improve compliance rates. We will also continue to work cooperatively with owners, industry, and regulators to ensure that preventing releases from USTs becomes a common business practice and that, if releases do occur, they are addressed in an appropriate and cost-effective manner.

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■ Where Do We Go? from page 1

Over the past year, the EPA Office of Underground Storage Tanks (OUST) has worked with

We still have a great deal of work to do to prevent leaks, address the approximately 170,000 cleanups yet to be completed, and ensure that human health and the environment are protected.

numerous UST program stakeholders and gathered feedback regarding the state of the UST program. This research confirmed that we still have a great deal of work to do to prevent leaks, address the approximately 170,000 cleanups yet to be completed, and ensure that human health and the environment are protected.



LUSTLine

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As a result, we've identified the following priority areas where we will focus our efforts over the next few years: UST systems evaluation; operation and maintenance of UST systems; tanks temporarily closed to meet the 1998 deadline; corrective action; and USTs in Indian Country.

So let's look to the future of the UST program and discuss how we plan to use these initiatives to take the program through 1999 and beyond.

UST Systems Evaluation

A significant challenge to the UST program is to prevent leaks by ensuring that tank systems are safe and managed properly. Although most UST systems are equipped to meet the technical requirements, we need to ensure that properly equipped UST systems do, in fact, protect the environment. That means we need to evaluate those systems.

EPA will work to help states evaluate the effectiveness of UST systems, particularly in terms of leak detection, cathodic protection, and lined tanks, to ensure they operate properly and to identify ways in which they can be improved.

Anecdotal evidence suggests that UST systems performance has improved greatly compared with that observed just a decade ago. However, we need to conduct a more comprehensive effort to check these anecdotes against reality and identify areas that need to be improved. EPA is interested in field performance over time, which portrays the real situation, rather than performance in factory testing, which shows only the best possible results.

The UST program is taking initial steps to begin this evaluation work, including conducting a University of California-Davis study of leak detection system performance, gathering qualitative input from experienced people in the business, and compiling existing studies and data bases. These efforts will help us verify and validate how effectively leak detection and other UST systems are working.

Operation and Maintenance of UST Systems

To achieve the goal of preventing another generation of leaking USTs,

EPA has targeted operation and maintenance (O&M) of UST systems as a priority. We've heard that owners and operators often do not have adequate knowledge of facility equipment and procedures and that, partly because of employee turnover, owners and operators need to be kept informed about and educated on the proper methods for using their equipment on a continuing basis. EPA wants to work to resolve this dilemma and ensure that owners and operators are properly operating and maintaining their UST systems and employing quality tank management practices.

As a preliminary step, we have formed an EPA-state workgroup whose goal is to develop ideas into useful products. In addition, we are working with the U.S. Postal Service to assist the agency in developing its O&M plan and to foster an exchange of ideas and information between our two agencies. Over the next few months, we will gather O&M information and work with the many stakeholders (other EPA offices, states, industry, trade associations, and other interested parties) to implement quality O&M ideas.

Although most UST systems are equipped to meet the technical requirements, we need to ensure that properly equipped UST systems do, in fact, protect the environment.

Temporarily Closed Tanks

To meet the 1998 upgrade requirements, many owners temporarily closed their tank systems. EPA estimates that, as of February 1999, the number of temporarily closed tanks was approximately 73,000. Perhaps these owners were not ready or able to make final decisions by December 1998 about the future of their tanks. However, it is important for the owners of these tanks to remember that temporary closure of substandard systems may not exceed 12 months, unless the implementing agency grants an extension.

Owners who chose to close temporarily should not forget the "tem-

porary" limitation on their closure. They should be taking steps now to close permanently, upgrade, or replace their USTs within the 12-month time limit. State and federal regulators will be working to ensure owners take appropriate action regarding temporarily closed USTs.

Corrective Action

EPA's work in the corrective action area has been, and will continue to be, extremely important to the UST program's success. As of March 1999, there were approximately 170,000 cleanups that had not yet been completed; EPA estimates that as many as 80,000 additional releases may be confirmed before 2005. As you are well aware, the UST program has a reputation for keeping current with change, as well as for serving as a model for other environmental programs. In that vein, we are continuing our corrective action efforts in two innovative areas: risk-based decision making (RBDM) and pay for performance (PFP).

EPA is advocating the use of RBDM at corrective action sites. RBDM provides UST implementing agencies with a reliable process to help them determine the extent and urgency of corrective action as well as the scope and intensity of their oversight of corrective actions.

We are seeing progress in this area as the varied stakeholders—federal, state, and private sector—work cooperatively to foster change. EPA is measuring RBDM performance in pilot programs by analyzing the effects of RBDM on reducing risk, expediting closure of impacted sites, and improving cost control and resource allocation. Some of the early results we've seen suggest that where states have used RBDM, they have realized increased closure rates and benefited from a decreased backlog of releases.

We are also championing the use of a pay for performance approach for UST cleanup work. The PFP concept is based on the premise that states pay cleanup contractors only for actual contamination reductions. Real results are showing that these PFP cleanups can reach environmental goals up to twice as fast as those using traditional ways of paying for UST cleanups—and they are as much

as 35 to 50 percent less costly! EPA is working with states, other federal agencies, and interested private entities on ways to create and operate PFP cleanup programs and is continuing to document the effectiveness and efficiency of this concept.

EPA is also developing strategies for reusing "USTfields," those commercial and industrial sites where gasoline and other regulated substances from underground storage tanks have contaminated the environment. After corrective action work has been completed, USTfield properties can be restored and

It is important for the owners of these tanks to remember that temporary closure of substandard systems may not exceed 12 months, unless the implementing agency grants an extension.

reused, and can serve as an asset to the community. We are working to prevent future USTfields and encouraging states to use scientifically sound, rapid, and cost-effective corrective action at leaking underground storage tank sites.

USTs in Indian Country

EPA has primary responsibility for implementing the UST program in Indian Country. There are approxi-

mately 3,000 active USTs in Indian Country, as well as approximately 3,700 closed USTs that may need additional remediation work. The major challenges for these UST owners and operators are finding the resources to operate their USTs properly and paying for cleanups if a release occurs. Because of some national and state institutional barriers for providing funds for UST work in Indian Country, we are taking steps to ensure that owners and operators will continue to make progress on both counts.

Let's Keep Up the Good Work

Finally, we greatly appreciate the exemplary efforts over many years of all owners, industry members, and regulators who have worked so diligently to prevent and clean up leaks from underground storage tanks, thereby keeping the nation's groundwater protected. Together we have made significant progress and can be quite proud of our accomplishments. By continuing to work together, we will make advances in making sure that the prevention of leaks is a common business practice. ■

Sammy Ng is the Acting Director of the U.S. Environmental Protection Agency's Office of Underground Storage Tanks (OUST). He previously served as the office's Director of the Policy and Standards Division and as chief of the Regulatory Analysis Branch. Sammy has worked in OUST since its inception in 1985.

L.U.S.T.LINE INDEX

August 1985/Bulletin #1 - March 1999/Bulletin #31

At Long Last...

The missing piece to the LUSTLine puzzle is in place!

The LUSTLine Index—the long and action-packed story of USTs and LUSTs in the late 20th century is here for you. (In fact, subscribers received their copy with this issue of LUSTLine.)

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Leak Prevention

UST System Performance Evaluation

Sorting Out the Nature of the Beast

by David Wiley

Now that the 1998 deadline for upgrading, replacing, or closing substandard UST systems has passed, we may need a rest—in fact, we may deserve a rest.

Break's over! Back to work.

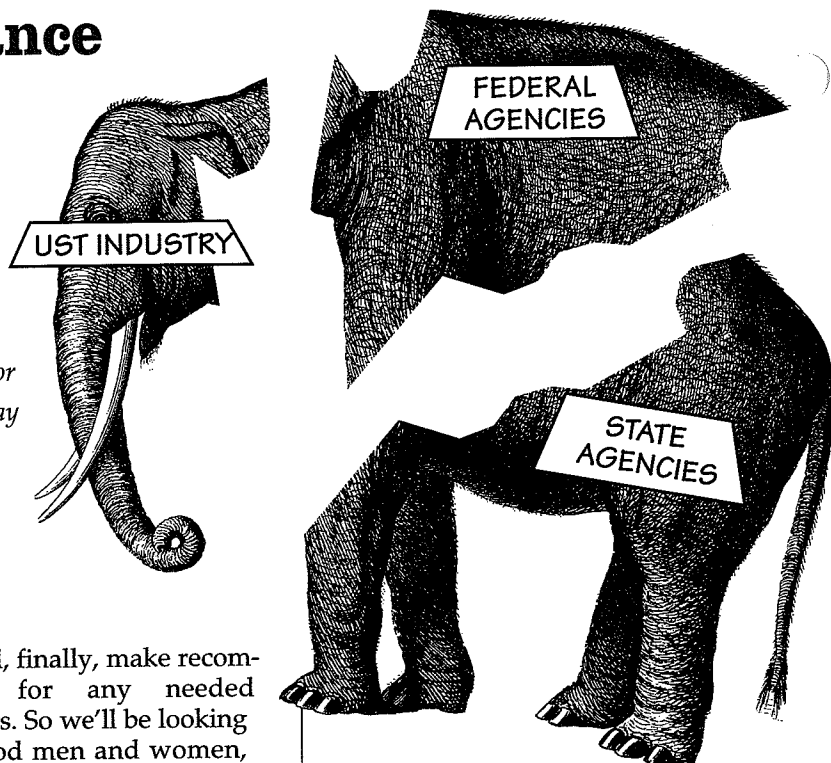
The challenge of achieving sound tank systems management is not over—one of the remaining priorities facing the UST program is improving operation and maintenance. (See "Where Do We Go From Here?" on page 1.)

In keeping with this challenge, we must also undertake the task of evaluating of how well UST systems are doing their job. We need to dig in and try to find out what's working, what's not, and why not. We need to zero in on real-world performance—in the field and over time—not just fresh-from-the-factory performance.

Because no one entity has all the relevant information needed to carry out this task, cooperation from both industry and regulatory agencies is essential. It's a bit like the story of blind-folded people describing an elephant. If each one draws a conclusion based on just one perspective, the picture is likely to be somewhat distorted. But if all parties talk (and listen) to each other, the true nature of the beast becomes clear.

Looking at All the Angles

The UST program is now following plans to evaluate performance from multiple angles. A nationwide study of leak detection system performance is now under way (but it's not too late to become a participant!). We've begun gathering existing studies and databases, plus new information and wisdom from "old hands" in the business. Next, we'll beef up our peer input (interested?), move partnering with states and industry (that's you) to an expanded level, analyze the



situation, and, finally, make recommendations for any needed improvements. So we'll be looking for a few good men and women, and we'll be asking them questions:

- Are you an experienced contractor or regulator with tales to tell?
- Do you have any studies of UST system performance?
- Do you have both UST and LUST site data (which would allow comparisons between the components/technologies used and the likelihood of leaks)?
- How well are UST systems doing their job? What are the root causes of remaining—or new—problems?
- What UST areas do you think need more or less attention?
- Can you help us get a handle on UST system performance (even if it's just relating experience over the phone)?

It is important that we do this work well and with conviction—an

honest evaluation will benefit everyone in the UST community, except perhaps providers of poor equipment and "fly-by-night" services. Let's share our individual "views" of the UST system animal as we move ahead. If you are interested in participating in this evaluation effort as a contributor of information or as an independent peer reviewer, contact David Wiley at wiley.david@epa.gov or (703) 603-7178. ■

David Wiley is an Environmental Engineer with the EPA Office of Underground Storage Tanks (OUST). He coordinates OUST's leak prevention technical program, leads the EPA portion of the UST system evaluation effort, and participates in the national Work Group on Leak Detection Evaluation.

FYI

A recent EPA Office of Research and Development report, "Oxygenates in Water: Critical Information and Research Needs," looked at all known research projects related to determining the presence of oxygenates in water (and to keeping oxygenates out of water). As of December 1998, only 3 of 77 known projects dealt with leak prevention. (U.S. EPA, EPA/600/R-98/048, Dec. 1998, Appendix 2)

Leak Prevention

Tanks Down East

by W. David McCaskill

David McCaskill is an Environmental Engineer with the Maine Department of Environmental Protection. **Tanks Down East** is a regular feature of LUSTLine. As always, we welcome our readers' comments.

Convenience Is Nice, But UST Systems Aren't Potato Chips

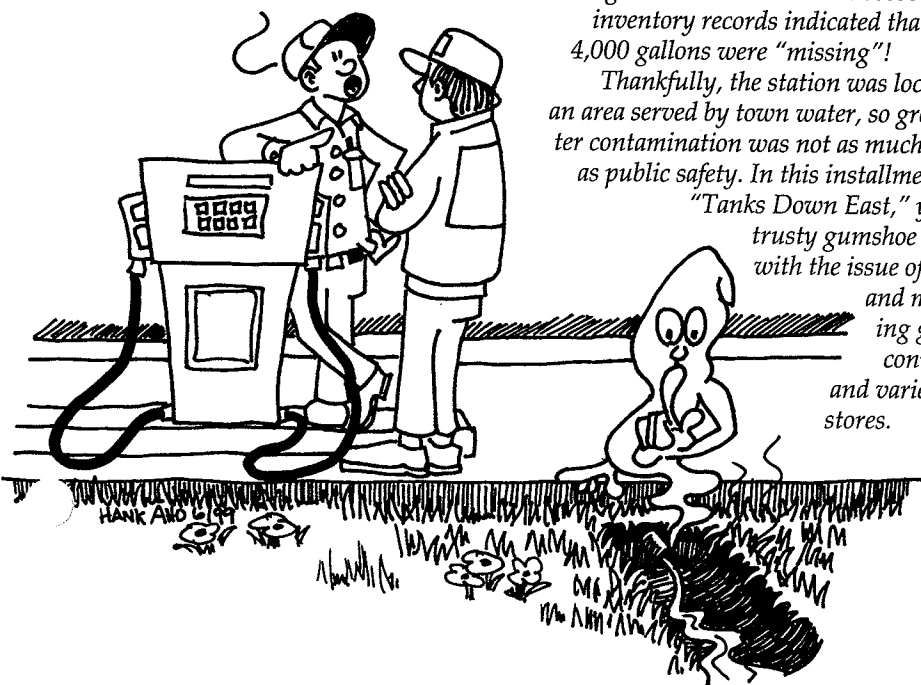
Life sure seems busy! During the week, we're busy filing into our local, super convenience store, fueling our car with gasoline and ourselves with designer coffee and gourmet danishes. On the weekend, we spend time driving our gritty, salt-sprayed, progeny-packed SUV back to the local convenience store to retrieve that showroom shine at the high-tech, brushless car wash. Then when we need our 3,000-mile oil and lube, we head right back to that very same convenience store. Yep, there's a lot going on at your typical, modern, co-branded convenience store. And just as we customers like our conveniences, so do tank owners and operators.

I'm thinking of one local convenience store just off I-95 and right down the road from a certain high-customer-traffic outlet town known for its rubber-bottom boots. The store has a high-throughput, highly pressurized fueling system that is just as high-tech as the coffee and the carwash. It's got double-walled tanks and piping, continuous interstitial-space monitoring, automatic tank gauges, line leak detectors—the works. The system is so well endowed, you'd think it could handle all its own affairs and make its own coffee to boot. But that's where we often fail our UST systems—we depend on them to do too much all by themselves.

Last March, the owner of this Maine facility got a major jolt that no high-test designer coffee could induce—raw gas came gurgling out of the adjacent storm drains! The troops, including the town fire brigade, a Maine Department of Environmental Protection (MDEP) responder, and the cleanup contractor with his ever-ready industrial-strength vacuum cleaner, were dispatched to the site. Over the course of two weeks, about 3,000 gallons of gasoline and water were recovered, but inventory records indicated that around 4,000 gallons were “missing”!

Thankfully, the station was located in an area served by town water, so groundwater contamination was not as much an issue as public safety. In this installment of “Tanks Down East,” your trusty gumshoe will deal with the issue of siting and maintaining gasoline convenience and variety stores.

And now, thanks to my double-walled tanks and piping and my sophisticated leak detection system—I don't have to worry!!



The Murky Details

So how the heck did 4,000 gallons slip through the multiple defenses of this very model of a modern storage system? Well, as with many such cases, it was the combination of cascading equipment failure combined with faulty follow-up.

This UST system consisted of double-walled fiberglass tanks and pressurized double-walled piping. In this type of piping system, the product is moved from the tank to the dispenser and nozzles by a submersible pump inside the tank. The product is sucked out of the tank by the pump to a manifold that sits on top of the tank, where it is then pushed up through the piping.

In this installation, the submersible pump manifold, which contains electrical connections to the motor and plumbing to the piping, is housed in the containment sump so that any leaks from the pump or piping can be contained and monitored. The sump itself is attached to the tank opening via a pressure plate and rubber gaskets.

This piping system is monitored for leaks in two ways. The first is a line leak detector—a device used to monitor for catastrophic piping leaks (i.e., three gallons per hour or more) and located, in most cases, in a port on the submersible pump manifold. The line leak detector will only detect three gallon per hour leaks downstream of where it is installed.

Second, smaller leaks are detected by leak detection sensors, which are located near the bottom of the containment sump. Most of these probes are micro float switches,

■ continued on page 6

■ Tanks Down East from page 5

which, when immersed in liquid, make an electrical contact, sending an alarm to the control box.

The stage is set, so now let's see how this chain reaction got started and what kept it going.

On March 10, a contractor was called to investigate a customer complaint about a low-flow condition at the dispenser nozzles. Gasoline was found dribbling out of the pump manifold, and about one-half gallon had pooled in the bottom of the sump. The pump manifold was opened and fibers from an ingested sorbent pad were found to be restricting the flow. A failed gasket was replaced, and product was removed from the sump.

On March 11, the gasoline gurgled out of the storm drain and the troops arrived.

On March 12, the contractor was called back to the site to test the product line for the unleaded tank, which was found to be tight; however, when the containment sump was tested by filling it with water, all the water leaked out. Further investigation found that the gasket at the bottom of the sump was torn and had allowed product to leak out.

Later, a review of the electronic alarm history by the MDEP showed sump alarms on December 21, 1998, January 3, 1999, and March 3, 1999. The owner stated that the first two alarms were the result of water infiltrating through the sump covers during a storm event (rain). Each time the alarm sounded, the manager had removed about two inches of water from the sumps. The owner stated that the manager was not aware of the March alarm.

A review of the inventory showed a loss of around 4,000 gallons of gasoline from March 3 to March 11.

Vigilance Matters

What could have been done to prevent this problem? It boils down to maintenance and vigilance. The system, as a whole—pump, line leak detector, containment sump—missed the boat, and someone didn't respond to the sump probe alarm (or at least not appropriately).

This UST system was literally screaming for help, but unfortunately the operator probably thought that it

was crying "water in the sump" wolf. The clues to this catastrophe were all there, but no one person heeded them all or knew what they all meant. Someone needed to step back and put the whole thing together.

In the design of the storage system, the owner could have elected to install fiberglass sumps, which are bonded directly to the tank and thereby eliminate the reliance on a gasket. Also, I believe that all containment sumps should be tested annually for leaks by filling with them with water to see if any leaks out.

As for false alarms caused by "nuisance" water coming through fitting penetrations and sump covers, the industry has been striving to develop a totally liquid-tight sump and, for the most part, has...well, they're gettin' there. However, we still have to contend with retrofitting those older first- and second-generation sumps that remain.

Station owners need to be more vigilant in inspecting and responding to problems. Another long-time station owner who now teaches UST management courses told me of a similar event at his station some years ago. As in the first story, he had a pressurized piping system with containment sumps, line leak detectors, and leak detection float switches.

As a cagey, veteran service station owner, he recognized the folly of relying solely on the technology, so once a month he would open up his containment sumps to take a look-see. During one of these monthly walkovers, he found, much to his horror, a sump a couple of inches shy of being full of gasoline!

In this case, the leak occurred near the top bolts of the actual line leak detector; since it couldn't check itself, it never "saw" the leak. The sump leak detection floats were physically stuck in place and could not float up with the product and signal a leak.

Facility Siting Matters

The sites mentioned above were in areas where water supplies were not threatened. In the case of the station mentioned in LUSTLine Bulletin 31, "A Little Drop'll Do Ya," and Bulletin #30, "The Holes in Our UST Systems," a modern convenience store was allowed to be located within 1,000 feet of a water supply well field.

For whatever reasons, the town carved an area out of its mapped wellhead protection zone so that the station could be built. Within less than a year of operation, MTBE was found in low ppb concentrations in the water district's monitoring wells and production wells (7,000 ppb concentrations were found in the tank excavation area).

The source of contamination was most likely several 10-gallon overfills, something that happens when fuel delivery truck drivers override the overfill prevention device. A driver may think he's filling a 10,000-gallon tank, but in reality, he is dealing with a 9,700-gallon tank. So, on occasion, he is stuck with a hose full of product. Because he has more in the truck compartment than the UST can hold, he empties the hose into the 3-gallon spill bucket and the rest spills over and seeps into the surrounding soil. Again, our fancy technologies will do little good if we don't fully understand how they work.

One year after responding to the MTBE problem at this site, perchloroethylene was detected in the monitoring wells and traced back to the store's septic tank and sink traps!

We don't know how or why perc was poured down the cleaning sink. The real lesson here is that this site is too sensitive for a convenience store or just about any other type of land use that could accidentally discharge a contaminant into the environment.

The real shame is that the water district will abandon this precious resource and pipe water at great expense to the area from a surface source.

Yes, Facility Siting Matters

Another case I know of involves a typical small mom and pop (except in this case, pop has a ponytail) variety store that sells gas. The store is located less than 1,000 feet from a major sand and gravel municipal water supply well.

For several years, the water district fought to prevent the construction of the store. Nevertheless, in the

This UST system was literally screaming for help, but unfortunately the operator probably thought that it was crying "water in the sump" wolf.

early 1980s it came to be, decked out with a suction piping system and bare steel tanks. In 1990, MDEP staff inspected this site and found that piping under the pump island had been damaged, most likely as the result of a car running into the dispenser.

The investigation that followed found minor contamination around the fill pipe, but much more from leaky aboveground suction pumps. Again, the tanks and underground piping were not the problem. The problem was that the leaks could have been caught early through simple, routine inspection.

By the grace of Gaia, the water district had installed a monitoring well system as part of its wellhead protection plan. This system allowed MDEP instant access to groundwater data to help expedite its plan of attack. Thankfully, the story ended well, with only the fairy edge of the gasoline plume tickling the production well with low and ephemeral hits of MTBE—but at a cost of \$600,000 to pay for a multiphase remediation system and two years of water piped in from the adjacent town

The Sermon

It's clear that some of these stations should never have been allowed to be built so close to major water supplies. Unfortunately, many towns and cities suffer from the all-consuming lust for property taxes, and we, the consumers, suffer from the insatiable need for convenience. We're such slaves to technology that we forget how far a little horse sense can go. No matter how good the storage technology, it is still true that an ounce of siting prevention is worth many hundreds of thousands of dollars of remediation.

In many cases, tank owners and operators think they can simply buy the convenience of compliance. But technology ain't all it's cracked up to be, and it is up to owners and operators to keep a vigilant eye on things. Large industrial plants go to great lengths to physically check and double-check processes that involve dangerous chemicals. Station owners, operators, and employees need to treat their facilities in much the same way, because gasoline is not potato chips—it is a dangerous chemical that is both toxic and flammable. ■

TIPS FOR TANK OWNERS AND OPERATORS

Maintaining a modern gas station is a team effort. Here are some timely tips for reducing your environmental impact.

Customers

- ✓ Encourage customers not to top off their tanks. This will reduce the likelihood of spills that could cause fires and contaminate groundwater and surface water.
- ✓ Place signs on the dispenser, encouraging customers to report problems, such as slow flow, excessive vapors, and spills, to the attendant.

Employees

- ✓ Hold monthly environmental, health, and safety meetings to review emergency response protocols with employees.
- ✓ Be sure employees know the meaning of all environmental and fire alarms, the correct response, and the consequences for not reacting properly.
- ✓ Educate employees on the dangers of gasoline and other chemicals with which they come in contact at work. (OSHA law 1910.120, Hazardous Communications)

Owner/Operators

- ✓ Understand how your UST system works, and read the operation manual for your leak detection system.
- ✓ Make sure you know how much fuel you can actually put in your tanks. You must know at what liquid level your overfill prevention devices are activated. Do not order more fuel than a tank can hold!
- ✓ Walk your facility site once a day to look for obvious signs of discharges (e.g., strong vapor odor, distressed or dead vegetation).
- ✓ Inspect containment sumps and look under dispensers once a month.

Tank and Pump Contractors

Once a year:

- ✓ Test and calibrate all electronic leak detection devices per manufacturer's recommendations.
- ✓ Leak-test all containment sumps with water.
- ✓ Inspect all fire safety equipment (i.e., proper anchoring and operation of crash valves and hose breakaways). These devices prevent fuel from spilling from pressurized piping systems if the dispenser is hit or a customer drives off with the hose still in the tank.
- ✓ Physically check all leak detection probes for proper operation. Make sure float sensors in containment sumps work by either immersing them in water or employing some other method described in the operation manual.
- ✓ Physically inspect all overfill devices for proper operation (i.e., do they shut off or set off the alarm at the prescribed level?). This step includes extracting ball float valves to make sure the cage hasn't rusted away.
- ✓ Perform quantitative 3 gallon per hour leak tests on both mechanical and electronic line leak detectors. These devices are very important, because they are designed to guard against catastrophic releases.

Fuel Delivery Drivers

- ✓ Contract with your fuel delivery company to ensure that all spill buckets are free of product after delivery, so that excess product does not float out during a heavy rain.
- ✓ Be sure delivery drivers understand how your overfill prevention device works.
- ✓ Observe your driver during a delivery to make sure that he or she is meeting requirements.

Leak Prevention

Tank -nically Speaking

by Marcel Moreau

Marcel Moreau is a nationally recognized petroleum storage specialist whose column, *Tank-nically Speaking*, is a regular feature of LUSTLine. As always, we welcome your comments and questions. If there are technical issues that you would like to have Marcel discuss, let us know.

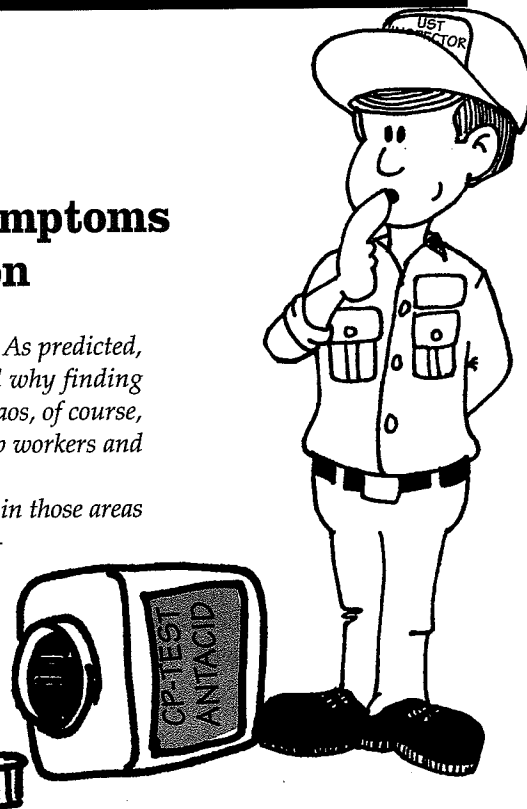
Combatting CP-Test Heartburn

A Thoroughly Documented CP Test Is the Recommended Antacid for Coping with Symptoms Associated with the Common CP Inspection

After 10 long years, the '98 deadline can finally be talked about in the past tense. As predicted, many storage system owners waited 'til the end was nigh and then wondered why finding people to do the work was like looking for water in the desert. Amidst all this chaos, of course, were the entrepreneurs who, upon seeing financial opportunity knocking, rummaged up workers and provided the "services" needed to meet tank owner demands.

The result is that a lot of shoddy tank work has been done in recent years, especially in those areas of the tank upgrade market that are attractive to tank owners on tight budgets—tank lining and cathodic protection (CP). Although the potential problems created by fly-by-night lining contractors may be buried and hidden from the inquisitive eyes of the typical UST inspector, there are some things that inspectors can see with regard to a cathodic protection retrofit—things that can give an inspector pause, if not heartburn.

Unfortunately, no matter how poor the workmanship, an inspector has little to say about the cathodic protection installation, as long as it has been blessed by a legitimate "corrosion expert" as defined in the rules and explained in EPA memos. (Refer to LUSTLine #23 for a description of qualified personnel.)



What Constitutes an Acceptable CP Test?

I do believe, however, that the regulatory inspector has some say when it comes time to evaluate the performance of a cathodic protection system by conducting the initial CP test or the triennial CP test. Here's how:

The federal rule (40 CFR 280.31(b)(2)) contains no specific CP test criteria; it defers instead to industry standards such as NACE RP0285, "Control of External Corrosion on Metallic Buried, Partially Buried, or Submerged Liquid Storage Systems." (The current edition of this document, RP0285-95, has a slightly different title, "Standard Recommended Practice—Corrosion Control of Underground Storage Tank Systems by Cathodic Protection.")

This NACE standard and others that I have reviewed describe specific testing criteria and methodologies for making measurements but provide

precious little guidance about what constitutes an adequate CP test. There are no specifications concerning how many measurements should be made or how thoroughly a CP tester should investigate a system. These types of decisions are apparently left to the discretion of the tester, leaving the door wide open for some testers to be thorough and others to be quick.

Because the requirements for a CP test are not specifically spelled out in the federal regulations or industry standards, it seems appropriate for regulators to fill the void and set a minimum standard for what constitutes an acceptable CP test. The folks in EPA Region 4 did just that; they developed a standardized form to be used when documenting the results of a CP test of an UST system.

What data should be recorded during a CP test and why are these

data important? A properly conducted and documented CP test will determine whether a CP system is adequately protecting its associated storage system. If the storage system is not protected, then all of the blessings of a CP expert are moot, and the system must be made to work.

A thorough, properly documented CP test should enable a knowledgeable reviewer to answer three questions about an UST system:

- Are sufficient data presented in the test report to evaluate the test results?
- Were a sufficient number of appropriate measurements conducted during the test to fully evaluate the storage system?
- Were appropriate CP test criteria used to arrive at a pass or fail test result?

Let's review each of these questions. But first, some caveats. To keep the

following discussion from becoming an epic, I have limited the scope to the "typical" underground storage system at the "typical" convenience store or service station. I am assuming that the reader understands the mechanics of making CP measurements (See LUSTLine #25, "Testing Cathodic Protection Systems," for a refresher) and has some knowledge of CP principles. While I believe the discussion that follows is generally applicable to most storage systems, no doubt valid exceptions exist to the information and opinions presented.

Are Sufficient Data Presented in the Test Report to Evaluate the Test Results?

All too many CP test reports merely indicate that on a certain day a certain facility was tested and that the storage system(s) "passed." In some cases, a number may be added (e.g., "-0.911 volt—pass"). In some cases, especially where the monitoring results are less favorable, a number (e.g., "-0.777"), without even a pass or fail conclusion, is the extent of the test documentation.

Such results are incapable of being evaluated, because there is nothing to evaluate. Simply not enough information is presented to determine whether the second and third questions listed earlier have been adequately answered.

My criterion for an adequately documented CP test is simple: There should be sufficient documentation so that any knowledgeable CP tester should be able to return to the facility and make the same measurements in the same places.

This criterion means that there should be fairly exact descriptions of where the reference cell was located, where connections were made to the cathodically protected structure, and what types of measurements (e.g., continuity, current-on, instant-off, polarization change) were conducted. There should also be a pass/fail conclusion and a statement describing which CP criterion was used to reach the pass/fail conclusion for the test results.

Such detailed documentation is critical to a long-term understanding of what is happening to a CP system. If performance of a system is to be compared from one CP test to the

next, all CP tests must be conducted in the same way. A remote "current-on" reading cannot be compared to a tank-top "current-off" reading. A reading where the reference cell comes in contact with soil cannot be compared to a reading where the reference cell is placed on concrete. Unless measurements are made in a nearly identical fashion each time a CP system is evaluated, comparison of CP test measurements conducted at different times is meaningless.

Because the requirements for a CP test are not specifically spelled out in the federal regulations or industry standards, it seems appropriate for regulators to fill the void and set a minimum standard for what constitutes an acceptable CP test.

Were a Sufficient Number of Appropriate Measurements Conducted to Adequately Assess the CP System?

I have monitored many systems, both impressed current and galvanic, where portions of a tank met acceptable criteria for cathodic protection, but other portions of the same tank did not. Cathodic protection is not an all-or-nothing phenomenon. It is the rule, rather than the exception, that different portions of a storage system will have different levels of protection, depending on distance from the anodes, areas of localized coating damage, variations in moisture content of the backfill around the storage system, and a host of other variables.

Therefore, it seems unreasonable to accept a single measurement with a reference cell in a single location as evidence that a storage system is adequately protected. Yet many CP test reports contain a single number for a tank. In some cases, tests of galvanic CP systems are conducted by moving the reference cell around until a "passing" reading can be obtained—regardless of whether the reading is local or remote, on concrete, or on the metal ring of a manway. Once this "passing" number is found, all other readings are discarded.

The UST rules require that all portions of a storage system that rou-

tinely contain product and that come in contact with the soil be adequately protected against corrosion. Thus a storage system must be thoroughly evaluated to ascertain that all portions of the tank and piping are protected—not just the end that happens to be close to a working anode.

In my opinion, voltage measurements for a standard-sized motor fuel tank should be made with the reference cell in at least three locations: one with the reference cell at one end of the tank, one on the other end, and one in the middle. The reference cell should be placed as close as possible to the top centerline of the tank. If the tank is completely covered by concrete or asphalt, then holes should be drilled into the concrete or test stations installed to provide access to the soil for placement of the reference cell.

Voltage measurements fall into two categories: current-on and current-off. Current-on measurements are conducted with the protective current applied (i.e., with the sacrificial anodes connected or the rectifier power turned on). Current-off measurements are conducted with the protective current turned off (i.e., with the sacrificial anodes disconnected or the rectifier power turned off).

Current-on measurements are the only option possible for virtually all galvanic systems installed on storage tanks, because the anodes are permanently attached. Both current-on and current-off measurements should be conducted for impressed current systems. The current-on measurements indicate the distribution of current on the structure and where the weak spots in terms of protection may be located.

The current-off (instant-off) measurements indicate whether the 0.85 volt current-off criterion has been met or what the starting point for the 100 millivolt polarization decay measurement is. If the 0.85 volt current-off criterion is not met, then voltage readings tracking the polarization decay should also be conducted and recorded, unless native potential readings are available to establish that the 100 millivolt polarization change criterion has been met.

Galvanic and impressed current systems should also include a conti-

■ *continued on page 10*

■ Tank-nically Speaking from page 9

nuity survey to establish that components, such as tank fittings, risers, and vents, are either isolated (galvanic systems) or continuous (impressed current systems). (See LUSTLine #25, "Testing Cathodic Protection Systems," for information on how to conduct a continuity measurement.)

Were Appropriate CP Test Criteria Used to Arrive at a Pass or Fail Test Result?

The appropriateness of CP criteria is one of the more prominent hot buttons among CP professionals. (For a great compilation of the CP criteria literature, see the 500-page NACE publication, "Cathodic Protection Criteria—A Literature Survey," published in 1989.) The 1995 edition of NACE Standard RP0285, "Standard Recommended Practice—Corrosion Control of Underground Storage Tank Systems by Cathodic Protection," contains three acceptable criteria for cathodic protection:

■ 0.85 volt (850 millivolts) current-on, defined as follows:

A negative (cathodic) potential of at least 850 mV with the cathodic protection applied. The potential is measured with respect to a satu-

rated copper/copper sulfate reference electrode contacting the electrolyte. Voltage drops other than those across the structure/electrolyte boundary must be considered for valid interpretation of this voltage measurement.

■ 0.85 volt (850 mV) current-off, defined as follows:

A negative polarized potential of at least 850 mV relative to a saturated copper/copper sulfate reference electrode.

■ 0.1 volt (100 mV) of polarization change, defined as follows:

A minimum of 100 mV of cathodic polarization. The formation or decay of polarization can be used to satisfy this criterion.

My criterion for an adequately documented CP test is simple: There should be sufficient documentation so that any knowledgeable CP tester should be able to return to the facility and make the same measurements in the same places.

What About the Criteria?

While the 0.85 volt current-on criterion is one of the most commonly used, it is also by far the most commonly abused. This criterion is most appropriate for use in structures where there is little current flowing through the soil (the meaning of the last sentence of the criterion), which, in most cases, means structures that are very well coated.

Application of this criterion to structures that are essentially bare (e.g., asphalt coated), whether the system has been equipped with galvanic or impressed current CP, in most cases will produce apparently "passing" results that are seriously in error. This criterion should be limited to well-coated, galvanically protected structures, such as STI P3 tanks. It is inappropriate for impressed current systems.

The -0.85 volt current-off criterion is simple and can be used on any cathodically protected structure, coated or uncoated, where it is possible to interrupt the protective current, either by temporarily disconnecting the anodes (galvanic systems) or temporarily turning off the rectifier (impressed current systems). If the potential (voltage) of the structure is -0.85 volt or greater (more negative) immediately after the pro-

CP-TESTING MEASUREMENTS	GALVANIC WELL COATED	GALVANIC POORLY COATED	IMPRESSED CURRENT
Current-on readings with reference cell in at least three locations: both ends and middle of the tank. For piping, reference cell at both ends and every 10 feet along the piping run.	X	X	X
Current-off readings with reference cell in three locations: both ends and middle of the tank. For piping, reference cell at both ends and every 10 feet along the piping run.		X	X
Continuity testing for all metallic components connected to the tank or piping, including fill pipes, vent lines, automatic tank gauge risers, electrical conduit, etc.	X	X	X
Impressed current systems may also need to be evaluated for possible effects on adjacent structures, such as metallic natural gas lines or water lines. This step would involve checking for continuity and comparing current-on and current-off potentials on the adjacent structures.			X
Impressed current system test documentation to include the voltage and amperage output of the rectifier.			X
To pass, the 0.85 volt current-on criterion must be met at all reference cell locations along the length of the tank.	X		
To pass, the 0.85 volt current-off or 100 mV polarization change criterion must be met at all reference cell locations along the length of the tank.		X	X
CP tests should be sufficiently documented so that any knowledgeable person can make the same measurements in the same places. At a minimum, the CP test report should include a site sketch, the reference cell locations, structure connections, voltmeter readings, type of measurement (e.g., continuity, current-on, instant-off), the criterion used to evaluate the storage system, and the conclusions (i.e., protected or not protected against corrosion).	X	X	X

tective current is interrupted, the criterion is met.

The -0.85 volt current-off criterion is rarely relevant to galvanic systems because, in most cases, the anodes cannot be disconnected. It can be applied to impressed current systems. In my experience, however, this criterion is rarely met on all portions of a storage system.

Like the -0.85 volt current-off criterion, the 100 millivolt polarization change criterion is suitable for any cathodically protected structure, coated or uncoated, as long as the protective current can be interrupted. The application of this criterion in the field is somewhat more involved. Just as for the -0.85 volt current-off criterion, the protective current is interrupted to obtain an instant-off or polarized potential, but the potential that is measured must then be compared with the potential of the structure prior to the application of any CP (the "native" or "freely corroding" potential). The polarized potential must be 100 mV different from the native potential.

If the native potential is known, this comparison is quick and simple. This statement assumes, though, that the native potential has not changed over time—an assumption that is more likely to be true if the moisture conditions around the storage system were similar at the time of the CP test measurement and at the time when the native potential measurement was made.

If the native potential is not known, then the polarization on the structure must be allowed to decay, a process that can take from minutes to as much as a day. This step can make this criterion expensive and inconvenient to implement.

Note that this criterion has nothing to do with -0.85 volt and that storage systems with instant-off readings well below -0.85 volt can still pass.

In a Nutshell

My suggestions for the types of measurements that should be conducted and documented when evaluating various types of CP systems are described in the chart on page 10.

So these are my thoughts...What are yours? ■

Leak Prevention

Impressed Current Cathodic Protection Systems...Just a Warning

by Howard Barefoot

During the first seven years of its UST program, Georgia, like most other states, focused most of its attention and resources on leak detection. During this period, leak detection outreach efforts were extensive—lots of workshops and seminars. At the end of these sessions we'd toss out a little reminder: "By the way, don't forget—if you have steel tanks and/or piping, you have to upgrade by 1998." There was no sense of urgency.

Toward the end of 1995, some UST owners had decided that the deadline was for real, and they were getting on with the job of upgrading or replacing their systems. By early 1996, we began getting calls and letters from vendors, complaining about the way their competitors were installing impressed current cathodic protection (ICCP) systems. One of the most disturbing complaints was that the state was allowing cheap, substandard systems to be installed.

With such accusations flying around, I became concerned because, after all, substandard facilities lead to compliance problems. So I decided to conduct a field evaluation of the types and quality of ICCP systems being installed.

From April to June 1996, I observed in detail the installation of six ICCP systems from ground breaking to energizing. The sites involved three vendors, each employing a variety of techniques, equipment, and materials to complete the job. This variety, coupled with the fact that the rectifier may be the only part of the system readily visible during an inspection, makes it difficult to determine why particular systems fail. It also underlines the importance of having a drawn-to-scale, as-built plan for each site available on site.

ICCP—How's It Done?

■ The Saw-Cut Method

This method is so named because it uses a diamond-blade concrete saw to make an approximate 1/3-inch-wide cut in the pavement. The depths of a cut may vary, depending on the saw operator; however, I have rarely seen cuts deeper than 4 inches. I have observed some cuts that were less than 1 inch deep. (See Photo 1.)

The width of a saw cut usually conforms to the diameter of the cable being used. For example, #10 HMW Poly Cathodic Protection Cable is 0.3 inch in diameter and the accompany-

■ *continued on page 12*



Photo 1 Saw cuts less than 1/2 inch deep with exposed header cable—doomed to rapid failure.

■ Impressed Current Cathodic Protection Systems *from page 11*

ing saw cut will be approximately 0.33 inch in width. Sadly, I have seen some installers use a screwdriver blade to push a cable into the saw cut when the cut was too narrow.

When placing the header cable in the saw cut, the best technique is to first place sealant in the bottom of the cut, then place the cable on top of the sealant and cover the cable with sealant to the top of the pavement. The sealant should be the type used by departments of transportation to seal traffic detector loops, not common hardware-store caulking material.

With this method, borings for the anodes are first made using a small, portable, power auger or air rotary auger. Saw cuts are then made, linking each boring (anode location), back to the rectifier. Most commonly, a single "header cable" connected to the positive terminal of the rectifier is installed in the saw cut and links all of the anodes together.

Saw-cut installations almost always involve cable splicing because the saw cut is not wide enough or deep enough to accommodate separate anode lead wires for each anode. The anode lead wire is spliced into the header cable at the anode hole location.

Splicing is usually accomplished by soldering, clamping, aqua-sealing, taping, and heat shrinking. It should be noted that this five-step process is employed in an attempt to ensure that the splice is waterproof. Waterproofing is an absolute necessity to prevent rapid corrosion failure of the anode lead wire and/or header cable.

In the opinion of some experts, the saw-cut method does not comply with the standards of the National Electrical Code (NEC NFPA 70, Section 300-5), which require direct-bury electrical cable to be installed 24 inches below grade in traffic areas. Whether meeting the electrical code or not, the fact is that many of these systems are already in place in many states, Georgia included. At this point, Georgia does not plan to have these systems removed.

■ The Trenching Method

This method requires the complete cut-through and removal of a line of pavement 4 to 18 inches wide and

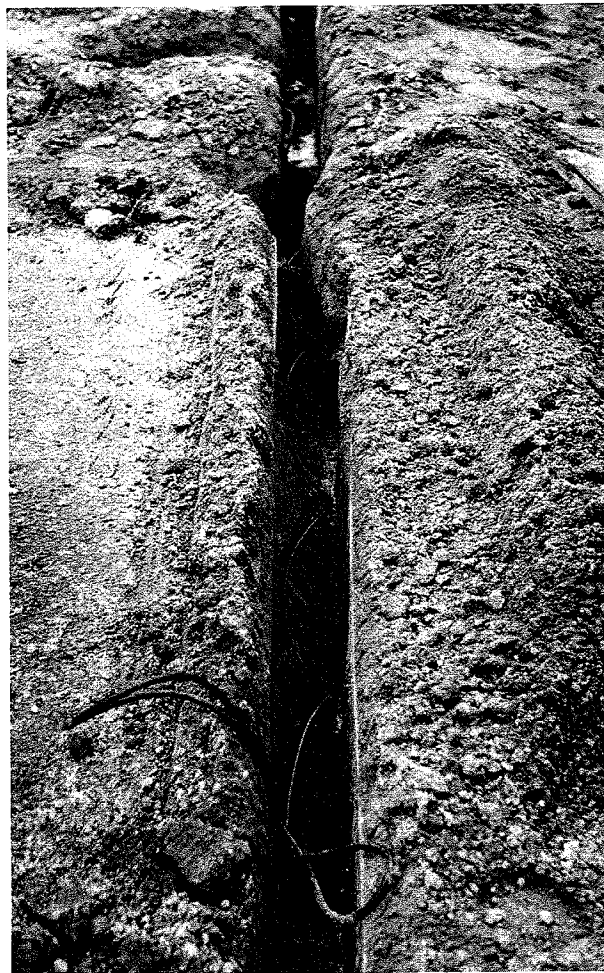


Photo 2 *Narrow trench with anode wire buried about 14 inches deep. Although it does not meet electrical codes, this technique provides better protection than the saw-cut method.*

excavation into the soil beneath the pavement (Photo 2). Although the NEC cable burial requirement in traffic areas is 24 inches, none of the installations I observed during the 1996 evaluation project placed the cable any deeper than 12 inches beneath the surface. The primary objection to the 24-inch depth is the risk of damaging the product lines, which are typically buried at a depth of 18 inches beneath the surface.

When trenching is used, rather than splicing each anode wire into a header cable, anodes with individual lead wires long enough to reach the rectifier are typically used. This method avoids the problem of buried splices, greatly improving the reliability of the system. In addition, wires are less likely to be damaged, because they are buried deeper. If a wire does break, only a single anode is lost from the system.

ICCP Systems—Will They Work?

If a system has been properly installed, will it work? The answer is

"yes," but not if the owner/operator fails to pay attention. From March through May 1999, our program conducted field evaluations of 100 ICCP systems. Eighty-four percent of these systems appeared to be operating as intended (at least for that moment in time). Six percent had unexplained problems, where portions of the storage system did not appear to be protected. The remaining 10 percent of the systems were totally noncompliant for the following reasons:

■ **The rectifier was off** Rectifiers on five systems were off. The most common reasons for this type of failure are power surges from nearby lightning strikes or overloaded circuits.

The federal UST rules require that all CP systems be maintained and operated to provide continuous corrosion protection; however, the same rules require only that ICCP systems be inspected every 60 days.

■ **The rectifier was operating at too low an output** Three systems did not appear to have adequate pro-

tection. As it turned out, the rectifiers were operating at half the amperage required.

■ **Other** Two additional systems had unexplained problems with total system failures. The rectifiers were operating, but the storage systems did not appear to be protected.

ICCP Systems—Will They Last?

ICCP systems are expected to last 20 to 40 years or longer when properly designed, installed, and operated. However, one can readily recognize that many factors will be at work over such a long period of time that could affect the integrity and longevity of a system. The following are key factors:

■ **Construction and paving** The cables and sometimes the anodes are vulnerable to excavation activities. In time, visible locations of anodes and saw cuts/trenches are likely to be paved over, emphasizing the need for and dependency on drawn-to-scale, as-built site plans. Of the 100 system evaluations we conducted to date, only five had plans on site or readily available. Owners had not requested plans and contractors did not provide them.

■ **Design** Probably the one design consideration that affects the life of an ICCP system the most is the number of anodes. The minimum number of anodes recommended per tank is two. As a rule of thumb, every part of a tank should be looking at an anode. I have evaluated some systems where fewer than two anodes per tank were used, leaving one end and/or side of a tank not visible to an anode.

■ **Installation** The following is a list of problems, actual and potential, that I have noted during my investigations of ICCP systems. Although some could be argued to be design problems, installation techniques could have improved the conditions:

- Failure to protect the header cable in the saw cut from broken pavement and sharp objects.
- Exposed negative cables that can be damaged.
- Exposed header cables and anode lead wires. (See Photos 3 and 4.)

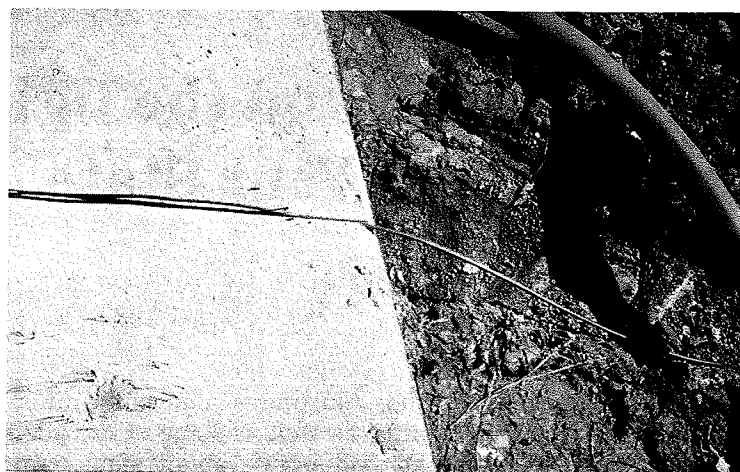


Photo 3 Transition of header cable from ground into saw cut in concrete PAD—not much protection for this important wire.



Photo 4 Exposed header cable repaired with tape—it takes more than a little tape to ensure longevity of header cables.

- Nonwaterproof splices.
- Failure to connect the rectifier to a dedicated electrical circuit.

■ **Operation** The number one and maybe the most serious operational problem noted during our evaluation was nonoperation (i.e., the rectifiers were off). In every case, this condition existed without the owner/operator's knowledge.

A Precarious Situation

As I observed the ICCP system installations in 1996, I had my doubts about some of the techniques being used. Now, three years later, some of the techniques I thought were marginally acceptable have already manifested themselves as real problems.

Many installations out there are precarious, to say the least, and more failures will become evident in a few years. This trend is likely to arise because, during the last six months before the upgrade deadline, the quality of ICCP system installations reached an all-time low, as less quali-

fied contractors jumped into the business and joined in the rush to get to the next site.

As regulators, we have a serious educational problem on our hands. In addition to having a poor understanding of cathodic protection, owners and operators frequently feel that they have spent enough money on this upgrade business, and they shouldn't have to worry about it.

Maybe they shouldn't have to worry about it, but they should, at least, be aware that their systems, especially the rectifier, must be checked every 60 days. Any time I'm in the field, I advise owner/operators of the importance of their ICCP system and the requirement to check its operation. At the marginal facilities, I'll go so far as to say, "If it were me, I'd check the rectifier every day." ■

Howard Barefoot is Manager of the Georgia Department of Natural Resources UST Program Regulatory Compliance Unit.

State Cleanup Funds

The Good, the Bad, and the Ugly Tips for Managing Your State Cleanup Fund

by Mary-Ellen Kendall

It's a sure bet that when the Environmental Protection Agency (EPA) gave states the right to create petroleum storage tank funds in 1990, no one had any idea to what extent the states would buy into the concept. However, based on the fact that almost every state now has a fund, it is fair to say that the idea was an overwhelming success!

The language under which these funds were created is fairly simple, general, and innocuous:

An owner or operator may satisfy the requirements of §280.93 for underground storage tanks located in a state, where EPA is administering the requirements of this subpart, which assures that monies will be available from a state fund or state assurance program to cover costs up to the limits specified in §280.93 or otherwise assures that such costs will be paid if the Regional Administrator determines that the state's assurance is at least equivalent to the financial mechanisms specified in this subpart. [40 C.F.R. §280.101(a)]

At the time, one might have thought that maybe a few states would get around to creating funds that were similar both in nature and administration. Nothing, however, could have been further from reality! States came up with funds that were uniquely tailored to individual state philosophies, policies, and statutes.

In LUSTLine #30 (September 1998), we discussed some "typical" reimbursement

funds, illustrating some of the differences, as well as some of the good and bad points about state reimbursement funds.

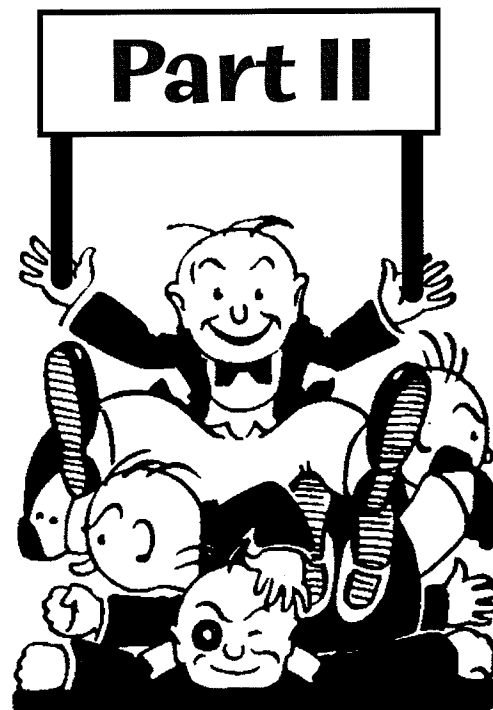
There are other states, however, that chose to create funds that are very different from the reimbursement-type fund. These funds are structured to provide UST owners and operators with financial assistance for cleanup costs using insurance rather than cash reimbursement payments. As is true with the noninsurance funds, each insurance fund is administered differently.

State Insurance Funds

Iowa, Missouri, Utah, West Virginia, and Washington are five states that use a form of insurance fund. At the time their funds were created, little or no private insurance was available for owners of petroleum USTs. In the late 1980s and early 1990s, most insurance companies were unwilling to assume the environmental risks that had evolved at petroleum storage facilities over the last 50 years.

Before 1988, the corner gas station was virtually unregulated. Although some industry standards for the storage and handling of petroleum products existed, very few were known to, or used by, the average gas station owner. Many tank owners were high-school-educated entrepreneurs who bought or managed gas stations when they returned from World War II. Their only contact with the petroleum industry was with the company that supplied petroleum. Even if the station was associated with a major oil company brand, no environmental risk training was provided for small station owners.

Once the federal UST regulations became effective in 1988, many major oil companies sold tanks to the station owner or operator for \$1. (See LUSTLine #31.) The corner gas station

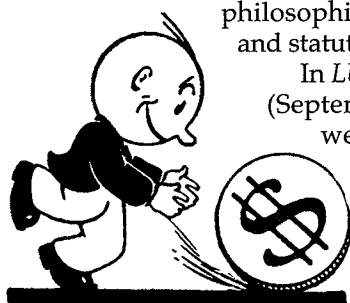


owner or operator who purchased these tanks was unaware of the impact that the regulations would have in the future. Even if the small station owner had wanted to purchase insurance in 1990, few companies were willing to insure older sites that had the highest probability of being contaminated.

The solutions that states with insurance funds devised to address this problem cover a wide range. Some states created funds that provided coverage for sites with existing contamination, some covered both existing contaminated sites and new installations, and some limited coverage to contamination that occurred only after a policy was issued.

Participation in these funds can be voluntary or mandatory. Initially, participation in Utah's fund was mandatory. After a constitutional challenge, which Utah lost, participation became voluntary. (Utah later won the case on appeal, but did not change back to a mandatory participation requirement.)

Today, approximately 95 percent of Utah's UST owners participate in this fund. To opt out of the fund, owners must be able to demonstrate that they can meet federal financial responsibility requirements on their own. Because so many owners cannot demonstrate financial responsi-



bility at the required levels, they participate in the Utah insurance fund.

Iowa's Two-Pronged Approach

One of the key questions that insurance fund administrators must address up front is whether to create a fund that covers sites with prior contamination. The standard in the insurance industry is to insure against future risks at a rate that reflects market forces.

With a program based on market forces, the premiums assessed reflect the true cost of the policy without any state subsidy. The companies that underwrite this insurance develop the premiums for specific tank issues, such as leak detection. A market force system provides a more accurate picture of the true cost of insurance. For example, Iowa's premiums average \$400 to \$1,100 per tank with a \$500 minimum premium for each tank owner.

Iowa took a very innovative approach in developing its fund. Because the state law governing USTs did not permit the state to set up a permanent assurance fund, Iowa used a two-pronged approach to solve the problem.

The insurance funds help the owners see that compliance is a good business practice that will extend the life and profitability of their facilities. This structure creates a win-win situation for both the regulator and the regulated community. It also protects the environment by reducing the potential for petroleum releases from USTs.

First, Iowa required everyone to test their sites by October 26, 1990. Seventy-one percent of the UST facilities in Iowa were found to be contaminated and were eligible for the remediation program. UST owners could purchase insurance from the fund voluntarily. Premiums were based on compliance with statutory and regulatory requirements.

By January 1, 1995, most of the sites had been cleaned up, and the state now bases its fund premiums

on the risk to the environment from a particular tank. UST owners who are serious about compliance see an immediate benefit in the form of lower premiums.

Iowa is now entering the next phase in the life of its fund. Because the fund is supported solely by the premiums paid by UST owners, a nonprofit mutual company is being formed that will allow the tank owners to own the insurance company. It will also end the state's involvement in managing and administering the fund. This move is consistent with Iowa's statutory mandate that prohibits the establishment of a long-term, entrenched bureaucracy for financial assurance.

Washington's Reinsurance Approach

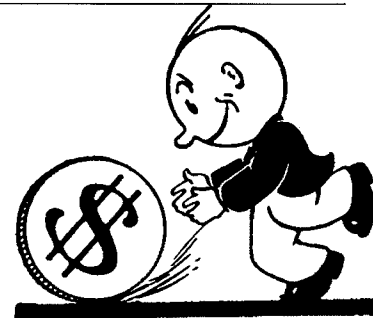
Washington developed an insurance fund that insures future risk rather than past activities. The fund serves as a "reinsurer" of two private companies to offset the insurer's obligation to pay \$1 million per occurrence. The private insurance companies pay the insured for all cleanup costs covered by the policy but can then turn to the fund if the costs exceed \$75,000.

By encouraging competition between the two insurance companies, Washington was able to reduce premiums. This type of structure has the same benefit as the Iowa fund in that tank owners who are in compliance with UST regulatory requirements pay lower premiums than those who are not.

States with premiums that are based on an arbitrary number (often set by statute) normally establish very low premiums that are not in line with commercial, private insurers. The artificially low premiums may provide a disincentive to the owners, because the cost is not commensurate with the true cost of owning and operating an UST. It is also virtually impossible to attract any private insurers, because they are not able to compete with the state insurance fund.

Deductibles and Claims

In addition to the premiums that tank owners pay for policies, there is a deductible associated with each occurrence. Washington has three deductible levels, ranging from



\$10,000 to \$25,000. West Virginia has two deductibles (\$5,000 or \$50,000), while Utah's deductible has been reduced from \$25,000 to \$10,000. Several of the insurance fund managers stated that offering lower deductibles for compliant tanks can be used as an incentive to ensure that tank owners comply with regulatory requirements, which should, in turn, reduce the number of releases and/or the cost to clean up these releases.

Claims are handled in a manner similar to reimbursement funds. Once the fund is notified of a release, a claims adjuster visits the site and approves the proposed cleanup activities. Because of the preapproval process, Utah is able to process claims within 30 days of receipt.

Missouri has tried several techniques used by reimbursement fund administrators to reduce the cost of claims, such as requiring competitive bids for all work and paying no markups. Although these tools were not very successful in reducing costs, Missouri has now developed an effective cost-saving tool: a strong field presence. Fund staff are out there verifying that work was actually performed and documenting the true cost of each activity. They also recommend that the fund or environmental field staff attend every tank closure, whether or not a release is reported, to verify the tank owner's compliance with the regulations and/or the presence of contamination at the site.

The Compliance Carrot

One of the chief advantages of an insurance fund from the state's perspective is that regulatory compliance is required for participation. Tank owners are given a monetary incentive (in the form of lower premiums or deductibles) to learn and implement UST regulatory requirements.

■ continued on page 21

Leak Prevention

Swamped in Free Product? Rise Above It With PFP

by William Foskett, Dana Hayworth, and Bob Cohen

One of the first actions typically needed at a newly discovered UST release is removal of free product. In reality, however, this step doesn't always happen in a timely fashion. In fact, free-product removal often gets out of control, running up high cleanup costs without solving the immediate environmental problem and, perhaps, making it worse.

Gasoline held in residual form above the water table will, in time, affect groundwater quality if it is not remediated. When free-product removal is delayed or too slow, the seasonal rise and fall of the water table can cause contamination to "smear" into the vadose zone. Even the process of conducting a pump test can smear free product into previously uncontaminated areas.

Free product can also migrate into utility conduits, surface water, and basements. At a site in north Florida, for example, free product migrated into a pond resulting in significant fish kills and a threat to the health and welfare of children playing nearby. Early mitigation of the free product would have prevented significant environmental damage.

The time-and-materials (T&M) terms on which cleanup contractors have customarily

been paid for free-product removal practically invite such problems, because T&M rewards slow and ineffective work. An alternative payment approach, known as pay for performance (PFP), is a system whereby you pay the contractor for free-product removal and keep yourself from being swamped by spreading plumes and rising costs. PFP fiscally rewards quick starts and fast results with prompt, low-hassle payment. It also forces you to set clear, measurable environmental goals and a firm, fixed price for the free-product removal.

Here's How It Works

Under PFP, the cleanup contractor is paid according to the amount of contamination that is actually reduced (e.g., decrease in free-product levels measured in feet or inches), not for the amount of time and materials expended. No change orders are allowed. In a large-scale, long-term free-product removal (or full-scale site cleanup), PFP payments are triggered as contamination levels decline to milestone levels set in the terms of the PFP agreement.

Often in full-scale PFP cleanups, a free-product reduction goal must be reached as part of the criteria to receive the first performance payment. In small-scale PFP free-product removal work, the intermediate mile-

stone payments may be omitted and the contractor may be paid simply on attaining the end goal.

For example, if three wells are identified with 12 inches of free product, then a PFP milestone could be set for when the measurable quantity of free product is reduced 25 percent, or 3 inches, in each well. Successive

PFP fiscally rewards quick starts and fast results with prompt, low-hassle payment. It also forces you to set clear, measurable environmental goals and a firm, fixed price for the free-product removal.

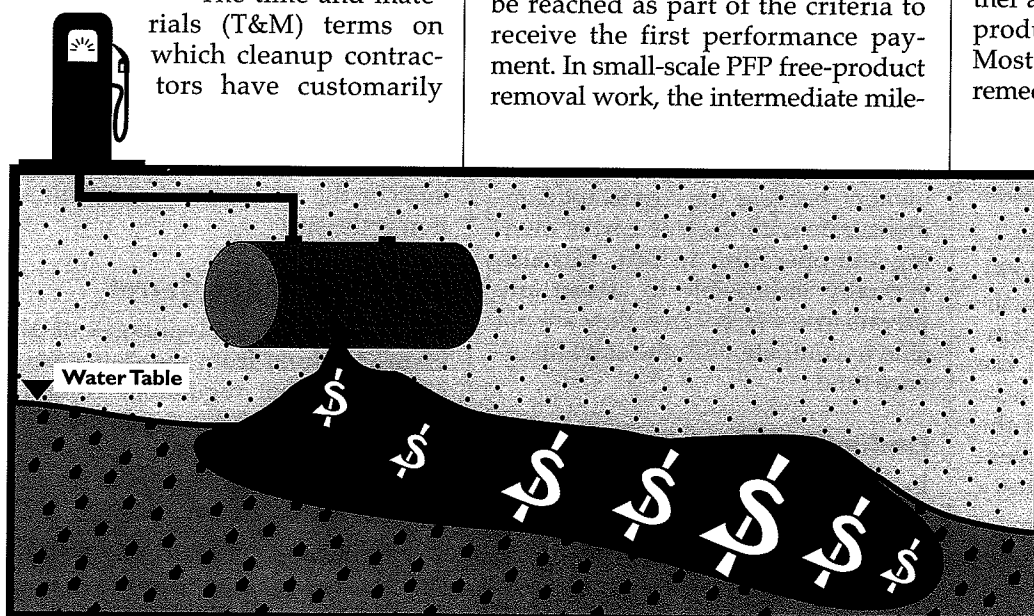
milestones could be set to trigger performance payments at 50, 75, and 99 percent reductions. As each milestone is reached, a milestone reduction payment is made until the final goal is reached and sustained.

The goals and the total price to be paid for a PFP cleanup are both firmly fixed at the beginning and do not change. On reaching a contamination-reduction milestone, the cleanup contractor submits independently confirmed monitoring data along with a request for the agreed-upon milestone payment.

Over 300 PFP cleanups are now in progress or completed in Florida, Oklahoma, and South Carolina. Some of these PFP cleanups focus only on free-product removal, with no further active remediation after the free-product removal goal is reached. Most also entail full-scale active remediation.

Where and How Free-Product Reductions Are Measured

A PFP cleanup also must specify where and how the free-product thickness data used to justify a payment will be collected and analyzed. In general, your PFP measurement plan should include payment-data collection locations and procedures that measure the contamination lev-



els directly in the environment at the cleanup site. It should also include data-collection locations and procedures to alert you if the contractor's approach begins to make the problem worse rather than better. In PFP you are paying for a clean site—not just a few clean measurement locations.

To measure free-product reductions for PFP milestone payments, identify the wells that have free product and record baseline levels of free product before beginning removal. For example, you can measure the apparent thickness of product in the aquifer by using an interface probe or an oil sensor. Once each well is measured and free-product accumulation recorded, set and measure the milestone-payment levels of free product in terms of thickness in each well.

Seasonal Water Table Variations and Measuring Free-Product Reductions

If free product is released during a dry season in certain lithologies, but its removal is delayed until (or includes) a rainy season, then the water table could later rise and smear the free product into the vadose zone, resulting in a misleading apparent reduction in free-product thickness as measured in the monitoring wells. Appropriate configuration of the measurement-payment criteria, sampling locations, and data-collection procedures will help to avoid this problem. You should take care that the free-product removal work really is removing free product and not just smearing it away into previously uncontaminated areas.

Seasonal variations in the water table should be taken into account when the measurements that trigger PFP payments are set up. Before you make a judgment on the total amount of measurable free product in each well, you should know when the water table has reached its peak and then collect the measurement data.

This collection can be done, for example, by preparing a hydrograph that shows water table elevations over time for the free-product removal site. A hydrograph will show potential smearing as opposed to real reduction in thickness for free product on the water table. It is also wise to monitor for three to six

months after the goal is attained to ensure that rebound does not occur due to a falling water table.

Also, know the groundwater flow rate and gradient to calculate potential migration speed and spread of the product plume. To minimize smearing across uncontaminated zones, avoid any type of pumping test that could cause free-product migration.

Ways Not to Measure PFP Free-Product Removal Progress

It is theoretically possible to measure free-product removal progress (and goals) based on the reduction in overall size of the free-product plume. Although software that may indirectly assist in this undertaking is being developed, it is not presently available. Thus, this method is not yet sufficiently reliable to be used for purposes of making PFP payments.

Do not measure PFP free-product removal progress by the amount of "effluent" free product that the removal system produces. It is not a direct measure of the environment that PFP is paying to clean up. In PFP payment measurement, data should be taken directly from the environment you are trying to clean up. However, most states require that influent data from the treatment system be reported. Both influent and effluent data can give you a check on the "thickness" data used to trigger a PFP milestone payment.

To measure free-product reductions for PFP milestone payments, identify the wells that have free product and record baseline levels of free product before beginning removal.

Timing and Time Limits for PFP Free-Product Removal

Timing is a practical consideration in setting the schedule for PFP free-product removal. If the free-product release takes place at the beginning of a period when the local water table is normally low in sandy or sandy clay lithologies, you should set the PFP time limit so that your goal is met

before the water table rises again.

If the free-product removal job begins too late in your "dry" season to reach your goal before the water table rises again, then withhold some contractor performance payments until the next dry season. Then make those payments if the free product has not exceeded your goal levels. If the site does not remain at or below goal levels, withhold payments and have the contractor resume appropriate remedial action until the site reaches and retains your free-product goals.

Goals for a PFP free-product removal job can be set so that a specific thickness of free product must be reached within a given time frame. For example, a goal for a PFP free-product removal might be to reach 1-inch thickness within 60 days of the effective date of the PFP contract.

Setting and Estimating the PFP Fixed Price for a Free-Product Removal Job

In PFP, we distinguish *setting* the firm fixed price that caps the amount to be paid out from *estimating* the actual cost of a PFP cleanup. The price is the dollar amount that the buyer agrees to pay (or reimburse) for reaching the cleanup goal. The cost of the cleanup is the actual amount of money spent to accomplish that goal. In reality, the cost can turn out to be either more or less than the price that was set for the job. The PFP price does not change, regardless of the actual cost. In PFP, Price minus Cost equals Profit.

A PFP cleanup price may be set (1) by public, competitive bidding, (2) by negotiation between the payer and the cleanup contractor, or (3) by the state based on some "fair and reasonable" rate schedule. Experience shows you will pay the lowest price for a PFP cleanup by using public, competitive bidding, with award to the lowest bidder.

Based on the number of bidders attracted when South Carolina publishes requests for PFP bids, confident, competent cleanup contractors find PFP cleanups an appealing business opportunity. Besides the prospect of gaining a healthy profit for working smart, PFP progress payments are typically made within a

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Investigation and Remediation

MTBE, Fuel Oxygenates...

By Jeff Kuhn

After last month's announcement of the phase out of MTBE in the State of California and legislative action by some states contemplating MTBE bans, we are all left wondering, "Okay, now what?" We've begun to move away from a chemical that at best provided questionable air quality benefits and at worst has contaminated many aquifers throughout the United States, leaving cleanups that will continue for many years to come.

Adding to the large body of MTBE information, the recently completed National Research Council report, *Ozone-Forming Potential of Reformulated Gasoline*, indicates that better vehicle emission control systems and the other nonoxygenating compounds of RFG—not the oxygenates—are responsible for reduction in ozone levels documented in RFG areas throughout the country.

Most importantly, the public needs to be involved in understanding the effect of gasoline formulation, not just on the pocketbook, but also on human health and the environment.

These conclusions demand recognition in the context of the MTBE debate. One could surmise that the report demonstrates how easily decisions allowing the use of specific chemicals can be made before a thorough scientific evaluation of human health and environmental impacts is completed and before other alternatives (use of better emission control technology) are considered. Most importantly, the report demonstrates that, thanks to the computer age, automobile technology may have at least temporarily surpassed the goals of gasoline reformulation in controlling and reducing air quality emissions and the perceived need for some of the fuel oxygenates.

The NRC report hits at the heart of the issue and the reason for the

complexity of the debate: It is not the presence of oxygenates that has led to air toxics reductions, but rather the displacement of the aromatic and more carcinogenic fraction of hydrocarbons by oxygenates and the use of better automotive technology.

A Pause for Reflection

Between the announcement of the California phase out and the anticipated results of the EPA Blue Ribbon Panel on MTBE (due out in July), there is somewhat of a lull in the MTBE debate. While we await the panel's findings, perhaps we need to consider the MTBE debate from a more philosophical perspective. Is the concern over MTBE really that different from the concern expressed over benzene in the early 1980s? Although there are some differences (e.g., MTBE's solubility and recalcitrance to biodegradation), the concern over MTBE may mirror the evolution of the LUST Program and EPA in general.

It's probably safe to say that we will never again take gasoline formulation for granted. After all, EPA, industry, and many states were aware in the late 1980s that MTBE created long plumes and could potentially impact drinking water wells located a great distance from petroleum source areas. But the collective "we" did nothing to address the issue.

We should probably also ask why no new health studies on the effects of MTBE have been completed or commissioned. Perhaps there is a feeling that if MTBE will not be used in the United States over the long haul, why spend the money to conduct the research?

In the meantime, however, the use of MTBE on a worldwide basis continues to grow in response to



Now What?

severe air quality problems in developing countries. Shouldn't the necessary health studies still be completed? And what about the health effects of whatever comes next? Where do we go from here? Time will tell whether we have learned from this experience and whether we apply what we have learned from addressing MTBE cleanups in communities on a nationwide basis.

Perhaps EPA should consider a more holistic approach to exploring the human health and environmental impacts of new chemicals proposed for introduction into motor fuels. The various branches of EPA need to work together jointly to address proposed gasoline reformulation issues in the future so the MTBE catastrophe is not repeated with a new oxygenate or chemical additive. The agency should also clearly communicate with state agencies (e.g., UST, air, drinking water programs) and encourage them to work together as well.

The question remains: Are gains in air toxics reductions through the use of MTBE and other alkyl ether oxygenates still worth risking contamination to drinking water aquifers? A standing panel of EPA, industry, research, and state representatives, similar to the Blue Ribbon Panel, should be created to review proposed changes to gasoline formulation.

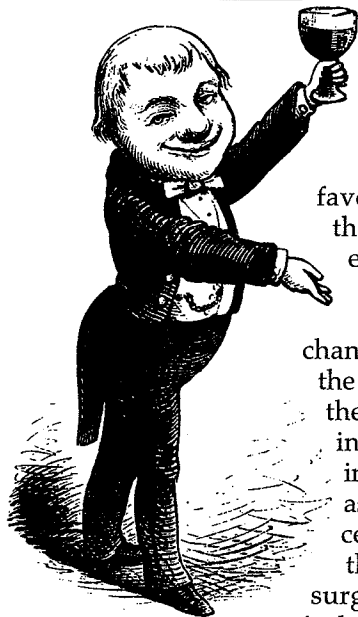
Most importantly, the public needs to be involved in understanding the effect of gasoline formulation, not just on the pocketbook, but also on human health and the environment. We anxiously await the conclusions of the Blue Ribbon Panel and other research currently under way, and look forward to the certain challenges ahead. ■

Jeff Kuhn is with the Montana DEQ Petroleum Release Section and is a member of the ASTSWMO MTBE Workgroup and editor of its newsletter.

Investigation and Remediation

With the Possible Phase Out of MTBE, What Do We Know About Ethanol?

by Bruce Bauman



Let's toast the fortunes of humankind's favorite beverage, that inebriating elixir—ethanol.

There is a reasonably good chance that within the next five years, the use of ethanol in gasoline could increase as much as 200 to 300 percent! With luck, that potential surge in demand won't drive up the cost

of your Saturday night Wild Turkey.

A quick recap will help explain this possible boost to domestic fuel ethanol utilization, and then on to the UST/groundwater implications. MTBE and ethanol are the two most widely used oxygenates—according to the Department of Energy, in 1997 about five times as much MTBE as ethanol was used in gasoline in the United States. Other oxygenates (TAME, ETBE, DIPE, methanol, TBA) are used in only a very small percentage of gasoline.

Oxygenates are blended into conventional gasoline to provide economical octane, typically at low volumes (e.g., less than 1–5 vol %); higher volumes are found in premium gasolines than in “regular.” Many urban areas of the United States are required to use reformulated gasoline (RFG) to reduce emissions that contribute to ozone formation. As required by Congress in the 1990 Clean Air Act (CAA) amendments, RFG must contain at least 2 percent oxygen by weight (about 11% volume MTBE or 6% ethanol).

In a much smaller number of urban areas, “oxyfuel” must be used in winter months to reduce carbon

monoxide emissions. Oxyfuel must contain at least 2.7 percent oxygen by weight (about 15 % volume MTBE or 8% ethanol). EPA's Office of Air maintains an excellent Web site that can give you details on which parts of the United States must use these special gasolines (<http://www.epa.gov/oms/fuels.htm>). (NOTE: Ethanol is sometimes used at 10 percent volume in gasoline, because there is a 5.4 cent/gallon federal subsidy. Smaller subsidies apply to gasoline using less ethanol.)

You are probably familiar with California's decision to phase out the use of MTBE in gasoline by December 2002. Currently, about 70 percent of the gasoline sold in California is RFG. (California has some specific regulatory gasoline requirements that make its RFG different than that found in the rest of the country, but it

A tank that is closed and left in place is still an environmental threat if it has not been properly closed and a headache for state UST/LUST program personnel, who will have to see that owners and operators finish the job or, in many cases, hope that someone steps forward to claim responsibility for the tank.

still needs to contain 2% oxygen by weight.) When MTBE is completely phased out, ethanol is the logical replacement oxygenate (assuming the CAA “oxygen mandate” is not repealed). This is no trivial issue from the supply perspective. Given that California uses so much gasoline and currently uses very little ethanol, this ethanol-for-MTBE substitution would require almost 50 percent of the current U.S. ethanol production capacity!

Ethanol in Groundwater?

All of this information is just background to get around to the main

question: What do we know about the behavior of ethanol in groundwater? Many of you who are reading this article have been responsible for overseeing UST sites where ethanol was released—especially in parts of the Midwest, where ethanol has found its greatest marketability. States like Nebraska have strongly supported and subsidized ethanol production to enhance both their economies and promote “energy security” (i.e., every barrel of ethanol produced for use in gasoline means one less barrel of oil that needs to be imported). In Illinois, an ethanol-in-diesel (“biodiesel”) demonstration program is in progress.

For almost a decade, however, I have attempted at infrequent intervals to unearth real-world field information on ethanol or ethanol-gasoline releases, but I have not been able to find much. I began my search in the late 1980s, when the American Petroleum Institute (API) was conducting the only known field study on alcohol fate and transport in groundwater.

We looked at methanol, as it was being seriously evaluated by California as a cleaner-burning gasoline substitute. We injected three simulated dissolved plumes side by side in the world-famous Borden Aquifer in Canada: (1) a typical BTEX plume, (2) a BTEX and MTBE plume, and (3) a methanol and BTEX plume. The plumes were monitored intensively for about 16 months, and mass balances were performed at the end of the experiment.

To briefly summarize the University of Waterloo report, the methanol did biodegrade to below detection limits (250 ppb), but the BTEX in that plume biodegraded much less than in the “BTEX only” plume, or the MTBE-BTEX plume.

Unless someone can provide evidence to the contrary, I would expect that the subsurface fate/behavior of methanol and ethanol would be fairly similar. So what does this simi-

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■ Ethanol from page 19

larity mean for real-world ethanol-gasoline releases? It suggests that at least for some release scenarios, ethanol-BTEX plumes would likely be a bit longer than "typical" BTEX plumes.

From a practical perspective, this potential plume elongation may not be very relevant for most RBCA evaluations, especially if it's only 1 to 200 feet or so. However, it would seem prudent for at least some situations, especially in Midwestern states where ethanol is the dominant oxygenate, to determine if ethanol is present at the release site and assess what its effects might be on the benzene plume.

Biodegradability and Other Knowledge Gaps

Despite this ethanol field data "black hole," several recent assessments of potential groundwater impacts from such UST releases seem to rather blithely assume that there will be no impacts, because ethanol is considered to be so biodegradable. For example, the comprehensive University of California evaluation of MTBE that formed the basis for that state's recent decision to phase out MTBE states that "Ethanol plumes will biodegrade fairly rapidly." The study does raise the issue of "preferred substrate utilization" and its potential impacts on the length of BTEX plumes (i.e., as the microbial population will prefer to extract its energy from the available ethanol, the onset of significant biodegradation of BTEX could be delayed by several days, weeks, months, depending on numerous site/release-specific factors).

The operative phrase here is "biodegrade fairly rapidly." How rapid is rapid? Furthermore, as no field data exist on this topic, these assessments are simply taking laboratory biodegradation data and extrapolating them to field situations. Most of us would agree that one must use a great deal of caution in making that lab-to-field leap.

Finally, it is very important to consider different release scenarios and their implications for ethanol-BTEX dissolved plume development. Most folks would agree that for small, slow, continuous releases (e.g.,

2-10 gal/day), dissolved ethanol would be rapidly biodegraded. However, if there is a large sudden release (e.g., 500-plus gallons in one day), the mass of ethanol that might be dissolved would be very large, and it might take a very long time (months?) for it to degrade.

I would suggest that there are a

I raise these issues not to imply that ethanol-gasoline releases may be worse than MTBE releases. Based on current information, it seems likely that their impacts on groundwater quality would be less than those of MTBE. However, there clearly are some knowledge gaps that need to be addressed, and UST site managers should begin to consider some of these issues.

number of other issues regarding ethanol-gasoline releases to groundwater that need to be thought through before we begin a massive migration to dependence on ethanol for all of our gasoline oxygen needs:

■ Maximum dissolved ethanol concentrations Because ethanol is miscible with water (completely soluble), very high concentrations are likely to occur near the source of the release, perhaps as high as 10,000 ppm or more. Although ethanol may be rapidly biodegraded, at these concentrations it will be toxic to microorganisms. Biodegradation will occur, of course, at the diluted fringes of the ethanol plume, but this much dissolved mass will take a long time to biodegrade, even at very high substrate utilization rates.

■ Plume elongation caused by electron acceptor depletion If the rapid biodegradation of ethanol uses up all of the available electron acceptors needed for aerobic and anaerobic biodegradation (e.g., oxygen, iron, sulfate), will BTEX biodegradation be impeded?

■ Cosolubility of BTEX Several authors have looked at the potential for methanol or ethanol to increase

the dissolved-phase concentration of BTEX. In general, the lab results seem to suggest that at the 5 to 10 percent volume concentrations found in gasoline, ethanol would not enhance the solubility of BTEX significantly. However, for releases of neat (pure) ethanol (see below), cosolubility effects would greatly increase dissolved BTEX.

■ Trace compounds in fuel-grade ethanol The presence of TBA in fuel-grade MTBE has been identified as an issue for MTBE release sites. Are there trace compounds in fuel-grade ethanol that might be of concern and that would be less biodegradable than ethanol?

■ Neat ethanol releases Unlike MTBE, which is blended at the refinery and then shipped through pipelines or tankers/barges, ethanol must be blended at the distribution terminal just prior to delivery to the end user. This requirement arises because the presence of as little as 1 percent water can cause "phase separation" of an ethanol-gasoline mixture into an alcohol-rich phase and a hydrocarbon-rich phase. Thus pure ethanol must be stored at terminals in separate tankage, which could also have a release and require remediation at some time.

I raise these issues not to imply that ethanol-gasoline releases may be worse than MTBE releases. Based on current information, it seems likely that their impacts on groundwater quality would be less than those of MTBE. However, there clearly are some knowledge gaps that need to be addressed, and UST site managers should begin to consider some of these issues.

What Information Is or Is Not Yet Out There?

If you're looking for a good summary of what we know and don't know about ethanol in groundwater, get a copy of *Evaluation of the Fate and Transport of Ethanol in the Environment*, a report from the American Methanol Institute by Malcom-Pirnie (keep in mind that methanol is a primary feedstock for making MTBE). It is the single best source of information available today.

Information on ethanol's health effects and a much briefer environ-

mental summary are accessible from the Renewable Fuels Association, at http://www.ethanolrfa.org/544_er_1999.html (keep in mind that RFA is an ethanol advocacy organization).

API is just beginning its own ethanol literature review and some laboratory studies evaluating whether the "preferred substrate" hypothesis is legitimate. It hopes to have this complete within the next four to six months.

Also of interest is some work going in Brazil, where gasoline with 20 to 25 percent ethanol has long been in use as a motor fuel. A field-release experiment on this kind of gasoline was just started by Brazilian researchers late last year, and initial results should be forthcoming within another year or so.

Finally, as required in the MTBE phase-out Executive Order Governor Davis signed in March, CalEPA needs to issue a report on ethanol environmental impacts by the end of this year. As this time, it is considering contracting for \$650,000 in ethanol fate and transport studies in surface and groundwater, trying to quickly come up to speed. Ideally, the agency's work will also shed some much-needed light on this issue.

The Jury's Still Out

So will we actually see this large increase in ethanol use in gasoline over the next several years? It is difficult to say, as there are more than a few tricky variables in this equation. It is likely that MTBE use will decline, and if the federal oxygen mandate is not changed, increased ethanol use is inevitable. However, Congress may

amend the CAA to specifically address this MTBE-ethanol issue through repeal of the oxygen mandate. There is increasing evidence that lots of oxygen is not really needed in our gasoline.

Several mandate repeal bills are under discussion in the Senate and House, and others are being discussed for potential consideration. Some of the bills would specifically target California, as it has already acted to phase out MTBE and is facing an ethanol mandate. (For an interesting review of some of this activity, see the testimony of a variety of people at the May 6 House of Representatives Committee on Commerce hearing on HR 11, one of California-specific bills, at <http://committees.house.gov/ccheat/hearings106.nsf/hemain>.)

Other bills would remove the mandate for the entire country. Congress is very aware of the activities of the EPA Oxygenate Blue Ribbon Panel, which appears to be leaning toward recommending a removal of the mandate, and also the National Research Council's recent report that downplayed the benefits of oxygenate use for ozone reduction. But if you think that science and facts will win the day with the political poohbahs in the Capitol, maybe you've had a little too much to drink. ■

Bruce Bauman, Ph.D., is the Groundwater Research Program Coordinator for API. For more information, contact Bruce at bauman@api.org. If you have real-world information on ethanol-release sites, he would love to hear about it!

Managing Your State Cleanup Fund from page 15

Although eligibility is open to all tank owners, the insurance funds are also advantageous to the regulated community. Many small station owners would be unable to meet the federal financial responsibility requirements without some form of state assurance fund. The insurance funds help the owners see that compliance is a good business practice that will extend the life and profitability of their facilities. This structure creates a win-win situation for both the regulator and the regu-

lated community. It also protects the environment by reducing the potential for petroleum releases from USTs.

A final advantage of insurance funds is that they are normally supported by premiums and fees paid by the regulated community, which places the cost associated with operating a petroleum storage tank squarely in the pocket of the person who stands to profit from its operation. This approach reduces the use of public funds and prompts states to develop innovative ways to reduce costs. Stakeholders in the states cited in this article have a high degree of

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few days of confirmed progress documentation.

PFP also has mechanisms for assuring that the contractor is held responsible to reach the free-product removal goal within both the time limit and the fixed price that is set for the cleanup, regardless of the cost of the work. In general, the cost of a free-product removal cleanup at a given site can be estimated and the price can be set based on the thickness and size of the plume and the physical characteristics of the site.

Strong PFP Fiscal Incentives and Good Contamination Measurement Foster Success

PFP is a very effective framework for accomplishing free-product removal quickly and with minimal further environmental harm at the best possible price. PFP accomplishes this goal because it gives the contractor a strong financial incentive to reach clearly set goals as quickly as possible. For more information about PFP, e-mail Bill Foskett at foskett.william@epa.gov. ■

Bill Foskett is with the U.S. EPA's Office of Underground Storage Tanks (OUST) and is the PFP Staff Lead.

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customer satisfaction with this type of state fund.

If you have any questions or would like additional information on the problems/solutions discussed in this article, contact Pat Rounds, Iowa; Carol Eighmey, Missouri; Doug Hansen, Utah; Jim Sims, Washington; or Gil Sattler, West Virginia. ■

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Investigation and Remediation

Evidence for Contamination of Heating Oil and Diesel Fuel with MTBE

by Gary A. Robbins and Brent J. Henebry

The widespread use of methyl tert-butyl ether (MTBE) at high concentrations in gasoline began in Connecticut and other areas of the United States in the early 1990s in response to requirements of the 1990 Clean Air Act Amendments. Relative to other gasoline contaminants of interest, MTBE has a higher affinity for groundwater and a lower potential for natural biodegradation and retardation. For this reason, MTBE has emerged as a common groundwater contaminant associated with gasoline releases and has become the focus of an ongoing national debate regarding its continued use.

To add to this debate, recent research conducted by the University of Connecticut Hydrogeology Program provides evidence for widespread contamination of heating oil and diesel fuel with MTBE. Inasmuch as MTBE is a fuel oxygenate that is blended with gasoline, its presence in heating oil and diesel fuel is troublesome. This article will summarize what we've found through our research and describe our ongoing investigation of this issue.

Evidence for MTBE in Diesel Fuel

Our story begins at the University of Connecticut Motor Pool, a gasoline fueling facility. Post-LUST-remediation groundwater monitoring in November 1997 and March 1998 revealed the presence of elevated levels of MTBE at the pump island. No BTEX or PNA constituents were present.

One hypothesis developed to explain these findings attributed the problem to spills of MTBE-contaminated diesel fuel. To investigate this hypothesis, four samples of diesel fuel were collected from the motor pool in March 1998 for analysis. The results of the analyses indicated the presence of MTBE in all four samples

at levels ranging from 61 to 66 mg/L.

Equilibrium octanol water partition calculations revealed that if this diesel fuel were to come into contact with groundwater, an MTBE concentration of up to 6,000 $\mu\text{g/L}$ could be achieved. This level of contamination was in the range of that observed in the groundwater at the motor pool site.

We determined that only 2.7 gallons of gasoline containing 15 percent MTBE by volume would be needed to contaminate a 5,000-gallon diesel tank to these levels.

A simple calculation was conducted to assess the amount of gasoline required to contaminate the diesel fuel to the concentrations detected. We determined that only 2.7 gallons of gasoline containing 15 percent MTBE by volume would be needed to contaminate a 5,000-gallon diesel tank to these levels.

Evidence for MTBE in Heating Oil

The motor pool diesel fuel findings were reported to the Connecticut Department of Environmental Protection's (CTDEP's) LUST Trust Program. Upon a preliminary file review, the department determined that MTBE groundwater contamination was often found in association with heating oil releases. In December 1998, we carefully reviewed a total of 78 case files to determine the frequency and magnitude of MTBE detection at heating oil release sites.

We looked for sites that met the following criteria:

- The site had been affected by a heating oil release and had no nearby source of gasoline contamination (e.g., gasoline station,

automotive repair shop);

- Groundwater analysis for MTBE had been conducted; and
- Petroleum product groundwater contamination had been detected through analysis of near-field groundwater.

A total of 37 sites met these criteria and were used as a population for a statistical evaluation.

MTBE was detected in groundwater at 27 (73 percent) of the 37 sites. The maximum reported MTBE concentrations ranged from 1 to 4,100 $\mu\text{g/L}$. With respect to regulatory limits, 19 percent of the sites had MTBE groundwater contamination levels that exceeded the CTDEP groundwater protection criteria of 100 $\mu\text{g/L}$.

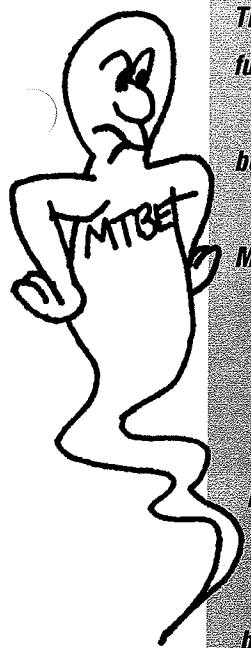
With respect to the U.S. EPA Drinking Water Advisory, 32 percent of the sites exceeded the upper limit of 40 $\mu\text{g/L}$ and 46 percent of the sites exceeded the lower limit of 20 $\mu\text{g/L}$. For a detailed description of this research, refer to "Evidence for MTBE in Heating Oil" in the Spring 1999 issue of *Groundwater Monitoring and Review*.

Consequences

The source of the MTBE contamination of diesel fuel and heating oil is currently not known. Contamination could result from the use of similar lines or vehicles during transportation from the refinery to end users. The presence of MTBE in fuel oil and diesel fuel is troubling, not only because it indicates that potential sources of MTBE contamination are widespread, but also because it could well result in increased remediation costs for heating oil and diesel fuel releases and increased litigation between home owners, insurance companies, and oil companies.

Current Research

Additional research is under way to determine the source and magnitude



The presence of MTBE in fuel oil and diesel fuel is troubling, not only because it indicates that potential sources of MTBE contamination are widespread, but also because it could well result in increased remediation costs for heating oil and diesel fuel releases and increased litigation between home owners, insurance companies, and oil companies.

of the MTBE contamination. We are currently testing an analytical method that can detect MTBE in product at low levels (ppb range) for reproducibility and accuracy. The method being tested is a static head-space procedure using gas chromatography. Quantification is made using a standard addition procedure.

Once the method has been verified, we will collect product at various key points in the fuel transfer chain to determine the source and magnitude of the contamination. Also, diesel fuel and heating oil will be collected from several locations at four different times during the year to determine the extent of seasonal variations of contamination levels. ■

Gary A. Robbins is a Professor of Hydrogeology in the Department of Geology & Geophysics at the University of Connecticut. During the last 20 years, he has been developing field screening methods and investigatory approaches for improving site investigations at leaking underground storage tank sites. Gary can be reached at gary.robbs@uconn.edu.

Brent J. Henebry is a graduate student pursuing an M.S. in hydrogeology at the University of Connecticut.

Investigation and Remediation

National Research Council Study Questions Need for Oxygenates in RFG

by Ron Kern

On May 11, 1999, the National Research Council (NRC), which is the main operational unit of the National Academy of Sciences and the National Academy of Engineering, issued a press release stating that "oxygen additives used in reformulated gasolines in the United States contribute little to reducing ozone pollution." The study, funded by the U.S. EPA, was conducted to evaluate differences between MTBE and ethanol in reformulated gasolines (RFG).

The federal Clean Air Act Amendments of 1990 require use of RFG with oxygenates in major urban areas of the United States that have significant ozone pollution. The NRC committee found, however, that the factors that have been most significant in lowering ozone levels are better vehicle emissions control equipment and the other nonoxygenating chemical components of RFG. The study further concluded that the potential for RFG with MTBE to curtail smog levels is low and also that, by comparison, RFG with ethanol results in an increased potential of vehicle emissions to form ozone.

The NRC predicted that vehicle emissions will continue to decrease

over the next few years as newer vehicle emission technologies are implemented. The study did note, however, that a high proportion of pollutants originate from older vehicles, which do not tend to be the targets of tests related to RFG. Consequently, the effects of RFG on older vehicles are uncertain, making it difficult to estimate both total vehicle emissions and the effects of different fuel formulations.

In response to the NRC report, the Oxygenated Fuels Association (OFA) stated that the report disregarded the findings of other state and federal environmental agencies and overlooked the benefits of RFG in reducing "both the exhaust and evaporative emissions from motor vehicles, including carbon monoxide." The Renewable Fuels Association (RFA) expressed concerns that the NRC report does not consider either the dilutive effects of oxygenates in RFG or the potential "impact on air quality of the gasoline components that might be used to replace the large volume and octane lost if oxygenates were not used in RFG." ■

Ron Kern is LUST Program Manager for the Arizona DEQ.

The complete NRC press release and information for obtaining copies of the report, *Ozone-Forming Potential of Reformulated Gasoline*, can be found on the National Academy of Science's Web site: <http://www2.nas.edu/whatsnew/2a16.html>. Additional information on the NRC's report and excerpted responses from the Oxygenated Fuels Association (OFA) and Renewable Fuels Association (RFA) are obtainable at: http://www.enn.com/enn-news-archive/1999/05/051399/rfgs_3180.asp.

OFA's response to the NRC report is obtainable at: <http://www.cleanfuels.net/ofa-nrc.htm>.

RFA's response to the report is obtainable at: <http://www.ethanolrfa.org/pr51199.htm>.

Investigation and Remediation

Some Enlightenment on Density

by Blayne Hartman

Editor's Note: This is the fourth in a series of articles reviewing some of the physical/chemical properties that are commonly used in environmental assessment and remediation. This article will focus on the property of density.

Okay, the quiz for today is:

A DNAPL is:

- (a) A liquid more dense than water.
- (b) A new oxygenate to replace MTBE.
- (c) A new EPA office. Department of Natural Attenuation Policy and Logistics.
- (d) A competitor of Snapple.

Bet you got this one, didn't you? For those who did not, the correct answer is (a). Translated into everyday English, a DNAPL (dense nonaqueous phase liquid) is a liquid that does not mix with water and is heavier (more dense—that is, a sinker). An LNAPL (light nonaqueous phase liquid), on the other hand, is a liquid that is lighter than water (less dense—that is, a floater). Oil floating on vinegar salad dressing, for example, is an LNAPL. (I was enlightened by one student, who said you can observe the same effect when making margaritas from scratch in a blender.)

Okay, let's name some DNAPLs. How about:
trichloroethane (TCA), trichloroethylene (TCE),
perchloroethylene (PCE), dibromoethane (EDB)

And some LNAPLs:
gasoline, diesel, motor oil, cooking oil

See Any Trends Here?

To understand what's going on, we need to review a few basic concepts relating to the relative weight of a liquid versus water. To do this, we need to start with the elements that make up these materials.

Notice that all of the LNAPLs listed above are common fuel products or oils—hydrocarbons. Hydrocarbons are compounds that consist primarily of two elements: hydrogen and carbon. Put the names together and you get "hydrocarbon."

Water is also composed of two elements: hydrogen and oxygen. (Do you ever wonder why we don't call water hydro-oxygen? I do.) Notice that hydrogen is common to both hydrocarbons and water—in both cases, there are about two atoms of hydrogen for each carbon or oxygen atom. So, in essence, the difference between hydrocarbons and water is that the former contains carbon and the latter oxygen. Carbon has an atomic weight of 12. Oxygen has an atomic weight of 16. So, as a first approximation, it is reasonable to expect hydrocarbons to weigh less than water.



Now let's look at DNAPLs. Most chlorinated and brominated solvents are simply hydrocarbon molecules (e.g., ethane, ethylene) that contain one or more chlorine or bromine atoms. The atomic weight of chlorine is 35.5. The atomic weight of bromine is 80. Both of these atoms are very much heavier than the oxygen in water, so we can reasonably expect materials with these elements in them to weigh more than water.

Are you starting to get the picture? In the discussion so far, I have made one tacit assumption: that the space that each compound takes up (i.e., its molar volume) is the same. In other words, a hydrocarbon, solvent molecule, and water molecule take up the same space. In actuality, this is not the case. So when determining whether a compound will or won't float in water, it is important to compare not just the weight of a material, but the weight for the same volume occupied.

This ratio of a compound's weight to volume is known as its density. Commonly, the density of a liquid is compared to that of water. The ratio of a compound's density to the density of water is known as the specific gravity. Specific gravity is a convenient reference point, because liquids with specific gravities greater than 1 are sinkers and those with specific gravities less than 1 are floaters.

So What?

Assuming you haven't memorized the specific gravity of many compounds, you can estimate whether a liquid is a LNAPL or DNAPL by comparing the atomic weight of the element in addition to hydrogen with the atomic weight of oxygen. For petroleum hydrocarbons, carbon is the primary element besides hydrogen, carbon weighs less than

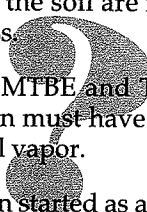
oxygen, and therefore liquid hydrocarbons are likely to float on water (and they do). For a compound containing chlorine or bromine, both of these elements are much heavier than oxygen, and it is likely that compounds with these elements will sink (and they do). Remember, this is an estimation only, because density is not dependent on atomic weight alone.

Wondering about MTBE? The above technique applies only to liquids (not gases or solids) that do not mix with water. MTBE mixes with water well enough that it does not form a separate fluid layer; hence it does not form a NAPL (non-aqueous-phase liquid).

Vapor Density

Now that you've got the concept of liquid density down, try this quiz:

You conduct a soil-gas survey at a facility containing aboveground tanks inside a building and find large concentrations of MTBE and TPH in the soil gas. You take soil samples to define the contamination and the soil analyses all are below detection. What's the explanation?

- 
- (a) VOC analyses in the soil are not always reliable due to volatile loss.
 - (b) The volatility of MTBE and TPH is high, so the soil contamination must have volatilized (evaporated) into the soil vapor.
 - (c) The contamination started as a vapor.
 - (d) Get a new lab.

Those of you who have managed to get through some of my previous articles (see "The Downward Migration of Vapors," LUSTLine #28) should know the answer to this quiz. For those of you who didn't (or those of you who have forgotten), the answer to this question requires us to consider the concept of vapor density.

The vapor density of a compound relative to air is approximately equal to the molecular weight of the compound divided by the molecular weight of air, or

$$P_v = MW_i / MW_{air}$$

Since the molecular weight of air is equal to 29 g/mole,

$$P_v = MW_i / 29$$

A familiar example is helium. With a molecular weight of 4 g/mole, it has a vapor density only 1/7 that of air, so of course, balloons filled with helium rise. Now, let's try a few of our favorite petroleum compounds:

Because many of the compounds associated with petroleum hydrocarbons have vapor densities significantly larger than air (two to four times), vapor density can play an important role in situations where petroleum hydrocarbons, such as fuels, are used or stored in an indoor, confined space. In these situations, the vapors emanating from a container or from liquid leaks can sink to the floor because of their high vapor density. Gas and electric companies are well aware of this behavior, which is why they require hot water heaters in garages to be a minimum distance off the floor to prevent the ignition of dense gasoline vapors "flowing" along the floor.

If air flow is restricted, such as in a closed room, the dense vapors can penetrate the concrete floor and enter the upper vadose zone. Such bulk dense vapor movement can continue to drive the vapor downward through the vadose zone until it is diluted to concentrations low enough (<1%) that density is no longer an important factor in the vapor transport process.

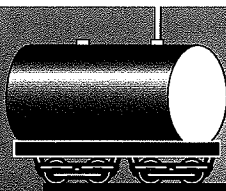
Vapor clouds reaching tens of feet into the uppermost vadose zone have been attributed, at least in part, to density-driven flow. Businesses and commercial operations that deal with chlorinated solvents (e.g., dry cleaners, vapor degreasers, spray facilities) are the most susceptible to this situation. Vapor clouds are a common occurrence beneath dry cleaners. The situation is not as common for petroleum hydrocarbons, because they rarely are stored indoors in confined spaces (due to their flammability). However, as far as USTs are concerned, leaks of "dense vapor" are possible from vent pipes, pipe joints, and tank bungs.

So, the answer to the quiz? Although there is currently much debate over the optimum way to measure VOCs in soils, it is likely that some would have been identified if the contamination was in the soil. Also, it is extremely unlikely that all of the soil contamination would have been lost to the vapor phase, especially if any moisture or carbon were present in the soil. Since you have no reason to doubt your lab, the remaining choice is (c). The measured contamination may have started as a vapor, penetrated into the vadose zone, and has yet to "equilibrate" with the surrounding soils, so it is detected in the soil vapor, but not in the soils themselves.

Two quizzes this time. I hope you enjoyed them. ■

Blayne Hartman is a regular contributor to LUSTLine. This article is taken from a presentation on physical/chemical properties that he gives as part of a training course on environmental geochemistry. For more information, either e-mail Blayne at bh@tegen.com or check out the information on his Web page at www.tegen.com.

Benzene:	Molecular weight: 78	Vapor density: 78/29 = 2.5
MTBE:	Molecular weight: 88	Vapor density: 88/29 = 3.0
Gasoline:	Molecular weight: ~100	Vapor density: 100/29 = 3.3



Coast to Coast

from the ASTSWMO Tanks Subcommittee

Coast to Coast is provided as a regular feature of LUSTLine to update state and federal UST, LUST, and cleanup fund personnel about the activities of the Association of State and Territorial Solid Waste Management Officials (ASTSWMO) Tanks Subcommittee. To find out more about the Tanks Subcommittee, contact Chairperson Scott Winters (CO) at (303) 620-4008 or Stephen Crimauo (ASTSWMO) at (202) 624-7883

Tanks Subcommittee

The Tanks Subcommittee had a very successful mid-year meeting in April in Denver, Colorado. Issues discussed during this meeting included preparation for the 2000 OUST National Conference, MTBE conference planning, implications of the 12/22/99 deadline for temporary tank closures, EPA's UST compliance/enforcement policy, USTfields, and budget numbers.

The Tanks Subcommittee members were active participants in the 11th Annual UST/LUST National Conference held in Daytona Beach, Florida, in March, drafting the agenda and planning, organizing, and speaking at a variety of the sessions. At the "State Fair" session, the Subcommittee presented results from informal surveys conducted during the past year: Survey of Residential Underground Storage Tank Enforcement and Contractor Certification; Average Cost per Site for Meeting the 1998 Upgrade Requirements; and Comparison of State UST and AST Leak Detection Requirements.

The Subcommittee is in the process of updating its "Report Card on the Federal UST/LUST Program." To date, 16 states have replied with all or most of the data requested. The results have been compiled and members will review the data and consider revising the questionnaire again to increase the amount of responses with usable data.

The Subcommittee also organized one peer match, allowing the Assistant Attorney General, Environment Division, State of Utah, to meet with the Assistant Attorney General for the State of Iowa in December to learn from Iowa's experience in LUST-site remediation cost recovery and witness an operator jury trial.

UST Task Force

The UST Task Force conducted a survey of state 1998 compliance data: "Where Are We with Respect to Meeting the 1998 Technical Standards?" Seventeen states replied, and the results were presented at the EPA National Conference "State Fair." Estimates, based on the survey of 17 states databases in early 1999 are as follows: 59.7 percent of the existing active tanks meet the 1998 technical compliance standards; 71.5 percent meet release detection requirements; 64.7 percent meet spill prevention requirements; 63.3 percent meet overfill protection requirements; and 64.3 percent meet corrosion protection requirements.

The UST Task Force is currently looking for new members. For more information on UST Task Force activities, contact Task Force cochairs Dale Marx (UT) at (801) 536-4100 or Juan Sexton (KS) at (785) 296-1685.

LUST Task Force

The LUST Task Force is preparing to present a 50-state MTBE (methyl tertiary butyl ether) conference, sponsored by ASTSWMO, on July 26-27, 1999 in Washington, D.C. The conference will bring together MTBE expertise from U.S. EPA, states, industry, and academia.

The MTBE Workgroup, a subset of the LUST Task Force, continues to publish its quarterly *MTBE Newsletter*, which includes updates of how state LUST managers are coping with MTBE contamination at LUST remediation sites. The workgroup produced *MTBE Newsletter* #5, January 1999. It can be found on the ASTSWMO Web page at <http://www.astswmo.org/Publications/summaries.htm#MTBE>.

The MTBE Workgroup has produced a total of five newsletters. The first provided background on the Workgroup and the latest four include in-depth information on MTBE research and reference sources. Newsletter #6 will be out this summer.

LUST Task Force members are participating in the development of two new ASTM standards, one on evaluating remedial decisions and another on integrated site management. Members are also working with EPA-OUST on adding an ORC (oxygen-releasing compounds) chapter to the agency's alternative technology guide.

For more information on LUST Task Force activities, contact cochairs Kevin Kratina (NJ) at

■ continued on page 27

■ **Coast to Coast** from page 26

(609) 633-1415 or Richard Spiese (VT) at (802) 241-3880.

State Cleanup Funds Task Force

The State Cleanup Funds Task Force has spent much of the last six months planning for what turned out to be a very successful Eighth Annual State Fund Administrators Conference held in Lexington, Kentucky on June 6-9, 1999. This year's "State Cleanup Funds Success Stories Compendium, Fourth Edition" included entries in Financial Success, Corrective Action, and Legal/Management. The State Funds Association honored Alabama as the "Best Fund for Getting the Job Done," Washington for Financial Success, Kansas for Corrective Action, and Vermont for Legal/Management.

Next year's conference will be held in June in Scottsdale, Arizona.

For more information on the State Cleanup Funds Task Force activities or on the Annual Conferences, contact George Matthis (NC) at (919) 733-1332.

TIE Task Force

The Training and Information Exchange (TIE) Committee worked hard to ensure the successful planning and implementation of the mid-year meeting in Denver. The TIE Task Force is currently working with the MTBE Workgroup on planning the MTBE National Conference. The TIE Task Force continues to work on and update ASTSWMO's Internet home page.

For more information on TIE Task Force activities, contact Task Force chairperson Kathy Stiller (DE) at (302) 323-4588.

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We welcome your comments and suggestions on any of our articles.

EPA HQ UPDATE

Updated Booklet on Financing UST Work

OUST has updated its 1995 booklet, *Financing Underground Storage Tank Work: Federal and State Assistance*. The updated booklet will help UST owners and operators, including those with tanks in Indian Country, obtain information about loans or grants for financing the costs of upgrading, replacing, or closing an UST, or of cleaning up an UST release.

The booklet describes federal loan and grant programs that, while not designed specifically for UST work, provide funding that owners and operators may be able to use for these activities. It also provides addresses and telephone numbers for potential sources of financial assistance in states.

OUST will include this revised tool in its compliance assistance packet being mailed to marketers and nonmarketers. Copies of the new booklet will be sent to regional and state UST program offices; the booklet will also be available on OUST's home page, www.epa.gov/oust under "OUST Publications."

OSWER Monitored Natural Attenuation Directive

The final version of a new OSWER Directive (9200.4-17P), *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, is now available. The purpose of this directive is to clarify EPA's policy regarding the use of monitored natural attenuation (MNA) for the remediation of contaminated soil and groundwater at sites administered by OSWER. The effective date is April 21, 1999.

This directive replaces the interim draft released in December 1997. Copies of the directive are being distributed by OSWER offices. The directive is available on EPA's Web site at www.epa.gov/swerust1/directiv/d9200417.htm. For more information, contact Hal White at (703) 603-7177.

RBCA Fate and Transport Models: Compendium and Selection Guidance

The American Society of Testing and Materials (ASTM) and OUST announce the release of *RBCA Fate and Transport Models: Compendium and Selection Guidance*.

This document is a compendium of commonly used fate and transport models and contains information to

aid in the selection of appropriate models to be used in the risk-based corrective action (RBCA) process. This guidance is presented so that information can be used by audiences with varying levels of experience in fate and transport modeling.

The information addresses all chemical fate and transport pathways, including vapor migration, soil leaching, and groundwater transport pathways. The guidance presents easy-to-use comparison tables, matrices, and flowcharts to convey and compare key information on specific models, such as equations, applicability, key/sensitive input parameters, model output formats, and limitations.

The document is an ASTM publication and was funded and technically coordinated by OUST under an assistance agreement. It received extensive review from states, EPA, and the National Partnership in RBCA Implementation (PIRI). Government agencies and the public may obtain the document at no cost by contacting EPA's National Service Center for Environmental Publications at (800) 490-9198. Businesses may obtain copies by contacting ASTM at (610) 832-9685. The document can be downloaded from OUST's home page at www.epa.gov/oust/rbdl/rbdlmfnt.htm.

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