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255 Ballardvale Street
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L.U.S.T. LINE

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

A Matter of Survival

As the '98 UST Upgrade Deadline Looms Ever Closer, "Mom and Pop" Gasoline Retailers Face Tough Financial Decisions And—In Many Instances—A Hefty Dose Of Confusing Information

Beaudry Store sits in rural splendor, framed by the backdrop of Camel's Hump Mountain, the fourth highest mountain in Vermont. Ten years ago, Terry and Linda Pecor made the decision that selling gasoline was essential to the viability of their small country store. "We knew we needed to be able to offer one-stop shopping," explains Terry. "We took a hard look at what we had and figured we stood to lose 40 percent of our business if we closed out our tanks."

"You really have to think about the amount of business you do and whether its worth keeping those tanks," adds Linda. "We are rural, and we do a lot of business with loggers, school buses, and the fire department. We're just far enough out that we don't have the competition. If we'd been someplace else, we might have decided differently. Like every business, you take long looks before you do something."

Terry and Linda mapped out a long-term plan. Their bare steel tanks were more than 20 years old. The first thing they did was to remove the tanks and replace them with fiberglass tanks and spill and overfill protection. In 1993, they had automatic tank gauges installed in both of their gasoline tanks and their kerosene tank. At the same time, they had vapor recovery piping installed in anticipation of any future Stage II requirements.

"We didn't want to have to tear up the parking area again if we could help it," says Linda. "I really like the automatic monitoring," she adds enthusiastically. "Every morning we push the monitoring button, and we know exactly the status of that tank. That's really important to me. I want to know that my tanks aren't leaking.

"Ten years ago," she recalls, "none of us knew anything about all of this. It used to be that we only needed to be concerned with weights and measures for our gasoline and the health department for our deli business. Now we have storage tank requirements, hazardous waste requirements, air pollution requirements, and health and safety requirements. The average person realizes why we're doing these things. No one wants to pollute. But for mom and pops it's harder."

■ *continued on page 2*

Inside

5 Drinking Water SRFs
6 The Last Lonely Gas Station
9 Contractor Availability
12 Testing Cathodic Protection
19 ALICE: An Evolving Concept
20 Status of ASTM ES 40-94
21 PA: 3rd-Party UST Inspection Program
23 Increasing Enforcement Presence
24 Contamination in Silts and Clays

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■ A Matter of Survival *from page 1*

With the leak detection and financial responsibility compliance deadlines behind them, tank owners and operators with unprotected steel tanks now face a deadline that will essentially define the course of their petroleum storage operations. They have until December 22, 1998 to comply with corrosion protection and spill and overfill prevention requirements. If they don't plan to close their tanks by then, they must decide whether to install new tanks and piping, or satisfy minimum federal requirements by retrofitting their existing systems.

While larger companies, such as major oil companies and convenience stores, and a sizable portion of independents have had upgrade programs underway for a number of years, nonretailers (e.g., trucking fleets), utilities, government entities (especially smaller municipalities), and small "mom and pop" businesses lag behind. The mom and pops, in particular, tend to be out of the retail marketing information loop.

"Many of these people either don't know what their upgrade and monitoring options are," says David Rubin, Principal Geologist with the New Jersey Department of Environmental Protection's (NJDEP's) Bureau of USTs, "or if they do know them, I'm not sure they fully understand all the advantages and disadvantages of each of the options. As a result, they rely on the vendors, who are selling a product that may satisfy the rules, but may not be the most cost-effective solution for that owner."

While larger companies, such as major oil companies and convenience stores, and a sizable portion of independents have had upgrade programs underway for a number of years, nonretailers (e.g., trucking fleets), utilities, government entities (especially smaller municipalities), and small "mom and pop" businesses lag behind. The mom and pops, in particular, tend to be out of the retail marketing information loop.

Getting the Story Straight

In deciding how to go about meeting '98 deadline requirements, tank owners need to know, first and foremost, exactly what those requirements are. Large corporations often have whole departments whose sole responsibility is to figure out the rules and regulations, provide facts and figures on options, and move the environmental compliance show along. Mom and pops, on the other hand, are the chief cooks and bottle washers of their own small enterprises. They are not likely to sink their teeth into the federal register or state statutes to find out every little thing the rules and regulations say they are supposed to be doing. Some of these small business owners are incapable of reading outreach material; others don't take the time.

Richard Ostrom, Supervisor of the Idaho Petroleum Storage Tank Fund (PSTF), has worked hard to provide state fund insurance policyholders (about 87 percent of the state's service stations) with clear and concisely written material, primarily through the fund's newsletter, *PIPELINE*. PSTF even published a special in-depth edition of *PIPELINE* dedicated solely to the '98 deadline. Even so, says Ostrom, PSTF field reps, who make annual visits to all policyholders to verify compliance, make it a point to "talk up" the '98 deadline.

"If you look at it from an insurance perspective," says Ostrom, "how many people know what's actually in their policy? That goes for the regs too. Unless there's an infraction they need to address, people rarely read the regs; many don't even read user-friendly written material."

Then again, questions come up that wouldn't necessarily be addressed in anybody's written material. Questions like, "Can I do my internal lining and cathodic protection at different times?"

Many mom and pop businesses find themselves unwittingly caught up in a survival catch-22—running marginally viable businesses and facing upgrade costs that could drive them out of business. As Linda Pecor points out, most tank owners know the rules came about for good reason, but for mom and pops, coping with these rules is particularly hard. Their survival margin is slim. If they don't get the story straight about their options, they won't be in a position to make intelligent, informed business decisions.

At the outset of a recent outreach workshop mounted by the NJDEP, a couple who owned a gasoline retail facility took the opportunity to launch into a tirade on the theme that they were overregulated and that the cost of compliance to station owners is enough to drive them out of business. At the end of their discourse, they received an enthusiastic round of applause from the others in attendance.

As the day went on and state staff and invited experts explained the technical requirements and how to get a loan, some of the anger and frustration that had filled the room earlier subsided. "Many of these tank owners were either misinformed or misunderstood the rules," says David Rubin. "By the end of the day, they had a better understanding about the options and were more comfortable about what they had to do to comply.

"Their concern is survival," observes Rubin. "They all want to do the right thing, but feel it could be done cheaper. After spending time

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Editor, *Ellen Frye*
Shushona Clark, *EPA Project Officer*
Jennie Bridge, *NEIWPCC Project Officer*
Kate Becker, OUST Liaison
Marcel Moreau, *Technical Advisor/Contributor*
Ricki Pappo, *Layout*

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The New England Interstate Water Pollution Control Commission was established by an Act of Congress in 1947 and remains the oldest agency in the Northeast United States concerned with coordination of the multimedia environmental activities of the States of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island and Vermont.

NEIWPCC
255 Ballardvale Street
Wilmington, MA 01887
Telephone: (508)658-0500
FAX: (508)658-5509
lustline@neiwpcc.org

talking to the couple who spoke out, we realized one big reason why they were so very angry. They were lead to believe, through an assortment of vendors and contractors, that they had to use literally every leak detection and corrosion protection option to be in compliance. They were getting astronomical prices to do their upgrades."

"Some people are scared, so they don't want to ask," says Dale Marx, UST Section Manager at the Utah Department of Environmental Quality. "A lot of tank owners think the rules are worse than they really are."

In Utah, every facility is inspected. When the inspection is completed, the inspectors let the tank owners know what they have to do to comply and have them sign an inspection sheet that says they know what they have to do. The department also provides training for owners and operators.

"In talking to owners and operators, we've had people who were planning to go out of business rethink their options because they realized they'd gotten the wrong story," says Marx.

Business Viability

In deciding whether to close, replace, or upgrade their tanks, owners and operators need to be able to evaluate all their options, the pros and cons of each alternative, and the costs. Examining the viability of the business—with or without gasoline sales—is an essential element in this process. An income/expense, or profitability, analysis should be conducted. Income should be calculated for each element of the business (e.g., gasoline sales, groceries, video rentals). All expenses should be included in the calculations (e.g., utilities, insurance, wages and benefits, taxes, debt service).

The resulting net profit calculation should be further analyzed in terms of the decision to close, replace, or upgrade. Gasoline sales, which may constitute just one element of the total profit picture of a rural convenience store, may well constitute the most important element of the profit picture. If the business does not sell gasoline, will it continue to attract the same levels of grocery sales or video rentals?

Once they've pulled together all their facts and figures, many tank owners will have to take a hard look at whether its worth staying in the gasoline retail business—closure may be the best business decision.

If a decision is made to replace or upgrade, most tank owners will need to be able to get a loan. At this point, a realistic evaluation must be made of the ability of the business to sustain additional debt. For example, a $80,000 loan for a period of 10 years at 9 percent interest, results in a monthly debt service of $1013.14. While the cost of replacing or upgrading an UST system may be less than $80,000, an accurate estimate of debt service is essential to future planning.

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Close, Replace, or Upgrade?

In general, the cost of upgrading a tank system is considerably less than replacing the entire system—tanks, piping, pads, dispensers. For tank owners or operators in states like Florida and Maine, the business decision is limited to two options: close or replace. In Maine, all bare (or asphalt-coated) steel tanks must be removed as of October 1, 1997 and all new tank systems must be double-walled. In Florida, cathodic protection and interior lining are no longer allowed, as of December 31, 1991.

If a tank owner or operator decides that he or she can afford to replace, then the decision becomes one of choosing an affordable system that, at the least, meets minimum regulatory requirements or, at the most, saves time and effort and "guarantees" that not one drop of product will ever find its way into the environment. Tank replacement also involves the uncertainty of not knowing what level of contamination will be found in the soil and groundwater when the old tanks are pulled, and thus, what cleanup costs might be incurred. On the bright side, however, tank replacement suggests the satisfaction of starting anew with a "clean slate" and reduced risk. Many tank owners are wiping their slates clean by removing their USTs and replacing them with ASTs (aboveground storage tanks).

If you're the only tank owner in town, you don't have price competition. If you decide to replace your tanks, you can pass some of this cost on to your customers. If you are competing with two or three other businesses and you are the only one who replaces, it will be more difficult to pass the cost on to customers.

In states that allow a third option to closure or replacement, if a tank owner wants to stay in business and can't afford to replace, he or she will need to upgrade. This means retrofitting the existing system with spill prevention and overfill protection. This means retrofitting the existing system, including the piping, with corrosion protection. This also means leaving any contamination that may be lurking in the soil or groundwater unattended until such time that it is inadvertently discovered...or not. Upgrading can add years to the life of an underground storage operation as long as all the upgrading has been done properly, and as long as the system is monitored properly and leak detection is in working order.

In deciding how to meet the '98 deadline, tank owners and operators who run retail operations tend to weigh-in one other significant factor: the cost of lost business. Many tank owners and operators make decisions based on how much, if any, down time is involved. Some choose to upgrade rather than replace their tanks, partly out of fear that customers will take their business elsewhere and never come back.

Financing

Tank owners and operators need capital to make improvements to their facilities. Lenders want to be able to extend secured loans where there is sufficient collateral to cover the loan should the business fail. In some instances, the assessed value of a

■ *continued on page 4*

■ A Matter of Survival *from page 3*

property with an UST is insufficient to cover a sizable loan, particularly if the property has contamination.

In recent years, lending institutions have been reluctant to extend loans to businesses where tanks are involved and where the real estate is the primary collateral because of uncertainty about their liability should the business fail and the lender take possession of the property through foreclosure.

EPA's recent UST-specific lender liability rule has helped ease these uncertainties by specifying the conditions under which secured creditors may be exempt from compliance with federal UST rules and thus avoid incurring cleanup liability. In doing this, EPA hopes it has removed a significant barrier to the financing of UST facility improvements. But in many states, environmental agencies still need to educate lending institutions on matters of USTs.

"We realized a while back that we needed to do something to address the hysteria in the lending institutions over UST facilities," says Herb Meade, Chief of Compliance at the Maryland Department of the Environment Oil Control Program. "The banks need to be comfortable about the tanks and the pollution liability. [The state had its own lender liability rule in place.] So we held a series of meetings across the state with loan officers and property assessors to put things into perspective and point out the questions that they need to be asking. They were envisioning a monster, and the meetings seem to help make tank properties a little less frightening. Things started rolling again."

Once the myths and misconceptions are stripped away, lenders should be able to look at UST sites strictly from a lender's standpoint. Many small businesses are able to obtain tank upgrade or replacement loans with relative ease. Some have to look around a bit before they find the right bank—it's important that the tank owner go to the "right" bank. Some banks are actually looking to lend money to small businesses or local businesses; others have some other criteria. The small business owner who has done his homework, has his financial house in order, runs a prudent gasoline retail operation, and has the wherewithal to secure the loan stands a good chance of finding a willing lender. The more secure the loan, the better.

Once the myths and misconceptions are stripped away, lenders should be able to look at UST sites strictly from a lender's standpoint. Many small businesses are able to obtain tank upgrade or replacement loans with relative ease. Some have to look around a bit before they find the right bank—it's important that the tank owner go to the "right" bank. Some banks are actually looking to lend money to small businesses or local businesses; others have some other criteria.

Unquestionably, however, some businesses will fail to qualify for a tank upgrade or replacement loan. "I've seen mom and pops whose profit margin is $4,000 a year," says Meade. "That's not a viable business. As regulators, we can give an owner or operator a little more time to see what they can do to come into compliance, but in most of these cases another month or two won't make any difference."

Financial Assistance and Public Policy

Should we care whether the mom and pops survive? If small business is, indeed, the backbone of America as many politicians proclaim, should government assist in ensuring its survival? In many rural areas, the loss of a small marketer would mean the loss of the only petroleum retailer for miles. (See the following article, "The Last Lonely Gas Station.") In many of these states, the programs were initiated because of concerns that small petroleum marketers would be forced out of business because of difficulties in obtaining financing for regulatory compliance outlays.

Some assistance is available to small businesses through Small Business Administration loan guarantees. Many mom and pops, however, are in such tenuous financial circumstances that a loan guarantee is of little value because they are not able to deal with additional debt service.

"It's a public policy issue," says Mike Brush, Claims Supervisor for the Idaho PSTF. "States may want to make sure there are way stations where people can pull off the highway to get gas, make an emergency phone call, get help if their car brakes down...to meet public need. This service is important for tourism as well as for local well-being. Mom and pop convenience stores are part of the economic fabric of many rural states. There are many issues besides profitability that fall into the area of public need."

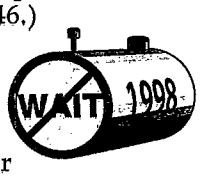
Many rural convenience stores are the source of gasoline, not just for motorists, farmers, or loggers, but also for such public entities as fire departments, police departments, school buses, and ambulances. The public safety support provided by mom and pops prompted the Washington legislature to maneuver through some rather serious constitutional constraints to conduct a grant program that reached 99 mom and pops throughout the state. During the devastating forest fires of 1995 in north central Washington, three gas stations that had been upgraded through the grant program were the sole source of fuel for the fire-fighting crews for more than 3 weeks.

Some state legislators and UST program managers have grappled with how to resolve a few basic questions: Who do we need to help just because of environmental issues? Can we make sure that environmental compliance concerns are not the single factor that puts a mom and pop out of business? If a mom-and-pop station is teetering on the brink of failure simply because it can't afford the upgrade, should the state step in and offer some assistance? If we offer assistance, what criteria do we use?

Fifteen states have instituted financial assistance programs for UST owners and operators. Most of these are loan programs; a few are grant programs. Kentucky is gearing up for a reimbursement program. Some programs, such as those in California and Oregon, address tank removal, installation, upgrade, leak detection, and cleanup. Most of the programs have a cap on what they will loan per site.

EPA published a document titled, *Financing Underground Storage Tank Work: Federal And State Assistance Programs*, to help all UST owners and operators—but especially those with tanks on tribal lands—obtain loans or grants for financing corrective action and upgrading UST systems to meet the 1998 requirements. (Copies can be ordered through the RCRA/Superfund Hotline at (800)424-9346.)

Why Not Wait Until 1998?



Terry and Linda Pecor upgraded their tanks on a phase-in basis. In terms of which tanks and what hardware they would install, they relied on their contractor. "You rely on others to make some of these decisions and hope you do the right thing," says Linda. "I find myself trying to second-guess everybody, and I don't hesitate to call the state if I have questions."

Terry and Linda have made their tank management decisions; they've addressed their corrosion protection, leak detection, and spill and overfill requirements; and now they are comfortably out of the fray should there be a last minute '98 deadline stampede. Unfortunately, this isn't the case for many others like them.

It's a matter of supply and demand. Iowa is a good example of demand for contractor services exceeding supply. Anyone who was using the Iowa state fund for insurance purposes, or who was self-insured and eligible for remedial benefits (about 3,000 facilities) had to be upgraded by January 1, 1995. According to Pat Rounds, Administrator of the Iowa Underground Storage Tank Financial Responsibility Program, a lot of people waited until the last minute.

Many of the owners and operators who would have replaced their tanks had difficulty scheduling their replacements to meet the deadline (even when it was extended an additional 3 months), so they selected the quickest and cheapest upgrade method they could find, which was either lining or cathodic protection. By not installing new systems, these tank owners also lost out on the benefit of a $10,000 grant the state fund was offering as an incentive for installing double-walled systems. "It was definitely a crunch," says Rounds.

The law of supply and demand was also operative in Florida in 1991. In that state, cathodic protection and internal lining were not allowed after December 31, 1991—this was the last chance for a cheap upgrade. As the deadline approached, the demand for contractors soared, but the supply was short. Florida contractors brought in personnel from other states to help them with the backlog.

Waiting until the last minute presents potential problems of backlogs, materials shortages, and worst of all, shortages of qualified, competent contractors to install new systems and upgrade or remove existing systems. While some tank and equipment manufacturers may not agree that there will be shortages, most agree that the costs for products and services are likely to go up as the '98 deadline approaches.

On the cleanup side of the equation, tank removals more often than not reveal some degree of petroleum contamination. If 1998 brings an upsurge in tank removals and associated remediation activity, state fund programs may experience claims processing problems, not to mention drawdown problems.

Many mom and pop businesses may have already made the decision to hang in there until the '98 deadline (or until they get caught) and then close up shop. Without some form of assistance, some of the marginal facilities will have to make that hard business decision to shut the doors and pull down the shades. For those small businesses who want to stay in business but haven't gotten their upgrade house in order, now is the time to act. ■

New Drinking Water State Revolving Loan Funds Leave Door Open For UST Projects

The new Safe Drinking Water Act (SDWA) amendments signed into law this past August authorized a total of $9.6 billion in capitalization grants for the establishmeLKLnt of State Revolving Loan Funds (SRFs) to offer financial assistance to public water systems. Eligible uses of these funds include a variety of source water protection measures, such as delineations and assessments of drinking water source protection areas, land acquisition, and a variety of source protection implementation activities.

The law states that up to 15 percent of a state's appropriation can be used to provide loans to community water systems for source protection measures, as long as no more than 10 percent of the appropriation is "set aside" for any single initiative. States are currently awaiting final guidance from EPA on how to administer the SRF program but have been advised to begin thinking about what types of activities they would like to fund using these "set-asides." Preliminary guidance, and the interpretation of this guidance by some states, acknowledges that eligible source protection measures could include UST projects, providing the tanks exist in a drinking water source protection area and the projects would prevent contamination of drinking water.

States will need to make careful decisions about how and to what extent they want to take advantage of the allowable set-asides. In Massachusetts, for example, should they choose to take advantage of all the allowable set-asides, 31 percent of their fund would be unavailable as loans to finance infrastructure projects.

States need to be thinking about how they will administer their SRF programs now. State UST/LUST programs that might want to consider this financial assistance option should contact their state SDWA primacy agency to discuss eligible projects and the possibility that UST projects could be considered for funding under the source protection set-aside. ■

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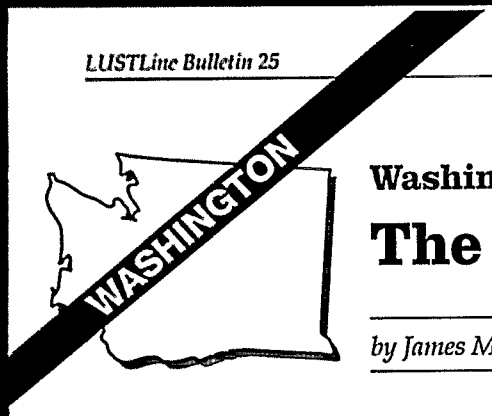
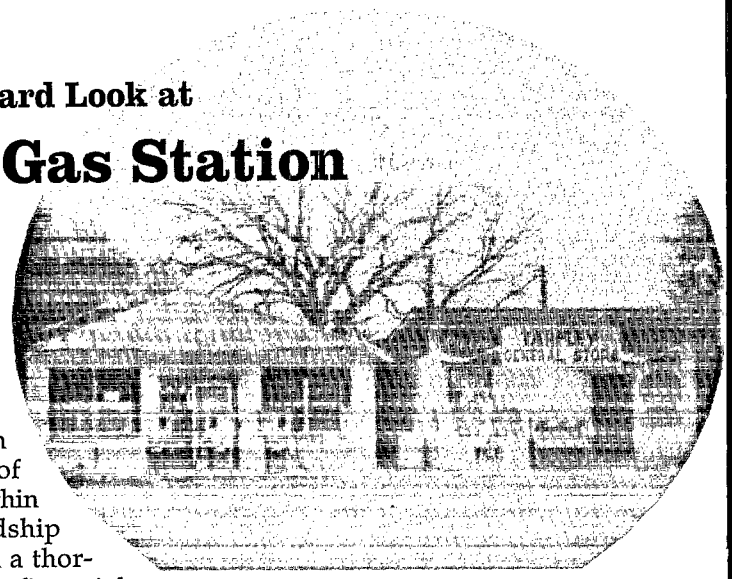


Washington State Takes a Hard Look at

The Last Lonely Gas Station

by James M. Sims



An effective petroleum supply and distribution system in rural America is essential to the flow of commerce and emergency services. This fuel distribution network, which can be found anywhere in rural America, was not created by design; it evolved as a simple and practical, market-driven notion that where there are people and fuel-driven vehicles, somebody will open a gas station. Ironically, however, little thought had been given to the importance of these far-flung fuel oases until their survival became uncertain. Many of these marginally profitable businesses face a host of costs associated with technological improvements and financial assurance to protect the environment and image requirements to remain branded dealers.

In 1991, the Washington State Legislature took steps to ensure the survival of the rural motor vehicle fueling network in our state. The legislature recognized that many of these rural gas stations were not generating the profit necessary to upgrade or replace their underground storage tank systems as required by federal and state law. In response to this problem, the Washington State Pollution Liability Insurance Agency (PLIA) was directed to establish the UST Community Assistance Program. PLIA began processing applications for grants to upgrade or replace USTs at remote and rural gas stations in January 1992.

The grant eligibility criteria established by the legislature specified that the station be rural and remote, that the owner demonstrate serious financial hardship, and that the local government entity certify that the continued operation of the station was vital to the community for public safety, education, or health reasons. Rural and remote was eventually defined as a facility where no more than one other retail source of petroleum is located within 5 miles. Financial hardship was evaluated through a thorough review of the financial records of the business by an independent small business financial analyst. Each grant was limited to $150,000, of which no more than $75,000 could be spent on remediating contamination.

PLIA awarded a total of 112 grants throughout the state; 99 were to small businesses and 13 to local government entities. In the process of evaluating the grant applications, PLIA staff traveled to more than 350 communities in the state to look at the sites, take pictures, and verify the locations and the fact that there were no other facilities within 5 miles. PLIA carefully reviewed the financial status of each grant applicant in terms of revenue, taxes, debt service, and past and projected sales.

PLIA determined not just the financial hardship but also the viability of the business to remain in operation for a period of 15 years. After investing a large sum of money to improve the business, assurance was needed that the business would survive. Because of the likelihood that low volume service stations would fail, grants were not awarded to businesses selling less than 120,000 gallons per year, roughly 10,000 gallons per month.

The Small Business Administration experiences a failure rate of almost 30 percent within the first 5 years for businesses comparable to those receiving PLIA grants. To date, only three grant recipient businesses have closed because of financial problems. Those of us at PLIA are confident that this low failure rate is the direct result of our financial scrutiny.

The Cost of Doing Business

UST owners and operators face a number of potential finance demands: upgrading or replacing their UST systems to satisfy 1998 technical standards; installing Stage II vapor recovery, if required; cleaning up contamination associated with a petroleum leak or spill; carrying pollution liability insurance or having access to some other method for satisfying financial responsibility; and satisfying image requirements in order to remain a "branded" dealer.

The replacement or upgrade of USTs to satisfy 1998 technical standards will typically cost (for a three- to five-tank system) between $60,000 and $100,000, not including the removal of old tanks and remediation of any existing contamination. Installation of Stage II vapor recovery, if required, will cost between $15,000 and $45,000 per site.

To illustrate the financial burden associated with UST system upgrading or replacement, consider the debt service on a 10-year, $80,000 loan—at 8-percent interest, the debt service is $970 per month; at 9 percent, the debt service is $1,013.14 per month. Expressed in terms of volume of business needed just to satisfy the debt service on such loans: $970 requires a throughput of 8,083 gallons per month at a 12-cent profit margin; $1,013.14 requires a throughput of 8,442 gallons per month at a 12-cent profit margin. (The next section discusses the issue of expressing debt service in terms of

the number of gallons sold, a dramatic means of expressing the plight of the small retailer.)

In terms of cleaning up any contamination, the experience here in Washington is that over 70 percent of sites with USTs older than 16 years have some level of contamination that will cost over $2,500 for removal and/or remediation. Very few sites actually involve a threat to human health and the environment, but most lenders and many regulators require removal and/or treatment of contamination.

Our experience shows that for over 80 contaminated UST sites included under the grant program, the average cost of cleanup was only about $20,000 per site. This low cost is the direct result of firm cost control measures, including preapproval of all work and close supervision of field work. Without such controls, we estimate that the average cost per project would have been some 20 to 30 percent higher.

Pollution liability insurance, or another method of satisfying financial responsibility, is probably one of the least of the financial concerns of the UST owner or operator. There was, of course, a time when pollution liability insurance was neither readily available nor affordable. In a number of states, state cleanup funds have filled this gap. Otherwise, pollution liability insurance remains expensive for UST systems that constitute a very high risk—over 20 years old, no cathodic protection, manual inventory system, high water table—while coverage on UST systems that have been upgraded is, for the most part, readily available and affordable.

Under our Washington program, premiums range from $500 per year for a state-of-the-art UST system with automated leak detection to $5,500 per year for a site with up to five older USTs that have not been upgraded and that rely on manual inventory as the method of leak detection.

Environmental requirements aside, the major oil companies have prescribed image requirements that dealers must satisfy to continue to fly the company flag and have the advantages of being a branded dealer. These requirements are neither trivial nor optional. Image requirements can entail painting, new signs, a canopy, new dispensers, card readers, and pumps for three or perhaps four products. The cost of satisfying these requirements can range from $20,000 to $50,000. The cost of additional tanks, lines, and dispensers will be even higher.

The consequences of a dealer losing a brand are significant. We've seen cases where sales have dropped by at least 50 percent within 6 or 8 weeks of loosing a brand and becoming independent. The inability to use major oil credit cards contributes significantly to the decline. Then, of course, there is the motorist's uncertainty about the product: "How much pinging will I hear, or how much water will I have in my tank if this is lousy gas"?

When considering the profitability of a retail petroleum outlet, a clear measure of profit is volume (gallons sold) per month. While most rural petroleum retailers have other profit sources, such as repair services, tire and battery sales, groceries, and video rentals, the volume of gasoline and diesel sales is a definitive measure of profit.

Profitability/Viability

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Most retail petroleum dealers calculate profit on the basis of a "pool margin," wherein, for example, the dealer makes only 3 cents profit on each gallon of regular unleaded gasoline, but 11 cents on super unleaded, and 7 cents on diesel. The dealer calculates the number of gallons sold in each category to determine the margin of profit for the entire pool of products sold.

In the metropolitan areas of Seattle, Tacoma, Everett, Spokane, and Tri Cities, the pool margin is usually 4- to 8-cents profit per gallon. In rural areas of Washington, the pool margin is more like 10- to 16-cents profit per gallon.

Reporting in the April 1994 issue of *National Petroleum News*, petroleum industry analyst Daniel Johnston states that gasoline retailers typically make between 3- and 6-cents net profit per gallon. After looking into the matter carefully, PLIA determined some regional trends, based on throughput:

- **125,000 gallons per month** - Currently in the Northwest, major oil companies are attempting to capture a larger portion of the retail market and are prepared to make considerable funds available for replacement of canopies, signs, dispensers, and card readers to large volume dealers if they will change brands. A major oil company will usually make such an investment only if the dealer sells at least 125,000 gallons per month.
- **70,000 gallons per month** - Some jobbers (distributors) make funds available to their dealers for upgrades, particularly if a major oil company establishes requirements to satisfy "image" standards. Most jobbers will not make these funds available unless the retail dealer sells 60,000 to 70,000 gallons per month.
- **55,000 gallons per month** - Daniel Johnston reports that "small service stations" pump between 55,000 and 75,000 gallons per month.
- **30,000 gallons per month** - A commonly accepted industry standard is that a convenience store should sell at least 30,000 gallons of gas per month to be profitable. Daniel Johnston states that gasoline accounts for about one-third of convenience store sales, with the typical store pumping between 30,000 and 40,000 gallons per month. Johnston notes that inside the store, the profit margin on products other than petroleum is usually 30 percent of gross sales. Delis can carry a

■ *continued on page 8*

■ **Last Gas Station** *from page 7*

50 percent profit margin, while soft drinks can yield a profit margin of up to 70 percent.

- **12,000 gallons per month** - PLIA examined the gasoline sales of 57 rural gas stations and convenience stores that received grants under the program. Ten of the businesses had monthly throughputs of 30,000 gallons or more. The average monthly gas sales of the other 47 businesses was 11,800 gallons. For this reason, PLIA concluded that a monthly throughput of 12,000 is the minimum level of sales required for a rural gas station to be barely profitable.
- **9,000 gallons per month** - This monthly throughput is not really a measure of profit so much as a level of survival. Based on PLIA's experience and observations, a gas station or convenience store with no (or at least very little) debt service can barely survive with sales of 9,000 gallons per month...and this figure depends on whether or not the gas station has significant sales of beer or soda, video rentals, mechanical work, or other revenue.

The sale of 9,000 gallons per month results in a monthly gross profit from gas sales of $720 to $1,080, based on a profit of 8 to 12 cents per gallon. Based on Johnston's estimated profit of 6 cents per gallon, the monthly gross profit from gas sales would be only about $540. On an annual basis, this throughput level would result in an annual gross profit of $8,640 to $12,960 at a profit of 8 to 12 cents per gallon, or $6,480 at 6 cents per gallon.

The Lil' General Store in LaCenter

In May 1994, Brian Chang, owner of the Lil' General Store in the town of LaCenter, was awarded a grant to replace his UST system under our UST Community Assistance Program. The new system included three new stiP3® tanks, new dispensers, and automatic tank gauging system, and Stage II vapor recovery. The replacement and construction portion of the grant amounted to $87,600. Corrective action for contaminated soil discovered when the old UST was removed would cost an additional $57,000. Chang borrowed money to install a canopy.

From the time that Chang and his family took over the business in 1989 to the time that the new grant was awarded, annual sales of gasoline increased from 220,00 to 350,000 gallons per year. After the new construction, sales increased dramatically: 820,000 gallons sold in 1995 and, during the first 9 months of 1996, more than 680,000 gallons.

> ***A gas station or convenience store that pumps less than 12,000 gallons per month is marginally profitable and is probably in a very precarious financial state. It is not entirely facetious to conclude that such a business is already closed. The owners just haven't reached that conclusion. Chances are, however, that station is not the last lonely gas station.***

The business sells gasoline to the local police and fire departments as well as school buses. It also sells groceries and rents videos. The Changs are active in the community, and the store acts as an informal information center for the community and the surrounding area.

Without the grant, the Lil' General Store might well have failed to secure the financing needed to meet environment standards and remain viable as a branded dealer. The community would have lost an important resource. The grant helped keep the rural petroleum distribution network in tact.

Will The Rural Network Survive?

In evaluating Washington's rural network, we learned that the notion of the last lonely gas station with no other service for 50 miles is exaggerated and, perhaps, mostly myth. In the entire State of Washington, with significant mountainous, rural, and remote areas, only 8 gas stations were identified where there is no other service within 15 miles.

Likewise, when the Iowa UST Financial Responsibility Program attempted to quantify the nature of the potential impact of UST regulations on rural petroleum marketers by reviewing the proximity of smaller communities to retail outlets throughout the state, they discovered only three communities with populations of less than 1,000 that might have been affected using the criterion of driving up to 15 miles one-way to obtain gasoline. As it turned out, two of those communities had access to facilities in Missouri and the other has access within a 20-mile radius.

Barring state assistance to preserve the rural petroleum distribution network, many businesses will fail. A gas station or convenience store that pumps less than 12,000 gallons per month is marginally profitable and is probably in a very precarious financial state. It is not entirely facetious to conclude that such a business is already closed. The owners just haven't reached that conclusion. Chances are, however, that station is not the last lonely gas station.

America's rural fuel network will probably, for the most part, remain viable. As with any business, however, the survival of the rural gasoline retailer depends upon good business and tank management practices. In states where the survival of this rural network is crucial to the state's economic fabric, providing some kind public support in the form of a low interest loan or grant program that helps out the marginal but responsible gasoline retailer can make good political and fiscal sense.

At the very least, state UST programs need to work with small business administrations and lending institutions to find ways to create opportunities and remove barriers. Finally, many of these small retailers might well need some help in understanding the ways in which they can comply with environmental laws in a cost-effective manner. ■

James Sims is Director of the Washington State Pollution Liability Insurance Agency.

Field Notes

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

It was originally my intent to write an article on the subject of UST contractor availability. Prior to writing the article, I attended a national convention where Becky Newberry of the Petroleum Services Division of Omega Environmental, Inc., Atlanta, Georgia, spoke on the same subject. Her presentation was so well received that I believe the reader will be better served by reading a summary of her presentation.

He or She Who Hesitates May Lose Out When That Deadline Bell Tolls

A number of people in the petroleum industry have started to wonder exactly how compliance with EPA requirements for underground storage tanks is going to be accomplished by the December 1998 deadline. The rate of compliance work has certainly not been steady since the federal rule was published in 1988, and the backlog is increasing sharply as the deadline nears.

Many industries are lagging behind in their efforts to meet the compliance deadline. Some government agencies feel that they will be excluded from the mandates or that the regulations will not be enforced in their case. For nonretail tank owners, compliance work represents an unwanted maintenance cost that is not directly related to revenue. It is also anticipated that many of the tank owners who plan to remove their tanks will wait until just before the deadline to do so, to keep revenue coming in as long as possible. Many had hoped for, and perhaps counted on an extension, but it is now clear that the 1998 deadline is definite.

It is generally assumed that as the deadline draws closer, contractors and manufacturers will simply "gear up" to accommodate the increased demand. After all, who can turn down work? There are several reasons why this may not be a good assumption.

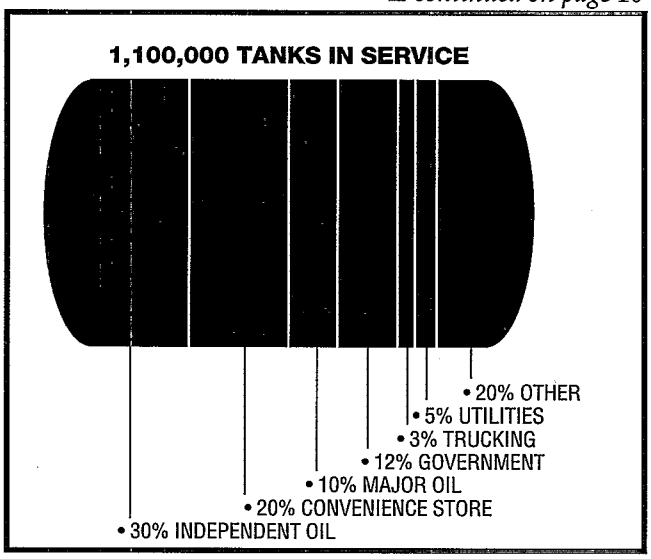
The petroleum equipment manufacturers are limited as to the quantity of tanks, automatic gauges, cathodic protection, and spill and overfill equipment they can produce, although it is likely that they can increase production somewhat. It is unrealistic, however, to expect that they will add the facilities, machinery, and personnel needed to meet the sharply increased demand that will occur if compliance work continues to be postponed. It is also unrealistic to expect that they will manufacture the equipment and stockpile it in advance, tying up their operating dollars.

The number of contractors and installers available to perform this work is also restricted to those able to meet certain qualifications. Contractors are expected to meet not only experience and quality requirements, but also special insurance or bonding capabilities, such as pollution liability insurance. Furthermore, a number of states now require contractor licensing or installer certification (or both) for tank removal, installation, or upgrade work. There is also a federal requirement for OSHA's 40-hour safety training for all employees performing work on existing systems. Contractors and installers must also be authorized by the equipment manufacturers to install tanks or most types of equipment. None of these requirements can be met quickly, cheaply, or easily enough to allow new contractors and personnel to enter the industry fast enough to meet the expected sharp increase in work to be done.

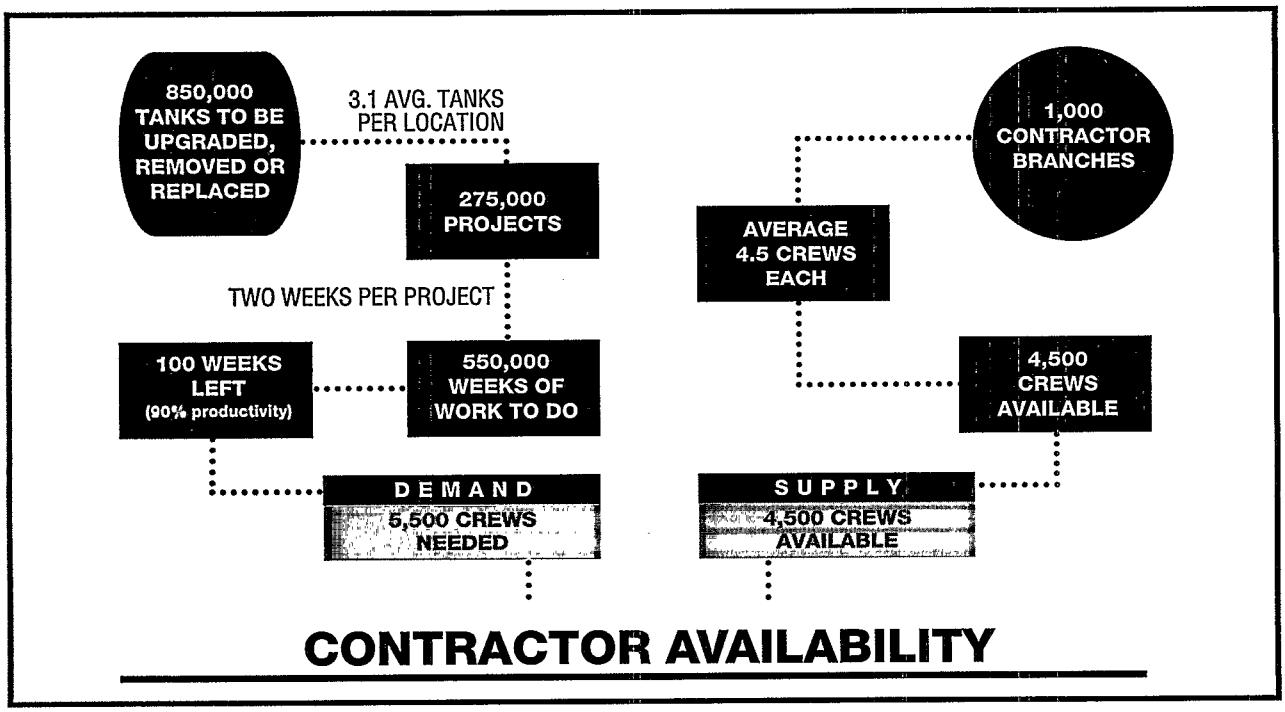
Even if all compliance work were scheduled now and spread out evenly over the remaining time before the deadline, there may not be enough qualified manpower available to complete the work on time.

An estimated 1.1 million or more tanks are in service at this time—roughly 30 percent independent oil, 20 percent convenience store, 10 percent major oil, 12 percent government, 5 percent utilities, 3 percent trucking, and 20 percent private other. It is estimated that only 26 percent of these are in compliance with 1998 regulations, leaving approximately 850,000 tanks to be upgraded, removed, or replaced. Of that 850,000, an estimated 25 percent, or 212,000, will be removals, while 75 percent, or 638,000, will be upgrades or replacements.

■ *continued on page 10*



Field Notes continued



Assuming an average of 3.1 tanks per location, approximately 275,000 projects will need to be completed within the next 114 weeks. If the productivity rate is 85 percent (due to weather and other delays), and the average length of time per project is two weeks, then 5,500 crews will be needed to perform the work.

On the supply side, there are approximately 1,000 PEI-member contractor branches who do compliance work. (Author's note: PEI membership is widely considered by many in the industry to be the main body of contractors who meet the necessary qualifications for compliance work.) If these contractors employ between four and five crews each, which is a reasonable number, we end up with about 4,500 crews available to perform the work. Not enough to meet the demand. None of these figures take into account the other UST and AST work, such as image upgrades and new facilities, that will be called for over the next 2 years.

It should now be obvious that waiting any longer to comply with the rapidly approaching deadline is not advisable. If the amount of work to be done exceeds the ability of qualified contractors and manufacturers to perform it, the owners left out will suffer. Not meeting the deadline may result in fines or facility closures. Equipment lead times will become longer and longer. As the deadline nears, prices will probably go up, and the quality of contractors available will go down. The top-quality contractors will have the luxury of selecting customers with long-term relationships, large or multiple projects, good potential for new construction after the deadline, and enough money to pay the higher prices.

If they are not already doing so, tank owners should start planning now to avoid the crunch. Even if the money can't be spent now, an owner can enter into a lump sum, multiple site or unit price contract now to have the work done later or over a period of time. Equipment can be ordered now, to be delivered later, maybe with just a down payment. Financing and lease packages are available to help owners buy now and pay later.

The planning process begins with having site surveys performed and with having lists of equipment, scopes of work, and budgets for each location. Priorities need to be set and decisions made to upgrade, remove, or replace equipment. The downtime for upgrade work is also be a good time for image upgrading, standardizing, centralizing, or automating equipment and tasks.

It is true that a job well planned is a job well done. If they haven't already, tank owners should begin planning their compliance projects now. ■

From the seminar, "Compliance '98: UST Deadline, Contractor Availability", NACS 96, by Becky Newberry, Omega Environmental, Inc. For more information, contact Becky Newberry at Omega Environmental, Inc., 1-800-39-OMEGA.

EPA HQ UPDATE

Anna Virbick is New OUST Acting Director

Lisa Lund, Former Acting Director of the EPA Office of Underground Storage Tanks (OUST) has moved to EPA's Office of Policy, Planning, and Evaluation as Deputy Assistant Administrator for Project XL (Excellence in Leadership), an EPA initiative that seeks to work with regulated entities to develop innovative approaches for addressing environmental issues. Lisa had been with the UST program for 9 years, first with the Arizona program and then at EPA headquarters. Good-bye and good luck Lisa.

Joshua Baylson, Director of OUST's Policy and Standards Division, served as Acting Director of OUST for 5 months following Lisa's departure. Now, as of January 6, Anna Virbick, will assume the post of OUST Acting Director. Virbick served as EPA's Deputy Inspector General for over 6 years and prior to that served as EPA's Assistant Inspector General for Management. Josh Baylson will now return to his former position.

New Guide on Free Product Recovery

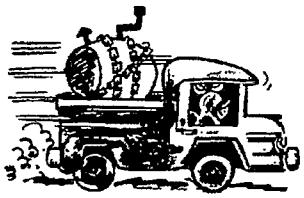
OUST has developed a guide to help UST regulators understand the portion of an UST corrective action plan that proposes free product recovery technologies. *How To Effectively Recover Free Product At Leaking Underground Storage Tank Sites: A Guide For State Regulators* (510-R-96-001) focuses on appropriate technology use, taking into consideration site-specific conditions.

The guide is designed to answer three basic questions:

- Is free product recovery necessary?
- Has an appropriate method been proposed for free product recovery?
- Does the free product recovery plan provide a technically sound approach to remediating the site?

OUST has distributed copies of the guide to its regional offices and to states and their regional offices in order to reach every state regulator who reviews corrective action plans. Consultants, engineers, lenders, public health professionals, environmental education centers, and others involved in the cleanup or remediation of a leaking UST site may also be interested in this guide.

The guide is available for $17.00 from the U.S. Government Printing Office, Superintendent of Documents, P.O. Box 371953, Pittsburgh, PA 15250-7954. Order stock # 055-000-00553-2.



New Leaflet on Tank Closure

OUST has prepared a leaflet, *Closing Underground Storage Tanks: Brief Facts* (EPA-510-B-96-004), which highlights closure as a compliance option for meeting the 1998 deadline and provides basic information on closing an UST properly. OUST encourages states or others who wish to get the word out on proper tank closure to adapt this leaflet to meet their specific needs.

You can use the Internet to download a copy of the leaflet (WordPerfect 6.1). To reach OUST's World Wide Web Home Page, go to http://www.epa.gov/OUST. The leaflet is also available on EPA's electronic bulletin board, CLU-IN, in Directory 4 (EPA/OUST Publications) as the file called "CLO.EXE." The leaflet is also available on a computer disk, as reproducible originals, and as printed copies. Contact Jay Evans at (703) 603-7149 for assistance.

Enforcement EPA Issues First-In-The-Nation UST Program Complaints Against The Navy For Violations At Two D.C. Facilities

On September 30, EPA Region 3 issued first-in-the-nation UST program complaints against the U.S. Navy for violations of federal underground storage tank regulations under RCRA Section 9006 at two sites: the Washington Navy Yard and the Anacostia Naval Station in Washington, D.C. The Navy is the owner of many USTs at these facilities, which are used to store regulated substances, such as petroleum.

"Environmental laws apply to government facilities, as well as private companies," said EPA Regional Administrator W. Michael McCabe. "EPA will bring appropriate enforcement actions to ensure that both public and private parties obey the law."

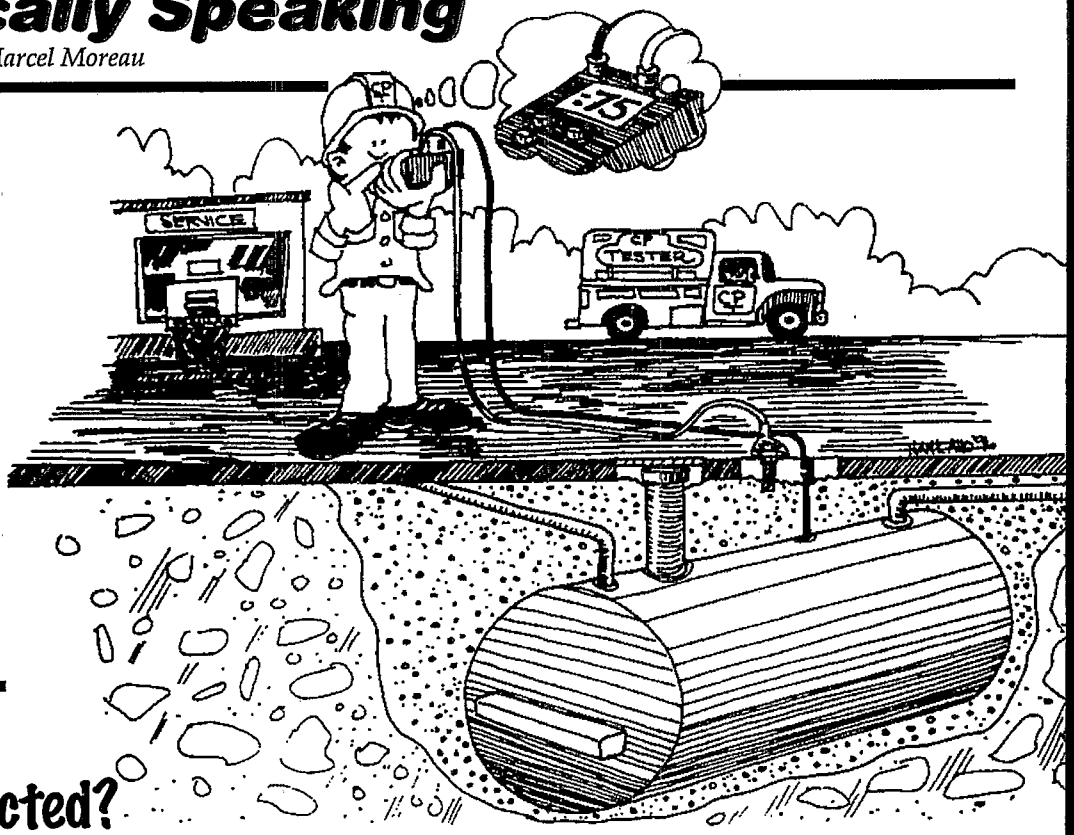
According to the EPA's complaints, the Navy failed to comply with UST release detection, notification, and recordkeeping requirements for several underground tanks at the two sites. In accompanying compliance orders, EPA directs the Navy to correct the violations and submit a report to EPA which certifies whether or not the requirements have been met. The Navy is entitled to a hearing to contest the alleged violations. Region 3 coordinated this action with the District of Columbia Environmental Regulation Administration. ■

Leak Prevention

Tank-nically Speaking

by Marcel Moreau

In this edition of "Tanknically Speaking," David McCaskill, who writes our "Tanks Down East" column, and Marcel Moreau, who regularly writes this column, have collaborated to discuss some of the problems associated with cathodic protection testing. It behooves anyone who has not read "Rust Though Art And To Rust Thou Shalt Return" in LUSTLine Bulletin #23 to do so before reading this article. Some background on cathodic protection will make this reading more meaningful. Marcel Moreau is a nationally recognized petroleum storage specialist. David McCaskill is a petroleum storage specialist with the Maine Department of Environmental Protection.



Is This Tank Cathodically Protected?

by David McCaskill

Delbert has had cathodically protected (CP) tanks at his station for 8 years and has yet to have them tested to see if they are, indeed, cathodically protected. Federal law requires that galvanic corrosion-protected systems like Delbert's be monitored within 6 months of installation and every 3 years thereafter. Now that the environmental regulatory agency has sent him a letter stating this fact and reminding him that he is in violation of the environmental regulations if his CP tanks haven't been tested, Delbert looks up the name of the guy his installer gave him 8 years ago. Delbert has had enough experience with the flatlanders from the capital to know that this letter is a harbinger of inspectors to come. He also knows that when his tanks were installed, his contractor gave him the low down on how his tanks were protected from corrosion holes. Delbert can see the wisdom of getting a CP tester over to see if everything really checks out.

Charlie, the CP tester, arrives with all the proper paperwork needed to document this blessed event. He brings out his magical meter and hooks one wire to what Delbert knows is his CP test station (a wire connected to the tank) and another wire from the meter to some sort of a probe. He pours water on the soil over the tank ends. He mashes the probe into the ground and peers deep into his meter as if to summon the CP spirit of the tank.

But Charlie's characteristic cherubic smile is soon replaced with a look of bedeviled puzzlement. He mashes the probe into other parts of the soil above the tank, as if dowsing for water. He borrows Delbert's dipstick, fastens a bolt with a wire attached to the bottom end, and lowers the apparatus down the fillpipe. He connects the wire from the dipstick to the voltmeter and peers at the meter again. Still not satisfied with the readings he's getting on his meter, he unhooks the lead to the test station and starts touching the vent pipe and some exposed electrical conduit as if to summon their opinion on the situation. But Charlie has performed CP tests often enough to know that he will have to tell Delbert what he surely doesn't want to hear, that his tank is not protected against corrosion.

Since 1986, Maine's rules have required that CP tests be made every year, rather than every three years, as required in the federal rules, either by a certified installer who has been trained by the Maine Department of Environmental Protection or by a cathodic protection tester. Two years ago our office sent out notices to owners of CP tanks to remind them about our annual CP testing requirements. We included sample CP recordkeeping logs in the mailing. We also sent these notices to our certified tank installers who would be getting the calls to do the work. Once these letters went out, many of the CP installation sins of the past came to light.

The galvanic CP steel tank design relies heavily on isolating the tank from other metallic structures, such as steel piping or electrical conduit which may overwork the CP system. Remember, the CP system was designed to protect only the defects in the tank coating. Isolation is accomplished by providing dielec-

tric bushings (usually made of nylon) at the tank openings. Failure to achieve isolation is the first issue that must be investigated when the CP readings don't meet the specs.

The CP tester in the illustration on page 12 is coming up with a reading of -0.75 volt, which is below the acceptable -0.85-volt level but still well above the naturally occurring reading of a bare steel tank (-0.4 to -0.6 volt). A voltage reading in this range is a positive sign that the cathodic protection system is operating but trying unsuccessfully to protect more than just the tank.

In the past, when a tank installer would call me with questions about a low CP reading, his (or her) first assumption was that the factory anodes had given out and that it was time to slap on a couple of 17 pound magnesium anodes and be done with it. I'd have to tell him that the answer was not necessarily that simple. He'd need to troubleshoot the system to be sure that the tank was, in fact, isolated from all other buried metals. (See Marcel's "How To..." section to find out how this is done.) If the tank is not isolated, then adding anodes will only defer the problem to another not-too-distant time.

Isolating the Problem

We had a rash of reports of low readings soon after our compliance letters went out. It seems that several of our CP testers were running across double-walled CP steel tanks with readings in the -0.6 to -0.7-volt range. The case was cracked when one installer figured out that the leak detection system used to test the interstitial space (the area between the two tank walls) was actually the source of the problem.

Most double-walled steel tanks have an attached 1.5-inch steel monitoring pipe that runs from the bottom of the interstitial space to the surface of the ground. Leak detection probes are placed in the bottom of the pipe where they can detect any leaks. A type of leak detection system popular in Maine uses a probe that senses changes in pressure resulting from changes in the level of the liquid in the bottom of the tube. These pressure changes are communicated to the alarm box by copper tubing that runs from the bottom of the monitoring pipe, up through the top of the monitoring pipe, then underground to the building where the alarm box is located. The copper tubing exits out of the monitoring pipe through an isolating fitting, but if it touches the inside of the monitoring pipe, the copper tubing and everything the tubing touches becomes, inadvertently, part of the tank's cathodic protection system.

When everything is electrically connected in this way, the anodes on the tank are trying valiantly to protect not only the tank but also the buried copper tubing and any other buried metal structures—plumbing, rebar in the concrete foundation, buried electrical conduit (you get the picture)—caught up in this vast electrical web. This problem is easily fixed by sleeving the copper tubing in small diameter PVC pipe so it doesn't touch the sidewalls of the monitoring pipe. Once this was done, our CP testers found that their readings quickly came up to spec. Needless to say, after that discovery I was a hero many times over. I simply disseminated my acquired wisdom when the subject of low readings on double-walled steel tanks was brought up, saving the contractor the agony of further troubleshooting.

Of course, lack of isolation is not the only possible cause of low readings, but it is the most common one. Very dry soils and spent anodes are also possible causes.

More is Not Better

Several years ago, a large heating oil jobber in our state tested the CP tanks of an industrial client. At this site, the jobber was getting readings that were too high. Now, where cathodic protection is concerned, more is not always better; the readings this tester was getting on these tanks were in the -2.0+ range and fluctuating. But such readings are no mystery to a corrosion expert when he knows that the industrial client is in the business of welding together steel beams.

When a piece of metal is electrically welded, a current must pass from a grounded welding machine, through the welding rod, to the metal, which is also grounded so the current can flow back through the earth, thus completing the circuit. But some of the current sometimes goes astray through the ground, striking other objects, like buried tanks. So the high readings that our CP tester encountered here were not from the tank's anodes but from the welding machine.

According to a corrosion engineer, the fix to this particular problem is to install a plastic vertical liner between the welding machine system and the tank to block the stray currents from affecting the tank. Of course, a better solution is to not install a CP tank in this kind of environment in the first place—a fiberglass, composite, or jacketed-steel tank is more appropriate. According to the installer, the client was given the fiberglass tank option; however, the low price of the CP tank and the client's affinity for things made of steel won the day. So, before buying a CP tank, check for possible sources of stray currents. If it's too late, then call a corrosion expert. (Contact NACE at (281) 492-0535 ext. 214 for a list of qualified corrosion professionals in your area.)

Other sources of stray currents include electric bus or subway systems, communication towers, or even adjacent impressed current cathodic protection systems protecting buried gas mains or other USTs.

Disappearing Anodes

During the first season of our cathodic protection compliance campaign, a coastal sewer district had the CP tested on an emergency generator tank at one of its coastal lift stations in close proximity to a salt marsh. The reading came in around -1.1 volts that year, but the next year, when the sewer district attempted to start the generator up for its own annual testing, it got a good dose of salty groundwater rather than its normal diet of diesel fuel. The tank was removed, and a couple of good-sized holes were found near the bottom. There was no sign of the anodes.

Several things could have gone awry here. First, the CP tank had been installed in a very aggressive environment. The groundwater in this area was affected by the ocean; it had a high salt content and would fluctuate with the tide. This made the electrolyte of our corrosion cell very conductive, meaning that the CP system would work very effectively but

■ *continued on page 14*

■ TANK-nically *from page 13*

also that the anodes would be used up faster. Again, a corrosion-protected fiberglass, composite, or jacketed-steel tank would have been a more corrosion-resistant solution in this location. Second, it is possible that the anode used in this early design was magnesium, which is not suited for saltwater environments. For this reason, zinc anodes are used on ship bottoms to fight the effects of saltwater corrosion.

There is still the disturbing question of why the tank had a passing reading one year and holes the next. There was no evidence of the anodes during the excavation, but then again, we're not talking about an archeological dig here either, so who knows if anything was left of them or not. I say "disturbing" because this means that a) the anodes were not protecting the whole tank, b) the anodes quit working and the holes were formed in less than a year, or c) the CP readings from the prior year were incorrect. Based on the contractor's prior experience in CP troubleshooting, I believe the initial readings were indeed correct. I might also add that the tank in this story was not a sti-P3® tank, which is the industry standard for pre-engineered cathodically protected tanks.

Most cathodically protected USTs are sold as pre-engineered packages, based on the assumption that one size fits all. These systems have been around since 1969, but until about 10 years ago, they were not installed in very large numbers. As this population of tanks ages, it will become increasingly important to monitor the effectiveness of their corrosion protection to avoid repeating the corrosion problems of the past.

Time And Testing Will Tell

As you can see from my smattering of stories, there are a lot things to consider when installing and testing cathodically protected UST systems. There are some sites in this state where installers have completed all troubleshooting and still can't get good readings on tanks less than 10-years old in relatively noncorrosive backfill. Jacketed tanks with a steel inner shells and polyeythelene or fiberglass outer shells that provide corrosion protection for the inner steel tank have become popular in Maine at the expense of CP steel.

Cathodic protection has had a long and successful track record in the protection of such steel structures as ship bottoms, cross-country buried pipelines, buried and submerged bridge supports, and oil terminal tank bottoms. Most of these CP systems have site-specific designs and are for the most part tested and maintained by corrosion technicians.

Most cathodically protected USTs are sold as pre-engineered packages, based on the assumption that one size fits all. These systems have been around since 1969, but until about 10 years ago, they were not installed in very large numbers. As this population of tanks ages, it will become increasingly important to monitor the effectiveness of their corrosion protection to avoid repeating the corrosion problems of the past. ■

Testing Cathodic Protection Systems

by Marcel Moreau

As David pointed out in the first part of this article, testing of cathodically protected structures is not always straightforward and does not always have the desired outcome. I had similar experiences this fall while teaching corrosion/cathodic protection courses across the country. It is clear to me that testing cathodically protected structures is rarely a "cookbook" type of procedure. A clear understanding of cathodic protection principles is a prerequisite for the correct execution of the monitoring procedure and reasonable interpretation of the monitoring results.

Having said that, I hereby offer my recipe for monitoring the status of a cathodically protected UST system. My goal is not to turn any casual reader into a cathodic protection tester but to provide some guidance for those who need a refresher. An understanding of how the monitoring procedure should be carried out may also help regulators and storage system owners understand what's what when they are reviewing cathodic protection monitoring reports.

As always, comments on how this recipe can be improved are welcome.

Testing Galvanic Cathodic Protection Systems

Equipment Needed:

- A voltmeter with at least 10 megohm (million ohms) input impedance. Most voltmeters with a digital display will meet this requirement. Although a model from a consumer electronics store will give accurate readings, a voltmeter specifically intended for cathodic protection monitoring will likely be more durable in the field environment.

- A copper/copper sulfate reference electrode (also known as a "half-cell" or "reference cell"). Typical reference electrodes are about 1 inch in diameter and 6 inches in length. They may have either a flat or a cone-shaped, porous ceramic tip at one end that is covered with a plastic cap. The cap must be removed when cathodic protection measurements are conducted, but it

should be kept in place on the reference electrode whenever it is not in use to minimize evaporation of the copper sulfate solution inside the electrode.

Maintain the reference electrode as follows:

- Keep the reference electrode about 3/4 full with distilled water.
- Be sure that undissolved copper sulfate crystals are always visible inside the reference electrode.
- Discard the solution inside the reference cell when it becomes cloudy. Refill the reference cell with copper sulfate crystals and distilled water. Clean the copper rod with nonmetallic sandpaper.
- Keep the reference cell away from freezing temperatures so that the copper sulfate solution does not freeze, or use the copper sulfate anti-freeze solution provided by the half cell manufacturer.

■ Two test leads (plastic coated wires with fittings on the end) that plug into the voltmeter and can be clipped onto the reference cell and the structure being monitored. Test leads can be any length; however, 2- to 3-foot lengths are typical. It is also a good idea to have a 20- to 30-foot length of wire handy, in addition to the two test leads for field work.

■ A standardized form that can be used to record pertinent information concerning the facility, sketch the facility, note voltage readings, and indicate the locations where voltage measurements were made.

Testing Procedure:

1 Determine how you will obtain an electrical connection with the structure that is to be monitored. If you are monitoring an sti-P3® tank, there may be a monitoring wire (usually green in color) coming up out of the ground and attached to the submersible pump riser, the automatic tank gauge riser, or the fill pipe riser ("riser" is a generic term for a vertical pipe attached to the top of an underground tank), or located in a special cathodic protection test station. If no wire can be found, see the "What If...?" section that follows.

The purpose of monitoring is to ensure that the entire tank is protected. This means that the portion of the tank farthest away from the anodes must still meet the criteria for protection. It is good practice to take voltage readings with the reference electrode in as many locations as practicable.

2 Determine where you will place the reference cell. The reference cell must be in contact with clean, moist soil, not with concrete or asphalt. See the "What If...?" section that follows if no clean soil is accessible. The ideal location is along the top middle of the tank. On many tanks installed after 1990 or so, this is where the automatic tank gauge riser is located and where soil is usually accessible. Other possible locations are around the submersible pump or, if a spill containment manhole has not yet been installed, around the fill pipe.

The purpose of monitoring is to ensure that the entire tank is protected. This means that the portion of the tank farthest away from the anodes must still meet the criteria for protection. Sti-P3® tanks of 10,000 gallons and less have anodes located on the ends; this means that the reference electrode should be placed at the top middle of the tank. Readings taken with the reference electrode placed near the ends of the tank will be higher. If there is no access to soil over the top of the tank, see the "What if...?" section that follows.

It is good practice to take voltage readings with the reference electrode in as many locations as practicable. I have seen tanks where one end of the tank registered 0.95 volts, the middle registered 0.88 volts, and the other end registered 0.83 volts. This situation could result from an actual deficiency in the cathodic protection caused by significant coating damage at one end of the tank or failure to unwrap the anode at one end of the tank. This deficiency could not have been discovered if only a single reading had been made at the middle of the tank. Note, however, that this situation could also result from petroleum contamination in the soil where the reference cell is placed (e.g., around the fill pipe) or from something that acts to shield the reference cell from the tank (e.g., a metal culvert around the submersible pump).

3 Unless the soil where you intend to place the reference electrode is quite wet, you will need to add moisture. Pour a quart to a gallon of water on the location where the electrode is to be placed and allow the water to be absorbed into the soil before taking the reading.

4 Turn on the voltmeter and watch the display to be sure that it is behaving normally. Consult the meter's instructions if you don't know what it is supposed to read when you first turn it on. If your instrument has multiple functions, be sure that it is set to make low voltage DC measurements and that the test leads are plugged into the correct sockets. Connect the positive lead of the voltmeter to the wire from the structure to be monitored and the negative lead from the voltmeter to the terminal at the top of the reference electrode. Do not touch any metal portions of the test leads when making a reading.

The display on the meter should be steady. Fluctuations of 0.01 volt are okay, but fluctuations greater than this may indicate a bad connection. There should be a negative sign in front of the reading, and the reading should be more negative (greater) than -0.85 volts (which is the same as -850 millivolts). Don't let the negative sign confuse you (-0.90 volts is greater than -0.85 volts [this is what you want]; -0.80 volts is less than -0.85 volts [this is what you don't

■ *continued on page 16*

INTERPRETING WHAT YOUR VOLTMETER IS TELLING YOU

READING	WHAT READING INDICATES
Greater than -1.65 volts for a structure with magnesium anodes	The maximum voltage output from a magnesium anode is -1.65 volts. If your reading is greater than this, the system could have impressed current cathodic protection rather than galvanic, or there could be stray currents in the vicinity. If it turns out this is NOT an impressed current system, have a corrosion engineer investigate as soon as possible.
Greater than -1.1 volts for a structure with zinc anodes	The maximum voltage output from a zinc anode is -1.1 volts. If your reading is greater than this, the system could have impressed current cathodic protection rather than galvanic, or there could be stray currents in the vicinity. If it turns out this is NOT an impressed current system, have a corrosion engineer investigate as soon as possible.
Greater than -0.88 volt	Structure is adequately protected.
-0.85 volt to -0.88 volt	Structure still meets the standard for corrosion protection, but there is not much of a safety cushion. Monitor the system closely to determine the rate at which the voltage is dropping and plan on adding anodes or performing other work on the system in the not too distant future.
Less than -0.85 volt	The structure does not meet the -0.85-volt standard for corrosion protection and is out of compliance with regulatory requirements. This does not mean, however, that the tank is leaking. (See "What if the tank or piping does not meet the -0.85 criterion?" in the following section.)
-0.4 volt to -0.6 volt	Expect this voltage range from steel that has no cathodic protection. This could indicate that the tank was not cathodically protected originally, or that the anodes are completely shot. Call in a corrosion engineer to investigate.
-0.3 volt to -0.4 volt	Rusty steel will sometimes register down in this range. Call in a corrosion engineer to investigate.
-0.1 volt to 0.0 volt	This type of reading is most likely to occur if you are measuring the potential of a piece of copper. Most likely the copper wire you are connected to is broken off underground. Find another way to get an electrical connection to the structure you want to monitor.
Variable readings	This could indicate stray currents, but check your meter to be sure that it is operating properly and that all test lead connections are in solid contact with shiny metal.
Wildly fluctuating readings (digital meter)	This probably indicates that one of your test lead connections is not good or that your reference cell is dry. Make sure that all your connections are solid metal to metal. Might also be indicative of extremely dry conditions in the backfill. Run water from a garden hose into the tank backfill for a couple of hours and take another reading.

■ TANK-nically *from page 15*

want]). The table on page 16 "Interpreting What Your Voltmeter Is Telling You" should help you interpret your readings.

5 No job is done until the paperwork is completed. While you should document the cathodic protection monitoring with the usual site information (e.g., facility name, address), you should also make a quick sketch of the layout of the facility and indicate the reference electrode location(s) and the corresponding voltage readings. Duplicating the reference cell locations over time is key to obtaining meaningful cathodic protection data.

What If...?

What if there is no monitoring wire for the tank?

You need an electrical contact with the tank. If the tank is an sti-P3® tank, all of the risers attached to the top of the tank are electrically isolated from the tank shell and cannot be used to obtain readings of the tank itself. To obtain a reading in this situation, make contact with the bottom of the tank through the fill pipe.

A "quick and dirty" way to do this is to fasten a length of wire (20-feet long or so) to a brass bolt and then fasten the bolt with a stainless steel hose clamp to the end of a dipstick so that the head of the bolt extends slightly beyond the end of

the stick. Clip the end of the wire that is not attached to the bolt to the positive test lead from the voltmeter.

Insert the bolt end of the stick into the fill pipe and press firmly against the bottom of the tank. There may be sludge and scale on the tank bottom which will require firm pressure and a little twisting motion on the stick to obtain good electrical contact. Good contact is indicated by a steady reading on the digital display of the voltmeter.

Be aware, some drop tubes are equipped with tank bottom protectors to prevent any damage that might occur when the dipstick repeatedly strikes the bottom of the tank. The tank bottom protector consists of a metallic plate that is attached to the bottom of the drop tube. A neoprene disc separates the bottom protector and the bottom of the tank, electrically isolating the tank bottom from the tank bottom protector.

Because the tank bottom protector is connected to the drop tube and the drop tube is connected to the fill pipe, the voltage reading obtained through the fill pipe will reflect the voltage of the fill pipe relative to the reference electrode, rather than the tank voltage. So if the dipstick method results in a reading in the unprotected range (0.4 to 0.6 volts) take a reading on the fill pipe. If the fill pipe reading and the dipstick reading are identical and a drop tube is present, remove the drop tube and check for a tank bottom protector before concluding that the tank is not adequately protected.

In some cases, if the tank is equipped with a manway at the bottom of a containment sump, it may be possible to contact the tank shell directly. Look carefully around the manway to determine how electrical isolation is being accomplished and whether any metal connected to the tank shell, or the tank shell itself, is accessible.

What if tank is equipped with a PP4 monitoring station?

If the tank is an sti-P3® tank installed around 1993 or later, it may have a test station consisting of a plastic dome about 3 inches in diameter with five metal terminals imbedded in it that are flush with the surface of the dome. The central terminal connects to a permanently buried reference cell (you don't need your copper/copper sulfate reference electrode to test this tank), and the four terminals around the center connect to one or more tanks. Simply connect the negative voltmeter lead to the center terminal and the other lead to each of the other terminals on the test station. You should get appropriate readings on as many terminals as there are tanks buried at the facility.

What if I need to monitor piping?

Cathodically protected piping is rarely equipped with monitoring wires to facilitate cathodic protection monitoring, but this is not a serious omission in most cases. Usually, the piping will be accessible at both the top of the tank and beneath the dispenser. There is typically also soil exposed at these locations for placing the reference electrode. If the anodes have been installed as suggested in the Petroleum Equipment Institute's "Recommended Practices for Installation of Underground Liquid Storage Systems" (PEI RP100), the ends of the piping will be the points in the system the furthest away from the anodes and are good places to locate the reference electrode. Be sure that the point of contact between the piping and the voltmeter test lead is clean shiny metal to ensure a good reading.

What if there is no soil along the tank top in which to place the reference electrode?

It is possible to get voltage readings by placing the reference electrode on damp concrete or asphalt, but these readings are generally not considered to be accurate or reliable. In my experience, readings taken with the reference electrode on concrete will always yield a reading in the range of -1 volt, regardless of whether the tank is cathodically protected. Readings through asphalt are unreliable because the voltage is determined by the location of cracks in the asphalt and not the actual placement of the reference cell. The reference electrode can be placed some distance away at the nearest available soil, but again, this is not the most accurate measure of the corrosion protection status of the tank. In my view, the solution is to drill a hole through the concrete or asphalt to allow direct contact between the reference cell and the soil in close proximity to the tank top.

What if the soil is "dry"?

I often hear that storage systems fail to meet cathodic protection criteria because the tank environment is too dry. While this may occasionally be true in parts of the desert southwest, it is not a likely occurrence in most other parts of the United States. If excessively dry conditions are suspected, run a garden hose to the tank top and pour a large amount of water into the tank backfill.

What if the soil where I need to place my reference electrode is contaminated with petroleum?

Don't take a reading in soil that is saturated with petroleum. Petroleum is not an electrolyte; the reference electrode must contact an electrolyte (e.g., water) for the reading to be accurate. A slight petroleum odor is acceptable for cathodic monitoring purposes, but soil saturated with petroleum will seriously affect readings.

What if the soil is frozen?

Traditional wisdom indicates that cathodic protection monitoring cannot be conducted in frozen soils because ice is not an electrolyte. Experience in Maine indicates, however, that monitoring can be successfully conducted in frozen soils if water is used to dampen the soil where the reference electrode is placed.

What if the tank or piping does not meet the -0.85 criterion?

The most common reason for failure to meet the -0.85 criterion for galvanic cathodic protection is failure to electrically isolate the cathodically-protected structure from other buried metallic or electrical components. The best method for identify-

■ *continued on page 18*

■ **TANK-nically** *from page 17*

ing such components is to measure the voltage of all accessible metal (e.g., piping, electrical conduit, utility piping, leak detection probes). This is done by measuring the tank voltage as described in steps 1 through 5 above and then connecting the negative lead of the voltmeter to all accessible metallic structures *without moving the reference cell.* (This is where that 20- to 30-foot length of wire from the "equipment needed" section comes in handy.) A reading of within a few millivolts of the tank reading indicates that the two structures are electrically connected. The exact place where the two structures are in contact must be located and the connection broken for the cathodic protection to work.

Inadequately isolated tank-anchoring hardware, although a likely source of electrical isolation problems, usually cannot be evaluated using this technique, because the voltmeter connection cannot be made unless the top of the tank is excavated.

Another possible reason for failure to achieve -0.85 volt is excessively dry soil. Refer to the "What if the soil is dry?" section above.

If the tank is isolated and the backfill is damp, but -0.85-volt reading still cannot be measured, research the installation procedures to see if you can discover any clues. Then call the Steel Tank Institute, the tank manufacturer, or a corrosion engineer for help.

Testing Impressed Current Cathodic Protection Systems

Equipment Needed:

The equipment list for monitoring impressed current cathodic protection systems is the same as for galvanic systems.

Testing Procedure:

1 Making an electrical connection to a structure with impressed current cathodic protection is relatively easy; none of the components should be electrically isolated from one another. The fill pipe or any other accessible tank riser is usually a good place to make a connection to the tank.

One case where this may not be true is when impressed current cathodic protection has been added to a sti-P3® tank. In this case, use the continuity test described under the galvanic cathodic protection question "What if the tank or piping does not meet the -0.85-volt criterion?" to check to be sure that all metallic components of the system are continuous. Use the dipstick method described under the question "What if there is no monitoring wire for the tank?" to check the voltage of the tank shell.

2 The guidelines for placement of the reference cell are basically the same as for galvanic systems. The reference cell should be close to the structure being monitored and as far away from the anode locations as possible. Anode locations can often be inferred from saw cuts and small areas of patched asphalt or concrete. Anode locations should also be indicated on the cathodic protection design documents.

3 The soil where the reference electrode is placed should be wet as for galvanic systems.

4 Test lead connections and voltmeter settings are also the same for impressed current systems as for galvanic systems.

5 The 0.85-volt criterion most commonly utilized for galvanic cathodic protection systems can be applied to impressed current systems but is not considered the most effective for these systems. There are many differing opinions among corrosion engineers as to the best technique for monitoring the effectiveness of impressed current systems. The 100 millivolt (0.1 volt) polarization decay criterion that is described here is included in the National Association of Corrosion Engineers' RP-0285-95. The set-up of the monitoring equipment (reference electrode, voltmeter, and test leads) is the same as for galvanic monitoring. What is monitored, however, is the change in voltage of the structure that occurs after the power to the rectifier is shut-off. This procedure requires two people to execute it properly: one person to switch off the rectifier, and the other to monitor the change in voltage of the underground storage system.

When the power to the rectifier is interrupted, there will be an immediate drop in the voltage reading at the tank, followed by a continuing slow decline in the voltage. The person monitoring the voltmeter must note the voltage reading immediately after the power to the rectifier is interrupted. (If the meter is digital, the numbers will change rapidly. The reading you want is the second number that appears on the meter's display.) The voltage is then monitored for several minutes (possibly much longer in stubborn cases) with the rectifier turned off. The criterion for cathodic protection is a voltage shift of at least 0.10 volt from the initial reading after the power to the rectifier is cut off. For example, a system might have a voltage of -1.1 volts with the power to the rectifier turned on. Immediately after shutting off the power to the rectifier, the voltage might drop to -0.83 volt. The voltage must then drop below -0.73 volt (0.83 - 0.10 = 0.73) to meet the criterion for effective cathodic protection.

Another way to determine if this criterion for cathodic protection has been met depends on whether the original voltage of the tank (i.e., before any cathodic protection was applied) is known. If the voltage reading immediately after the rectifier is turned off is at least 100 millivolts more negative than the original unprotected voltage, then the 100 millivolt criterion has been met. ■

Do not forget to restore power to the rectifier before you leave the site!

Prevention/Enforcement

ALICE: An Evolving Concept For Documenting Good Tank Management

ALICE is not an acronym; it's a concept in progress. The concept seeks to address a simple question: Wouldn't it be helpful if there were a recognized standard certificate, signed by a licensed, certified inspector, that documents good tank management? A certificate of this sort could provide entities such lenders, insurers, and real estate professionals with a mechanism for making better business decisions and facilitating transactions where USTs are involved.

ALICE evolved out of discussions between the EPA Office of Underground Storage Tanks (OUST) and representatives from the real estate, lending, and insurance industries as part of a Private Sector Initiative developed by OUST to identify and use market forces to ensure good tank management. By incorporating consideration of tank management practices into their everyday business decisions and asking the right questions, those business entities that have some stake in UST-related properties could help create market incentives for proper tank management and, at the same time, protect their own interests and the environment. While federal and state UST programs have made tremendous progress in educating tank owners about good tank management, realizing EPA's goal of making good tank management a common business practice will require considerably more time, effort, and a broader range of players.

After discussions with several state program managers and after learning what some states are already doing in terms of using self-auditing programs (e.g., Minnesota) and third-party inspection programs (e.g., Pennsylvania), OUST recognized that an ALICE-type certificate could also be used by state UST programs to augment or supplement their inspection and compliance programs.

"People are always asking me what the name "ALICE" means," says OUST's Sammy Ng, who has been the ALICE helmsman. "We needed a unifying concept to present to ASTM as a possible standard. What we had was an array of diffuse ideas from many interests that needed to evolve into a working concept. Many terms were being suggested, like "green certificate" or "compliance certificate," but these terms all had connotations that meant different things to different people. In order not to get sidetracked with having to define a concept that, as yet, had no final definition, I picked a name that had no particular meaning. Since womens' names seem to be popular these days—Rebecca [risk-based corrective action - RBCA] and Renee [remediation by natural attentuation - RNA], I picked ALICE, my mother's name."

By incorporating consideration of tank management practices into their everyday business decisions and asking the right questions, those business entities that have some stake in UST-related properties could help create market incentives for proper tank management and, at the same time, protect their own interests and the environment.

An ASTM Standard?

In April, Ng approached the American Society of Testing Materials (ASTM) E50.01 Subcommittee (on USTs) for approval to develop an ALICE standard for a third-party inspection and certification program for USTs. As proposed, this standard would specify items that should be included in such an inspection program; the specifics of different inspection tiers (e.g., ALICE-1, ALICE-2), if needed; and the training and experience requirements for certifying third-party inspectors.

ASTM gave approval to have an informal Task Group begin scoping out the standard. That group, made up of tank owner trade associations, insurers, lenders, several state programs, and OUST has met twice. While there is some consensus among the group's members that the concept has some merit and should be developed further, tank owners voiced strong concerns about the potential additional cost and burden of a third-party inspection program, especially if the benefits (e.g., lower insurance premiums or loans) are not certain.

Several states supported the concept as a means of augmenting their inspection programs. For some states, a third-party inspection program may represent an alternative to no inspection program. A few states indicated that they had adequate resources for annual inspections at every UST location and had no need for a third-party program, others were concerned about how an ASTM inspection framework would affect their own inspection program.

Through the ASTM meetings and discussions, ALICE continues to evolve. There seems to be consensus that the most useful inspection would be one that is similar to a typical state inspection. One state proposed that tank owners be allowed to use the ALICE standard to do their own inspections. State inspectors would spot check items on the inspection checklist, allowing them to do more inspections as a result of spending less time at one facility. Self-inspections could also spare tank owners the cost of having to hire a third-party inspector.

As a result of an October 1996 ASTM meeting in New Orleans, a formal go-ahead was given for the Task Group to move ahead and draft a standard. The Task Group writing the standard is comprised of representatives from the four ASTM stakeholder categories: industry (tank owners), regulators, consultants, and general interest (e.g., lenders, insurance). The Task Group hopes to have a draft proposed standard ready for the next ASTM meeting in April 1997 in Baltimore. ■

For more information, contact the co-chairs: George Kitchen, International Lubrication and Fuel Consultants, Inc., (505) 892-1666, or Sammy K. Ng, OUST, (703) 603-7166, ng.sammy@epamail.epa.gov

Leak Prevention

ASTM's Emergency Standard for Assessing Bare Steel Tank Integrity Goes Back to The Drawing Board

EPA Issues Interim Guidance

On November 15, ASTM's "Emergency Standard Practice for Alternative Procedures for the Assessment of Buried Steel Tanks Prior to the Addition of Cathodic Protection" (ES 40-94) expired, and a proposed replacement standard was not adopted. The proposed replacement standard received a number of negative responses in the American Society for Testing Materials (ASTM) balloting process, too many for ASTM's Committee on Environmental Assessment to tackle at its October meeting in New Orleans.

Shortly after the New Orleans meeting, the ASTM G01 Committee on Corrosion agreed to form a Joint Task Force with the ASTM E50.01 Subcommittee for Storage Tanks to continue the activity on the standard. Prior to this agreement, the corrosion standard work had been carried out by the E50.01 Subcommittee through its cathodic protection task group. The new Joint Task Force will work to develop a new technical standard to evaluate corrosivity on tanks, but not to address environmental compliance. Dennis Rounds, Chair of the ASTM E50.01 Subcommittee, has established a new task group under E50.01 to draft a standard that will focus on environmental issues and serve to complement the corrosion standard activity. Both task groups are scheduled to begin meeting soon.

ASTM published the emergency standard in fall of 1994 to address industry concern that the internal inspection method for structural assessment of older steel tanks cited in the 1988 federal rule (40 CFR 280.21) made tank upgrading prohibitively expensive. Inasmuch as the rule left the door open for the approval of other methods, members of the corrosion protection and lining industries, EPA, and state regulators took the opportunity to organize a Task Group within ASTM to write a standard practice for conducting structural assessments for tanks over 10 years old.

The ES 40-94 standard provided minimum performance practices for three tank integrity assessment alternatives to physical internal inspection:

- **Noninvasive** - Data about the tank and its environment are gathered and analyzed and then the remaining tank life is estimated statistically.
- **Ultrasonic Robot** - The tank's thickness is measured robotically over a certain percentage of the tank interior and analyzed in combination with portions of the noninvasive method.
- **Video Camera** - A visual tank integrity assessment is performed using a video camera in combination with portions of the noninvasive method.

The standard also required that the tank be assessed to ensure it was not leaking prior to employing any of these alternative techniques.

Interim Guidance From OUST

In the absence of a standard, EPA and many of the state UST programs find themselves in a kind of structural assessment policy limbo. The EPA Office of Underground Storage Tanks (OUST) issued interim guidance in an October memo from Acting Director Josh Baylson, recommending that implementing agencies continue to follow their current policies regarding allowed integrity assessment methods until more information is available, and OUST issues further guidance.

In his memo, Baylson was careful to point out that it may be inadvisable to use a tightness test as an accepted means of determining whether a tank 10 years of age or older is suitable for upgrading, an approach similar to one of the options listed in the federal regulations for upgrading tanks less than 10 years old. He cautioned states against "changing to a policy that relies only on leak detection for assessing older bare steel tanks for integrity."

OUST is concerned about this method for a few important reasons. First, unprotected steel tanks often corrode through but do not leak, because the corrosion product, backfill, or interior sludge fill the hole. In writing the regulations, EPA believed that newer tanks were much less likely to have corrosion holes than older tanks.

Also, there is uncertainty about the prevalence of tightly adhering "rust plugs," which could begin to leak after the addition of cathodic protection. A tank that has a very small leak or a hole that is not yet leaking because it is blocked by something (e.g., clay, sludge) external to the tank, may pass a tightness test, but begin to leak or leak at a higher rate over time. In short, a tightness test could be used to inaccurately conclude that a structurally unsound tank is sound.

"It is imperative that we assure that only those tanks suitable for upgrading are upgraded," says Baylson, "so as to prevent another generation of leaking tanks." ■

For more information on ASTM activity regarding developing a corrosion standard for tanks, contact Dennis Rounds at (605) 773-3769.

For more information on EPA's recommendations, contact David Wiley at (703) 603-7178.

PENNSYLVANIA

Prevention/Enforcement

Pennsylvania's Third-Party UST Inspection Program Appears To Be Getting the Job Done

In June 1994, the Pennsylvania Department of Environmental Protection (PADEP) initiated a third-party inspector program which requires owners or operators of USTs whose facilities are due for inspection to hire private, certified UST inspectors to perform the required inspections at their facilities. As of November 1996, approximately 2,500 facilities have undergone facility operations inspections.

Inspector certification is a two-step process. Prospective inspectors submit an application describing their education and experience. If their credentials are approved, they must take and pass a two-part (administrative - 80% minimum passing score, technical - 90% minimum passing score) certification examination administered by a contractor. Certifications are valid for 3 years. PADEP has the authority to suspend or revoke a certification. Circumstances under which these actions can occur are listed in the PA DEP regulations. Suspended certifications may be reinstated, but a revocation is permanent.

PADEP targets facilities for inspection by looking at tank system age, type of product stored, number of tanks, and history of environmental or regulatory problems. Facilities identified for inspection are sent a packet which includes a certified letter notifying the owner that an inspection is due (within 45 days from receipt of the packet), a list of certified inspection companies, information on what the inspection will cover and how to prepare for it, an inspection report form, and a postcard to be returned to PADEP to confirm that the inspection is scheduled. It is the owner's responsibility to set up and pay for the inspection.

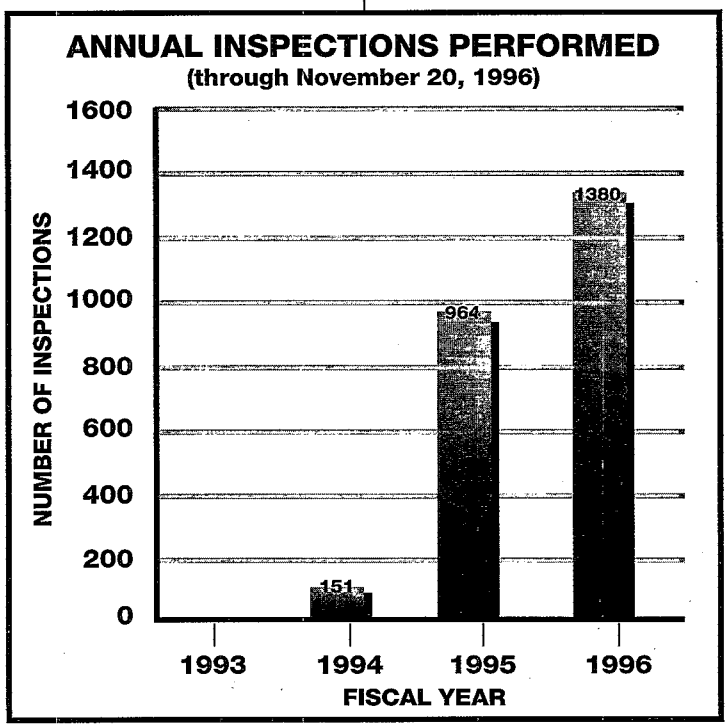
Inspectors use a standard PADEP inspection form. Once an inspection is conducted, the inspector has 60 days to submit a report to PADEP. During that period, inspectors can work with UST owners or operators to help them correct violations. If the help includes installation of equipment, the inspectors must have the appropriate PADEP installer certification. To help prevent conflicts of interest, inspectors may not inspect their own employer's facilities.

PADEP does not initiate enforcement action on the basis of a third-party inspector's report. When such a report indicates that an UST facility is not in compliance, PADEP sends the owner either a letter or notice of violations. If an owner does not respond with evidence that the violations have been corrected, PADEP regional staff will conduct an inspection to confirm that the violation still exists before formal enforcement action is initiated. Third-party sector inspectors are not authorized to initiate enforcement actions.

Program responsibilities are shared by PADEP headquarters and regional offices. Headquarters established the program and developed the regulations, and it has continuing responsibility for communications, coordinating training, developing the examinations, reviewing applications, and issuing guidance. Regional office responsibilities include targeting facilities for inspections, reviewing inspection reports and other paperwork, taking follow-up actions against facilities, and conducting inspector oversight.

PADEP managers and staff were initially skeptical about the program, but many of them are now convinced that it has been beneficial. While the inspectors' reports submitted thus far have indicated that only 40 percent of UST facilities were in compliance when they were inspected, PADEP's follow-up letters and notices of violation have raised the rate to 90 percent. Common violations include failure to perform inventory reconciliation, failure to have tank testing performed, and lack of documentation of tank testing. ■

For more information about PADEP's third-party inspection program, contact Glenn Rider at (717) 772-5599.



Qs and As

Where UST regulations are concerned, questions do pop up. No matter how obscure some of these questions may be, they merit exploration. No matter how obscure the question, someone out there needs an answer. Our answers derive from a carefully considered interpretation of the federal rule, based on EPA guidance. Keep in mind, individual state requirements may differ. Your questions and comments are welcome.

The last issue of *LUSTLine* contained the following Q & A:

Q. *When is the last possible date that inventory control + tightness testing can be used as a legitimate method of leak detection for an existing tank? For a newly-installed tank?*

A. For existing tanks (i.e., those installed on or before December 22, 1988), the last possible date that inventory control + tightness testing can be used is December 22, 1998. For newly-installed tanks (i.e., any tank installed after December 22, 1988), there is no single date; all new tanks may use inventory control + tightness testing for the first 10 years after installation. For example, a tank installed in 2001 can use this method of leak detection until 2011.

Several astute readers called us to task for neglecting to point out that if an existing tank is upgraded with three things—corrosion protection (internal lining or cathodic protection), spill buckets, and overfill devices—an extension is granted for the use of the combination of inventory control and tightness testing as a leak detection method. If the three items are done at the same time, this extension ends 10 years afterwards. This means that a tank installed in 1980 and structurally assessed by means of an internal (human entry) inspection and then upgraded with corrosion protection and spill and overfill protection in 1997 could use the combination of inventory control plus tightness testing *every five years* for leak detection until 2007.

If you upgrade corrosion protection at a different time than spill and overfill, what then? That is a question pending EPA interpretation, and we have to defer it until the next issue.

Note, EPA guidance recommends that states have owners give up the combination method of inventory control plus tightness testing when any of the ASTM ES 40 methods for integrity assessment of existing tanks prior to the addition of cathodic protection are used. This means, in many states, that if a 1980 tank is assessed using an ASTM ES 40 technique and is upgraded with cathodic protection in 1997, this tank would have to stop relying on inventory control plus tightness testing for leak detection immediately after the upgrade is completed. *And we wonder why owners and operators have trouble understanding the rules!*

Don't forget piping! Even after upgrading, pressurized piping must have an automatic line leak detector and either monthly monitoring or an *annual* tightness test.

■ *continued on page 31*

Enforcement EPA Settles Multi-Million Dollar Action Against Worsley Companies, Inc. and Related Companies for Alleged Violations of UST Regulations

In September, EPA Region 4 settled a consolidated administrative enforcement action against Worsley Companies, Inc., Worsley Oil Company of Wallace, Inc., and Worsley Oil Company of Elizabethtown, Inc. for alleged violations of federal UST regulations. The Administrative Compliance and Complaint Orders alleged a range of violations including the failure to notify proper authorities of the existence of USTs, failure to comply with tank and piping release detection requirements, and failure to comply with the requirements to investigate and confirm releases.

Under the terms of the Consent Agreement and Consent Order, the companies have agreed to pay a civil penalty of $199,325 to the United States Treasury, correct the violations, implement a comprehensive environmental compliance policy, and perform three Supplemental Environmental Projects (SEPs). The civil penalty is the largest penalty settlement for EPA's UST program nationwide.

The total cost of the SEPs is estimated at $2,539,133. They include:

- Enhanced Upgrades - the installation of double-walled tanks with pump sumps, double-walled product piping, and dispenser liners with continuous interstitial monitoring for tank and piping leak detection at a minimum of eighteen and a maximum of thirty facilities.
- Accelerated Implementation of Minimum Upgrades - implementation of minimum upgrades at forty-five facilities in North Carolina, South Carolina, and Florida that include the installation of spill and overfill equipment and cathodic protection equipment.
- Implementation of "Stage 1" Vapor Recovery on UST facilities in South Carolina - the installation of Stage 1 Vapor Recovery equipment on all UST systems owned in South Carolina to secure significant environmental or public health protection and improvements. ■

Enforcement

Those Extra Pairs of Eyes

Maryland and Connecticut Increase Enforcement Presence Without Increasing Budgets

Through an agreement with two other state agencies whose inspectors regularly visit gasoline stations, Maryland's UST program has substantially increased its field presence without any increase in its budget. The Connecticut UST program is set to embark on a similar type of alliance.

Under Maryland's agreement, inspectors for the UST program, the Bureau of Weights and Measures, and the Motor Fuel Tax Division look for possible violations of all three agencies' regulations. Thus, the UST program, which employs 24 inspectors, has help from 74 weights and measures inspectors and 34 fuel tax inspectors—a more than five-fold increase in its field presence.

When the three agencies began discussing ways to work together, they first focused on the possibility of combining their inspection activities, but they quickly concluded that such an arrangement was not feasible. They did agree, however, that they could assist each other if all their inspectors were trained to look for certain indications of possible violations of the other agencies' regulations.

To keep the arrangement simple, inspectors have been trained to check for just a few signs of possible violations. As the three agencies gain experience with the program, they will train the inspectors to check additional items.

Inspectors for all three agencies use a standard form to record and report their observations. When inspectors spot a possible violation of one of the other agencies' regulations, they use the standard form to report that finding to the appropriate agency; they also give the facility owner or operator a copy of the form.

The three agencies have an annual one-day cross-training program, in which inspectors and managers educate each other on what their regulations require and what to look for when they are conducting inspections. They also share information about their experience in the field. In addition, all inspectors have opportunities to spend one day in the field with colleagues from the other agencies.

> ***Leveraging enforcement presence by coordinating and communicating with other programs that send inspectors out to UST facilities is one practical way to let tank owners and operators know your UST program is alive and well.***

Herb Meade, Chief of Compliance in the Oil Control Program of the Maryland Department of the Environment, says this arrangement has benefitted the UST program in several ways. The UST program receives reports on possible violations weeks before an UST inspector would have visited the facilities in question. In the first 2 months, the Department of the Environment received reports identifying 16 possible violations; most of them involved improper or missing markings of fill and monitoring pipes, but there also were reports of leaks and spills of petroleum products, particularly when dispenser sumps were inspected.

Another benefit of the program is that the three agencies are sharing information. They have compared and adjusted their facility databases. They are also coordinating enforcement activities by sharing information on facility owners and on the 'track records' of individual companies. In a recent UST enforcement case, for example, the Department of the Environment was able to use data from the Motor Fuel Tax Division to demonstrate that a defendant had a history of noncompliance with Maryland law. This data provided evidence that the alleged violation of UST regulations was willful and thus added to the penalty imposed on the company.

While Connecticut hasn't, as yet, established a formal program, the Connecticut UST program has begun to expand its enforcement coverage through an alliance with the state air compliance and consumer protection (weights and measures) programs. "The other inspectors will help us check on '98 deadline and leak detection compliance," says Scott Deshefy, Coordinator of Enforcement for the Connecticut Department of Environmental Protection's UST program. "Weights and Measures already lets us know about leaks and spills, and we have good communication with Air Compliance."

This "good communication" can help bring about compliance results in more ways than one. For example, Air Compliance has a loan program for Stage II vapor recovery. In reviewing loan applications, air personnel run compliance checks using information on the UST program's database. They look for any information on violations. Any apparent problems will be factored into the loan decision. "This provides an incentive for compliance," says Deshefy.

Leveraging enforcement presence by coordinating and communicating with other programs that send inspectors out to UST facilities is one practical way to let tank owners and operators know your UST program is alive and well. In the next issue of *LUSTLine*, we'll take a look at states that are "red tagging" delinquent UST owners and operators. ■

Investigation and Remediation

When Bad Things Happen to Silts and Clays

API Focus Papers Shed a Collective Light On Processes, Human Exposures, and Technologies Applicable to Low Permeability Soils

*The following article is adapted (with permission) from the API document: **Summary of Processes, Human Exposures and Technologies Applicable to Low Permeability Soils**, by Terry Walden, BP Oil Europe, a member of API's Soil and Groundwater Technical Task Force. Although the language in the article is uncharacteristically "technical" for LUSTLine, we "threw caution to the wind," thrilled, as it were, that somebody had assembled such information on these clayey and silty soil types.*

The American Petroleum Institute (API) has published a series of ten focus papers on the topic of light nonaqueous phase liquids (LNAPLs) in low permeability (e.g., clayey) soils. Collectively, the papers address four key issues:

- Physical and chemical processes affecting the migration and removal of LNAPLs;
- Available models for predicting this behavior;
- Exposure potential posed by clay soil hydrocarbons via a soil, groundwater, or air pathway; and
- Available techniques for removing or enhancing the removal of contaminants.

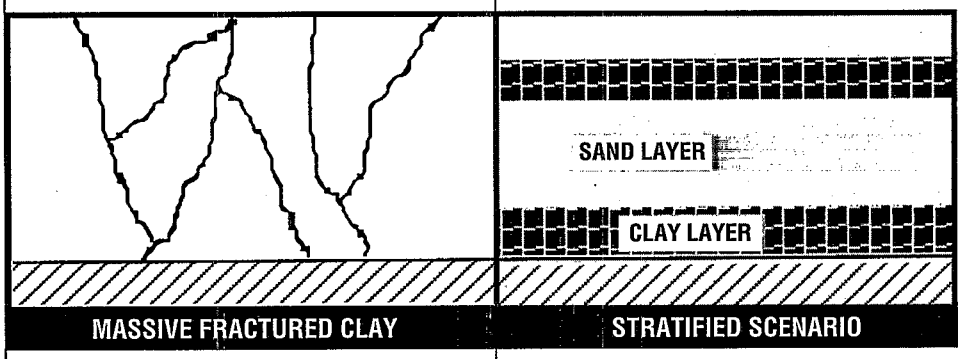
The papers were prepared to provide guidance and understanding on the need and ability to remediate low permeability soils in-situ. Recognizing the limited options available to field practitioners charged with remediating sites with silty or clayey soils, the API initiated a 3-year program (beginning in 1992) to consolidate information on the topic and conduct research on technologies that show promise for removing, or enhancing the removal of, contaminants from this media.

A multi-discipline group was assembled under the umbrella of the API to address the four phases of the problems listed above. These individuals agreed to work as a team and write focus papers on their areas of expertise. Emphasis was placed, primarily, on the vadose, or aerated, zone of contaminated petroleum sites.

The focus papers are compiled in API Publication 4631, *Petroleum Contaminated Low Permeability Soil: Hydrocarbon Distribution, Exposure Pathways, and In-Situ Remediation Technologies*, August 1995.

Process Issues

Low permeability soil refers to silts or clays whose saturated hydraulic conductivity is generally below 10^{-5} centimeters per second (cm/s). These soils can be encountered in three distinct types of geologic settings:



- Massive clay formations where the permeability is very limited and, in fact, dominated by secondary fractures that typically result from desiccation or weathering processes;
- Layered or stratified formations where silt or clay layers are interspersed within sandy or higher permeability layers; and
- Silt or clay "lenses" that tend to be discontinuous and of a limited lateral and vertical extent within a sandy matrix (a subset of layered or stratified formations).

Fluid (including contaminant) migration is distinct in each setting, and the remediation strategies differ accordingly for each media.

In massive clay formations containing natural fractures in nonarid regions, the fractures a short distance above the water table are generally air-filled, while the adjoining "solid" matrix blocks between fractures are water-saturated as a result of capillary pressure forces. This means that should a hydrocarbon spill occur, the LNAPLs will fill the fractures in the soil and bypass the matrix blocks, traveling downward until they encounter the capillary fringe (the area just above the water table), at which point they will spread laterally into cross-cutting fractures. The large entry pressures required to "push" the LNAPL into the matrix will tend to hold these separate-phase hydrocarbons in the fractures.

Although separate-phase product (i.e., LNAPL) will not invade the water-saturated matrix to any great extent, its constituents will eventually appear in the matrix as a result of the process of diffusion (i.e., movement resulting from the existence of concentration gradients). This is an aqueous phase—not a separate phase—process.

In this situation, the soluble constituents in the LNAPL will dissolve, and a concentration gradient will be established between the dissolved hydrocarbon components in the fracture and the uncontaminated pore water in the matrix. The more soluble components will partition out of the LNAPL phase first, and over a period of weeks to months, part or all of the LNAPL mass in the

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fractures will diffuse into the matrix. Equilibrium is established when the matrix storage capacity (including both dissolved and adsorbed phases) is reached.

The process of diffusion has a rather significant impact on remediation strategy. Diffusion is a slow process. It has been said that if it takes a substance x number of years to diffuse into the soil, it will take x number of years to get it out. In fact, this is extremely optimistic.

Simple diffusion calculations indicate that the time it takes to achieve 85-percent mass recovery is nearly 10 times longer than the time the contaminant was in the ground before remediation began. So, if a spill were to occur 2 years before remediation (defined as an air or liquid flushing system that sweeps the fractures free of contamination), it may take 20 years to get 85 percent of the mass out, and 200 years to achieve 95 percent removal.

These long remediation periods are the result of disparate concentration gradients. High gradients drive the contaminants out of the fractures; only low gradients exist when the fractures are cleared, establishing the slow process of reverse diffusion out of the matrix. It is apparent that technologies that rely strictly on diffusion-controlled fluid movement will take a long time to achieve success (if ever) and could, therefore, have high life-cycle costs.

An important example of this concept is in the application of soil vapor extraction. The remediation literature has numerous examples in which high vacuum systems (some approaching 25 inches of mercury, or 0.8 atm) are used for clay soils, presumably to improve the zone of influence of the induced air flow around the extraction wells. Air is, however, most likely to flow through the fractures in a massive clay formation, or the sandy layers in a stratified formation. Thus, the implication that flow through the subsurface is uniform is misleading.

If the mass transfer of contaminants is diffusion-limited, the air flow rate through the fractures or high permeability layers should be maintained at a level that will simply keep the fractures swept clear, thereby minimizing operating costs.

Modeling Issues

To define the exposure potential, as well as the need for remediating hydrocarbons in low permeability media, it is necessary to have a good understanding of the chemical composition of the LNAPL (e.g., crude oil or refined petroleum products), the geology, as well as the subsurface processes affecting LNAPL.

Regarding chemical composition, the critical parameters for each key compound are vapor pressure, solubility, and mole fraction in the LNAPL mixture. The geologic factors that control exposure are the permeability of the subsurface, the degree of stratification or fracturing of the soil, the moisture content of the soil, and distance of the source from the water table (for a groundwater pathway) or from the receptor (for a vapor inhalation route of exposure).

In order to assess exposure and the need or ability to remediate the site, the following parameters should be measured in each geologic setting:

Massive Clay
- Permeability and air-filled porosity of the fractures
- Average spacing and connectivity of the fractures

Stratified Soil
- Permeability over discrete intervals
- Air-filled porosity in low permeability layers
- Average fracture spacing and connectivity (if any)

Clay Lenses
- Diffusion coefficient of contaminants in clay
- Thickness and length of clay lenses

Tracer data can be used to estimate parameters such as air-filled porosity or average fracture spacing (which could be calculated from the tracer flow data after assuming or measuring an average aperture dimension).

To establish the need for, or efficacy of, remediation, the tracer data can be modeled to determine the fate and transport of the contaminants, both with and without remediation. At this juncture, the third element of the evaluation—the subsurface process data—comes into focus. Partitioning, biodegradation, and retardation effects need to be considered. Biodegradation in low permeability soils is particularly relevant because of the generally long residence times of dissolved or vapor-phase product in the subsurface as it moves between a source and a receptor.

Given the varied subsurface conditions and contaminant compositions one might encounter and the data requirements for modeling heterogeneity, the use of analytical models for screening purposes rather than numerical models for detailed prediction is considered the more practical approach at the present time. This approach answers the questions: Will this particular remedial action be effective?; or What gross exposure threats are posed by leaving the soil untreated?

Exposure Issues

Human exposure to contaminated media can be the result of either direct or indirect contact with soil, groundwater, or their vapor emissions. The factor that distinguishes the potential for exposure to contaminated media in clay soils from other more permeable media is the unique soil structure of the clay.

In clays, the small pores comprising the soil matrix blocks increase the capacity of the soil (relative to a more permeable media) to store and "sequester" contaminants over time and to retain water in the matrix. The secondary or "dual-porosity/dual-permeability" nature of the material, which is a consequence of the presence of natural fractures, results in the nonuniform distribution and transport of LNAPL, water, and vapor

■ *continued on page 26*

■ Silts and Clays *from page 25*

phases throughout the subsurface. The low permeability of the bulk media affects the migration of contaminants in the vadose and groundwater zones.

■ SOIL CONTACT

The direct soil contact pathway is strongly influenced in clays by bioavailability of the contaminant compounds. Bioavailability is a concept that refers to the fact that contaminants which may be present in the matrix (in the sense they are extractable with a solvent) may no longer pose a toxicity risk because of the way they are retained or sequestered in the soil matrix. In the simplest terms, the contaminants diffuse into the interior pores of the soil or into the humic fraction, and are increasingly slow in reappearing at the surface of the soil (where their toxicity can manifest itself) because of mechanisms that limit the desorption rate.

While the phenomenon of desorption rate limiting mechanisms applies to all soils, it is particularly relevant to clay because of clay's small pore structure. From an exposure standpoint, reduced bioavailability lessens the absorbed dose (and hence risk) of direct soil contact, either by ingestion or dermal contact. Recent research led by the Gas Research Institute and the oil industry has been directed at identifying the suite of tests needed to demonstrate and quantify bioavailability.

■ GROUNDWATER EXPOSURE

Exposure via the groundwater pathway is very much a function of the type of fine-grained geologic setting. In thick, massive clay soils, with no underlying sandy aquifer, there is little exposure threat in the source zone because drinking water wells are rarely placed in low-yielding clays. Also, downgradient plume migration is less likely relative to sandy soils. However, when a contaminated clay stratum that contains fractures lies above or below an aquifer, mass transfer must be considered under each of the following two scenarios:

- If LNAPL is present in the fractures, rainfall or a fluctuating water table flowing through the fractures will release dissolved-phase components at their effective solubility limit (defined by Raoult's Law as the pure phase solubility multiplied by the mole fraction of the constituent in the mixture) into the aquifer. Dissolved-phase concentrations of the BTEX compounds that are in excess of their drinking water standards (e.g., their MCLs) could occur in the aquifer directly beneath the source.
- If the LNAPL has been depleted from the fractures (by some combination of the processes of volatilization, dissolution, biological degradation, or diffusion into the matrix blocks), reverse diffusion of the dissolved-phase contaminants from the matrix back into the fractures will occur. Unless the distance between fractures is on the order of meters, the resulting concentration in the fractures will (essentially) be equal to that of the water held in the matrix. For high matrix concentrations and limited mixing of the fracture leachate in the aquifer, dissolved-phase concentrations of BTEX could also exceed their MCLs in the aquifer.

Both scenarios indicate that an exposure risk in the aquifer beneath the source area is possible. However, if the receptor well is downgradient of the source, exposure will be mitigated by natural attenuation processes affecting the BTEX plume.

■ VAPOR EMISSIONS

Vapor emissions from low permeability soils are generally unlikely to pose an inhalation exposure threat. This fact is true even when the hydrocarbon source is directly adjacent to a basement, an excavated trench, or the soil surface. Diffusional transport is limited by the normally high moisture content of the clay soils, which limits the number and size of the air-filled passages through which the volatile organic vapors can migrate. The vapor plume is further attenuated by the processes of dissolved-phase partitioning into the pore water in the vadose zone, adsorption onto the organic fraction, and biodecay.

Technology Issues

In developing these focus papers, seven technologies were judged to have some potential for the remediation of low permeability soils in the vadose zone. These technologies can be broadly segregated by the type of process that they induce:

Contaminant Removal
- Soil vapor extraction (SVE)
- Bioventing

Mobility Enhancement
- Thermal processes
- Surfactant flushing
- In-situ soil mixing

Permeability Enhancement
- Hydraulic fracturing
- Pneumatic fracturing

To evaluate the technologies by comparing them to one another, we posed an identical set of questions to each of the authors of a technology paper. Generic questions addressed the effects on contaminant removal posed by high moisture content, the ability to access under buildings, the maximum depth to which the technology is appropriate, and the capability to remediate petroleum products other than gasoline.

In addition, the two major geologic settings of a naturally-fractured massive clay formation and a stratified formation were described; in each case, the author was questioned on the ability of the technology to remove free product, dissolved product, adsorbed product, and residual product trapped within pore throats. Each paper concludes with a breakdown of the costs to close a hypothetical site; commercial availability; case histories; and a summary of the strengths, weaknesses, and complementary technologies which could enhance remedial effectiveness.

The most salient points for each technology follow; they are described in the paragraphs and summarized in the table below. A common set of cost data (e.g., well costs) has been used to derive comparable data for each technology as applied to the hypothetical site.

■ REMOVAL TECHNOLOGIES

In-situ technologies that actually remove the contaminants, and not simply enhance their removal from the ground, are limited to two air flushing techniques—soil vapor

extraction and bioventing—which are very closely related.

- **Soil Vapor Extraction/ Bioventing**

  Soil vapor extraction and bioventing refer to either the injection or extraction of air through a nonsaturated medium. Both rely on the same technique for achieving success—the ability to sweep air through regions of contamination within the formation. In soil vapor extraction, the air induces volatilization of the contaminants; in bioventing, the oxygen encourages biodegradation. The distinguishing feature between the two processes is the rate of the air flow. Bioventing requires less flow because the biodegradation rate (and thus the oxygen demand) is relatively low.

In either case, the air will flow preferentially through the fractures in a massive clay soil and the higher permeability layers in a stratified soil. Remediation of the matrix blocks or the clay layers/lenses will then be limited by diffusion.

For vapor extraction, the term "diffusion" refers to the migration of contaminants into the swept fractures. For bioventing, "diffusion" refers to the movement of oxygen into the lower permeability regions. The success of both technologies depends on the diffusion path length (i.e., the distance between fractures or thickness of the clay layer).

These technologies are deemed reasonably effective, both from a technical and a cost perspective. Stratified formations are somewhat problematic in soil vapor extraction because it is difficult to move the air anywhere other than into the high permeability layers. In bioventing demonstrations, this difficulty is partially overcome by injecting air over narrow-screened intervals at close spacing in the clay layers.

Both technologies have the potential for enhancement through dewatering and induced (pneumatic or hydraulic) fracturing, as long as the geometry and spacing of the fractures is well controlled. Soil warming could also enhance performance, although temperatures that would significantly improve vapor extraction (through pore water evaporation) would be at the expense of biological activity. Optimum tempera-

■ *continued on page 28*

TECHNOLOGY COMPARISON MATRIX

	SOIL VAPOR EXTRACTION	BIOVENTING	THERMAL TECHNIQUES	SURFACTANT FLUSHING	SOIL MIXING	HYDRAULIC FRACTURING	PNEUMATIC FRACTURING
Applicability	Volatile fractions	Middle distillates	Gasoline, diesel and crude oil	Diesel and crude oil	Volatiles & semi-volatiles	Massive clay formations	Massive clay formations
Strengths	Proven technology	Low cost(f)	Improved HC recovery	Residuals reduction	- Fast(f) - Enhanced mass trans.	Reduce diffusion path length	Reduce diffusion path length
Limitations	Low K layers in strat. soils	- Slow(f) - Low K layers	- Non-uniform heating - High cost(f)	- Emulsions - High cost(f) - Limited experience	- Large equipment - Boulders - High cost(f)	- Overconsolidated geology only - Surface heave	- Geology - Surface heave - Fractures close w/time
Costs ($/yd^3)[a]	$24(b)	$23(b)	$62(c)	$65(d)	$125	$6(e)	$7(e)
Time to Closure[a]	9 months	2 yrs	50 days	64 days	50 days	3 weeks (fracturing only)	3 weeks (fracturing only)
Availability	Widespread	Widespread	Sparse	Very limited	Sparse	Very limited	Very limited
Complementary Technologies	- Fracturing - Dewatering	- Fracturing - Warming	- Fracturing - SVE	Fracturing	Heating	All fluid flush technologies	All fluid flush technologies

NOTES

(a) Costs were calculated from information provided in the papers included in this report; closure refers to gasoline cleanup from 1000 to 200 ppm in stratified site, with 100 ft x 100 ft x 15 ft source dimension.
(b) Includes $15k for design, $20k for a pilot study, and $20k for pre and post-soil sampling.
(c) Assumes steam stripping.
(d) Assumes 80% recycling of the surfactant.
(e) Costs are for fracturing only, not subsequent remediation.
(f) Relative to other technologies described in this report.

■ Silts and Clays *from page 27*

tures for bioventing are in the range of 20 to 30 degrees centigrade.

■ MOBILITY ENHANCEMENT TECHNOLOGIES

Mobility enhancement is broadly defined as a process which accelerates the movement of contaminant vapors or liquids to a subsurface collection system. Surfactant flushing is the typical example of this type of technology, but this definition also includes thermal techniques and soil mixing.

- **Thermal Processes**

  Soil can be heated in one of two ways—hot fluid injection (i.e., hot water, air, or steam) or direct heating (i.e., electrical resistance [ER] or radio frequency [RF] heating). In the former, the fluids are introduced through wells or trenches. In the latter, the heat is introduced through electrodes or antennae that are placed in the ground. In both cases, the key design goal is to spread the heat away from the source and maintain roughly uniform temperatures throughout the remedial area. The increased soil temperature must be maintained near the extraction wells to avoid recondensation or immobilization of the contaminants.

  Thermal applications of water, air, and steam differ according to function. Hot water, for example, is used to improve mobile LNAPL recovery in water extraction wells by lowering the interfacial tension and contaminant viscosity. The hot air acts to dewater the formation by vaporizing the pore water near the flow channels, thereby improving the performance of vapor extraction. Steam is used to remove both residual and free-phase hydrocarbons that are volatilized and recovered as a gas or as condensate.

  Like vapor extraction, hot fluid injection is compromised by the tendency of the fluid to flow either through higher permeability layers in a stratified formation or through the fractures in a massive clay formation. These preferential pathways make it difficult to heat the formation uniformly, limiting the remedial effectiveness of hot fluid injection as a stand-alone technology.

  The ER and RF heating systems attempt to raise the vapor pressure of the contaminants to improve hydrocarbon recovery through vapor extraction wells. ER can heat the soil to close to the boiling point of water, while RF can heat significantly above the boiling point, providing the added benefit of drying the soil (but at high cost). These technologies actually perform better in low permeability media because they depend on the water content of the soil to conduct energy, and capillary forces retain higher moisture levels in silts and clays than in sands and gravels. Still, sufficient permeability must exist to remove the vapors.

  Undoubtedly, thermal technologies improve hydrocarbon recovery (especially of middle distillates), but the costs are high and field experience is limited. In low permeability soils, a complementary technology, such as fracturing, may be needed to ensure more uniform heat distribution and a hydrocarbon removal pathway.

- **Surfactant Flushing**

  Injection of surfactants through wells can aid in hydrocarbon recovery in one of four ways:

  - Promote dissolution of an LNAPL by increasing its solubility in the flushing solution;
  - Increase LNAPL mobility in the subsurface by lowering the water-LNAPL interfacial tension;
  - Reduce sorption onto soil particles; or
  - Accelerate the release of soil colloids which may be carrying sorbed contaminants.

  There are two principal drawbacks to the general use of surfactants. The first is their cost, and the second is their tendency to form emulsions that are difficult to break. Unfortunately, in an attempt to overcome the first problem through recycling, the second problem of emulsions manifests itself. There are relatively few examples of surfactant usage in the literature. Those that exist apply mostly to DNAPLs (dense nonaqueous phase liquids, which are typically solvents) rather than to petroleum hydrocarbons.

  Low permeability media further complicate the effective use of surfactants. As with other fluid flushing approaches (air or liquid), the surfactant will bypass the lower permeability regions, relying on a diffusional process to reach the contaminants in the clay layers or matrix blocks. Induced fracturing of the soil can alleviate this problem to some extent, but when combined with the cost and emulsion issue, the feasibility of cost-effectively treating a silt or clay media with surfactants is doubtful. The technology appears to have limited potential at the present time.

- **In-Situ Soil Mixing**

  In-situ soil mixing refers to the process of physically disturbing the soil with the use of large diameter (up to 14 ft) augers mounted on a drill rig. Overlapping columns of soil are augured down to depths as great as 25 feet. The technology requires that the site be relatively level and free of overhead obstructions; the subsurface must likewise be free of boulders or other large buried objects.

  In the process of mixing the soil, treatment of the contaminants can take one of three forms:

  - Grout can be injected down the hollow auger stem to solidify the soil;
  - Air can be injected to volatilize the contaminants (which are then collected under a shroud placed on the surface); or
  - A chemical oxidant (e.g., peroxide) can be introduced to promote contaminant removal through chemical transformation.

All three treatments have been demonstrated in the field, although the long-term stability (leachability) of the grout has yet to be determined.

Soil mixing is an aggressive technology that causes significant site disturbance; the mixed soil has a volume at least 15 percent greater than the original volume. It is also very costly, relative to other technologies, averaging as much as $150 per cubic yard. The advantages of soil mixing are that it is not very sensitive to the geologic conditions and that treatment is extremely fast (i.e., each soil column takes hours). The size of the equipment, however, makes it impractical for service-station-type settings. In summary, soil mixing is a "niche" technology that may be uniquely suited to some applications; it is not expected to see widespread usage.

■ Permeability Enhancement Technologies

Enhancing the permeability of low permeability media is possible using two techniques that involve artificially fracturing the soil—hydraulic fracturing and pneumatic fracturing.

The permeability of silts and clays can be significantly increased by inducing the fracturing of the soil. It is important, however, that the fracturing process be controlled, because random fracturing can create unwanted short circuits, making it difficult for a remedial flushing solution to treat bypassed areas. The goal is to create a pattern of fractures that decrease treatment time by minimizing the distance over which the diffusional process is required to remediate the contaminated zone.

Controlled fractures can be created either hydraulically or pneumatically. In hydraulic technology, a fracture is nucleated through the injection of a fluid, followed by a slurry of granular material and gel to "prop open" the fracture, thus maintaining a permanent channel in the matrix. In pneumatic fracturing, high pressure air creates the channel, which is "self-propped" and will tend to close over time. In stiff clays, the time to closure may be on the order of a year or more; it could however be much less in soft saturated clays.

The key to successful fracturing is the ability to propagate the fractures in a horizontal plane. Horizontal fracturing will occur where the soil is "overconsolidated," meaning that the horizontal compressive stresses exceed the vertical stresses. Under these conditions, both techniques are capable of initiating fractures to a radius of 20 to 25 feet before they begin to rise toward the surface. Fractures can be created with a vertical spacing of 1 to 2 feet, providing a reasonably short diffusion path length for remediation. Creating fractures near building foundations must be carefully considered; surface displacements of up to 2 inches have been recorded.

Induced fracturing offers significant potential for remediating low permeability media by incorporating the technology with air flushing technologies or with thermal treatment. Air flushing may allow the amount of vacuum (and thus size of the equipment) to be reduced for moving comparable amounts of air through the subsurface. Both hydraulic and pneumatic fracturing have similar costs and installation requirements, but hydraulic fracturing has one distinct advantage: sand-propped fractures are permanent and will not close over time, making the technology less sensitive to moisture levels and the degree of stiffness in the clay. ■

More detailed information on silt and clay remediation can be found in the focus papers listed below.

API's publication 4631,
***Petroleum Contaminated Low Permeability Soil Hydrocarbon Distribution, Exposure Pathways, and In-Situ Remediation Technologies*, August 1995, contains the following focus papers:**

Summary of Processes, Human Exposures and Technologies Applicable to Low Permeability Soils
Terry Walden, BP Oil Europe

Relevant Processes Concerning Hydrocarbon Contamination in Low Permeability Soils
David B. McWhorter, Colorado State University, Fort Collins, Colorado

Assessment of Human Exposure Posed by LNAPLS in Low Permeability Soils
Terry Walden, BP Oil Europe
David B. McWhorter, Colorado State University

Soil Vapor Extraction in Low Permeability Soils
Frederick C. Payne, ETG Environmental Inc.

Bioventing in Low Permeability Soils
Robert Hinchee, Parsons Engineering Science

Hydraulic and Impulse Fracturing for Low Permeability Soils
Larry Murdoch, University of Cincinnati

Pneumatic Fracturing for Low Permeability Soils
John R. Schuring, New Jersey Institute of Technology

Thermal Technologies in Low Permeability Soils
Kent S. Udell, University of California at Berkeley

Surfactant-Enhanced Soil Flushing in Low Permeability Media
Thomas M. Ravens and Philip M. Gschwend, Massachusetts Institute of Technology

Mixed Region Vapor Stripping and Chemical Oxidation for In-Situ Treatment Of NAPLS in Low Permeability Media
R. L. Siegrist, O. R. West, and D. D. Gates
Oak Ridge National Laboratory

Modeling Issues Associated with Fractured Media
Marian W. Kemblowski, HydroGaia Inc.

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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. If you want to learn more about the Tanks Subcommittee, contact the Subcommittee Chair, Scott Winters (CO) at 303/620-4008, or Stephen Crimaudo (ASTSWMO) at 202/624-5828.

Tanks Subcommittee

Chuck Schwer, Vermont Department of Environmental Conservation, received a Certificate of Appreciation from ASTSWMO at its annual meeting in October in Washington, D.C. Chuck received the tribute in recognition of his continuing efforts to compile the information and data for the State Cleanup Funds Task Force's Annual State Fund Survey. The latest survey results (June 1996) contain five tables: Design Characteristics of State Financial Assurance Funds, Funding for State Financial Assurance Funds, Level of Activity in State Financial Assurance Funds, Cost Control Measures and Management Practices Used by State Financial Assurance Funds, and a State Fund Legislative Update. Congratulations Chuck!

The Subcommittee and all of the Task Force groups completed work on a "report card" questionnaire on the Federal UST/LUST program. The group decided there was a need to demonstrate the scope and effectiveness of the federal and state UST/LUST programs. Much of the data that will be included in the report card will derive from USEPA STARS data and the State Financial Assurance Fund survey conducted by the Vermont DEC. To complete this effort, however, additional information will be needed. Hence, report card questionnaires were sent out to state and federal officials in early December. The recipients of these questionnaires are encouraged to submit their responses by December 17, so that the results and statistical information can be compiled for presentation at the 1997 UST/LUST National Conference, which will be held in Charlotte, North Carolina in March.

LUST Task Force

The task force is developing follow-up reviews on the Lawrence Livermore National Laboratory Report on LUST cleanups in California. The group also sent a letter to EPA OUST expressing concerns about the agency's initiative to change reporting requirements for "environmental indicators." The task force is in the planning stages of developing an innovative technology web site to be housed on both OUST's and ASTSWMO's home pages. Members of the task force are participating on an EPA MTBE work group.

Jeffrey Kuhn, Montana Department of Environmental Quality, is the newest member of the LUST Task Force. For more information on LUST Task Force activities, call co-chairs Richard Spiese (VT) at (802) 241-3888 or Kevin Kratina (NJ) at (609) 633-1415.

UST Task Force

Members of the UST Task Force worked on completing the UST portion of the UST/LUST program report card.

For more information on UST Task Force activities, call task force co-chairs Paul Sausville (NY) at (518) 457-4351 or Doyle Mills (KY) at (502) 564-6716.

State Cleanup Funds Task Force

Task force members have completed an agenda survey for the next State Fund Administrators Conference which will be held in Sacramento, California on June 16 - 18. The group will meet in January to develop an agenda.

The task force completed and mailed out its "Success Stories Compendium," a collection of the state fund success stories submitted for "Oscar" awards by various state fund programs at the June 1996 State Fund Administrator's Conference in Charleston, SC. The Success Stories Oscar winners were: Iowa for Best Cost Savings, Minnesota for Best Fund For Getting The Job Done, Vermont for Best Future Planning Effort, and Washington State for Best Success With Stakeholders.

The task force welcomed three new members: Arthur Zontini, Massachusetts Department of Public Safety; George Matthis, North Carolina DEHNR; and Kelly Ward, Virginia Department of Environmental Quality. If you have questions or comments on State Cleanup Funds Task Force activities, call task force co-chairs Dan Neal (TX) at (512) 239-2258 or George Matthis (NC) at (919) 733-1332.

TIE Task Force

The Training and Information Exchange (TIE) Task Force continues to address the training and information needs of the state UST/LUST programs. The task force has assigned its members to serve as liaisons to the UST, LUST, and State Cleanup Funds Task Forces. The task force has been assisting with preparations for the ASTSWMO mid-year meeting in New Orleans, April 7 - 9.

If you have questions or comments on TIE Task Force activities, please call task force co-chairs Pat Jordan (WY) at (307) 777-7684 or Kathleen Calloway (DE) at (302) 323-4588.

Qs and As *from page 22*

Q. *We received a query from a reader who has the following problem. He owns several hundred tanks with suction pumping systems that have their check valves located at the tank top. He has attempted to meet leak detection requirements for his piping by conducting tightness testing every three years. Unfortunately, in many cases, an accurate evaluation of the piping is not possible using traditional test methods that pressurize the pipe to conduct the test, because many of the tank top check valves are leaking product back into the tank. Is there a method that can be used that does not rely on the check valves to hold pressure in the piping?*

A. A tracer-based method of piping testing is the first solution that comes to mind. The tracer technique works by inoculating the storage system with a special compound and then operating the system normally. About 2 weeks later, soil gas samples are taken from around the storage system to determine whether any of the tracer compound has escaped from any portion of the system, including the piping. This technique does not rely on the ability of check valves to hold product in order to conduct the test.

Of course, alternative leak detection methods, such as groundwater or soil vapor monitoring could also be used if the environmental conditions were appropriate. SIR would also be an option. Any other ideas?

◆

Q. *For tracer-type leak detection test methods, does the detection of any tracer outside the tank or piping constitute a failed test?*

A. Yes.

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This publication provides a basic overview on proven technologies for the assessment and remediation of petroleum releases that may contaminate soil and groundwater. This document is intended as a guide for those who must deal with accidental releases arising from the production, transportation, refining, and marketing of liquid petroleum products or refined crude oil. It may also be a useful manual for environmental professionals, regulatory agencies, consultants, attorneys, fire marshals, and citizens. Order No.: A16283, Price: $50.00

◆ Publ. 1628A, **Natural Attenuation Processes**, 1st Edition, July 1996
This publication describes the physical, chemical, and biological processes that decrease the concentrations and, ultimately, limit the extent of the dissolved plume migrating from a hydrocarbon spill or leak. It focuses primarily on the more soluble hydrocarbon fraction that makes up the dissolved plume. Emphasis is given to the biological processes that can play a major role in the attenuation of a dissolved plume. Order No.: A1628A, Price $15.00

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◆ Publ. 1628C, **Optimization of Hydrocarbon Recovery**, 1st Edition, July 1996
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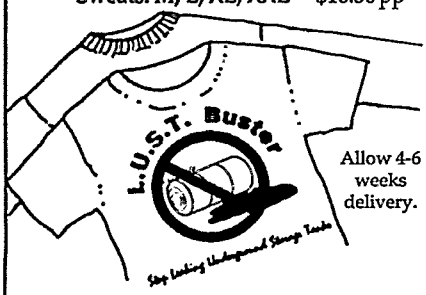

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