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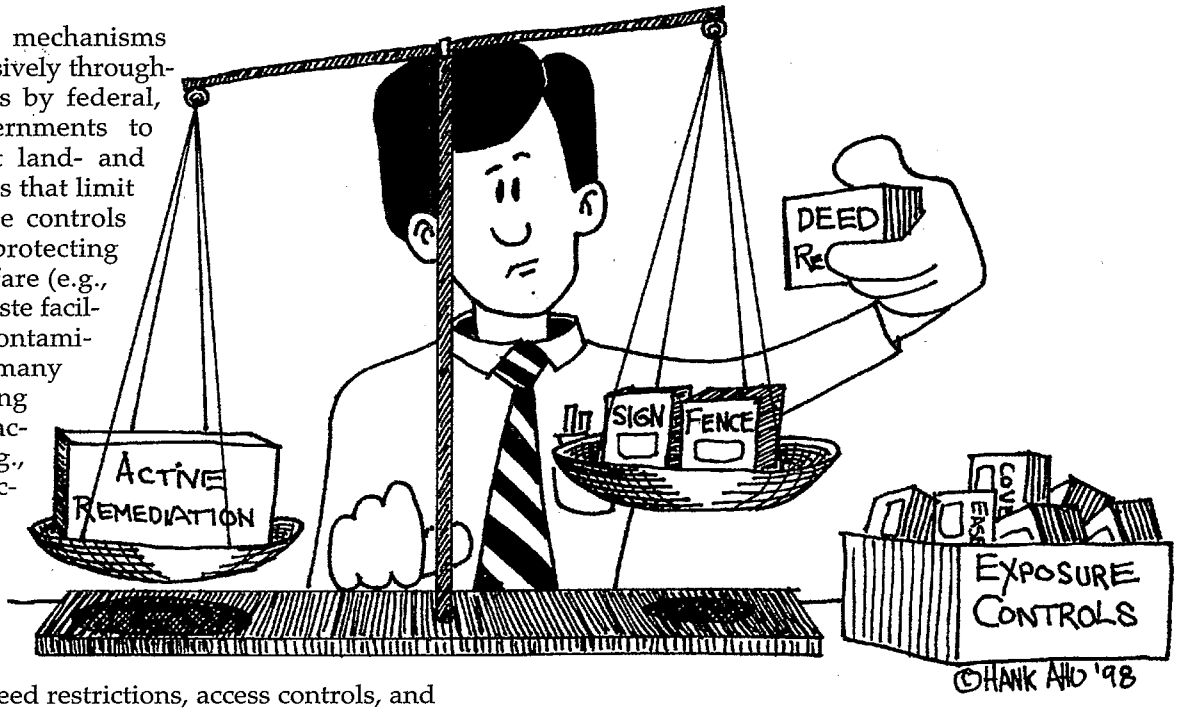
# L.U.S.T. LINE

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

# Institutional Controls *A Means to an End at LUST Sites*

*By Kevin Kratina*

Institutional control mechanisms have been used extensively throughout the United States by federal, state, and local governments to impose and document land- and resource-use constraints that limit human activities. These controls serve as a means for protecting human health and welfare (e.g., hazardous and solid waste facility closure, notice of contaminated site) and in many instances for preserving and protecting the function of a resource (e.g., conservation area protection, aquifer protection, historic preservation). They include such mechanisms as land-use restrictions, structure-use restrictions, well-restriction areas, deed restrictions, access controls, and restrictive covenants (see sidebar). In all cases, control requirements or notices must be recorded with the appropriate regulatory agency(ies) so that anyone who needs to uncover the existence of such a notice can find it.




Our experience over the past several years with risk-based decision making, coupled with our need to undertake protective, flexible, and common-sense remediations has, in effect, opened the doors to the use of institutional controls at sites managed throughout the New Jersey Site Remediation Program. In a 1995 survey of LUST state program managers conducted by the Association of State and Territorial Solid Waste Management Officials (ASTSWMO), 14 of 27 respondents acknowledged that they use institutional controls in their site remediation procedures.

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## ■ Institutional Controls *from page 1*

In New Jersey statute N.J.S.A. 58:10B 1, "institutional controls" are defined as "a mechanism used to limit human activities at or near a contaminated site, or to ensure effectiveness of the remedial action over time when contaminants remain at a contaminated site in levels or concentrations above the applicable remediation standard that would allow for unrestricted use of that property." New Jersey's institutional controls may include, without limitation, structure-, land-, and natural resource-use restrictions, well-restriction areas, and deed notices.

### A Bridge to Closure

Institutional controls have their place in LUST site remediation and closure. They can help bridge the "how clean is clean?" gap by providing a means for closing a site sooner rather than later. They can help bridge a number of "what if?" concerns regarding potential exposure to soil contamination—What if someone drinks the water? What if property use becomes residential after a site has been closed? Institutional controls can also provide regulators with a certain degree of flexibility in making remedial decisions that are both protective of public health and the environment and cost-effective.

It would be ideal if we could return contaminated land and groundwater to conditions that are acceptable for unrestricted or residential use. At many petroleum release sites, however, that goal is prohibitive or may take many years of relying on natural attenuation processes; furthermore, that endpoint is not always warranted for a host of reasons. As a result, the New Jersey legislature has developed a policy that provides for alternatives to cleanups prescribed for residential or unrestricted uses. Institutional controls are an alternative that allows a site to be closed, but only if specific provisions are in place to protect against potential exposure. An institutional control, for example, could require that the approving agency be notified prior to any land disturbance or land-use change that would create an unacceptable exposure.

**TYPES OF INSTITUTIONAL CONTROLS**

- Structure-Use Restrictions
- Land-Use Restrictions
- Natural Resource-Use Restrictions
- Well-Restriction Areas
- Deed Restrictions
- Deed Notices
- Declaration of Environmental Restrictions
- Access-Controls Monitoring Requirements
- Site-Posting Requirements
- Information Distribution
- Notification in Closure Letter
- Restrictive Covenants
- Federal/State/County/Local Registries

### Technical and Philosophical Reservations

Many institutional control issues are hotly debated for both technical and philosophical reasons. While no one state's policy is the ideal model or is completely transferable to another state, in most states similar issues are being debated in efforts to shape institutional controls policy. Such recurring themes include:

- Can residual levels of contamination remain behind in soil and groundwater and result in no further impact on the environment or exposure to receptors if land and resource uses don't change?
- Can a risk-based case closeout be allowed without future land-use constraints and/or notifications?
- When natural attenuation processes are deemed to be a protective and viable remediation alternative, is it acceptable to allow the remediation to be ongoing for many years under an institutional control rather than require a more active remediation process?

Certainly, states must consider current and projected future land-use pressures whenever contamination is allowed to remain in soil and groundwater at levels that are unacceptable for unrestricted use. Any change in a current land-use scenario (e.g., installation of a new drinking water supply well, a new property owner's plans for a residential development, new subsurface structures, utility worker exposure) has the potential to change the institutional control scenario.

Furthermore, while human health is the primary consideration in institutional-control decisions, issues such as ecological impact, natural-resource restoration, natural-resource damages, groundwater ownership, prospective-purchaser liability, property devaluation (actual or perceived) on and off site, a property owner's ability to use the property as he or she chooses, and the property owner's concurrence with any restrictions or notices must be factored into the debate as well.

### Using Controls Effectively

Institutional controls are most effective when the regulatory agency clearly defines its requirements for

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what levels of contamination can remain at a site and under what conditions, or "how clean is clean," based on current land-use and exposure scenarios. This is particularly important when the continued existence of such "protective" conditions is beyond the control of the regulatory agency.

Institutional controls should be designed to remain protective over time, especially when risk-based remedial decisions are made based on current land and resource use in combination with prescriptive engineering controls. These controls should retained (i.e., "run") with the land (e.g., in the form of deed notices, use restrictions) or property file, be filed with the appropriate local/county/state land/resource-use control agencies, and, as needed, have affirmative obligations for maintenance requirements that are passed on to prospective purchasers/operators/ site occupants.

Future land-use considerations should be factored into the scope of a remedial strategy early on in the decision-making process. If property purchasers are involved, the scope of the remedial effort and the use of any institutional controls should be consistent with the purchaser's intended property use. Prospective property transactions may be affected or become complicated by the existence of contamination that remains above levels that are acceptable for unrestricted use, particularly when liability is unclear or contamination is not well defined.

Generating the data necessary to define the "scope" of the institutional control is a regulatory policy decision. Once the scope is defined, then we need data that support stated goals. In evaluating what data are necessary for a site, it is particularly important to consider how much field data will be needed versus how much to rely on the projections generated by a model.

Having an accurate basis for determining the extent of contamination is especially meaningful in instances when the institutional control (e.g., deed notice) requires concurrence from the property owner. Delineation in these circumstances must be conducted so that the property owner, purchaser, or neighboring property owner is able to use his/her property in a manner he/she chooses, so that all parties are aware of any impacts associated with potential property values, and so that there is concurrence with the requested land-use restriction.

***Institutional controls can ... provide regulators with a certain degree of flexibility in making remedial decisions that are both protective of public health and the environment and cost-effective.***

## Questions of Public Policy

There are many public policy questions that must be considered in designing a remedial program that incorporates and relies upon the use of institutional controls. Some of these questions include:

- What land-use and population pressures might lead to a change in the exposure scenario (e.g., industrial use to residential use)?
- Should a state have penalty/enforcement capability if the site maintenance requirements are not followed (e.g., should it allow for breeches in exposure control mechanisms)?
- Will a responsible party have the option to place a "use restriction" on property he or she does not own? Will this constraint be considered a "taking" of property?
- Should there be a preference for permanent remedies that are consistent with the National Contingency Plan, and how should the cost of the remedy be considered?
- Will the repositories for the institutional controls provide reasonable notice to current users, future purchasers, and resource- and land-use decision makers? Is there redundancy in the multilevel notice requirements to prevent "system" notification failure? Can the diligent inquiry for such notices be required in law at the time of property transfer?
- Can the existing government structure be used to record the *institutional control mechanism*? For example: Will a county repository for deed notices serve to provide notice to future property purchasers?
- Will local officials be notified of restrictions that may limit property use in a manner that is inconsistent with local zoning plans?
- Should the institutional control have an affirmative obligation to allow site inspections? Should this access be required only if some form of "maintenance" is required?
- What level of public notice should be required?
- Is the groundwater beneath a given site considered state or private party property? If the site is located in a nonground-water-use area, should all property owners be notified?
- Should a state establish a mechanism to evaluate the effectiveness of institutional controls over time?

## Institutional Controls in New Jersey

Institutional controls are a crucial tool in New Jersey's risk-based decision-making process. They build flexibility into the closeout process and provide protective and cost-effective options to remediate sites. Since the late 1980s, New Jersey has used institutional controls in combination with engineering controls (e.g., capping) that are designed to eliminate exposure in some scenarios as part of its remediation strategy. To date, about 500 sites have been issued conditional "no further action" letters utilizing institutional controls.

Legislation (P.L.1993, c139) passed in 1993 formally granted the New Jersey Department of Environmental Protection (NJDEP) the authority to use institutional controls when the remedy is protective of human health and the environment. As a result, persons conducting cleanups in New Jersey have the opportunity to utilize two primary institutional control options, provided their sites meet certain criteria. These options are:

■ *continued on page 4*

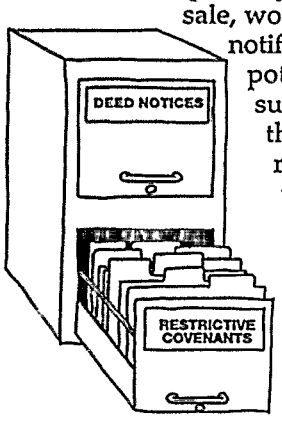
## ■ Institutional Controls *from page 3*

- **Declaration of Environmental Restriction (DER)** - Used from 1993 through 1997 to record, with county agencies, the presence of soil contamination above residential-use criteria. Per recent legislation, as of January 6, 1998, the use of DERs is no longer allowed. The mechanism for recording the presence of soil contamination is now a deed notice. The deed notice entails a more formalized filing system for county agencies.
- **Classification Exception Area (CEA) Combined with a Groundwater Well-Restriction Area** - Used to provide notification to local, county, and state agencies involved with well installation/land use.

New Jersey allows soil contamination to remain at a site under the following conditions:

- When the contamination no longer degrades groundwater;
- When soils do not represent a direct contact threat to the current use or when engineering controls are in place to protect the current use; and
- When the contamination will no longer migrate.

The DER/deed notice option contains an obligation on the part of the property owner to maintain any engineering control and to notify the NJDEP of any disturbances that could represent an unacceptable exposure. If soil at a site is remediated at the level that is protective of an industrial-use scenario and a new property owner decides to redevelop the site as a residential property, the new owner or the seller, possibly as a condition of sale, would be required to notify the NJDEP of the potential for exposure. The site would then require either remediation to the unrestricted residential criteria or the incorporation of engineering controls to be protective in a residential-use scenario.




To balance a risk-based remediation process with natural-resource restoration, the CEA process for groundwater requires remediation of contaminant sources in the soil as well as documentation of decreasing trends in groundwater contamination levels. Site-specific groundwater data can be used to validate a model that projects when the groundwater contaminant will meet standards. Once these "performance" criteria (as opposed to a numeric standard) are achieved, the case can be closed with the CEA. As part of the CEA, the extent of the plume must be documented.

***Institutional controls are most effective when the regulatory agency clearly defines its requirements for what levels of contamination can remain at a site and under what conditions, or "how clean is clean," based on current land-use and exposure scenarios.***

To formally remove the CEA designation, a sample from the groundwater must be provided to document compliance with the groundwater standards. Removal of the CEA designation in areas where groundwater is not currently used (based on a 25-year planning horizon) is strictly voluntary.

The CEA is the single most important institutional control process in New Jersey's LUST remediation program. Virtually all UST remediations that have an impact on groundwater will utilize this control.

The NJDEP has initiated an inspection program to evaluate compliance with the institutional/engineering control practices. To date, compliance rates have been approximately 90 percent. The inspections have provided some helpful hints regarding the implementation of institutional controls. For example:

- If only a portion of a site has been investigated or remediated, be sure that the notice specifies what portions of the site were or were not investigated and remediated. That there is no institutional control on a particular site "subdivision" does not mean it is clean.
- Try to achieve consistent recording procedures if multiple agencies (e.g., counties, municipalities) are involved in the institutional control process. For example, if a registry is used to record the notices, the final notice of filing should specifically reference the page numbers where the notice is recorded for easy future reference. Also, be sure filing documents are sized to meet the criteria of the recording agency. For example, oversized maps may represent a filing/storage problem that can result in lost maps or long retrieval times. If deed notices are used, be sure the notice is not removed during the course of transactions such as foreclosures or subdivisions. One reason the legislature opted for the use of deed notices rather than DERs was to ensure a more efficient recordkeeping and retrieval process.
- Consider inspection programs to ensure compliance, possibly on a 3- to 5-year schedule. Be sure any legislation allows for enforcement actions for noncompliance (and possible elimination of any liability protection for noncompliance) as well as state inspector access to these sites.
- Require a diligent inquiry or search for the presence of any notice during any property transfer.

In short, in all situations where institutional controls have been combined with a "no further action" letter in New Jersey, the full extent of contamination has been defined, controlled, and remediated to the current use criteria. The results of the initial institutional control inspections efforts have been favorable and lessons learned will help us improve on the existing program. ■

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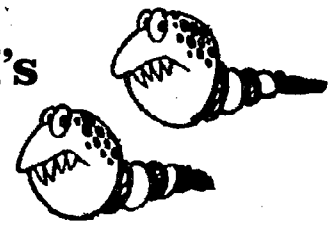
Investigation and Remediation

# Natural Attenuation

## EPA's New Policy Directive Vis à Vis ASTM's New Industry Standard



*by Matt Small and Hal White*

Two guidance documents on "natural attenuation" were completed in late 1997—EPA's OSWER Directive titled *Use Of Monitored Natural Attenuation At Superfund, RCRA Corrective Action, And Underground Storage Tank Sites* and the American Society of Testing Materials' (ASTM) standard of practice titled *Guide For Remediation Of Groundwater By Natural Attenuation At Petroleum Release Sites*. Although neither document provides detailed technical guidance, they both offer guidance on evaluating natural attenuation as an appropriate remedial alternative.

The EPA directive is applicable to remediation of contaminated soil and groundwater at sites regulated under all programs administered by EPA's Office of Solid Waste and Emergency Response (OSWER), including Superfund, RCRA Corrective Action, and USTs. It is intended to promote consistency in how monitored natural attenuation (MNA) remedies are proposed, evaluated, and approved for protection of human health and the environment. As a policy document, it provides guidance to EPA and state staff, to the public, and to the regulated community on how EPA intends to exercise its discretion in implementing national policy on the use of MNA.

The ASTM standard is a guide for determining the appropriateness of remediation by natural attenuation (RNA) and implementing RNA at petroleum release sites. Its emphasis is on sites where groundwater is impacted; it does not address situations where contaminated soil exists without an associated groundwater impact. The standard describes a consistent, practical approach to evaluating and utilizing natural attenuation as a remedial alternative in an effort to reduce the costs associated with cleanup of petroleum releases. As an accepted industry code of practice, the standard is intended to be used by environmental consultants, industry, and federal, state, and local regulators involved in response actions at petroleum release sites.

Naturally, there are some differences between the two documents, but these are primarily in tone and emphasis, reflecting the different perspectives and responsibilities of the two entities that developed them. On the whole, the two documents are consistent in their approach to natural attenuation. EPA's policy, however, presents a somewhat more cautious approach, especially in the areas of site characterization, source control, performance monitoring, and contingency plans.

The ASTM document is an industry-consensus standard and should be interpreted as the minimum requirements for adequate demonstration that natural attenuation is an appropriate remedial alternative for a given site. Because EPA's directive represents official regulatory policy, in cases where the two documents are not in agreement, the EPA directive takes precedence over the ASTM standard of practice.

The need for these documents is borne out by the fact that there is little available published information on natural attenuation and that this remedial alternative is being used at thousands of sites nationwide. Scientific understanding of natural attenuation processes continues to evolve rapidly, and significant advances have been made in recent years. However, there is still a great deal to be learned about the mechanisms governing these processes and how they respond to different types of contaminants and hydrogeologic environments. Therefore, a natural attenuation remedy should be used with caution commensurate with the uncertainty associated with a particular situation and only where it will meet remedial objectives that are protective of human health and the environment.

### "Natural Attenuation"

The EPA directive distinguishes between "natural attenuation processes" and "monitored natural attenuation" as a remedial alternative. The "natural attenuation processes" that are at work in this type of remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in *situ* processes include biodegradation, dispersion, dilution, sorption, volatilization, chemical or biological stabilization, transformation, and destruction of contaminants.

The term "monitored natural attenuation" is defined as "the reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remedial objectives within a time frame that is reasonable compared to that offered by other more active methods." Other terms associated with natural attenuation, but not strictly synonymous, include "intrinsic bioremediation," "intrinsic remediation," "passive bioremediation," "natural recovery," and "natural assimilation."

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■ **Natural Attenuation** *from page 5*

**MONITORED NATURAL ATTENUATION =**
***"The reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remedial objectives within a time frame that is reasonable compared to that offered by other more active methods."***

*EPA OSWER Directive*

While MNA is often dubbed "passive" remediation because it occurs without human intervention, its use at a site does not preclude the use of "active" remediation or the application of enhancers of biological activity (e.g., electron acceptors, nutrients, and electron donors). However, by definition, a remedy that includes the introduction of an enhancer of any type is no longer considered to be "natural" attenuation. Because the directive applies to sites where contaminants other than petroleum constituents (including some that are not biodegradable) may be present, EPA uses the term "monitored natural attenuation" throughout OSWER remediation programs unless a specific process (e.g., reductive dehalogenation) is being referenced.

The ASTM RNA standard makes a distinction between the processes and remedial action that is similar to EPA's directive. Although the RNA definitions for "processes" and "remediation action" sound somewhat more broad, the ASTM standard applies only to petroleum constituents in groundwater. Thus, the definitions are actually more narrowly focused. "Natural attenuation" is defined in the RNA standard as "reduction in mass or concentration of a compound in groundwater over time or distance from the source of contamination due to naturally occurring physical, chemical, and biological processes." Remediation by natural attenuation is defined as "a remedy where naturally occurring physical, chemical, and biological processes will effectively achieve remedial goals. "

**REMEDIATION BY NATURAL ATTENUATION =**
***"A remedy where naturally occurring physical, chemical, and biological processes will effectively achieve remedial goals. "***

*ASTM Standard*

## CONTAMINANTS OF CONCERN AND AFFECTED MEDIA

**EPA** The EPA directive is applicable to a wide variety of sites and potentially unlimited combinations of contaminants and geologic media (including soil) as well as groundwater. Many of the organic contaminants associated with petroleum products are biodegradable, but some are not (e.g., MTBE). Some sites may have organic solvents and other chemicals that are not associated with petroleum fuels. Additionally, RCRA and Superfund mixed-waste sites may have nonbiodegradable inorganic contaminants, including metals and radionuclides. The directive also points out that, in some cases, transformation products may present a greater risk than the parent materials.

**ASTM** *The ASTM RNA standard clearly states that its emphasis is on the use of remediation by natural attenuation for petroleum hydrocarbon constituents where groundwater is impacted. It does not address situations where contaminated soil exists without an associated groundwater impact. It also states that while much of what is discussed is relevant to other organic contaminants, these situations will involve additional considerations that are not addressed in the guide. The guide emphasizes that care must be taken to ensure that degradation byproducts will not cause harm to human health or the environment. Furthermore, if compounds are present that do not readily attenuate (e.g., MTBE), RNA may not be a suitable remedial alternative or may need to be supplemented with other remedial technologies.*

## REMEDY SELECTION CRITERIA

**EPA** EPA does not consider MNA to be a "presumptive" or "default" remedy; rather the agency advocates using the most appropriate technology for a given site. Determination of the most appropriate technology requires that it meet the applicable statutory and regulatory requirements, that it be fully protective of human health and the environment, and that it meet site remediation objectives within a time frame that is reasonable compared with that offered by other methods.

In general, EPA anticipates that MNA will be used as one component of the total remedy—either in conjunction with active remediation or as a follow-up measure to active remediation—and more rarely as the sole remedy at contaminated sites. Selection of MNA as a remediation method should be supported by detailed site-specific information that demonstrates the efficacy of this remediation approach, including comprehensive site characterization, source control, performance monitoring, and contingency remedies (where appropriate).

**ASTM** *The ASTM standard specifies that RNA is a remedial action approach that is compatible with existing remedy selection processes but should not generally be considered a presumptive remedy. RNA is not exclusive of other options and should be evaluated in the same manner as other remedial action options for a site. Remedial options should be selected based on their potential to achieve remedial goals.*

*Several actions are necessary to determine whether RNA is an appropriate remedial alternative, including site characterization, assessment of potential risks, and evaluation of potential effectiveness similar to other remedial action technologies. The standard explicitly recognizes that there are situations where it is either not necessary or cost-effective to expend resources (e.g., time, money) to undertake a more aggressive approach to remediation.*

*RNA may be used as a stand-alone option for meeting remedial goals within groundwater if the potential for a near-term impact to an existing receptor is determined to be low. However, if risk-management strategies are not sufficient to*

*prevent impacts to an identified receptor, then remediation by natural attenuation is inappropriate as a stand-alone option.*

▶ Due to the uncertainty of the effectiveness of natural attenuation, both documents recommend that contingency remedies be identified for implementation should natural attenuation fail to meet remediation objectives.

## SITE CHARACTERIZATION

**EPA** EPA requires that decisions to employ monitored natural attenuation as a remedy or remedy component should be thoroughly and adequately supported with site-specific characterization data and analysis. Site characterizations for natural attenuation generally warrant a quantitative understanding of source mass; groundwater flow; contaminant-phase distribution and partitioning between soil, groundwater, and soil gas; rates of biological and nonbiological transformation; and the variation of all these factors with time. This information is generally necessary because contaminant behavior is governed by dynamic processes that must be well understood before natural attenuation can be applied appropriately at a site.

From this site characterization information, a conceptual model, which provides the basis for assessing potential remedial technologies at a site, can be developed. A conceptual site model is a three-dimensional representation, which may vary over time, that conveys what is known or suspected about contamination sources, release mechanisms, and the transport and fate of those contaminants.

In general, the level of site characterization necessary to support a comprehensive evaluation of MNA is more detailed than that needed to support active remediation. The EPA directive provides a couple of examples where, because of site complexity, MNA may not be an appropriate remedy (e.g., where technological limitations may preclude adequate monitoring or the determination of the pathways of groundwater flow).

**ASTM** *The ASTM RNA standard states that site characterization must provide the user with adequate information to determine if RNA is a viable remedial option for the site, either by itself or in conjunction with other technologies. Information on site assessment techniques is referenced in other ASTM guides. Because the RNA standard is applicable only to groundwater contamination, the implementation of RNA requires adequate definition of the groundwater plume and understanding of site hydrogeology. The lack of necessary site data or the inability to obtain representative or otherwise requisite samples necessary to construct an acceptable site conceptual model (e.g., aquifer parameters, groundwater and soil chemistry) can preclude appropriate implementation of RNA.*

*Specific types of site characterization information that may be necessary to support RNA are listed in an appendix and include lines of evidence (discussed in next section), details about the release, regional and site hydrogeology, locations of nearby receptors, contaminant concentrations, and extent of contamination. The ASTM standard states that technical limitations may obstruct the implementation or progress of RNA and require the consideration or use of other remediation alternatives. Such limitations can include constraints associated with inadequate data used to construct the site conceptual model, the inability to implement the monitoring program, insufficient data to perform predictive modeling, and changes in site conditions.*

▶ EPA's directive differs from the RNA standard in that it conveys the unequivocal message that site characterizations for remedies that propose to use natural attenuation should be necessarily more detailed than those for active remediation technologies.

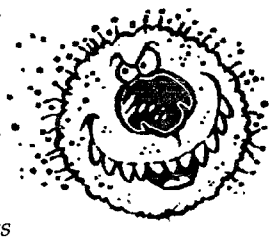
## EVIDENCE OF NATURAL ATTENUATION

**EPA** The EPA directive outlines three lines of evidence that can be used to evaluate the efficacy of MNA as a remedial approach:

1. Historical groundwater and/or soil chemistry data that demonstrate a clear and meaningful trend of decreasing contaminant mass and/or concentration over time at appropriate monitoring or sampling points;
2. Hydrogeologic and geochemical data that demonstrate the types and rates of natural attenuation processes active at the site; and
3. Data from field or microcosm studies conducted with contaminated site material that demonstrate the occurrence of biological degradation processes (for biodegradable components only).

Unless EPA or the implementing agency determines that evidence from item #1 is sufficient to support a decision that the use of MNA is appropriate, then evidence from item #2 should be provided. Evidence from item #3 is generally required when evidence from items #1 and #2 is inadequate or inconclusive.

Where contaminants are not readily degraded through biological processes, where toxic and/or mobile transformation products are formed, or where groundwater and soil chemistry data have been collected for only a short time, more supporting information may be required. It is the responsibility of the regulatee to provide the evidential data to EPA or the appropriate implementing agency.



**ASTM** *The RNA standard defines its three lines of evidence as follows:*

1. *Observed reductions in concentrations of the compounds of concern in the field (the primary line of evidence for RNA);*
2. *Geochemical indicators of naturally occurring degradation and estimates of attenuation rates (secondary line of evidence); and*
3. *Microbiological information and more sophisticated analysis of primary and secondary lines of evidence such as modeling or estimates of assimilative capacity (additional optional lines of evidence).*

*The first line of evidence is the primary line of evidence and is required to demonstrate RNA. The decision to collect secondary and optional lines of evidence should be based on the intended use of the data. The cost benefit of obtaining these*

■ *continued on page 8*

■ **Natural Attenuation** *from page 7*

*lines of evidence should also be considered. The primary lines of evidence include concentration data for the compounds of concern at the site, used to define the plume as shrinking, stable, or expanding. For sites where there are sufficient historical monitoring data, the primary lines of evidence will often be adequate to demonstrate RNA.*

*As for secondary lines of evidence, the standard states that if the primary lines of evidence are inconclusive, it may be necessary to obtain secondary lines of evidence. For those sites where assessment and data collection efforts have recently been initiated, it may be appropriate to supplement the primary lines of evidence with geochemical indicator data. The primary line of evidence is still required at these sites and must be built through data collection over time.*

▶ Thus, both documents outline three essentially identical lines of evidence, but EPA's directive promotes collection of first and second lines of evidence as a general rule, while the RNA standard requires the first line of evidence to demonstrate natural attenuation.

## GROUNDWATER PLUME STATUS

**EPA** The EPA directive addresses the issue of plume status by noting that MNA would more likely be appropriate if the plume is not expanding nor threatening downgradient wells or surface water bodies. MNA should not be used where significant contaminant migration or unacceptable impacts to receptors would result. The most appropriate candidate sites for MNA remedies are those where contaminant plumes are no longer increasing in size or are shrinking in size.

**ASTM** *The ASTM standard requires that the dissolved petroleum plume be categorized as shrinking, stable, or expanding based on historical contaminant concentrations (first line of evidence) obtained from monitoring wells. For sites where there are sufficient historical monitoring data, the primary lines of evidence will often be adequate to demonstrate RNA. A minimum of four monitoring events will likely be required to evaluate the plume status.*

*The standard explains that it may be necessary to obtain additional monitoring data before a plume can be defined as stable or shrinking and outlines the implications of the three plume categories as follows:*

1. *A shrinking plume is evidence of natural attenuation;*
2. *A stable plume is evidence of natural attenuation; and*
3. *In the case of an expanding plume, the contaminant mass loading rate to groundwater exceeds the natural attenuation rate. It is important to continue to monitor the expanding plume.*

*With regard to RNA as an appropriate remedy, the performance of RNA is generally acceptable if a plume is shrinking or stable (primary line of evidence) and there are no impacts to receptors. If a plume is expanding but at a rate lower than the groundwater velocity, the risk reduction and performance goals may be met depending on the presence and location of receptors.*

▶ At first glance, both documents seem to be in harmony on this issue. However, there is potentially significant divergence in two areas. First, the RNA standard states that natural attenuation is occurring where a plume is shrinking or *stable*. However, RNA may be appropriate at sites where the plume is shrinking, stable, or expanding, as long as the requirements for no receptor impacts are met, as discussed earlier. EPA's directive takes a somewhat more cautious position in recommending that monitored natural attenuation may be appropriate where a plume is shrinking or *no longer expanding*. The difference between these two conditions is EPA's implicit assumption that where a plume is no longer expanding, it is shrinking. When a plume is stable, there is the implication that the source is continuous, which is usually unacceptable from a regulatory perspective.

Second, the RNA standard states that it is important to continue to *monitor* an expanding plume. This approach allows for application of RNA at sites where it is anticipated that the plume will stabilize within limits that are appropriate for risk management and will eventually begin to shrink. From the EPA MNA directive perspective, an expanding plume indicates that natural attenuation is not effective and that a more aggressive remediation technology (the "contingency remedy") should be implemented.

## REMEDIATION TIME FRAME

**EPA** The EPA directive recognizes that defining a reasonable time frame for achieving remediation objectives is a complex and site-specific decision and that, in general, time frames are longer for MNA than for active remediation technologies. Additionally, because of these extended time frames, hydrogeologic conditions and plume behavior can also change. Factors that influence the determination of what is a reasonable time frame include:

- The relative time frame in which affected portions of an aquifer are needed for future water supplies;
- The classification and value of affected resource(s);
- Uncertainties in the data, assumptions, and predictive analyses (e.g., travel time for contaminants to reach receptors);
- Reliability of monitoring and institutional controls; and
- Public acceptance of the extended time for remediation.

In addition, state groundwater protection programs should be consulted for guidance and requirements. A careful analysis of such factors should enable an environmental agency to determine whether a MNA remedy will fully protect potential human and environmental receptors and whether site remediation objectives and the time needed to meet them are acceptable. When these conditions cannot be met using MNA, a remedial alternative that does meet them should be selected instead.

**ASTM** *The RNA standard also recognizes that time frames for achieving remedial goals can be relatively long. A long*

*period of time may be required to remediate heavier petroleum products. RNA may take longer to mitigate contamination than more aggressive remedial measures do. Thus, RNA may not always achieve the desired cleanup levels within a manageable time frame. The longer time frame, therefore, may require the use of institutional controls to manage and prevent exposures.*

*If, on the other hand, RNA is likely to meet the remedial goals within the desired time frame, then it is a viable alternative. However, if the probability of RNA meeting remedial goals is low or uncertain, then supplementary or alternative remedial action measures may be appropriate. The time frame for achieving remedial goals is an important criterion for comparison of RNA with other remedial options. The standard cautions that care should be exercised in estimating remediation time frames for other remedial options so as to not bias the comparison with overly optimistic representations of cleanup time frames.*

▶ There is essentially no difference between the EPA directive and ASTM's standard on this issue. Both acknowledge potentially extended time periods for natural attenuation to meet remediation objectives as well as potential need for more aggressive ("contingency") remedies should natural attenuation fail to meet remediation objectives within a reasonable (or "manageable") time frame.

## SOURCE CONTROL

**EPA** EPA expects that source control measures will be evaluated for all sites under consideration for any proposed remedy, especially where MNA is under consideration as the remedy or as a remedy component. The need for such evaluation is largely a reflection of the uncertainty associated with the potential effectiveness of MNA to meet remedial objectives that are protective of human health and the environment within a reasonable time frame.

Source control measures include removal, treatment, or containment measures (e.g., physical or hydraulic control of areas of the plume in which NAPLs are present in the subsurface). EPA prefers remedial options that remove or treat contaminant sources when such options are technically feasible. The need for source control is clear—contaminant sources that are not adequately addressed complicate the long-term cleanup effort by leaching significant quantities of contaminants into the groundwater, which can extend the time necessary to reach remedial objectives.

EPA believes that control of source materials is the most effective means of ensuring the timely attainment of remediation objectives. Following source control measures, monitored natural attenuation may be sufficiently effective to achieve remediation objectives at some sites without the aid of other (active) remedial measures. Typically, however, monitored natural attenuation will be used in conjunction with active remediation measures even at petroleum release sites.

**ASTM** *The ASTM standard states that an evaluation of the need for source area control measures should be integrated into remedial decision-making at all sites where RNA is under consideration. Source area control measures include physical removal, treatment, and stabilization. The standard acknowledges that the RNA option is subject to approval by the regulatory agency responsible for the oversight of the cleanup of the petroleum release and source area control decisions.*

▶ Perhaps the most significant difference between EPA's directive and ASTM's standard is EPA's emphasis on the need for source control (including free product recovery). Federal regulations (specifically 40 CFR 280.64), which are acknowledged by the ASTM standard, require that free product be recovered to the maximum extent practicable as determined by the implementing agency. EPA's directive advocates source control measures in all cases, but especially when employing natural attenuation, so that remediation time frames are not unacceptably extended. EPA also expresses a preference for source control measures that remove or treat sources rather than merely contain them.

## PERFORMANCE MONITORING

**EPA** The EPA directive includes the term "monitored" when referring to a remedy that utilizes natural attenuation processes to emphasize that this is not a "do-nothing" or "walk-away" remedial option—long-term performance monitoring is an essential component of MNA and any other remedial option. Use of MNA does not imply that activities (and costs) associated with investigating the site or selecting the remedy (including performance monitoring) have been eliminated. These elements of the investigation and cleanup must still be addressed as required under the particular OSWER program, regardless of the remedial approach selected.

MNA will not generally be appropriate where site complexities preclude adequate monitoring or in cases where the associated costs are high compared with the cost of active remediation technologies. While performance monitoring to evaluate the effectiveness of a remedy and to ensure protection of human health and the environment is a critical element of all response actions, it is of even greater importance for MNA because of its longer remediation time frames, potential for ongoing contaminant migration, and other uncertainties.

The monitoring program developed for each site should specify the location, frequency, and type of samples and measurements necessary to evaluate remedy performance as well as define the anticipated performance objectives of the remedy. In addition to verifying the attainment of cleanup objectives, an adequate monitoring program should identify any potentially toxic transformation products resulting from biodegradation, determine if a plume is expanding (either downgradient, laterally or vertically), ensure adequate warning of potential impact to downgradient receptors, detect new releases of contaminants to the environment that could have an impact on the effectiveness of the natural attenuation remedy, demonstrate the efficacy of institutional controls that were put in place to protect potential receptors, and detect changes in environmental conditions (e.g., hydrogeologic, geochemical, microbiological, or other changes) that may reduce the efficacy of any of the natural attenuation processes.

■ *continued on page 10*

## ■ Natural Attenuation *from page 9*

Typically, performance monitoring is continued for a specified period (e.g., 1 to 3 years) after cleanup levels have been achieved to ensure that concentration levels are stable and remain below target levels. The institutional and financial mechanisms for maintaining the monitoring program should be clearly established in the remedy decision or other site documents, as appropriate.

**ASTM** *The ASTM standard acknowledges that implementation of RNA requires demonstration of remedial progress and attainment of remedial goals through monitoring. The inability to obtain representative or otherwise requisite samples necessary to design an adequate long-term monitoring plan can preclude appropriate implementation of RNA. According to the standard, once an RNA option is selected, it is necessary to develop and implement a monitoring program that is both capable of yielding adequate information to evaluate the progress of RNA in meeting remedial goals and cost-effective.*

*The cost associated with monitoring may well be the most expensive part of a natural remediation project. The objectives of the monitoring program are defined as:*

- *Evaluating performance and progress of RNA toward meeting remedial goals, and*
- *Ensuring that the plume is not migrating to an extent greater than expected.*

*The standard states that the monitoring program should include appropriate sampling locations, adequate sampling frequency, and meaningful sampling parameters and that it should include sufficient groundwater monitoring wells, both in number and location, to determine changes in groundwater flow directions and velocities, trends in contaminant concentrations within the plume (over time and/or distance), and any further migration of the plume.*

*According to the standard, although monitoring frequency is a site-specific consideration, it should be at least quarterly for a minimum of 1 year so as to define seasonal fluctuations in contaminant concentrations, water table elevations, and hydraulic gradients. The lack of these data could make it very difficult or impossible to adequately resolve concentration trends in subsequent data sets.*

*Where variability in concentration of the compounds of concern precludes the resolution of any trends, or if monitoring data do not indicate significant natural attenuation, then the standard recommends that geochemical indicator parameters be evaluated in addition to the primary line of evidence. Monitoring results should be evaluated to determine progress toward meeting remedial goals.*

*If remedial goals are met, then no further action is required. If remedial goals are not met, RNA remedial progress should continue to be evaluated. When remedial goals have been achieved, and further monitoring is no longer required to ensure that conditions persist, then no further action is necessary, except to ensure that institutional controls (if any) remain in place, and regulatory concurrence should be pursued.*

▶ There are no major differences with regards to performance monitoring. However, EPA cautions that monitoring generally should continue for 1 to 3 years after cleanup levels have been achieved to ensure that concentration levels are stable and remain below target levels.

## REMEDIATION OBJECTIVES

**EPA** EPA has responsibility for establishing site-specific remediation objectives that are fully protective of human health and the environment. In the EPA directive, remediation objectives are defined as the overall objectives that remedial actions are intended to accomplish and are not the same as chemical-specific cleanup levels. Remediation objectives could include preventing exposure to contaminants, minimizing further migration of contaminants from source areas, minimizing further migration of the groundwater contaminant plume, reducing contamination in soil or groundwater to specified cleanup levels appropriate for current or potential future uses, and other goals. EPA supports the use of risk-based decision-making in establishing remedial goals for UST corrective actions (OSWER Directive 9610.17).

**ASTM** *The ASTM standard advocates that remedial goals be determined by applying the risk-based corrective action process in [ASTM] Guide E 1739 or another state-approved method. Remedial goals established to protect human health and the environment may take the form of concentration target levels at specific points or performance criteria, such as demonstration that the petroleum hydrocarbon plume has been contained. Remedial goals may also have some time frame associated with them.*

*In general, the ASTM risk-based approach requires that the potential for impacts to human health and the environment be determined by conducting surveys of primary and secondary sources, transport mechanisms, viable exposure pathways, and potential receptors. Target levels must be either an achievable numeric value or other performance criteria that protect human health, safety, and the environment.*

*In general, RNA is more amenable to achieving performance-based goals, such as demonstrated containment of the groundwater plume or demonstrated reduction in contaminant concentrations over time within the plume or with distance from the source area.*

▶ Both documents are in harmony with regard to remediation objectives. However, the ASTM standard defines remedial goals that are applicable only to UST release sites, while EPA's directive is designed for a broader class of contaminated sites.

## CONTINGENCY REMEDIES

**EPA** EPA recommends that remedies employing monitored natural attenuation be evaluated to determine the need for including one or more contingency measures that would be capable of achieving remediation objectives. EPA believes that a contingency measure may be particularly appropriate for a monitored natural attenuation remedy that has been selected based primarily on predictive analysis (the second and third lines of evidence discussed previously) as compared with natural attenuation remedies based on historical trends of actual monitoring data (the first line of evidence).

According to the directive, contingency remedies should be employed where the selected technology is not proven for a specific site application, where there is significant uncertainty regarding the nature and extent of

the contamination at the time the remedy is selected, or where there is uncertainty regarding whether a proven technology will perform as anticipated under the particular circumstances of the site.

Criteria that may trigger implementation of the contingency remedy include:

- An increasing trend in contaminant concentrations in either groundwater or soil at sampling locations;
- Evidence of a new or renewed release;
- Discovery of contaminants in sentry/sentinel wells located outside of the original plume boundary (indicating renewed contaminant migration);
- Contaminant concentrations that are not decreasing at a sufficiently rapid rate to meet the remediation objectives; and
- Changes in land and/or groundwater use that will adversely affect the protectiveness of the monitored natural attenuation remedy.

**ASTM** *The RNA standard states that if it is shown that RNA is not solely sufficient to provide adequate protection of potential receptors, the data collected for the RNA study can be used to design supplemental remedial alternatives. If remedial progress does not match estimates, RNA should be reevaluated as to whether it is an appropriate remediation option for the site. If at any point during the long-term monitoring program, data indicate that natural attenuation is not adequate to contain the plume, the contingency plan should be implemented.*

▶ Again, there are no major conflicts between EPA's directive and ASTM's standard. The EPA directive is somewhat more adamant about the need for considering contingency remedies at the beginning of the site evaluation process rather than later, when it may be too late for the contingency remedy to be protective of human health and the environment.

## NO FURTHER ACTION

**EPA** The EPA directive recommends that performance monitoring should continue as long as contamination concentrations exceed the required cleanup levels. It recommends that performance monitoring be continued for a specified period (e.g., 1 to 3 years) after cleanup levels have been achieved to ensure that concentration levels are stable and remain below target levels. It also recommends that institutional and financial mechanisms for maintaining the monitoring program be clearly established in the remedy decision or other site documents, as appropriate.

**ASTM** *The ASTM standard states that when it can be demonstrated that target cleanup levels or performance-based criteria for a site have been achieved, and further monitoring is no longer required to ensure that conditions persist, then no further action is necessary. Mechanisms or procedures must be implemented to ensure that institutional controls (if any) remain in place. Regulatory concurrence should be pursued on a determination of no further action.*

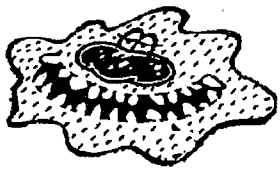
*The ASTM standard lists four key criteria for no further action at a site that has undergone remediation by natural attenuation:*

- *There are no existing or potential receptor impacts;*
- *Remedial goals have been met, or it has been demonstrated that natural attenuation will continue and ultimately meet remedial goals;*
- *The plume is stable or shrinking; and*
- *If needed, institutional controls are in place and maintained.*

*If natural attenuation is demonstrated to be effective at a site, and site conditions will not change, natural attenuation will continue to serve as an ongoing remedial action regardless of whether it is monitored.*

▶ Both documents recommend that monitoring be continued to ensure that conditions persist. However, the ASTM standard allows for a determination of no further action prior to actually meeting remedial goals if it has been demonstrated that natural attenuation will continue and ultimately meet remedial goals. This idea means that, in some cases, the implementing agency could approve termination of monitoring before remedial goals are met. The EPA MNA directive takes a more conservative approach, recommending that performance monitoring continue as long as contamination concentrations exceed the required cleanup levels. Once cleanup levels are met, the directive recommends additional monitoring to ensure that conditions persist. ( See chart on page 12.)

## To Obtain the Standards...



The EPA OSWER directive, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites,* OSWER Directive 9200.4-17, is available in several electronic formats from EPA's web site; the address is: http://www.epa.gov/swerust1/directiv /d9200417.htm.

The anticipated approval date for the ASTM standard of practice, *Guide For Remediation Of Groundwater By Natural Attenuation At Petroleum Release Sites,* is March 10, 1998. As of press time, no designation has been assigned the standard. Please check the ASTM web page, www.astm.org, to obtain up-to-date information. For information about ASTM or the work of committee E-50 (for UST/LUST-related work), contact Susan Canning at (610) 832-9714. ■

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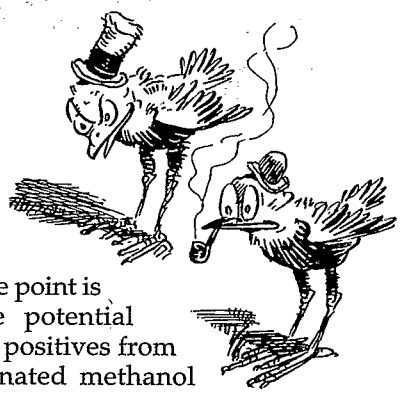
## A COMPARISON BETWEEN THE EPA MNA DIRECTIVE AND THE ASTM RNA STANDARD

| | **EPA MNA Directive**<br>OSWER Policy | **ASTM RNA Standard**<br>Industry-Consensus Standard |
|---|---|---|
| **Applicability and Audience** | RCRA, Superfund, and UST program-regulated sites. | UST program sites. |
| **Definition of Natural Attenuation** | All attenuation mechanisms, including those affecting nonbiodegradable contaminants. | Mechanisms affecting biodegradable components of petroleum products. |
| **Contaminants of Concern and Affected Media** | Petroleum hydrocarbons as well as organic solvents and other hazardous chemicals, inorganics, metals, radionuclides, and mixed-waste contaminants in groundwater and soil. | Petroleum hydrocarbons in groundwater. |
| **Remedy Selection Criteria** | MNA is not a "default" or "presumptive" remedy, it is one of many potential remedies. Selection is site-specific and all relevant program-dependent criteria must be met. Requires site characterization, source control, performance monitoring, and contingency remedies (where appropriate). | In general, RNA should not be considered a presumptive remedy. Selection requires site characterization, assessment of potential risks, and evaluation of potential to meet remedial goals. |
| **Site Characterization** | Adequate to demonstrate that MNA is an appropriate remedial technology—generally more extensive than active remedial technologies. | Same requirements as for any other remedial option. Recommend collecting secondary lines of evidence at new sites. |
| **Evidence of Natural Attenuation** | Primary (historical concentration data) and secondary (hydrogeologic and geochemical data) typically required. Tertiary (field or microcosm data) required when primary and secondary data are inadequate or inconclusive. | Primary (historical concentration data), secondary (geochemical data), and optional (modeling, assimilative capacity estimates, and microbiological studies). Secondary and optional data can be used to support choosing RNA at sites with no historical data. |
| **Groundwater Plume Status** | MNA is more likely an appropriate remedial technology at sites where plume is no longer increasing or is shrinking. | RNA is appropriate for stable or shrinking plumes and, in some cases, expanding plumes if risk reduction and performance goals are met. |
| **Remediation Time Frame** | Time required to reach remedial goals is site-specific and should be "reasonable" when compared with active remedial technologies. | Time frame must be considered as part of establishing remedial goals. It is left up to regulatory agency. |
| **Source Control** | Evaluate all sites regardless of remediation technology selected. Remove free product to the maximum extent practicable. Source area removal and/or treatment is preferred. | Integrate evaluation of need for source area control measures into remedial decision-making at all sites where RNA is under consideration. Degree of source control or removal required is at the discretion of the regulatory agency. Approval of RNA may require source area removal or more aggressive remediation based on potential risk. |
| **Performance Monitoring** | An essential component of any remedial option, especially MNA. Monitoring program is based on site-specific conditions and should continue as long as contamination levels remain above specified cleanup goals. Site closure is generally 1 to 3 years after contamination levels have decreased sufficiently to achieve, and remain at or below, cleanup goals. | Minimum of one upgradient point and two or more monitoring points within the plume but outside free product zone, and a downgradient monitoring point. Frequency based on site-specific conditions; no receptor impacts; remedial goals met or proven to ultimately be met; plume stable or shrinking; and, if needed, institutional controls in place and maintained. |
| **Remediation Objectives** | Defined as the overall objectives that remedial actions are intended to accomplish—although not the same as chemical-specific cleanup levels, these may be included as part of the objectives. Cleanup levels are site-specific and consider such factors as risk and current and potential future uses of the affected resource. | Determine remedial goals by applying risk-based corrective action. Goals may take the form of concentration target levels or performance criteria, including containment, and can be developed through predictive modeling. |
| **Contingency Remedies** | Need should be evaluated for every site where MNA is proposed, and implemented if concentration decreases do not meet expectations. | Should be implemented if data indicate that RNA will not meet remedial goals, including containment. |
| **No Further Action** | Monitoring should continue as long as contamination levels remain above required cleanup levels. Once cleanup levels are met, additional monitoring is needed to ensure that conditions persist. | No existing or potential receptor impacts. Remedial goals are met, or it has been demonstrated that natural attenuation will continue and ultimately meet remedial goals. The plume is stable or shrinking. If needed, institutional controls are in place and maintained. |

**Investigation and Remediation**

# To Methanol Preserve or Not to Methanol Preserve? (That Is the Question)

*by Blayne Hartman*



Over the past few years, several states (e.g., Wisconsin, Massachusetts, Maine, New Mexico) have adopted regulations or policies requiring that soil samples slated for volatile organic compound (VOC) analysis be preserved in methanol immediately upon collection. Other states are considering similar measures. Why is this?

We have known since the early 1990s that volatile compounds can be lost quite readily from soil samples, even when the soils are kept chilled. A number of articles written by independent researchers have demonstrated that VOC losses from soils can reach 50 percent within 2 hours of collection and can exceed 90 percent within 24 hours. However, when preserved in an organic solvent, such losses were prevented. Fearing that regulatory decisions were being made based on data that woefully misrepresented true concentrations, the Wisconsin Department of Natural Resources adopted a methanol preservation requirement in 1994. Other state agencies began to follow Wisconsin's lead. But, alas, questions linger.

## Preservation Protocol

At first glance, the preservation protocol appears simple enough: Upon collecting an aliquot of the soil sample (typically 5 to 10 grams), immediately immerse it in vials containing methanol (typically 5 to 10 mL). Seal the vials and transfer them to the laboratory for subsequent analysis. Collectors may use vials containing premeasured amounts of methanol obtained from the laboratory prior to the sampling effort, or alternatively, they may purchase the methanol directly and add it to the vials themselves. The result? Immediately preserved soil samples that bear values more indicative of the true soil concentrations.

## So What's the Worry?

Methanol has an extremely high affinity for many organic compounds. In fact, laboratories sometimes receive freshly purchased methanol with contaminant levels exceeding method detection limits. Once opened, a bottle (or vial) of methanol will adsorb organic compounds rapidly; the "shelf life" is very short if any organic compounds are immediately present. Because prices for laboratory-grade methanol can exceed $30 per liter, it is difficult to "toss away" a partially used bottle of methanol once opened.

So now let's travel to the job site. Our on-site environmental geologist is busy directing and supervising the sampling subcontractor (e.g., driller, excavator), logging samples, screening samples with a hand-held PID, washing sampling sleeves, and communicating with the front office. Where does this flurry of activity normally take place? Typically on a tail gate of a pick-up truck (or some equivalent workbench), in close proximity to the sampling truck.

Now let's add methanol preservation to the other tasks. If everything is going fine, the methanol preservation step should be relatively painless. However, what happens when things don't go so fine? The driller has problems. The wind shifts and the "work area" is now downwind of the diesel exhaust. The job's running late and everyone is in a hurry. It starts to rain. The office calls. Now what happens to the vials or bottle of methanol? Was it left uncapped for a while? Do we use it the next day if the job shuts down for some reason? Two days later? Three days? How does one know if the methanol is still okay? What happens if the methanol-preserved samples are put in the same cooler as the highly contaminated soils themselves? Will the samples cross-contaminate the methanol extracts?

The point is that the potential for false positives from contaminated methanol increases with methanol preservation. If it occurs, the false positives will most likely not be discovered until after the job is demobilized. In this situation, who pays for the job to be redone? The tank fund? The consultant? The lab? Or does the job not get redone and the data "corrected" before submission?

## Are There Alternatives?

Yes. The best alternative is on-site analysis. On-site analysis mitigates the volatile loss problem and also mitigates the potential for false positives because the real-time analysis will reveal the existence of the contaminated methanol before it is too late to correct the problem. Costs for on-site analysis have dropped over the past few years, and many reimbursement funds now allow it.

If the budget or logistics do not allow for the use of methanol, you have the alternative of using water as the preservation liquid. While this may initially sound strange, it turns out that MTBE, most aromatic compounds (BTEX), and many chlorinated compounds prefer to be in water over air by ratios exceeding 4 to 1. Thus, in a vial filled with 5 grams of soil, 5 mL of water, and 5 cc of air, 80 percent of the analyte will partition into the water. If the water to air ratio in the vial is 2 to 1 (say, 10 mL to 5 cc), about 90 percent of the analyte will partition in the water.

Why water over methanol? Because inexpensive, uncontaminated water is readily obtainable at every convenience store and its shelf life is much longer than that of methanol. If the job gets delayed for a day or two or three, a fresh, unopened bottle of drinking water can be purchased for $1.

■ *continued on page 21*

**Investigation and Remediation**

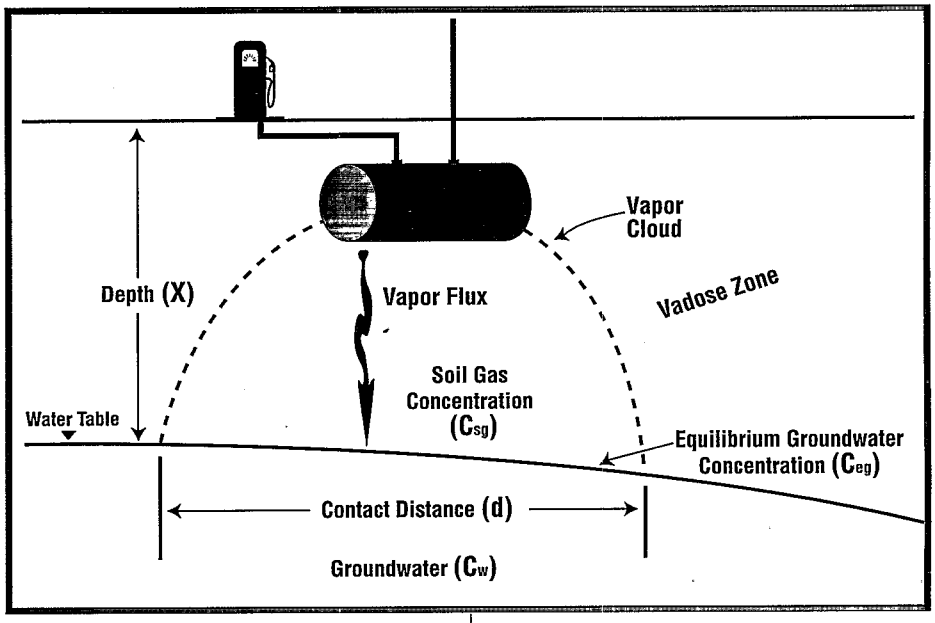
# The Downward Migration of Vapors

*by Blayne Hartman*

*In the last issue of* LUSTLine, *we discussed potential risk to human health with respect to the upward migration of vapors into overlying structures. In that scenario, the health risk of concern was the inhalation of contaminant vapors from room air. This risk pathway has gained increasing attention over the past several years and has been addressed in a number of published documents, including the 1995 ASTM Risk-Based Corrective Action (RBCA) document.*

*In contrast to the upward vapor risk, potential risk to groundwater associated with the downward migration of vapors has been relatively ignored. The principal reason for this is that it is generally assumed that contaminated soil vapor is the result of contamination in the soil. Therefore, there is the perception that the real risk to groundwater is not the soil vapor, but the contaminant in the soil that makes its way to the groundwater.*

*So why worry about risk associated with downward vapor migration? Because, over the past few years, more and more sites have been discovered that have high contaminant concentrations in the soil vapor but no corresponding soil contamination. In this article, I'll explore this phenomenon. Is it a problem? If it is, then when should we start to worry?*




## Vapor Clouds

How can a site have contaminated soil vapor with no corresponding soil contamination? One explanation is that the contamination entered the vadose zone as a vapor. Many compounds in fuels and many chlorinated solvents have relatively high vapor pressures and vapor densities three to six times greater than those of air. Because of these physiochemical properties, vapors may emanate from containers holding gaseous or liquid products that are used or stored in an indoor confined space or from pipe joints and then sink to the floor. If air flow is restricted, such as in a closed room, the dense vapors can penetrate the concrete floor and enter the upper vadose zone.

Such bulk-dense vapor movement will continue to drive the vapor downward through the vadose zone until it is diluted to low enough concentrations (<1 percent) that density is no longer an important factor in the vapor transport process. "Vapor clouds" reaching tens of feet into the uppermost vadose zone have been documented and attributed, at least in part, to density-driven flow. Business and commercial operations that are most susceptible to this situation include perchloroethylene (PCE) washing units at dry cleaners, vapor degreasers at machine shops, and spray booths at inking or painting facilities where chlorinated solvent-based inks or paints are used. As far as USTs are concerned, underground vent pipes are typically filled with high concentrations of MTBE and gasoline vapors that can conceivably migrate through pipe joints and create vapor clouds.

As vapor clouds are discovered in the vadose zone at more and more sites, we must try to determine whether they are a potential risk to groundwater. If they are, at what soil vapor concentrations should we start to worry? I'll start with a quick review of the basic processes by which vapors move through the vadose zone. (Refer to *LUSTLine* Bulletin #27 for a more complete discussion.) Then I'll discuss, compute, and summarize in a table the potential risk that results from downward vapor migration. I'll conclude with a recommended protocol for collecting soil vapor data for assessing the downward vapor risk. Like my article on the upward migration of vapors, this one will also be somewhat technical; however, I have attempted to keep the subject understandable and have refrained from including so many "daunting" equations.

## How Do Contaminants Move in the Vapor Phase?

There are primarily two types of physical processes by which contaminants are transported in the vapor phase: advection and gaseous diffusion. The process of advection refers to the bulk movement of the vapor itself (e.g., the movement of vapor by wind). In advective transport, any contaminants in the vapor are carried along with the moving vapor. Advective transport processes can be

an important factor in the movement of soil vapor. This phenomenon is especially true where vapors are near the ground surface, where atmospheric pressure variations come into play, or near buildings, which can create pressure gradients because of differential heating or density-driven flow.

The second type of transport process, gaseous diffusion, refers to the motion of the contaminants by molecular processes through a non-moving vapor column. Gas diffusion is the primary transport mechanism for contaminants in the vapor phase through the vadose zone down to groundwater. Contaminant transport by gaseous diffusion is described by Fick's first law as:

$$\text{Flux} = \frac{D_e \times dC_{sg}}{dX}$$

Where:

- Flux is the rate of movement of a compound per unit area.
- $D_e$ is the effective diffusion coefficient in the vadose zone.
- $dC_{sg}$ is the contaminant concentration gradient in the soil vapor.
- dX is the depth interval in the vadose zone.

Similar to momentum transfer (e.g., water running downhill) and heat transfer (i.e., movement from hot to cold), contaminant transfer by gaseous diffusion moves from areas of high concentration to areas of low concentration. The flux will always be down the concentration gradient, regardless of the orientation of the concentration gradient with respect to depth below the surface.

## How Fast Do Contaminant Vapors Move?

An approximation of the mean distance that contaminant vapors can move by gaseous diffusion can be made as:

$$\text{Distance} = (2 \times D_e \times t)^{1/2}$$

Where:

- $D_e$ is the effective diffusivity.
- t is time.

### *Through the Vadose Zone*

The effective diffusion coefficient for contaminant vapor transport through the vadose zone is the gaseous diffusion coefficient corrected for soil porosity. For many vapors, the gaseous diffusion coefficient is approximately 0.1 $cm^2/s$. The effect of soil porosity varies depending on the type of soil. Several equations are available to calculate the effect of air-filled and total porosity on the diffusivity. A conservative approximation is that the porosity reduces the gaseous diffusivity by a factor of 10. Thus, for vapors, $D_e$ can be approximated as 0.01 $cm^2/s$.

The mean distance that contaminant vapors can move through the vadose zone in a year, assuming no adsorption, can be estimated as:

$$\text{Distance} = (2 \times 0.01\ cm^2/s \times 31{,}536{,}000\ s)^{1/2} \sim 800\ cm = \sim 25\ \text{feet}.$$

This calculation shows that contaminant vapors can move long distances through the vadose zone in a short period of time. Within a few years, vapor contamination can move laterally underneath a neighboring room or building, or downward to the groundwater surface.

### *Into or Out of Groundwater*

In contrast to movement through the vadose zone, the movement of contaminant vapors into or out of groundwater is controlled by the rate at which vapors partition into and move through the liquid. Because groundwater movement is so slow, the water interface remains relatively undisturbed (laminar flow), and vertical mixing of the water is minimal. The primary exchange process is again molecular diffusion, but in this case the exchange rate is controlled by liquid diffusion, not gaseous diffusion. A general value for the liquid diffusion coefficient for compounds is approximately 0.00001 $cm^2/s$. Using the same factor of 10 reduction to account for soil porosity, $D_e$ for most liquids can be approximated as 0.000001 $cm^2/s$.

The mean distance that contaminants can move into and through the groundwater in a year, assuming no absorption, can be estimated as:

$$\text{Distance} = (2*0.000001\ cm^2/s \times 31{,}536{,}000\ s)^{1/2} \sim 8\ cm = \sim 3\ \text{inches}$$

These calculations show that although contaminant vapors can move through the vadose zone relatively quickly, they partition into and move through groundwater extremely slowly. The reverse situation is also true; the partitioning of contaminants out of groundwater into the soil vapor is also extremely slow and very unlikely to reach the equilibrium values predicted by Henry's law constants. The reason equilibrium is not reached is because the mixing processes between the soil vapor and the groundwater are extremely slow (i.e., there are no blenders or mixers in the vadose zone mixing things up).

## Can the Downward Transport of Vapors Contaminate Groundwater?

The calculations summarized in the preceding section indicate that although contaminant vapors can move quickly down to groundwater, they do not partition into the groundwater very quickly. Using a modification of Fick's first law, the transfer of a contaminant from the soil vapor into the groundwater can be estimated. The flux is calculated as:

$$\text{Flux} = K_L (C_{eq} - C_w)$$

Where:

- $K_L$ is the gas exchange coefficient (length/time).
- $C_{eq}$ is the equilibrium water concentration at the interface.
- $C_w$ is the background groundwater concentration.

$C_{eq}$ represents the groundwater concentration in equilibrium with the overlying soil vapor at the interface between the soil gas and groundwater. It is easily calculated from the measured soil gas concentration as:

$$C_{eq} = C_{sg}/H$$

Where:

- H is the dimensionless Henry's law constant.
- $C_{sg}$ is the soil vapor concentration.

The gas exchange coefficient has units of velocity and essentially represents the distance that contaminants move vertically through the

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## ■ Downward Migration
*from page 15*

groundwater per unit time. This exchange coefficient is primarily dependent upon two transfer processes: dispersion caused by advective mixing and molecular diffusion at the interface. A full discussion of the relative importance of these processes is beyond the scope of this article; however, for groundwater velocities less than 100 ft/yr and soil grain sizes less than 0.5 mm, diffusional transport dominates over dispersion and $K_L$ can be approximated as:

$$K_L = 1.1 \times (D_e \times d/v)^{1/2}$$

Where:

- d is the horizontal distance (downgradient) over which the soil vapor plume and groundwater are in contact.
- v is the horizontal groundwater flow velocity.

Using this equation to estimate the gas exchange coefficient, estimates of the expected contaminant concentration in the groundwater that results from contamination in the overlying soil vapor can be calculated. The computed groundwater values are dependent on the depth into the groundwater that the contamination is mixed. The assumption used in these calculations is that the typical well-purging process mixes (homogenizes) the contamination in the groundwater uniformly over the entire well screen interval. Table 1 summarizes expected groundwater concentrations ($C_w$) for various equilibrium concentrations ($C_{eq}$).

In order to use Table 1, you must convert equilibrium groundwater concentrations ($C_{eq}$) into the corresponding soil vapor concentrations. Remember that the corresponding soil vapor values will vary for different compounds because Henry's law constants are compound-specific. Table 2 summarizes the soil vapor concentrations ($C_{sg}$) for various equilibrium concentrations ($C_{eg}$) for four common compounds (at 20°C).

Table 1 shows that for equilibrium concentrations up to 500 $\mu$g/L, the resulting groundwater concentration after 5 years will be low if liquid molecular diffusion is the only

**Table 1**
**Expected contaminant concentration in groundwater for various equilibrium concentrations ($C_{eq}$) at the groundwater interface.**

Calculations assume equilibrium partitioning at the soil vapor/groundwater interface, transfer by molecular diffusion only ($D_e = 10^{-6}$ cm$^2$/s), and uniform mixing of the contaminant into the groundwater over a well screen interval of 5 meters.

| $C_{eq}$ (µg/L) | Flux (µg/yr-cm$^2$) | 1 yr GW Conc (µg/L) | 5 yr GW (µg/L) |
|---|---|---|---|
| 10 | 0.08 | 0.006 | 0.28 |
| 20 | 0.16 | 0.01 | 0.55 |
| 30 | 0.24 | 0.02 | 0.83 |
| 40 | 0.32 | 0.03 | 1.1 |
| 50 | 0.40 | 0.03 | 1.4 |
| 100 | 0.80 | 0.06 | 2.8 |
| 500 | 4 | 0.3 | 14 |
| 1000 | 8 | 0.6 | 28 |

**Table 2**
**Soil gas concentrations ($C_{sg}$) for four common compounds for various equilibrium groundwater concentrations ($C_{eq}$) at the groundwater interface (values at 20°C).**

| $C_{eq}$ (µg/L) | MTBE Csg (µg/L) | Benzene Csg (µg/L) | PCE $C_{sg}$ (µg/L) | Vinyl Cl Csg (µg/L) |
|---|---|---|---|---|
| **10** | 0.1 | 2 | 6 | 10 |
| **20** | 0.2 | 4 | 12 | 20 |
| **30** | 0.3 | 6 | 18 | 30 |
| **40** | 0.4 | 8 | 24 | 40 |
| **50** | 0.5 | 10 | 30 | 50 |
| **100** | 1 | 20 | 60 | 100 |
| **500** | 5 | 100 | 300 | 500 |
| **1000** | 10 | 200 | 600 | 1000 |

exchange process. Table 2 shows that $C_{eq}$ values of 500 $\mu g/L$ correspond to soil vapor concentrations exceeding 100 $\mu g/L$ for most compounds. In most situations, contaminant vapor concentrations at the groundwater surface are far below 100 $\mu g/L$, and the contact time of the vapor contamination with groundwater is less than 5 years (the time it takes the groundwater to move across the site).

Thus, in areas with low groundwater flow velocities, contamination of the groundwater by downward vapor transport is not likely to be significant. In areas with higher groundwater flow velocities (>100 ft/yr), large variations in the water table, coarse soil, or high recharge, the gas exchange rate may be higher because of dispersive mixing. Groundwater contamination by vapor transport could be significant.

Does the conclusion that downward vapor transport into groundwater is a slow process make intuitive sense? The concept can be illustrated if you think of what is happening with air bubbles in a fish tank. If the air bubbler is turned off, the fish will go to the surface to gulp air; without the bubbles, they'll eventually die. Air contains nearly 21 percent oxygen, so there is plenty of oxygen sitting on the surface of the fish tank water. However, despite the large supply of oxygen at the surface, the transport mechanism into the water (liquid diffusion) is too slow across the laminar interface to supply enough oxygen to the water for the fish to live. So, the air must be bubbled through the water to increase the oxygen transfer process (by creating turbulent mixing).

### Protocol for Determining Risk Caused by the Downward Migration of Vapors

With Table 1 in hand, we can make reasonable judgments on whether measured soil vapor concentrations are likely to be a threat to groundwater. In order to use Table 1, we need to collect soil vapor data using the active soil gas technique and collecting data from as close to the groundwater interface as possible. (See the last issue of *LUSTLine* for a review of the different sampling methods.) In some situations (e.g., where the source of the soil vapor contamination is unknown or the depth to groundwater is uncertain), vertical profiles of the soil vapor may prove useful for determining the source of the contamination and the values at depth.

Based on the discussion presented in this article, I recommend the following procedure for collecting soil vapor data that will be used to determine risk to groundwater as a result of downward vapor flux:

1. Collect active soil vapor data near the water table at the location of highest contaminant concentration. If the location of highest contaminant concentration is unknown, collect soil vapor data at 5 feet below ground surface (bgs) across the site to identify the location of highest concentration.
2. Calculate $C_{eq}$ from the measured soil vapor values using the Henry's law constant for the contaminant of concern (or use Table 2). Use Table 1 to estimate the impact to groundwater. If Table 1 indicates that downward vapor poses no threat to groundwater, then this risk pathway need not be considered further, assuming the source of the soil vapor contamination is mitigated.
3. If Table 1 indicates that downward vapor may pose a threat to groundwater, then collect additional soil vapor samples near the water table across the entire soil vapor plume.
4. Calculate an average $C_{eq}$ for the entire plume. Use Table 1 to estimate the impact to groundwater. If Table 1 indicates that downward vapor poses no threat to groundwater, then this risk pathway need not be considered further, assuming the source of the soil vapor contamination is mitigated.
5. If Table 1 still indicates that downward vapor may pose a threat to groundwater, then both the soil vapor contamination *and* the contamination source likely need to be mitigated. ■

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## Still Searching for Integrity

*February 10, 1998* - It's crunch time for tank owners and operators who are looking to upgrade their bare steel tanks without putting a person inside the tanks to inspect them. According to EPA's Office of Underground Storage Tanks (OUST), no vendors currently meet its guidance for "alternative" (non-human-entry) integrity assessment methods issued in July 1997. The guidance recommends that after March 22, 1998, states allow alternative integrity assessments on bare steel tanks only if the procedure meets a current national standard or if it has been evaluated by a third party to meet certain criteria.

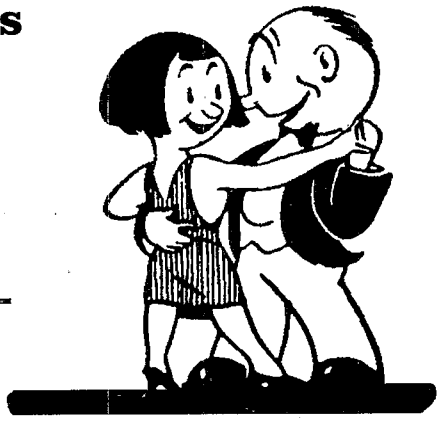
According to the American Society of Testing Materials (ASTM), a standard code of practice will not be ready by the March 22 recommended deadline. However, an ASTM task group in which EPA is participating continues work on a draft standard.

To OUST's knowledge, no vendor's procedure has completed a third-party evaluation in accordance with EPA recommendations. The "FURY" robotic ultrasound procedure has had some evaluation, but no final evaluation has been completed.

Some states recently received documentation, dated January 19, 1998, from Corrpro Companies Inc. and Warren Rogers Associates Inc. (WRA), asserting that their procedure meets the criteria. EPA says that the documentation does not fulfill its criteria for integrity assessment. Corrpro and WRA plan to provide more documentation.

Meanwhile, OUST has been contacted by some vendors who have indicated that third-party evaluations for their procedures are under way and, therefore, expects that some evaluations will be completed soon. EPA will distribute lists of completed evaluations periodically. ■

# MTBE & Underground Storage Tank Systems
# A Question of Compatibility



*by James M. Davidson*

*Methyl tertiary butyl ether (MTBE) was first used commercially in the United States as a gasoline additive in 1979. Its use increased gradually through the 1980s as an octane enhancer (typically 1 – 8% by volume). By the 1990s, higher levels of MTBE (11 – 15%) were added to gasoline in order to increase oxygen levels, and thereby reduce air pollution. Now, about half of all gasoline sold in the United States contains MTBE. (For an in-depth introduction to MTBE, see "MTBE...If Ye Seek It, Ye May Well Find It...And Then What?" in* LUSTLine *Bulletin #24.)*

*Common sense tells us that if an underground storage tank (UST) has an accidental release of gasoline, and the gasoline contains MTBE, then MTBE will escape into the environment along with the other gasoline components. However, with the recent discovery of subsurface MTBE contamination at many UST facilities, concern has arisen whether MTBE can preferentially leak from UST systems, or whether the MTBE itself can cause leakage from UST systems. Some people are fearfully wondering: Is there something about MTBE that causes releases from USTs?*

*In this article I review the available knowledge regarding the compatibility of MTBE with UST systems, as extracted from published studies and as collected from discussions with numerous UST experts. As I'll explain, it does not appear that there are any obvious compatibility problems between USTs and the gasoline additive MTBE. On many of the specific compatibility issues, significant supporting scientific data exist. However, for a few topics the available information is limited or contradictory, and so more research is needed.*

**COMPATIBILITY = *The ability of two or more substances to maintain their respective physical and chemical properties when in contact with one another. For UST systems, compatibility with the substance stored must be for the design life of the tank and under conditions likely to be encountered in the UST.***

## UST Systems

Modern USTs are most often made of cathodically protected steel, fiberglass-reinforced plastic (commonly called fiberglass), or composite materials (such as steel with fiberglass coatings). Product piping used in modern underground storage tank systems is typically made of fiberglass or thermoplastic lined with nylon (associated with flexible piping). Bare steel product piping is, of course, more typical in older UST systems.

When considering the compatibility of gasoline, or a gasoline additive, with UST system components, one should take into account:

- Compatibility with metal tanks and piping;
- Compatibility with fiberglass tanks and piping;
- Permeability of liquid and vapors through the UST system components;
- Compatibility with flexible piping; and
- Compatibility with seals and gaskets.

## Compatibility with Metal Tanks and Piping

Like all other oxygenating additives, MTBE adds oxygen to gasoline, so we need to consider whether oxygen enhances corrosion of metal tanks and piping systems. In 1988, Sun Refining and Marketing Company (an early major manufacturer of MTBE) tested this possibility by immersing metal samples (also called "coupons") in seven gasoline blends (some with MTBE levels of up to 15% by volume, some with no MTBE) for 6 to 7 months. Nine different metals commonly used in automotive fuel systems and gasoline distribution systems were tested. The metal coupons showed small weight changes in all the fuels. Weight loss (i.e., corrosion) of the 10/20 steel coupons over 6 months of immersion increased from a 2.95 percent weight loss to a 10.75 percent weight loss when MTBE was added to the base gasoline. While this difference is noteworthy, the researchers concluded that "the small amount of weight loss indicates no potential problems."

In 1989, two other researchers (Lang and Palmer) reported on a compatibility study that used standard reference gasolines combined with four possible gasoline additives: methanol, ethanol, tertiary butyl alcohol (TBA), and MTBE. Through a variety of immersion tests, they tested gasoline mixtures of all these additives for tendency to corrode metals commonly used in automobiles, including brass, aluminum, zinc, and mild steel. They found that MTBE was the *least* aggressive of the additives tested.

I found no other pertinent studies pertaining to MTBE and metal tanks and piping.

## Compatibility with Fiberglass Tanks and Piping

Many modern USTs and product pipes (including many double-walled systems) are made from fiberglass. Similar to the compatibility testing on metals, several series of immersion tests have been conducted on fiberglass. In 1988, Sun conducted fiberglass compatibility testing with six test fuels (two base gasolines with no MTBE and four fuel blends with MTBE at 7.5% – 15%). Testing was conducted by immersing a coupon of fiberglass tank material (Xerxes) in the six test fuels for 7 months at 68 to 70°F. Essentially, no volume changes were measured for any of the fiberglass tank coupons after 6 months of immersion in the test gasolines.

A subsequent publication provides additional results from these same 7-month-long immersion tests (Douthit et al., 1988). The paper reports that the fiberglass tank sample had volumetric shrinkage of 0.35 percent when immersed in a base gasoline (no MTBE), a volumetric shrinkage of 0.33 percent when in the base gasoline with 11 percent MTBE, and a volumetric shrinkage of 0.24 percent when immersed in the base gasoline with 15 percent MTBE. In other words, the MTBE-blended gasolines had slightly less volumetric impact on the fiberglass than did the base gasoline.

Also in 1988, Sun conducted similar immersion testing on Ciba-Geigy fiberglass piping. After 7 months, the volumetric change for piping sections in MTBE-blended gasolines ranged from +2.26 percent swelling to -1.32 percent shrinkage. The Sun researchers reported that these volumetric changes were smaller than those seen with most other components and materials previously tested. Additional reporting on these same tests indicated that the fiberglass pipe samples had volumetric "swelling" of 0.33 when immersed in a base gasoline (no MTBE), a volumetric shrinkage of 1.09 percent when in the base gasoline with 11 percent MTBE, and a volumetric shrinkage of 0.43 percent when immersed in the base gasoline with 15 percent MTBE (Douthit et al., 1988). These data indicate that the MTBE-blended gasolines caused slightly greater volumetric change in the fiberglass piping samples than did the base gasoline.

Even more "real world" are the recently released results of long-term compatibility testing by one of the fiberglass manufacturers (Fluid Containment). Although a full report was not available for review at press time, in a summary of its findings, Fluid Containment describes a series of long-term immersion tests.

Researchers placed a series of nine fiberglass samples in gasoline with 20 percent MTBE for up to 94 months. They report that throughout this nearly 8-year test period, the hardness and strength of the fiberglass samples did not vary by more than 2 percent from their original values.

These ranges in values are similar to those seen with fiberglass samples exposed to gasoline with no MTBE for equal durations. Fluid Containment concluded that "the MTBE fuel blend acted no differently than straight gasoline and had essentially no effect on the tank sample after almost 8 years" (Fluid Containment, 1997). The company also reported that it had not experienced a single tank failure from internal corrosion, with over 250,000 fiberglass tanks sold. (This number includes tanks manufactured under its present name and its previous name of Owens-Corning Fiberglass, Tank Division).

You may wonder: If fiberglass is compatible with MTBE, what about the glues used to bond fiberglass systems together? In neither a thorough literature search nor discussions with knowledgeable UST experts could I establish any cases where MTBE was suspected of having dissolved the glues used with fiberglass systems. The only related information I found was in two early American Petroleum Institute publications (API, 1985 & 1986), where it was noted that some alcohol-based pipe thread dopes were not recommended for use with methanol or ethanol-blended gasoline if the pipe dope had been recently applied.

In summary, several short-term (6 to 7 months) immersion tests showed no difference to very little difference in how MTBE-enhanced gasoline affected fiberglass samples, as compared with gasolines without MTBE. Long-term (nearly 8 years) immersion tests by Fluid Containment showed similar results.

## Permeability Through Fiberglass

I found some information regarding the possibility that MTBE permeates directly through the walls of fiberglass tanks and pipes. One study (Smith Fiberglass Products Inc., 1996) investigated liquid gasoline permeability through fiberglass pipe by using standard permeability testing methods. This study showed, essentially, that no liquid gasoline loss occurred through the fiberglass piping after 31 days while using 90 percent gasoline and 10 percent ethanol (not MTBE). This test demonstrates the extremely low permeability of fiberglass piping to liquid gasoline components. MTBE-blended gasoline was not tested.

Sun tested the evaporative losses of six gasoline blends from several types of vehicle fuel-line and gasoline-dispenser hoses. The 6-month evaporative-loss tests showed that "there were no large differences between the samples containing base fuel and samples with base fuels and 15 percent MTBE" (Sun, 1988).

In a 1996 letter to Fluid Containment, Bruce Curry of Alpha/Owens-Corning discusses the polymer being used in the manufacture of the company's fiberglass tanks. He reported that larger molecules in liquids have a more difficult time permeating fiberglass laminates than do smaller molecules. Since the

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■ **Compatibility** *from page 19*

molecular size of MTBE (molecular weight = 88) is fairly large, it would not be likely to swell fiberglass or to be readily permeable through fiberglass. In contrast, smaller molecular compounds like methanol (molecular weight = 32) would be more permeable. This same viewpoint was expressed in a 1997 paper by Sully Curran, Executive Director of the Fiberglass Tank and Pipe Institute. Alpha/Owens-Corning (1996) also states that MTBE would not be prone to affecting fiberglass laminates because of its relative chemical inertness. In summary, the opinions of the fiberglass manufacturers and experts are in agreement that MTBE's molecular size should deter its permeation through fiberglass.

## Fiberglass Manufacturers' Warranties

In a 1995 letter to its customers, Owens-Corning/Fluid Containment said that it had extensively tested fuels containing up to 20 percent MTBE and that there was very little effect on the fiberglass laminate. As a result, Fluid Containment has warrantied its tanks against internal corrosion for 30 years for the storage of up to 20 percent MTBE for *any* of its tanks manufactured since 1964. Another major manufacturer, Xerxes, first listed MTBE-blended gasolines (up to 20% MTBE) on its April 2, 1988, warranty, where it warrantied its fiberglass tanks for 30 years. Prior to April 2, 1988, MTBE was not mentioned in the Xerxes warranty, although other, more aggressive additives (i.e., alcohols) had been previously addressed and covered by warranty.

## Compatibility with Flexible Piping

While many product piping systems are made from fiberglass-reinforced plastic, the use of flexible piping systems (made from thermoplastics or polyethylene) has increased greatly in recent years. In a 1997 data compilation conducted for USEPA, ICF Inc. found that seven of the eight manufacturers of flexible piping had tested and approved their piping systems for primary pipe compatibility with MTBE-blended gasolines. Five of the eight manufacturers had tested and approved their flexible-piping systems for secondary pipe compatibility with MTBE-blended gasolines. One manufacturer did not report whether MTBE had been tested yet. While this summary is promising, no details were available regarding the testing conducted on MTBE's compatibility with flexible piping. No information was found regarding studies of MTBE permeation through flexible piping, and so no conclusion can be made. This topic may warrant additional research.

***...it does not appear that there are any obvious compatibility problems between USTs and the gasoline additive MTBE... However, for a few topics the available information is limited or contradictory, and so more research is needed.***

## Compatibility with Seal and Gasket Materials

Several studies have shown that "pure" (or "neat") MTBE can adversely affect some elastomeric materials used in seals and gaskets. Seal and gasket deterioration from exposure to pure oxygenates usually comes in the form of swelling and softening (API, 1990; Alexander et al., 1994). However, these data are Not directly applicable to releases from USTs as USTs are Not used to store neat MTBE.

When considering MTBE as a gasoline-blending component, a 1994 study used MTBE at 20 percent by volume (which is higher than current commercial grades) for immersion tests on six seal materials. After 168 hours of immersion, five of the seal types (including two types of Viton) had no swelling and one Viton formulation had minor swelling (about 12%). The researchers concluded that MTBE did "not significantly swell any of the elastomeric seals tested," and that all six seals were deemed appropriate for use when MTBE concentrations were less than 20 percent of the gasoline (Alexander et al., 1994). This immersion study provides much useful information, but some followup work may be advisable because of the relatively short duration of the tests (1 week).

Similarly, Lang and Palmer (1989) conducted immersion tests to determine fuel additive compatibility with five common commercial mixes of rubbers (elastomers) used in vehicle fuel systems. Using standard reference gasolines containing either methanol, ethanol, TBA or MTBE, they determined that MTBE was the *least* aggressive additive toward rubbers.

A variety of plastic and elastomeric parts commonly used in automobiles and gasoline distribution systems were tested in 7-month-long immersion tests (Sun, 1988). Fifteen materials and automotive components were immersed in six test fuels at 68 to 70°F. Results showed that some materials had about the same swell in 15 percent MTBE gasoline as in non-MTBE gasoline, while other materials swelled less. Only Viton seal formulations had more swell (up to 7%) with MTBE present, though the degree of swelling was not considered significant by the authors (Sun, 1988).

Since 1985, the General Valve Company (as reported by Smith in 1995) has worked closely with DuPont to conduct Viton compatibility testing. General Valve concluded that up to 25 percent MTBE in gasoline will not diminish the life of the Viton Type A (66% fluorine) seals commonly used in petroleum storage and transport facilities. Similarly, a comprehensive study by Aloisio (1994) investigated how gasoline can impact various elastomers, depending upon such variables as temperature, fluorine content, and MTBE content. He reported that because blending MTBE into gasoline reduces the fuel's polarity, the fluorocarbon elastomers (like Viton) can be used with MTBE-blended fuels, as long as the concentration of MTBE in the gasoline does not exceed 25 to 30 percent. This highly technical paper would be best interpreted by a materials specialist.

Another comprehensive study of the MTBE impacts on seal materials was conducted by Hotaling (1995). Seal material samples were exposed for 6 months to test fuels of

100 percent MTBE, 95 percent gasoline with 5 percent MTBE, and 100 percent MTBE vapors. The seal material parameters tested were volumetric swell, tensile strength, and elongation. Similar to other studies, Hotaling found the 100 percent MTBE liquid impacted seal materials much more than the 5 percent MTBE gasoline blend. In contrast to other researchers, Hotaling reports that even the 5 percent MTBE-blended gasoline created serious degradation of some seals.

## MTBE Vapors

Vapor-phase MTBE is of interest because MTBE's high vapor pressure (roughly three times that of benzene) can, theoretically, cause the vapors in an UST system to be more enriched with MTBE than the liquid gasoline from which the vapors originally evaporated. (No literature was found that documented the composition of recovered vapors from MTBE-enhanced gasoline.) As such, gasoline vapors, or liquid gasoline condensates that form from those vapors, will likely contain relatively high percentages of MTBE. MTBE-enriched vapors could occur inside the headspace of USTs and also inside the vapor recovery system. Liquid-phase MTBE-enriched condensate could form in small volumes inside the vapor recovery system.

Hotaling (1995) reports that many seal materials tested in 100 percent MTBE vapors experienced "significant adverse changes in the properties measured." Some of the seals that reacted very little with 5 percent MTBE gasoline were severely impacted by 100 percent MTBE vapors. The opposite is also true—some of the seals that reacted very strongly with 5 percent MTBE gasoline were not impacted by 100 percent MTBE vapors. These complex responses are not fully understood.

While MTBE may constitute a significant portion of the vapors in an UST headspace and vapor recovery system, it certainly won't constitute 100 percent MTBE. Therefore, Hotaling's study may not be directly applicable. However, the limited data reviewed here do suggest that vapor-phase compatibility with, and vapor-phase permeability through, the tank, piping, and seal materials is a topic that requires further study.

## In Summary...

- Of the common gasoline additives, MTBE was found to be the least aggressive to steel and other metals. One study indicated that adding MTBE to gasoline increased the weight loss from some steel coupons.
- All studies reviewed here indicated that MTBE-blended gasoline is compatible with underground storage tanks and piping made from fiberglass.
- Permeation of liquid-phase MTBE directly through fiberglass materials seems unlikely, but only limited test data were available.
- Regarding flexible piping, most manufacturers state that their products are compatible with MTBE-blended gasolines; however, information is limited.
- Of the numerous tests conducted on seal and gasket materials, almost all indicated they were compatible with the range of MTBE concentrations used in gasoline (i.e., up to 15% MTBE by volume). However, because of conflicting findings from one report and the numerous seal/gasket materials in use, additional investigation would be beneficial.
- Because of MTBE's high vapor pressure, some vapors and condensates enriched with MTBE may exist in UST systems. Therefore, how vapor-tight, how compatible, and how permeable the UST system components are to MTBE-enriched vapors and/or MTBE-enriched condensates appear to need further investigation.

After reviewing the available literature and speaking with numerous UST experts, I have concluded that currently there are no obvious compatibility problems between USTs and MTBE used as a gasoline additive. Supporting scientific data demonstrate that MTBE-blended gasoline is compatible with UST tanks and pipes made from either fiberglass or metal, as well as many common elastometric seals. However, the available information regarding permeability and vapor-phase compatibility are limited. More research on these topics and other compatibility issues would be beneficial. ■

*See page 30 for references cited in this article.*

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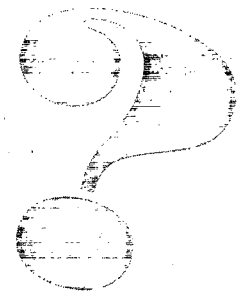
## ■ To Methanol Preserve or Not?

*from page 13*

### Thus...



If you choose to use methanol VOC preservation, be sure to take appropriate steps (e.g., additional trip blanks) to ensure that the methanol doesn't become contaminated. While methanol preservation certainly is a proven way to maximize VOC concentrations from soil, the realities of life in the field introduce potential complications that may favor other alternatives. On-site analysis is by far the best alternative. Water preservation, although not as quantitatively accurate as methanol, does provide certain advantages depending on the compounds of interest. If water preservation is performed, the preserved samples should be kept chilled (4°C) and, preferably, poisoned with a bactericide to eliminate biodegradation prior to analysis. ■

Leak Detection

# Are Leak Detection Methods Effective in Finding Leaks in UST Systems?

## California Survey Uncovers Some Cold, Hard Facts

*Shahla Dargahi Farahnak*

The increased use of oxygenates as fuel additives combined with recent concern over environmental and health effects of some of these additives, such as MTBE, has drawn attention in California to the reliability of leak detection systems. For this reason, staff at the California State Water Resources Control Board conducted a survey to determine the effectiveness of leak detection methods in finding UST system leaks. A total of 345 leak cases (reported between October 1995 and May 1996) were included in the survey.

### How Are UST Releases Detected?

One important question we sought to answer in our survey was: How are UST releases, in fact, detected? Information on the leak discovery method was available in 313 cases—some was included in the original statewide database, and some was provided by local permitting agencies. Analysis of these data indicates that tank closure is the dominant method for discovering leaking USTs (84%). In most cases, therefore, we do not know about leaks until the UST system is removed.

### What About Leak Detection?

Because of what the survey data revealed, we became concerned about the consistent use of leak detection methods. At many of the leaking sites, leak detection was not used or was not performed regularly. For 281 cases for which we received a response, an estimated 149 UST systems (53%) were not monitored (a few because the tanks were abandoned), monitoring records were not in the agency files, or monitoring histories were not known. For 132 cases with available monitoring information, there were long-time gaps, an average of 29 months, between the last monitoring date and discovery of a leak.

These gaps in monitoring data not only make the evaluation of leak detection methods difficult, they also send up a red flag that UST owners and operators still haven't gotten the leak detection message. While the information in our survey is not adequate to make a statement about whether leak detection works, it does highlight some problems. We believe, however, that tank owner education and consistent enforcement of monitoring requirements will give leak detection a better chance to work.

### Do Leak Detection Methods Discover Leaks?

Overall, it appears that leak detection methods are not discovering

Table 1 **Summary of the Leak Discovery Methods**

| Leak Discovery Method | Number of sites |
|---|---|
| Dispenser Relocation (DR) | 2 |
| Monitoring Well installation (MW) | 1 |
| Piping Modification (PM) | 1 |
| Property Sale/transaction (PS) | 5 |
| Piping Work (PW) | 1 |
| Site Assessment (SA) | 6 |
| Site Investigation (SI) | 4 |
| Soil Boring (SB) | 1 |
| Subsurface Monitoring (SM) | 13 |
| Site Work (SW) | 1 |
| Tank closure/removal (TC, TR) | 223 |
| Upgrade/lining (UP) | 4 |
| Water Sampling (WS) | 1 |
| ***Total leaks discovered through site activities category*** | **263** |
| ***Percent of cases based on total sites [1]*** | **76%** |
| ***Percent cases based on number of cases with leak discovery information [2]*** | **84%** |
| Inventory Control (IC) | 2 |
| Leak Detector (LD) | 1 |
| Piping Test (PT) | 1 |
| Tank Test (TT) | 8 |
| Annual leak detection equipment inspection/maintenance check (AI) | 3 |
| ***Total leaks discovered by leak detection*** | **15** |
| ***Percent of cases based on total sites [1]*** | **4%** |
| ***Percent cases based on number of cases with leak discovery information [2]*** | **5%** |
| Other means (OT) | 31 |
| Visual (V) | 1 |
| Nuisance Conditions (NC) | 3 |
| ***Total leaks discovered by other methods*** | **35** |
| ***Percent of cases based on total sites [1]*** | **10%** |
| ***Percent cases based on number of cases with leak discovery information [2]*** | **11%** |
| ***Total cases with no information on leak discovery methods*** | **32** |
| ***Total number of cases with leak discovery information*** | **313** |
| ***Total number of sites in the database*** | **345** |

1 With respect to 345 cases
2 With respect to 313 cases

Table 2 **Leak Sources**

| Leak Source | Number of sites |
|---|---|
| Dispenser (D) | 11 |
| Dispenser & Line (DL) | 1 |
| Dispenser & Overfill (DO) | 2 |
| Above ground Piping (AP) | 1 |
| Piping (P) | 35 |
| Previous Leak (PL) | 1 |
| Spill (S) | 2 |
| Overfill (O) | 7 |
| Overfill / Line (OL) | 1 |
| Tank (T) | 54 |
| Tank & Dispenser (TD) | 2 |
| Tank & Line (TL) | 2 |
| Tank & Line & Dispenser (TLD) | 2 |
| Unknown (U) | 154 |
| Blank entries | 70 |
| **Totals For Each Leak Source** (includes overlapping cases) | |
| Total number of cases with the dispenser as leak source | 18 |
| Percent based on total number of sites[1] | 5% |
| Percent of cases excluding cases without information[2] | 15% |
| Total number of cases with piping as leak source | 41 |
| Percent based on total number of sites[1] | 12% |
| Percent of cases excluding cases without information[2] | 34% |
| Total number of cases of overfill as leak source | 12 |
| Percent based on total number of sites[1] | 3% |
| Percent of cases excluding cases without information[2] | 10% |
| Total number of cases with the tank as leak source | 60 |
| Percent based on total number of sites[1] | 17% |
| Percent of cases excluding cases without information[2] | 50% |
| Total number of cases with an unknown leak source | 154 |
| Percent based on total number of sites[1] | 45% |
| Percent of cases excluding cases without information[2] | 127% |
| Total number of cases with information | 121 |
| Total number of cases with no information | 224 |
| Total number of sites in the database | 345 |

1 With respect to 345 cases

2 With respect to 121 cases

many leaks. (See Table 1.) There were only 15 cases (4.8%) in which leak detection identified a leak. This is a very low number, but it is an indication that if used properly, leak detection has the potential to find leaks. Our review of these data and available monitoring reports highlights two of the main concerns with with the use of leak detection. First, owners, operators, and sometimes regulators ignore or overrule the results of failed tests and have another test performed (which is not always performed by the same tester). It is important to investigate the failed test report before redoing the test or accepting the result of the retest. Second, some SIR vendors and tank testers are incorrectly reporting their test results. Some testers tend to ignore excess gains and call them a "pass." A few of the leaking sites had previous excess-gain SIR results that were reported as a "pass" or "inconclusive" by the vendor, and no followup was done by the tank owner to determine the cause. Available records point to a few cases where we suspect that the leak detection method failed to identify the leak. (The leak discovery date and the date of last "pass" monitoring result were very close.)

To evaluate the effectiveness of leak detection methods that are required annually (i.e., annual line testing, annual tank tightness testing), we need information on the estimated age of the leak. This, in turn, suggests that to detect leaks within a reasonable time frame, we should encourage the use of frequent monitoring methods (monthly or continuous) rather than annual monitoring.

It appears that the main problem with this failure to discover leaks is that many of the leaking sites have not been properly monitored. For this reason, I believe that regulatory agencies should focus on proper review of monitoring records and test reports, adequate followup on reported fail and inconclusive results, and periodic maintenance checks of leak detection equipment. (California requires annual leak detection equipment maintenance testing.)

## What Are the Sources of UST Releases?

Most leaks evaluated in the survey were from tanks and piping systems. (See Table 2.) Of the 121 cases for which leak source information was available, 50 percent were tank leaks and 34 percent were piping leaks. A total of 18 dispenser area and 12 overfill/spill releases were reported. These data contrast with past leaking UST site surveys that reported that most leaks came from piping and overfilling. Most of the leaking systems were single-walled USTs, 10 to 40 years old. There were 10 cases in which the leak most likely came from a double-walled tank system (less than 10 years old). In these instances, one leak was caused by a fiberglass tank rupture (discovered during the annual equipment maintenance check), and two leaks were in the dispenser area. It is important to note that without containment under the dispenser, dispenser-piping leaks and fuel releases during filter changes are not contained and can remain undetected for years.

Automatic tank gauging (ATG) systems, groundwater and vapor monitoring, and manual tank gauging (MTG) methods of monitoring were not included in this survey. Vapor and groundwater monitoring and manual tank gauging are rarely used in California. Access to ATG test reports requires tank owner cooperation, because these reports are not submitted to the regulatory agencies. However, our review of data indicates that at some of the survey sites, an ATG system was installed. But was it used? We do not know. We do know that none of the leaks in our survey was discovered by an ATG system.

## Recommendations?

Clearly, leak detection has not become a way of life for many tank owners/operators or leak detection service providers. We have yet to drive home the true function of leak detection, which is to prevent a small leak from becoming a big leak and, hence, a big problem. It is apparent that those of us who are UST regulators have a good deal more work to do. We need to pursue diligent oversight by regulatory agencies, proper use and maintenance of leak detection equipment by tank owners, adherence to test protocols, and accurate reporting of test results by testing companies. Is leak detection working? As Marcel Moreau suggested in his article in *LUSTLine* Bulletin #26, we will need a more comprehensive survey on this subject that is national in scope. ■

*Shahla Dargahi Farahnak, P.E., is Associate Engineer with the California State Water Resources Control Board. For a copy of the complete survey report, contact Shahla at farahnas@gwgate.swrcb.ca.gov.*

Leak Prevention

# Tank-nically Speaking

by Marcel Moreau

*Marcel Moreau is a nationally recognized petroleum storage specialist whose column, **Tank-nically Speaking**, is a regular feature of **LUSTLine**. As always, we welcome your comments, questions, and suggestions regarding Marcel's discussion.*

## WHAT ABOUT TANK LINING?

If you have a steel underground petroleum storage system that is not protected against corrosion, you can meet the federal December 22, 1998, UST upgrading deadline requirements by closing your system, by replacing it with a new corrosion-protected system, or by upgrading your existing system. The federal regulations refer to the addition of corrosion protection to storage systems that are not presently protected against corrosion as "upgrading." These regulations provide three options for applying corrosion protection to existing storage systems:

- Add internal lining;
- Add cathodic protection to the outside of the tank; or
- Add cathodic protection and internal lining.

In this article we'll explore the options that include internal lining.

### Internal Lining

The process of adding a coating to the inside of a tank is called internal lining. The procedure involves emptying the tank of all liquids, freeing the tank of explosive vapors, excavating to the top of tank, and cutting a hole about two feet square in the tank top for a person to enter.

This person then cleans any sludge out of the tank and carefully sandblasts the entire inside surface of the tank. The tank is then structurally assessed by visually checking for corrosion holes and split welds; determining the thickness of the tank wall, either ultrasonically or by banging on the tank walls with a hammer (not very sophisticated but, I am told, effective); and measuring the tank diameter to determine whether the tank is still reasonably round.

If the tank has a few holes, industry standards indicate that they can be plugged and patched, and the tank can still be lined. If the tank has too many holes, the walls are too thin, or the tank is too out of shape (an oval-shaped tank indicates that the tank is collapsing) the tank cannot be lined and must be properly closed. If it is determined that the tank is sound, a lining of epoxy or polyester resin with a nominal thickness of 1/8 inch is applied. The entry hole in the tank is then sealed, and the tank is considered to be upgraded with corrosion protection. The tank must then be inspected when the lining is 10 years old and every 5 years thereafter.

Internal lining contractors generally provide a 1-year warranty on workmanship and materials and a 10-year warranty against corrosion-induced leaks. The warranty covers fixing the hole but not cleaning up the leak. There is no warranty against leaks resulting from structural failure such as failed welds.

While a simple internal lining is all that is required to meet the regulations, some companies also offer a secondary containment retrofit option, which provides a cost-effective way of gaining the added security of secondary containment without replacing existing tank systems. There are three techniques:

- Lining the tank as usual and then inserting a flexible bladder in the tank that becomes the primary container for the liquid in the tank. The space between the bladder and the lining is monitored with a vacuum so that the integrity of both the bladder and the tank wall can be verified.
- Lining the tank as usual, then applying a thin layer of a porous material to the inside of the tank, followed by a second layer of the lining material. This second layer of lining material then becomes the primary container for the liquid in the tank. Again, a vacuum can be maintained in the porous material that is sandwiched between the lining layers, thus verifying the integrity of both lining layers.
- Building a fiberglass tank inside an existing tank by inserting prefabricated panels into the tank and fastening them together with fiberglass cloth and resin.

### A Historical Look at Tank Lining

With the December 22, 1998, deadline upon us, 1998 is bound to be a boom year for the tank-lining industry. While never a prominent or highly visible segment of the petroleum industry, tank lining has been with us for almost 50 years, dating back to the early 1950s. At the time of UST rule promulgation, the federal register noted that 300,000 heating oil tanks and over 70,000 motor fuel tanks had been lined in the previous 25 years (*Federal Register*, Vol. 53, No. 185, p. 37132).

For most of its life, especially in the motor fuel storage industry, tank lining has been largely a repair business. Although sometimes applied as preventive maintenance, lining was usually a stopgap procedure used to extend the life of tanks that had already leaked. Tank repair is explicitly permitted in the federal rules, so this aspect of tank lining is destined to continue. Lining has also been a long-standing technique for extending the life of the bottoms of large aboveground tanks.

### Is Tank Lining Really Corrosion Protection?

Although we use coatings (i.e., paint) to forestall corrosion of our automo-

*biles, we also recognize that the* paint on one side of a piece of metal has little effect in preventing corrosion on the other side of the metal. While internal corrosion is a factor to consider with steel USTs, historically, bare steel USTs have failed primarily because of corrosion working from the outside of the tank inward. So, how is a coating on the inside of the tank going to help solve the corrosion problem?

We're pinning our hopes on the fact that the lining is not just mere paint but a "thick film," with a nominal thickness of 1/8 inch. As the theory goes, should the tank perforate from the outside, the lining will have sufficient strength to bridge the gap. The preamble to the federal rule acknowledges that tank lining "...as the sole method for corrosion protection is not regarded as a permanent upgrade, but is adequate if it continues to meet original lining design specifications as determined by periodic inspections." (*Federal Register* Vol. 53, No. 185, p. 37131) In other words, the periodic inspection requirement at 10 years after lining and every 5 years thereafter is an integral part of the tank-lining upgrade endorsed by the federal rule. There is an implicit assumption where, at some point in time, lined tanks will fail to meet industry standards and will need to be replaced.

## The Challenges of Tank Lining

Anyone who has ever tried to keep a piece of metal painted, be it on a boat, car, or child's swing set, knows that this procedure must be repeated with frustrating regularity. Automotive manufacturers have gotten pretty good at keeping paint on cars, but they use sophisticated techniques to do so. The problem of keeping a coating on steel is twofold: adhesion of the coating material to the steel and thermal expansion and contraction.

Making certain that a coating adheres to steel properly requires an extremely clean surface, completely free of scale, oil, or any corrosion products, and a certain amount of surface roughness to give the coating something to grab on to. This is why prior to the application of the lining, the inside of the tank must be sandblasted to "white metal" (a specific level of sandblasting defined by the Steel Structures Painting Council), and the lining must be applied within 8 hours after the blasting procedure (to minimize the opportunity for corrosion of the metal to take place).

Tank liner applying coating to the inside of a tank.

PHOTO COURTESY OF ARMOUR SHIELD, INC.

Most bulk storage fuel facilities use aboveground storage tanks; seasonal variations in the temperature of fuel stored in aboveground tanks are much greater than those of fuel stored in underground tanks. In many parts of the country, maximum summer/winter temperature differentials of 20 to 30°F are to be expected between the product in the ground and the product delivered from aboveground tanks. Imagine sitting cozily in a hot tub half full of 110° water and then having a truck fill the tub the rest of the way with 80° water, and you can begin to appreciate the meaning of thermal shock. Such rapid changes in the temperature of the tank contents cause the tank wall to shrink or expand. The coefficient of expansion and contraction of the lining material must be nearly identical to that of the metal or else the differential movement will tend to cause the coating to become unglued.

## What Do Fire Officials Think About Tank Lining?

Historically, fire officials have been of two minds with regard to tank lining. The two dominant flammable liquid storage codes in this country are the National Fire Protection Association's (NFPA) Code 30, "Flammable and Combustible Liquids Code," and Code 30a, "Automotive and Marine Service Station Code," and the International Fire Code Institute's (IFCI) Uniform Fire Code Article 79, "Flammable and Combustible Liquids." The NFPA has generally been silent on the subject of tank lining, presumably leaving the matter to the judgment of local officials. The IFCI, which is a consensus organization, has debated the issue and, to date, has been reluctant to accept tank lining as a repair procedure.

The development of the IFCI position, however, appears to have been a less than scientific process. A report prepared on behalf of USEPA ("A Survey of Fire Service Position Regarding Repairs to Underground Storage Tank Systems," prepared by Fred C. Hart Associates, Inc., dated June 5, 1987) and intended to gather information for formulating the federal rule indicates quite strongly that the controversy surrounding the Uniform Fire Code position on tank lining came about because parties with financial interests (i.e., tank manufacturers) tried to deal a blow to their competition (i.e., tank liners). The report points out that none of the fire departments contacted had any "engineering data to support their position," (p. 11) either for or against tank lining, and that individual opinions appeared to be based on "supposition and personal preference" (p. 10).

Be that as it may, since the 1991 edition of the Uniform Fire Code appeared, repair of leaking tanks by any method has not been allowed. Tank lining is viewed strictly as a method of "protecting the (tank) interior from corrosion or providing compatibility with a material to be stored." Since at least 1988 (the earliest edition of the code that I have handy), the code has required that tank lining be used in conjunction with either cathodic protection or corrosion-resistant materials of construction. Thus in those portions of

■ *continued on page 26*

■ **Tank Lining** *from page 25*

the country where the Uniform Fire Code is enforced (primarily the western United States), the federally allowed option of upgrading by tank lining only is not permitted.

## UL and Tank Lining

Underwriter's Laboratories (UL) has a methodology (Subject 1856) for evaluating both tank-lining materials and the tank-lining process. A UL "Subject" has not undergone the extensive external review and examination required for an official UL "Standard." The evaluation of lining material described in UL 1856 includes:

- Immersing samples of the lining material in an assortment of test liquids and looking for changes in the physical properties of the material;
- Testing for absorption or dissolution of the lining in the test liquids;
- Dropping a 1.18-pound steel ball from a height of 6 feet to test the bonding of the lining to a steel plate; and
- Testing for corrosion beneath the lining.

Testing the lining process, as described in UL 1856, involves burying a "worst case" tank (i.e., a tank with the maximum number of holes allowed by the lining standard), plugging and patching the holes, applying the lining, and then conducting an air-pressure test on the tank. The tank excavation is then filled with water to grade for 24 hours, and a vacuum is applied for 1 minute while the tank is submerged.

The lining process tests, contained in UL Subject 1856 (November 1992), parallel the testing required by UL Standard 1746 at the time that UL Subject 1856 was developed. UL 1746 is the standard that applies to new steel tanks that achieve corrosion protection through the application of a thick coating (cladding) on the outside of the tank.

Both of the lining standards commonly used in this country, American Petroleum Institute (API) 1631, "Interior Lining of Underground Storage Tanks," and National Leak Prevention Association (NLPA) 631, "Entry, Cleaning, Interior Inspection, Repair, and Lining of Underground Storage Tanks," contain lining material evaluations that are similar to the one in UL 1856. UL 1856 is the only evaluation that looks at the completed lining process on an actual tank.

To be in conformance with an industry standard and thus the federal rule, tank liners must document that their lining material has passed the tests specified in either API 1631, NLPA 631, or UL 1856. Industry standards do not specify that the lining process must be evaluated, although some lining companies have achieved a UL 1856 listing.

■ *continued on page 28*

## A Tank Lining Inspection Checklist*

- ✔ Ask to see a copy of the lining applicator's insurance policy.
- ✔ Ask for references and call a few. Ask whether the work was done on schedule, whether the workers were clean and neat, and whether the site was left in a clean condition.
- ✔ Ask to see documentation that the tank lining crew members have received the appropriate OSHA training (at a minimum, 40-hour health and safety plus annual 8-hour refresher courses) and have experience in this line of work.
- ✔ Ask for documentation that the lining material has been tested and is compatible with the liquid you plan to store (including oxygenated fuel).
- ✔ Ask who will be responsible for disposing of the tank bottom sludge (which could well be a hazardous waste). If you, the tank owner, are responsible, be sure disposal is handled properly.
- ✔ Ask to review the results of the structural assessment of the tank Before the workers proceed to apply the lining. The structural assessment usually involves checking the metal thickness (typically by pounding on the tank walls with a hammer or measuring with an ultrasonic gauge), usually after a preliminary sandblasting to get a good view of the metal.
- ✔ Verify the amount and type of sand used for sandblasting. A 10,000-gallon tank typically requires at least a ton (twenty 100-pound bags) of 18 grit abrasive. Ask what is going to happen to the sand after the blasting is complete. If your tank held leaded gasoline at some point, the sand/metal mixture may be a hazardous waste. If the sand is to be disposed of at your facility (i.e., as part of the backfill for the excavation required to reach the top of the tank), have the tank-lining company certify that the material is not a hazardous waste, or add the cost of disposing of the material properly to your cost of doing this work.
- ✔ Verify that the pressure used to sandblast is at least 90 psi.
- ✔ Verify by looking through the hole in the tank top that at least the portion of the tank you can see has been blasted to "white metal" before the lining is applied. A "white metal" surface should have a "gray-white uniform metallic color" and should be free of "all oil, grease, dirt, visible rust, scale, corrosion products, oxides, paint or other foreign matter."
- ✔ Verify that there is adequate lining material on hand to do the lining. A 10,000-gallon tank typically requires about 60 gallons of lining material.
- ✔ Verify that the lining will be applied within 8 hours of sandblasting the tank and before any visible rusting occurs.
- ✔ After the lining has cured, verify that the tank has been reentered and that the lining has been tested for thickness, hardness, and defects.
- ✔ Be sure to obtain the tank-lining warranty paperwork.

* Adapted from a list prepared by Teri Bahrych, USEPA - Region 8.

Field Notes

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

# Let's Be Careful Out There

Underground storage tank contractors tell us they expect that 1998 will be the busiest year yet for companies involved in underground storage tank work. Contractors expect that their crews will be called upon to work long days this year as tank owners prepare their sites to comply with EPA's 1998 deadline. Pressure to get the job done quickly and efficiently will grow with each passing day. As a result, new and relatively inexperienced workers will be hired by some companies to handle the demand.

With so much work to do, it's easy to put safety on the back burner. But that should never happen. Three recent tank-related accidents in California in which one man was killed and several others were injured serve as poignant reminders that UST work is a dangerous profession that requires constant attention to the safe and proper way to do the job. Over the years, PEI has collected numerous accounts of accidents that have occurred throughout the country. I'll share some examples of these accounts with you in hopes that they will serve as a reminder that safety should be foremost in everyone's mind. Remember, these stories are true. It is the contractor's responsibility to make certain that safety is a number one priority on all job sites.

## Testing Tanks and Lines

■ A tank was air tested aboveground prior to installation. The mechanic used a vacuum gauge instead of a pressure gauge. As a result, tremendous pressure developed, blowing out one end of the tank with sufficient force to damage a truck and a nearby building.

■ A foreman was pressure-testing a tank when a plug blew out of a tank opening and struck him in and around his left eye.

## Lining Tanks

■ While in the process of relining an UST, a 4-inch rubber Expando plug was placed in the product line from inside the tank. During the sandblasting procedure, an employee in the tank hit the Expando plug, which was located directly above him. The Expando plug eventually worked itself loose and fell out, causing the employee to be soaked with fuel.

■ Two workers were preparing to line an underground tank. They had driven 150 miles in a shop truck to the tank site. Before cutting an entry hole in the top of the tank, they evacuated the vapors in the tank. Then one of the workers held an explosimeter over the top of the fillpipe to determine if there were ignitable vapors present. They did not, however, first test the accuracy of the explosimeter by holding it over the opening of the gas tank of the shop truck. The explosimeter indicated that the vapors in the underground tank were minimal and that it was safe to proceed. But when one of the workers started the power saw and began to cut the entry hole, there was a spark and an explosion. One worker was killed and the other was seriously injured. Investigators determined that the explosimeter had been damaged from bouncing around in the back of the shop truck during the 150-mile trip to the tank site.

## Removing Tanks

■ Several very old tanks were being removed from the ground. Each contained 20 to 30 gallons of product. One of the tanks ruptured as it was being removed from the hole, spilling product onto the asphalt surrounding the excavation. The backhoe operator attempted to soak up the product by covering it with the soil he had removed from the excavation. Some time later, as the backhoe operator began to collect the contaminated soil with the backhoe, the loader bucket apparently scraped the asphalt. Sparks caused by the friction ignited the gasoline fumes emanating from the soil. As fire engulfed the backhoe, the operator jumped through flames to safety.

■ A crew had been subcontracted to remove USTs from a gasoline-marketing facility. Because of the size of the buried tanks, a crane with a large boom had to be used. One of the tanks was buried near a high-voltage (36,000 V) wire. As the operator swung the boom around to position it over the tank, the boom continued to move forward for a short distance after the operator had actually stopped it with his controls. The boom touched the wire for a second and then bounced back to its position over the tank. The operator, who was wearing leather gloves and holding rubber control handles, was knocked out of the control cab by the electric shock. The general contractor who was standing on the ground and leaning against the stabilizer on the crane was electrocuted.

## Decommissioning Tanks

■ The top of an empty UST, which had been inerted with dry ice, was uncovered while the tank was still in the ground. In order to render the tank nonhazardous for transportation purposes, the tank was triple-rinsed according to state environmental agency requirements. The tank openings were sealed, as required by city fire regulations. The tank was removed from the ground, placed on a flatbed trailer, and transported to a tank disposal yard. The disposal yard would not accept the tank with the ends on it, so the crew transported the tank to the plumbing contractor's storage yard. The tank sat in the yard for several days. Fire officials speculate the plumbing firm considered the tank safe after it had been triple-rinsed. During that time, however, the seals were removed from the tank, allowing the gasoline vapors and air to mix again. A welder was

■ *continued on page 28*

■ Field Notes continued from page 27

sent to cut the ends off of the tank with his acetylene torch so that the tank could be returned to the disposal yard. The tank was still chained to the flatbed trailer when the top blew off the tank. The explosion flung the welder off the truck, over an 8-foot chain-link fence, and into the street. The blast killed him instantly.

■ A workman was cleaning out an UST. After the tank was scrubbed, and before it was abandoned in place by being filled with sand, the workman used a ladder to climb down into the vessel. He carried an electric lamp and an electric saw—both connected to an extension cord—into the tank. (Investigating fire officials were baffled as to what the man hoped to accomplish by doing this.) Fumes lingering in the tank ignited and surrounded the workman in flames. He suffered second- and third-degree burns over 86 percent of his body.

### Installing Underground Storage Systems

■ A veteran mechanic was replacing an old steel line with new fiberglass piping. The line was drained the first day he was on site. The next morning when he returned to complete the job, he did not test the line. The worker assumed the line would be free of vapors, because it had been left open all night. He elected to cut it with an electric band saw. A small flash fire occurred when the accumulated vapors were ignited by a spark from the saw.

■ An installation crew was cleaning up a job site. A manhole had just been cleaned out and the cover had not been replaced. The crew chief was walking backward, blowing debris off the concrete with an air compressor hose. He backed into the open manhole and broke his rib.

■ A blister formed on the palm of a laborer's hand while he was digging in a tank hole at a service station. Later, while he was installing new fiberglass piping, the blister broke, and his hand became infected when fiberglass glue entered the open cut. Although the employee was issued cloth gloves, he was not wearing them on this occasion, because he was fearful that he would drop the fiberglass pipe and cause it to crack or fracture. The laborer spent 7 days in the hospital recovering from blood poisoning. ■

*In the next issue of* LUSTLine, *a health and safety specialist will delve further into issues of UST/LUST-related safety.*

■ **TANK-nically Speaking** *from page 26*

### Consumer Tips

As with most other underground storage system work, quality control is a big issue. The three most important things you should demand if you are having a tank lined are; 1) skilled, conscientious workers; 2) skilled, conscientious workers; and 3) skilled, conscientious workers. Good workmanship is critical because verifying that work is being done according to industry standards requires diligent oversight and is difficult for the average tank owner or regulator to do. Entering underground tanks to check on the work is risky business that requires OSHA confined space entry training. There are a few things that can be checked (see the checklist on page 26), but, by and large, a tank owner's best bet is to hire a reputable contractor who has been in business for quite a while, and who is planning to be around at least until the warranty on the lining runs out. Contractor's liability insurance is also something that I would require if I were hiring a tank-lining company.

Like many other aspects of tank work, tank lining can be hazardous. Although the overall safety record of the tank-lining industry is very good, accidents can happen. One man died and three others were injured in two recent tank-lining–related accidents in California. Be sure that the contractor doing the work can demonstrate that the workers in the tank have the required OSHA training.

### Would I Choose This Upgrade Option?

Over the last few years I have had occasion to talk to hundreds of tank owners (most of whom own or operate only a few tanks) about the 1998 upgrading requirements. After describing the options of lining, cathodic protection, and replacement, I am often asked the question, "What would you do if you owned a tank?"

Let me preface my answer by saying that I would feel better if I had some hard data to support my upgrading decision. It would be nice if there were a study that had been conducted by an independent third party that had randomly selected several hundred lined tanks and several hundred tanks that had been retrofitted with cathodic protection a decade earlier. It would be nice if that third party had thoroughly evaluated these tanks to see how they were faring. It would be nice. But, to my knowledge, such a study does not exist. Instead, what we have are a few surveys indicating that as far as anybody knows, things are okay.

Thus, my answer usually goes something like this: We don't have any independent engineering studies that provide hard data on the actual performance of cathodic protection or tank lining, so we don't really know exactly how well these technologies work in the long run. I've heard good and bad stories about both cathodic protection and lining. But there are people who do know. The major oil companies have been using lining since the 1950s; they used cathodic protection in the 1960s and 1970s; in the 1980s most of them went to large-scale replacement of their tank populations.

The major oil companies, of course, have the money to replace their storage systems, and they probably plan to be in business for the long haul. If you are not a major oil company, however, and you are only planning to use your storage tank(s) for a few more years, then I think upgrading with either lining or cathodic protection makes sense. If you are planning to store petroleum underground for a while and want to have an asset rather than a potential liability when you're done, then replacement is the way to go. ■

*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) 624-7883.*

## Tanks Subcommittee

■ The Tanks Subcommittee, along with all of the Task Force members, completed work on the "UST Report Card on the Federal UST/LUST Program" (a review of the program, its goals, achievements, and shortcomings), which is now in print. Copies may be obtained by contacting Steve Crimaudo.

■ At the ASTSWMO annual meeting, held in Arlington, Virginia, on October 27–28, 1997, Subcommittee members met with representatives of EPA OUST to discuss current issues, including the 1998 upgrade deadline, results of the May 1997 enforcement sweep, OUST's planning for 1999 and beyond, preparation of the 1998 OUST National Conference, MTBE issues, and the budget. The chairpersons for the four different Subcommittee Task Forces met at this conference to lay out a strategy and agenda for 1998.

■ Each of the four Task Forces is currently looking for new members. If you are interested in taking part in the work of any of the Task Forces, or if you have questions or comments on overall Subcommittee activities, contact Steve Crimaudo or Scott Winters.

## UST Task Force

■ The UST Task Force has been working, primarily, on issues relating to the 1998 UST technical standards for the upgrading of USTs.

■ The Task Force has begun preparing for a presentation on managing hazardous waste/hazardous substance USTs, which will be given at EPA's National UST/LUST Conference in March. This presentation will highlight the similarities and differences between managing chemical-storage USTs and petroleum-storage USTs. The LUST Task Force will also be participating in this session, presenting issues on site assessment at closure, reporting, site investigation, and cleanup associated with these types of tanks.

*For more information on UST Task Force activities, contact the Task Force Co-chairs, Paul Sausville (NY) at (518) 457-4351 or Dale Marx (UT) at (801) 536-4131.*

## LUST Task Force

■ The LUST Task Force continues to review several innovative technologies.

■ Members of the Task Force are ongoing participants of the EPA/OUST MTBE workgroup. This workgroup will hold a "states only" meeting on MTBE issues at the National UST/LUST Conference in March.

■ Members of the Task Force are participating in ASTM E50.01 Subcommittee work on two new standards: "Evaluating Remedial Decisions" and "Integrated Site Management."

■ The Task Force drafted a letter to EPA on the new EPA Monitoring by Natural Attenuation Policy.

■ Planned projects include producing a document on possible environmental indicators states may use for LUST programs, reviewing and commenting on the Texas and Florida risk and RBCA reports, and preparing to speak on site assessments, notification, and remediation of hazardous substance/hazardous waste USTs at the National UST/LUST Conference.

*For more information on LUST Task Force activities, contact the Co-chairs, Kevin Kratina (NJ) at (609) 633-1415 or Richard Spiese (VT) at (802) 241-3880.*

## State Cleanup Funds Task Force

After completing a very successful Sixth Annual State Fund Administrators Conference in June in Sacramento, California, the State Cleanup Funds Task Force is busy planning for the Seventh Annual State Fund Administrators Conference, which will be held in Austin, Texas, on June 22–24, 1998. The Task Force met in Washington, D.C., on January 8 and 9, 1998, to prepare the draft agenda for this conference. With the enthusiastic participation of the planning committee, this year's conference is shaping up to be the best one ever. If you have ideas for additional sessions for this conference, please contact a member of the Task Force. Also, look for this year's State Funds Questionnaire, which will be sent to State Fund Managers in May.

*For more information on the State Cleanup Funds Task Force activities or on the Sixth Annual Conference, contact the Co-chairs, Dan Neal (TX) at (512) 239-2258 or George Matthis (NC) at (919) 733-9413.*

## TIE Task Force

■ The Training and Information Exchange (TIE) Committee performed the lion's share of the work in completing the "Report Card" project.

■ The Task Force is coordinating and moderating the session on Hazardous Substance Tanks at the National UST/LUST.

■ The Task Force is working hard to ensure the successful planning and implementation of the ASTSWMO Mid-Year meeting, which will be held in Kansas City, Missouri on April 20–22.

■ The TIE Task Force continues to work on and update ASTSWMO's Internet home page.

*If you have questions or comments on TIE Task Force activities, call Task Force Chair Kathy Stiller (DE) at (302) 323-4588.*

# States/ASTSWMO Form MTBE Workgroup

*by Jeff Kuhn*

The ASTSWMO LUST Task Force began organizing an MTBE Workgroup in early 1997 in response to a increasing need for information and discussion on MTBE issues. The idea of a workgroup grew out of the participation of state representatives in the EPA-sponsored MTBE Task Force, which was organized to study the magnitude of the MTBE problem and discuss the experiences and concerns of regulatory agencies and industry. Since that time, members of the LUST Task Force have continued to gather information for dissemination to the states. The goal of the workgroup is to function as a clearinghouse for new information on MTBE and to get the word out by way of a quarterly newsletter. The newsletter will include information on state and federal government activities and policies regarding MTBE, new publications and research papers, the results of various surveys that are currently under way, and postings of internet web sites where additional information can be found.

A tremendous amount of research activity is currently under way through the efforts of EPA, API, industry, states, city municipalities, and private organizations with an interest in contaminant fate and transport and public health. Although a great deal of information on MTBE has become available in the last two years, little is known about the long-term effects on humans from exposure to low concentrations of MTBE and other fuel oxygenates. The presence of MTBE in the environment has become a national public health and research concern and requires greater focus and coordination on the part of all parties involved. We hope that our efforts will lead to a greater level of communication among interested parties and that we will be able to assist states in finding much needed resource information on MTBE-related topics and case-incident studies.

The workgroup welcomes the input of all individuals and organizations involved in the MTBE issue and is soliciting help from other state representatives who are interested in participating in work efforts. To contribute information to the ASTSWMO MTBE newsletter, to participate in the workgroup, or to receive the newsletter, contact Jeff Kuhn, Montana DEQ Petroleum Release Section (406) 444-5976 (jkuhn@mt.gov), or Pat Ellis, Delaware DNREC-UST Branch (302) 323-4588 (pellis@DNREC.STATE.DEC.US).

Topics covered in the upcoming issue of the newsletter include:

- EPA MTBE Fact Sheets
- MTBE Surveys in Progress
- EPA's Drinking Water Health Advisory
- Fuel Oxygenates and Testing Requirements
- Compatibility Issues
- MTBE News from the States
- Treatment Technology Research
- Legislative Activity on MTBE

*Jeff Kuhn is with the Montana DEQ Petroleum Release Section and is a member of the LUST Task Force.*

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# EPA HQ UPDATE

### '98 Deadline Press Conference

On December 22, 1997, EPA officials Timothy Fields, Acting Assistant Administrator of the Office of Solid Waste and Emergency Response, and OUST Director Anna Virbick joined Jane Nishida, Secretary of the Maryland Department of Environment, and representatives from five petroleum industry associations (American Petroleum Institute, Petroleum Marketers Association of America, Society of Independent Gasoline Marketers of America, Service Station Dealers of America, and National Association of Convenience Stores) in a joint press conference to remind UST owners and operators that the deadline for upgrading, replacing, or closing substandard tanks was exactly one year away. Speakers stressed their support for the deadline and urged owners and operators who have yet to comply to begin work now in order to meet the deadline. CNN and C-Span cable broadcast the program, and a number of print media—particularly trade press—provided coverage.

### Letter to Oil Company Executives

In November 1997, OUST sent a letter to executives of about 400 small and large petroleum marketing firms across the country reminding them that the 1998 compliance deadline is only one year away. OUST included a list of publications and other materials available in quantity to help companies understand the UST regulations and the 1998 requirements.

### MTBE Fact Sheets

OUST has just published the first three in a series of fact sheets of on methyl tertiary butyl ether (MTBE). MTBE Fact Sheets #1: *Overview* (EPA-510-F-98-001), #2: *Remediation Of MTBE-Contaminated Soil And Groundwater* (EPA-510-F-98-002) and #3: *Use And Distribution Of MTBE And Ethanol* (EPA-510-F-98-003) are available from NCEPI at (800) 490-9198 or can be downloaded from OUST's web page at http://www.epa.gov/OUST/mtbe.

### Correction

The publication number for *Controlling UST Cleanup Costs: Fact Sheets,* which appeared in the November 1997 *LUSTLine* has been changed. The new number for this series of 1992 fact sheets, which has been reissued with an update page, is EPA-510-F-98-008. Note: These fact sheets are not available on the OUST home page.

### OSWER Directive on Monitored Natural Attenuation Released

OUST announced the release of a new OSWER directive entitled *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites.* (See "Natural Attenuation..." article on page 5.) OUST distributed hard copies of the directive to regional and state UST program offices; other OSWER offices also distributed copies. The directive is available in several electronic formats from EPA's web site; the address is http://www.epa.gov/swerust1/directiv/d9200417.htm. Questions about this new guidance can be directed to Hal White or Dana Tulis.


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## EPA Issues MTBE Drinking Water Advisory

In December, the U.S. EPA Office of Water released an advisory on MTBE entitled *Drinking Water Advisory: Consumer Acceptability Advice and Health Effects Analysis on Methyl tertiary-Butyl Ether (MTBE)*, EPA 822-F-97-008. The recommendations of this advisory are based primarily on taste and odor thresholds. The advisory states that drinking water containing MTBE "...concentrations in the range of 20 to 40 $\mu$g/L [ppb] would likely avoid unpleasant taste and odor effects..." for a large majority of the people. EPA believes that MTBE concentrations within this range are safe from a health standpoint, because they are 4 to 5 orders of magnitude lower than the lowest concentration observed to cause any adverse health effects in laboratory animals.

The primary purpose of a health advisory is to provide information to public drinking water suppliers that will allow them to make more informed decisions about acceptable levels of a specific contaminant. Health advisories are not regulatory documents and, as such, do not impose maximum contaminant level requirements for drinking water. This type of advisory can, however, be useful to state UST programs managers in determining appropriate action levels and cleanup levels for remediating MTBE contamination, particularly where drinking water is affected.

The use of this advisory in determining the acceptability of local drinking water quality is complicated by the fact that taste and odor thresholds for individuals, and even entire communities, can vary widely depending on a number of factors, including individual sensitivities to MTBE and water quality (e.g., the types and quantities of different constituents in the water supply). In some cases, consumer complaints about taste and odor may dictate that MTBE levels be less than 20 ppb. In other cases, MTBE concentrations may be in excess of 40 ppb without any complaints being registered.

In order to better define the level of risk posed by various MTBE concentrations in drinking water, EPA plans to conduct additional research on the health effects. Once this research is completed, a final health advisory will be issued. This advisory, however, is not expected to be completed for at least 3 years.

The MTBE advisory can be accessed through OUST's web page at http://www.epa.gov/OUST/mtbe. ■

## The Countdown Has Begun!

**1998 DEADLINE**

### The '98 Deadline For Upgrading UST Systems Is Nigh.

**States are busy sending out notices and reminders to tank owners and operators. Connecticut and New Hampshire are reminding owners and operators with special '98 deadline pens and refrigerator magnets. A few Connecticut tank contractors have placed very visible reminders on billboards and buses.**

***What's happening in your state?***

**Oops...**

In the last issue of *LUST-Line*, we left off a zero in one of the "Qs and As." On page nine in the last sentence of the last paragraph, the sentence should read as follows: "The study also noted that these statistics were valid for retail-type facilities with storage capacities in the range of 500 to 50,000 gallons with throughputs of 1,000 to **100,000** gallons per month."

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