APPENDIX 8
Survey of Current UST Management and Operation Practices

Survey of Current UST Management and Operation Practices

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Limitations

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List of Acronyms

ACWA:	Association of California Water Agencies
ANSI:	American National Standards Institute
API:	American Petroleum Institute
ASTM:	American Society for Testing and Materials
ATG:	automatic tank gauge
BTEX:	benzene, tuolene, ethylbenzene, and xylenes (o-, *m-,* p-xylene)
CARB:	California Air Resources Board
CPPI:	Canadian Petroleum Products Institute
DOT:	Department of Transportation
FM:	Factory Mutual
GSA:	General Service Administration
IFCI:	International Fire Code Institute
LG:	Local Guidance
LIA:	Local Implementing Agencies
MTBE:	Methyl Tertiary Butyl Ether
NACE:	National Association of Corrosion Engineers
NFPA:	National Fire Prevention Association
NLPA:	National Leak Prevention Association
NWRI:	National Water Research Institute
O&M:	Operation and Maintenance
OFA:	Oxygenated Fuels Association
PEI:	Petroleum Equipment Institute
QA/QC:	Quality Assurance/Quality Control
RWQCB:	Regional Water Quality Control Board
STI:	Steel Tank Institute
SWRCB:	State Water Resource Control Board
UL:	Underwriters Laboratories
ULC:	Underwriters Laboratories of Canada
USEPA:	United States Environmental Protection Agency
USGS:	United States Geological Survey
UST:	underground storage tank
WSPA:	Western States Petroleum Association
Y2K:	Year 2000

4.0 Suggestions for Improved UST Management and Operation Practices

This section presents a summary of suggestions for improved UST management and operation practices. These suggestions were extracted from the recent UST literature, including documents prepared by the California Stormwater Quality Task Force (1997), State Water Resource Control Board (1998, 1999a, 1999b, 1999c, & 1999d), and Western States Petroleum Association (1999). Technical data contained in numerous back-issues of L.U.S.T.LINE (see Appendix A), the examples in Appendix B, and other UST documents provided the basis for refining some suggestions. In addition, several previously undocumented suggestions for improved UST practices were identified during a l-day workshop of UST experts (see Appendix C).

Many of the suggestions listed below were found in more than one document. In order to compile a succinct list for the reader, Alpine has combined the similar suggestions into singular statements. Additionally, because the sources of several suggestions wished to remain anonymous, specific suggestions are not referenced back to individual documents or people.

These suggestions are meant to focus attention on potential improvements in UST management practices and to isolate the primary topics for possible research that might lead to further identifying, reducing, and eliminating gasoline and MTBE releases from USTs (see Section 5.0). These suggestions are not meant to be inclusive of all UST management practices that will reduce releases to the environment. Instead, it ' is a list of many of the technical improvements suggested by UST experts in recent publications. It should be noted that some UST owners and operators have already incorporated many of these recommendations into their normal operations. In addition, some of the recommendations listed below have been addressed recently in federal or California documents.

Based on a review of the current UST practices literature and the UST workshop, the suggestions for improved UST management and operation practices can be organized into the following general categories:

- Equipment Design
- Service Station Site Design
- UST System Installation
- Leak Detection Systems
- Customer Education
- UST System Inspection and Maintenance
- Owner/Operator Certification and Training
- Tanker Driver Certification and Training
- Regulatory Enforcement

Each of these general categories is discussed in subsections 4.1 through 4.9; fifty-four different suggestions are described in these subsections. To aid the reader, these 54 suggestions for improved UST practices are also compiled in Table 5.

Improvements to UST designs and management practices are iterative. They have been significantly advanced with time as the required upgrades have been implemented and as UST systems knowledge has increased. Therefore, it is expected that this list of suggestions for improved UST practices will likely change as UST knowledge and technology develop further.

4.1 Equipment Design

Based on a compilation of the current literature on UST management and operation practices, it has been suggested that, with regards to Equipment Design, some possible improvements could include:

- Striker plates for all tanks to reduce potential for tank damage due to repeated hitting with gauging stick.
- Under dispenser containment sumps (or pans) to capture drips and small spills, in combination with sump monitoring devices to provide early warning of dispenser area leaks.
- Spill containment boxes at UST Stage I vapor recovery risers to minimize potential for release of overflow from the fill riser containment box.
- Dispenser hoses equipped with dry-breakaway connections to minimize product losses due to customer drive-offs.
- Fuel dispensing nozzles with "hold-open latches" (automatic shutoffs) except where prohibited by local fiie departments.
- UST systems designed to minimize vapor losses to the subsurface including from the vapor return lines, the UST headspace, the vapor recovery systems, the tank vent lines, and the fillports. This may include modifications to materials (compatibility and/or permeability problems), condensate pots/sumps, and fittings/connectors (design changes)
- Post-installation tightness testing of overfill containment sumps. A protocol for this type of testing is needed.
- Design and implementation of overfill protection systems that cannot be easily disabled or do not malfunction due to inappropriate tank fill-up procedures. One suggestion is to install overfill protection devices on tanker trucks instead of USTs. This may reduce overfills due to tanker driver errors (overfill protection systems on USTs vary widely and are often not well marked as to which method/equipment type is used).
- Phase-out of float-ball valves as primary overfill-protection devices. Experience has shown that these devices are significantly less effective than other methods/equipment.

- Integrity testing of secondary containment systems (including the development of associated protocol). In particular, there is no regulatory requirement for integrity testing of secondary containment system "except at the time of initial installation" (SWRCB, 1999a).
- Compatibility and permeability testing (particularly vapor-phase testing) of select UST system components for use with MTBE-enriched gasoline.

Not all of these potential improvements are of equal value or equal importance for minimizing fuel losses. More work is needed before these potential improvements are proven to be valuable. As concluded in the SWRCB Advisory Panel report (SWRCB, 1999a), "...additional research is needed to quantify the leak history for the post-1998 UST population before it can be determined what, if any, changes to the current design, construction, and monitoring standards are needed to assure the prevention and detection of oxygenates releases at UST facilities."

4.2 Service Station Site Design

Based on a compilation of the current literature on UST management and operation practices, it has been suggested that, with regards to Service Station Site Design, some possible improvements could include:

- Service station designs that minimize the potential for gasoline/MTBE to contaminate stormwater runoff. Surface water drainage patterns could be designed to minimize the flow of stormwater over refueling areas, product and vapor recovery spill containment boxes, and air/water supply areas. This can be done by grading and paving to prevent run-on of stormwater and/or by installation of a roof over the area in question.
- Design all catchments on-site to dram to oil-water separators.
- Highly visible signs posted at all fuel dispensers warning customers against "topping- off" vehicle fuel tanks.
- All signage at service stations (including the emergency shutoff switch sign and the labels for fill pipes, vent systems, aboveground system piping, and water drains) to be legible and clearly visible.
- Complete documentation kept on site at all times, including a spill response plan, contact information, site plan, operation and maintenance manuals, UST equipment manuals and specifications, operation and maintenance records, etc.
- Label drains within the facility boundary, by paint/stencil (or equivalent), to indicate whether they flow to an oil/water separator, directly to the sewer, or to a storm drain.

4.3 UST System Installation

A poorly conducted UST system installation can be one of the primary causes of fuel releases to the environment. As shown on Tables 1 and 2, there are numerous components and

activities involved in UST installation that can be problematic. The potential for problems is greatly increased if unqualified or unlicensed workers conduct UST installation or maintenance work. However, the problems identified from the current literature indicate that human error is the primary challenge to overcome during UST system installation (as opposed to equipment problems). Based on a compilation of the current literature on UST management and operation practices, it has been suggested that, with regards to *UST System Installation,* some possible improvements could include:

- Training and certification requirements for all personnel involved in UST system installation activities (e.g., materials/equipment selection, tank placement, sensors placement, corrosion protection installation and testing, leak detection system installation and testing, etc.).
- Qualified third-party oversight for all aspects of UST-system installation.
- Complete QA/QC documentation that includes materials and equipment used, equipment performance certifications, personnel involved in the installation, and installation procedures followed.

4.4 Leak Detection Systems

As shown in Tables 2 and 4, numerous systems associated with USTs require periodic maintenance and testing, including leak detection systems. Leak detection systems can be placed on USTs, product piping, under dispenser containment sumps, etc. Testing these different systems requires varying approaches and methods based on the equipment being tested and the leak detection sensitivity required. There is a wide range of leak detection equipment available and a wide range of testing methods that can be used to evaluate the system tightness. Based on a compilation of the current literature on UST management and operation practices, it has been suggested *that, with* regards to *Leak Detection Systems,* some possible improvements could include:

- More careful selection of the appropriate system for a site. Site-specific design is a critical step in the application of leak detection protocol. Qualified third-party oversight and documentation are critical during this phase of the work.
- SWRCB (1998) states that ". ..the use of frequent monitoring methods over annual type monitoring are the preferred alternative because of their ability to detect leaks within a reasonable time frame." SWRCB (1998) also concludes that primary concerns with leak detection systems include ignoring or overruling failed monitoring results and incorrect reporting of monitoring results. To avoid these problems, it is necessary to ensure that: 1) leak detection testing methods are appropriate for the site conditions; and, 2) testing/ monitoring results are interpreted and reported by qualified personnel.
- As concluded by SWRCB (1998), leak detection systems at many sites are not consistently monitored. Therefore, more emphasis should be placed on the importance of following manufacturer and industry protocols and their recommended schedules for maintenance.

- Appropriate QA/QC documentation and reporting during all phases of installation, maintenance, and testing of leak detection systems. This documentation should be kept on-site with copies forwarded to the appropriate regulatory agencies and to the off-site office of the owner/operator (if applicable). It has been suggested that regulatory agencies should be more involved in enforcement of this aspect of UST management. For example, SWRCB (1998) recommended "an aggressive enforcement of leak detection requirements."
- The adequacy and sensitivity of current leak detection systems and sensors may also need to be evaluated and improved. If current systems are found to be inadequate to detect and prevent small/subtle gasoline losses, then improved systems may need to be researched and developed, particularly if generally recalcitrant additives like MTBE are added to gasoline.

It should be noted that several LG letters are available on the World Wide Web (www.swrcb.ca.gov/%7Ecwphome/ust/avail.htm) that address specific aspects of leak detection systems for USTs. These include:

LG 43	Reporting of Failed Precision Tests
LG 105-10	Licensed Tank Testers and Tank Testing Companies
LG 108	How to Demonstrate that Underground Storage Tank Leak Detection Methods Meet Performance Standards
LG 113-12	List of Leak Detection Equipment and Methods for Underground Storage Tanks
LG 118	Underground Storage Tank Test Result Reporting

4.5 Customer Education

There currently is very little emphasis placed on public outreach with regards to leak prevention at service stations. In 1993, USEPA's Office of Air and Radiation produced a booklet, Your *Car (or Truck) and the Environment,* that addressed emissions during fueling. Some local programs have implemented attempts to educate the general public about their role and responsibility in the proper handling and use of gasoline. This has been done primarily through "don't top-off your tank" stickers or flyers. These often stress air-emission reductions but could be readily changed and expanded to also include other spill prevention benefits such as protection of water resources. Based on a compilation of the current literature on UST management and operation practices, it has been suggested that, with regards to *Customer Education,* some possible improvements could include:

- Training materials showing proper refueling techniques provided to full-service attendants and self-service customers. Possible ways to disseminate this information include: placing educational stickers or signs near/on all dispensers; inserting information in credit card customers' monthly bills; setting up point-of-sale flyers and materials; preparing public service announcements for radio and television; and, providing instructional videos for driver-education classes and traffic schools.

Areas that could be addressed in public outreach efforts include:

- Importance of not "topping-off tank" during fueling (provides air benefits and helps prevent subsurface contamination).
- Avoiding and reporting surface spillage.
- Using portable fuel containers and properly disposing unused gasoline to prevent spills in remote locations.
- Avoiding customer drive-offs.
- Improving signage at service stations.
- Overall importance of public activities with respect to spill prevention.

It should be noted that the SWRCB Advisory Panel report (SWRCB, 1999a) concludes that small spills that occur during dispensing may "cause some occurrences of MTBE in groundwater at petroleum facilities."

4.6 UST System Inspection and Maintenance

Since December 1998, all new and upgraded UST systems are required to have leak detection and protection from spills, overfills, and corrosion. However, due to the wide variety of acceptable equipment, the inspection and maintenance requirements for these systems can not be standardized (as of October 1998, over 250 leak detection systems had undergone third-party evaluations, per USEPA, 1998c). This leads to the potential for human error and, hence, accidental releases of gasoline to the environment. Based on a compilation of the current literature on UST management and operation practices, it has been suggested that, ***with*** regards to ***UST System Inspection and Maintenance,*** some possible improvements could include:

- Training and certification requirements for all personnel involved in UST system maintenance and testing (e.g., corrosion protection systems, leak detection systems, overfill protection systems, product dispensers, vapor recovery systems, etc.).
- Qualified third-party oversight for critical aspects of UST-system maintenance and testing.
- Complete QA/QC documentation and reporting during all phases of maintenance and testing of UST systems. This documentation should be kept on-site with copies forwarded to the appropriate regulatory agencies.
- Interpretation and reporting of maintenance testing results by qualified/certified personnel for critical UST components.
- Periodic inspection of fill riser spill containment boxes that are not secondarily contained for liquid leak tightness. Protocol is needed for inspecting and quantifying leakage from spill containment boxes.

- Development of well-defined protocols for maintenance, inspection, and testing of the various types of UST equipment. It should be noted that many of the equipment manufacturers have operations and maintenance manuals for their specific piece(s) of equipment. However, more care is needed to ensure that appropriate protocols are used.
- Increased awareness of proper handling and disposal techniques for used gasoline filters located inside dispensers and submerged turbine pump enclosures.
- More frequent testing of overfill protection systems on USTs to ensure they are functional and operate within design tolerances.
- Consistent and timely monitoring and maintenance of the corrosion protection systems.
- Dispensing nozzles should be periodically inspected to assure that the automatic shutoff works properly and that components and fittings are free of liquid product leaks. Nozzle shutoffs should be checked by observing "hands-off" fill-ups of vehicles at stations. Defective shutoffs and leaking components should be repaired or replaced.
- Joints and cracks in paving at vehicle refueling areas and around UST fills should be sealed/caulked to reduce potential for gasoline/water infiltration.
- Maintain and keep current a spill response plan, as required by other regulations.
- Complete spill cleanup supplies should be kept onsite and maintained regularly. Spent sorbent materials used to clean up spills should be segregated in closed containers and properly managed.
- Good housekeeping practices should be used to minimize possible contamination of stormwater runoff from stations.
- "Spot clean" leaks and drips routinely. Leaks are not cleaned up until the absorbent is picked up and disposed of properly.
- Cleaning and spill response methods that do not involve water or that collect the water used are recommended. Maintain fuel-dispensing areas using dry cleanup methods such as sweeping for removal of litter and debris, or use of rags and absorbents for leaks and spills. Avoid "washdowns" with water hoses or steam cleaners. Fueling areas should not be washed down unless the wash water is collected and disposed of properly.
- At stations equipped with groundwater monitoring wells, well-water samples should periodically be collected and tested for gasoline components, including MTBE.
- Inspect and clean (if necessary) storm drain inlets and catch basins within the facility boundary before the start of rainy seasons.
- Consider developing site-specific "Best Management Practices" for each UST system (Note: the U.S. Post Office is working toward this goal for its USTs). Keep document on-site at all times.

It should be noted that the SWRCB has produced model forms for UST monitoring procedures and response plans (see local guidance letter LG 133). LG 145 addresses requirements for contractors performing cathodic protection testing. In addition, the "Handbook for

Tank Owners, Manual and Statistical Inventory Reconciliation" is included with LG 52-1. This handbook includes forms for:

- Dispenser meter recording sheet
- Dipstick recording sheet
- Meter calibration check form
- Fuel delivery recording sheet
- Monthly inventory reconciliation worksheet
- Annual inventory reconciliation summary report
- Annual statistical inventory reconciliation summary report

4.7 Owner/Operator Certification and Training

There is no requirement, nor any authority, in federal law for certification of owners, operators, inspectors, or contractors. However, California does have a certification and licensing program for contractors involved with the installation, removal, and upgrade of USTs (see local guidance letters LG 48-5 and LG 119- 1). Currently, training classes are available for the following: UST installation, UST upgrading - interior lining and corrosion protection; UST leak detection standards and systems; UST compliance inspections; and, UST removal - technical and regulatory aspects. In addition, there are numerous other federal, state, local, and private training classes available. However, the literature suggests that the current extent of training may be inadequate. Based on a compilation of the current literature on UST management and operation practices, it has been suggested that, with regards to Owner/Operator Certification and Training, some possible improvements could include:

- Provide specialized training and certification within the following areas:
  - Spill response and reporting
  - Site maintenance and cleanup
  - Inventory control
  - Overfill prevention
  - Operating and understanding leak prevention and alarm systems
  - Requirements for third-party oversight and QA/QC documentation
- Train all employees upon hiring and annually thereafter on proper methods for handling and disposing of waste. Make sure that all employees understand storm- water discharge prohibitions and wastewater discharge requirements. Use a training log or similar method to document training.
- Certify service station attendants (similar to Oregon)

California may have already implemented many of these suggestions. As presented in LG 48-5, a licensing and certification program has been implemented for contractors involved in installation, removal, and upgrading of underground storage tanks. In addition, a program for certification of UST installations is presented in LG 119-1.

It should be noted that the SWRCB report (SWRCB, 1999a) determined that "immediate improvements are warranted in areas such as owner/operator, contractor, and inspector training" and "operator compliance with leak detection and response requirements." That report also stated, ". ..training should emphasize operation of leak detection systems and response procedures to suspected releases."

4.8 Tanker Driver Certification and Training

Tanker driver training programs and materials have been available for years and have surely produced benefits. However, refinements and improvements can be made which could potentially reduce overfills and surface spillage even more. Based on a compilation of the current literature on UST management and operation practices, it has been suggested that, with regard to Tanker Driver Certification and Training, some possible improvements could include:

- More rigorous training programs for all tanker drivers, including sections on: importance of drivers' roles in avoiding and reducing spills; spill response and reporting; tank gauging; purpose and function of overfill protection devices and spill boxes; vapor recovery systems; and, health and safety.
- Consistent certification requirements for all tanker drivers (Note: Department of Transportation [DOT] requirements for this already exist).
- Third-party oversight during product delivery, particularly for newly trained drivers.
- Statistical study of pertinent driver errors that lead to fuel losses.

4.9 Regulatory Enforcement

The SWRCB Advisory Panel report (1999a) states that "immediate improvements are warranted in areas such as.. .regulatory agency inspection and enforcement procedures." The report also states that "there appears to be a lack of adequate enforcement against owners/operators who are not complying with leak detection requirements or who fail to follow-up on suspected releases." Similarly, during a l-day workshop (see Appendix C), UST experts suggested several other improvements to the regulatory enforcement process, including:

- Consolidate regulations to reduce overlap and improve clarity (e.g., clearly define "reportable quantity").
- Expand training for regulatory inspectors and ensure the uniformity of that training.

- Increase administrative and legal support for enforcement activities.
- Provide suffkient funding and human resources for these regulatory improvements, particularly at the local level.

4.10 Summary

In the previous subsections, 53 suggestions for possible improvements to UST management and operation practices were summarized based on a review of the current literature and upon the workshop of UST experts. Some UST owner/operators and regulatory bodies are already implementing many of these practices; they are to be commended for their progress. However, more improvement is possible. A recent summary report by SWRCB (1999a) contained an extensive list of UST practice recommendation; these were summarized from three companion documents (SWRCB, 1999b, 1999c, & 1999d).

This report does not advocate implementation of all of the suggestions listed here. The suggestions are not all of "equal value" in reducing/eliminating gasoline and MTBE losses. In fact, not all of these suggestions are ready for immediate implementation (Table 5). While some of these suggestions can be quickly implemented, others require further development or analysis (e.g., cost-benefit analysis). Several suggestions require additional research before deciding whether or not any change should be implemented. Prioritizing and researching these suggestions for possible improvement to UST management and operations are tasks appropriate for a multi-party team comprised of various stakeholders, including UST experts from government and industry.

5.0 Primary Topics for Further Research

This section presents the primary topics for further research that might lead to better identification, reduction, or elimination of gasoline and MTBE losses from operating UST systems. These research topics were identified in Section 4.0 (see Table 5) and are further discussed here to more fully describe what critical information is still unknown. This section also presents how new information may allow further refinements and improvements to be made to UST management and operation practices.

5.1 Training and Education for UST Personnel

Some training courses are already available for UST personnel, such as tanker drivers, service station attendants, and UST inspectors. However, more training seems to be needed to ensure that spills caused by mechanical failure and human error are prevented, reported, and handled as best possible. The training should educate both frontline UST personnel and customers so that relevant human behaviors and procedures may be further improved.

Before increased training and education are implemented, several topics will require further analysis/research, including:

- Study current field behaviors to identify the most critical training for leak prevention (see Note' below).
- Review the content, methodology, duration, certification, and documentation of existing UST training programs.
- Establish how to best improve and customize the training for the different UST personnel involved (e.g., tanker drivers, service station attendants, UST inspectors).
- Determine the best means to educate customers.
- Conduct cost/benefit analysis of the refined and expanded UST training.

Summary: Study current training sufficiency and if necessary, develop refined and expanded training/education programs for improving the behavior of customers, service station personnel, owner/operators, and tanker drivers.

Note: Levine Fricke Recon (Emeryville, CA) is currently performing a project entitled "Leak Detection and Prevention Field Study" under a contract with NWRI and the California MTBE Research Partnership. The first phase of this project may include a field survey and interviews with UST personnel. A later phase of this project may include on-site observations of UST system operations practices. It is expected that results of this project will be useful in developing appropriate training programs.

5.2 Third-Party Oversight and Inspection

Many of the potential problems listed in Tables 2 and 4 could be avoided if there were more comprehensive third-party oversight and inspection. Improved oversight could be quite beneficial during UST installations and, to a lesser degree, during critical operation, maintenance, and testing activities. The need for oversight and inspection was mentioned several times in the workshop of UST experts (see Appendix C). Similarly, SWRCB (1999a) concluded that regulatory agencies should be more involved in oversight. SWRCB (1998) stated that most of the USTs in the database "had not been monitored at all or were not monitored consistently."

Summary: Perform cost-benefit analysis of having additional personnel on-site for third-party oversight and inspection during UST installations and during critical operation and maintenance activities.

5.3 UST System Design

Section 4 presents several suggestions with respect to UST-system design that will help prevent and detect gasoline/MTBE releases. Most of the suggestions given do not require further research (see Table 5). However, there are some issues that may need more research, including:

- Are current leak detect@ systems designed correctly?
- Are they being operated, maintained, and tested properly? Frequently enough?
- . Are current leak detection systems sufficiently sensitive to find the small/subtle leaks that may cause environmental problems (particularly in light of using MTBE or other generally recalcitrant additives)?
- Are new leak detection systems or procedures needed?
- Are overfill protection devices (especially float-ball valves) operating as designed?

The answers to these research questions will allow equipment manufacturers, UST owners /operators, and UST installers/contractors to design and maintain UST systems better.

Summary: Conduct field and laboratory studies (as necessary) to determine if the leak detection and overfill protection portions of the UST systems can/should be designed, installed, maintained, and operated better.

Note: The Levine Fricke Recon project, "Leak Detection and Prevention Field Study," may include a screening-level investigation of a range of UST system components and the effectiveness of leak detection equipment at approximately 30 sites. It is expected that results of this project will be useful in addressing some of the UST system design issues discussed above.

Note: The USEPA has several on-going workgroups that are studying some of the UST design issues listed above (see Appendix C).

5.4 Vapor Losses, Permeability, and Compatibility

Because of the physicochemical properties of MTBE, concern has arisen that relatively small/subtle gasoline releases may cause significant MTBE contamination of groundwater. There is also concern that gasoline vapors and/or MTBE-enriched vapors may be escaping from UST systems, thereby impacting shallow groundwater (see Section 3.1.4 and 3.6). As a result, vapor losses, permeability, and compatibility of UST system components with vapor-phase gasoline and vapor-phase MTBE are topics that may require additional research. As concluded in the SWRCB Advisory Panel report (SWRCB, 1999a), ". . .there is insufficient information available to determine whether there are UST system material or permeability problems associated with vapor-phase MTBE."

Field and laboratory research could be performed to evaluate these possibilities, including determination of locations and magnitudes of vapor escape. The answers to these research questions will allow equipment manufacturers to redesign, if necessary, UST systems to be more vapor-tight and/or more vapor compatible.

Summary: Conduct field and laboratory (if necessary) studies to determine if current UST systems are having vapor loss, vapor permeability, or vapor compatibility problems with gasoline vapors and/or MTBE vapors.

Note: The Levine Fricke Recon project, "Leak Detection and Prevention Field Study," may include a screening-level investigation of a range of UST system components, including searching for vapor losses from the UST systems. The results may be useful in addressing some of the vapor issues discussed above.

Table 1
Factors to Consider for UST Design and Installation

Activity	Factor to Consider
‘ reinstallation site analysis	soil conditions (stability, corrosion potential, etc.) nearby subsurface structures (utilities, wells, etc.) ground-water level site drainage and topography corrosion protection requirements secondary containment requirements
iite design/layout	federal, state, and local requirements and permits stormwater drainage system shoring evaluation UST system location dispenser and fillport locations tanker truck entry/exit pathways customer entry/exit pathways nearby structures/utilities
Materials/equipment selection	federal, state, and local requirements and permits material selections material specifications handling requirements preinstallation inspection and testing installer qualifications inspection/oversight
Excavation	OSHA/safety considerations excavation dimensions variances based on soil type inspection/oversight requirements
Tank placement	tank bedding material tank bedding material placement/compaction tank placement anchorage/ballasting (for high ground water) secondary containment (tank sump) tank sump sensors fillport connections piping connections (fuel, vapor recovery, vent) drop tube for gauging tank level probe installation procedures installer qualifications inspection/oversight
Overfill protection	automatic shutoff devices flow restrictors/ball float valves overfill alarms testing requirements installer/inspector qualifications inspection/oversight

Table 1 *(continued)*
Factors to Consider for UST Design and Installation

Activity	Factor to Consider
Fillport spill containment	catchment basins/containment sumps drainage systems sump manway installer/inspector qualifications inspection/oversight
Vapor recovery systems	system design/layout Stage I systems Stage II systems fill buckets vent lines testing requirements installer/inspector qualifications inspection/oversight
Product dispensers	dispenser pans dispenser pan sensors under dispenser piping automatic shutoff system for nozzles vapor recovery systems impact valves dispenser protection posts product filter system signage for customers meter calibration testing requirements installer/inspector qualifications inspection/oversight
Pumping systems	suction pumping systems pressurized pumping systems remote pumping systems check valves pump turbine containment sumps sump manway sump sensors testing requirements installer/inspector qualifications inspection/oversight
Other equipment	waste disposal equipment signage and labeling emergency shutoff switch paving/foundations stormwater control structures driveway manholes station spill kit

Table 1 (continued)
Factors to Consider for UST Design and Installation

Activity	Factor to Consider
Tankpit and trench backfilling	initial UST system tightness test initial secondary containment testing (e.g., soap test) soil placement/compaction contractor qualifications underground line considerations underground tank considerations grading and paving aboveground labeling post-backfill inspection of UST system final testing installer/inspector qualifications inspection/oversight
Documentation	As-builts facility plot plan equipment warranties permits O&M Plan final checklist and walkthrough report installer certification of installation

Table 2
Potential Problems During UST Design and Installation

Activity	Potential Problems
Preinstallation site analysis	analysis not performed or not performed correctly nearby underground structures/utilities/wells unknown high ground-water level problematic soil conditions
Site design/layout	problematic site layout poor site drainage tanker truck entry/exit problematic
Materials/equipment selection	materials/equipment don't meet specifications poor material selection (e.g., seals not compatible with gasoline/MTBE) materials/equipment damaged during transport materials/equipment damaged during unloading preinstallation inspections not performed unqualified installers inspector not qualified/not present oversight/inspection not performed/inadequate poor documentation
Excavation	OSHA safety guidance not followed excavation too small for clearance requirements
Tank placement	tank damaged during unloading/placement tank bedding materials don't meet specifications placement of tank bedding materials doesn't meet specifications ballasting/anchorage not performed properly oversight/inspection not performed/inadequate unqualified installers inspector not qualified/not present poor documentation
Corrosion protection	improper selection of cathodic protection method/devices improper installation of cathodic protection initial testing not performed exposed surfaces not insulated impressed-current system disabled inspection/oversight not performed/inadequate UST system not isolated from nearby electrical sources bimetallic corrosion problems underground wire not properly insulated unqualified installers inspector not qualified/not present poor documentation

Table 2 *(continued)*
Potential Problems During UST Design and Installation

Activity	Potential Problems
Leak detection and prevention Systems	tank and line tightness testing not performed/performed incorrectly automatic tank gauging system not installed properly tankpit observation wells not installed properly unqualified installer/inspector secondary containment sumps not sealed/installed correctly alarms not in appropriate location (inaudible) vapor monitors, or other monitors, not installed properly poor selection of system for product types, site conditions, etc. improper initial calibration of sensors improperly installed electrical systems ground-water monitoring wells not installed properly poor selection of leak detection system for site conditions, etc. system not sensitive enough to detect small/subtle leaks integrity of fiber trenches line leak detectors not installed properly alarm panel not installed correctly striker plates not installed correctly unqualified installers inspector not qualified/not present
Piping	poor layout/design piping materials do not meet specifications pipe fittings not secured properly improper fiberglass/steel connections improper unions or swing joints trenches incorrect depth/slope flexible connectors not secured properly backfill materials selected or placed/compacted improperly initial tightness testing not performed aboveground piping not labeled unqualified installers inspector not qualified/not present
Overfill protection	overfill protection devices not installed properly poor selection of overfill protection system flow restrictors/ball float valves not installed properly overfill alarms not installed properly unqualified installers inspector not qualified/not present
Fillport spill containment	catchment basin not installed/sealed properly poor selection of containment/drainage system unqualified installers inspector not qualified/not present

Table 2 *(continued)*
Potential Problems During UST Design and Installation

Activity	Potential Problems
Vapor recovery systems	poor system design/layout equipment does not meet specifications Stage I equipment not installed properly Stage II systems not installed properly systems not vapor/liquid tight unqualified installers inspector not qualified/not present
Product dispensers	poor system design equipment does not meet specifications under dispenser containment not installed/not required/ not installed properly under dispenser monitoring not installed/not required/ not installed properly under dispenser piping not installed/secured properly meters not calibrated properly automatic shutoff valves not tested impact valve not installed properly filter not installed/secured properly unqualified installers inspector not qualified/not present
Pumping systems	pumping systems not installed/not secured properly poor selection of pumping system for site conditions pump turbine containment sumps not installed/secured properly inadequate cleaning of piping adjacent to check valve before startup unqualified installers inspector not qualified/not present
Other equipment	tank fittings not secured inadequate signage stormwater control structures not installed improper identification of driveway manholes or UST fillports
Tankpit and trench backfilling	secondary containment tightness testing not performed/ performed incorrectly inspection/oversight not performed post-backfill inspection not performed final testing not performed
Documentation	inadequate documentation for: As-builts facility plot plan equipment warranties permits O&M Plan final checklist and walkthrough report installer certification of installation

Table 3
Factors to Consider for UST Operations and Maintenance

Activity	Factor to Consider
Product delivery	predelivery product level gauging water gauging fuel hose hookup overfill protection engaged spill box drainage vapor recovery system hookup driver responsibilities owner/operator responsibilities receipt of delivery documentation spill response
Product dispensers	customer education owner/operator staff training maintenance requirements visual inspections (dispenser pans, drippage, etc.) filter changeout (frequency, spent filter handling/disposal) testing/calibration of meters testing procedure for automatic shutoff systems testing schedule response to failed test tester qualifications
pumping Systems	proper usage inspection and maintenance requirements inspection and cleanout of check valves inspector/maintenance personnel qualifications
Leak detection and prevention systems	inventory reconciliation/interpretation (daily; monthly) evidence of leakage periodic visual inspections of equipment tankpit monitoring automatic tank gauging (ATG) test tightness testing (tanks and lines) periodic sensor calibration under dispenser monitoring pump turbine sump monitoring inspection and maintenance of overfill sump interpretation of monitoring/test results alarm panel testing proper response to leak alarms communication/documentation system sensitivity
Vapor recovery systems	proper usage fill bucket inspection/drainage maintenance requirements inspection/testing criteria

Table 3 *(continued)*
Factors to Consider for UST Operations and Maintenance

Activity	Factor to Consider
Spill response	spill response plan personnel training and responsibilities spill response equipment agency notification and communication documentation spill kit maintenance stopping the spill/leak/release reporting the release emergency response investigation of spill cause containment of released product spill response follow-up
Tank/line repairs	industry codes contractor qualifications equipment certification testing requirements tester qualifications documentation
Inventory control	federal, state, and local requirements manual tank gauging manual tank gauging before and after product delivery proper tank charts water gauging procedure accounting system requirements daily reconciliation record and reconciliation forms/instructions product losses: sources unavoidable losses controllable losses procedures for reduction of controllable losses procedure for receipt of product response to inventory variance
Tank/line precision testing	testing requirements/frequency environmental conditions recorded/considered tester qualifications criteria for pass/fail response to failure of test documentation sensitivity
Corrosion protection systems	maintenance/monitoring requirements sacrificial anode replacement inspection/testing criteria tester qualifications

Table 3 (continued)
Factors to Consider for UST Operations and Maintenance

Activity	Factor to Consider
Stormwater control/cleanup	inspection/cleaning of storm drain inlets inspection/cleaning of catch basins spot cleaning of drips/spills disposal of cleanup materials
Training for station personnel and tanker truck drivers	alarm panel testing procedures for receipt of product product delivery/tank fillup inventory reconciliation station inspection response to alarms spill response site cleanup/waste disposal on-site record keeping daily procedures tank gauging dispenser inspection/calibration oversight of personnel communication/documentation
Record keeping	history of UST usage prior to current usage equipment maintenance schedules equipment certification and testing equipment operating manuals from manufacturers station operating permits records of maintenance, calibration, repairs suspected/confirmed releases corrective action taken ground-water monitoring vapor monitoring temporary closures corrosion protection system analysis of corrosion potential leak detection performance inventory variance repair/upgrade documentation change-in-service accidents/incidents/spills

Table 4
Potential Problems During UST Operations and Maintenance

Activity	Potential Problems
Product delivery	not gauging tanks before and after delivery fill hose not connected properly overfill due to failure to account for accurate ullage volume inaccurate gauging stick driver not present during entire filling process driver unaware of overfill protection type spill boxes not emptied properly Stage I vapor recovery systems not connected properly overfill alarm ignored or inaudible overfill protection system disabled/malfunctioning (e.g., leaking) improper draining of fill hose proper procedure for receipt of product not followed surface spill ignored by tanker driver improper spill response stress/damage to UST and/or piping due to heavy delivery truck no reporting of known spill
Product dispensers	customer drive-off causes release automatic dispenser shutoff not functioning properly spills caused by customer top-off improper cleanup of spills near dispensers improper handling/disposal of product filter too long between filter changeouts dispenser pans not liquid tight and/or not checked
Pumping systems	pumping systems not installed/secured properly poor selection of pumping system for site conditions pump turbine containment sumps not installed/secured properly inadequate cleaning of piping adjacent to check valve before startup unqualified installer/inspector
Leak detection and prevention systems	inventory variance not detected/reported leak detection systems not tested/calibrated regularly leak detection systems disabled/ignored leak alarm disabled/ignored/inaudible poor selection of leak testing method visual inspections not performed or performed poorly scheduled maintenance not performed testing performed too soon after product delivery leak detection system computer malfimction (e.g., Y2K) failure of automatic tank gauging (ATG) test misinterpreted line leak detector malfunction due to faulty check valve, etc. failure of tightness test ignored or misinterpreted (tanks and/or lines) evidence of leakage ignored (e.g., slow pumping dispenser) incorrect interpretation of monitoring/test results tanks not checked periodically for water under dispenser monitoring not performed pump turbine sump monitoring not performed significant vapor releases not detected maintenance/testing performed by unqualified personnel inadequate communication/documentation

Table 4 *(continued)*
Potential Problems During UST Operations and Maintenance

Activity	Potential Problems
Vapor recovery systems	improper usage (e.g., bypassed) leaking (i.e., not vapor tight) inadequate/improper maintenance unqualified maintenance personnel
Spill response	inadequate spill response plan, or not followed properly inadequate cleanup equipment available inadequate personnel training personnel responsibilities not understood reportable quantity is unclear in regulations poor communication between owner/operator and regulatory agency inadequate documentation of release release not contained ASAP release washed down with water release not reported improper emergency response
Tank/line repairs	repairs insufficient/inappropriate (not to code) inadequate maintenance/inspection unqualified or inadequately-trained repair personnel tightness testing after repairs not performed/not performed properly
Inventory control	federal, state, or local requirements not followed meter and tank readings not reconciled inaccurate gauging stick product level not stabilized in tank prior to gauging tanks not gauged before and after product delivery improper temperature compensation automatic tank gauging system not calibrated properly tank not level causing gauging inaccuracies theft water gauging not performed properly dispenser meters inaccurate/not tested adjustments for water level not made tank volume chart used incorrectly/wrong chart used math errors/transcription errors improper response to inventory variance inadequate documentation
Tank/line precision testing	required testing frequency/procedures not followed unqualified or inadequately trained testers misapplication of volumetric testing methods leakage rate below threshold detection level ATG system not calibrated properly tank volume too low/too high for testing criteria for pass/fail not followed or not known improper response to failure of test math errors/transcription errors inadequate documentation

Table 4 *(continued)*
Potential Problems During UST Operations and Maintenance

Activity	Potential Problems
Corrosion protection systems	maintenance procedures not followed sacrificial anode not replaced as necessary corrosion protection system disabled inspection/testing not performed anchoring system not protected loss of electrical isolation (various causes) unqualified or inadequately trained testing personnel unqualified or inadequately trained maintenance personnel inadequate documentation
Stormwater control/cleanup	inspection/cleaning of storm drains not performed inspection/cleaning of catch basins not performed spot cleaning of drips/spills not performed improper disposal of cleanup materials
Training for station personnel and tanker truck drivers	inadequate training of various procedures inadequate understanding of responsibilities poor oversight of personnel inadequate communication/documentation
Record keeping	poor record keeping for any of the following: historical UST usage prior to current usage schedules of calibration, maintenance, and repairs inventory reconciliation suspected/confirmed releases corrective action taken ground-water monitoring data vapor monitoring data temporary closures corrosion protection system data analysis of corrosion potential certification of equipment performance leak detection performance repair/upgrade documentation change-in-service documentation records for all manufacturers and installers

Table 5
Suggestions for Improved UST Practices

Category: Equipment Design	Additional Knowledge Needed for Implementation		
	Some[A]	Moderate[B]	Extensive[C]
Implement properly installed striker plates for all tanks.	x		
Implement under-dispenser containment sumps, in combination with sump monitoring devices.	x		
Implement spill containment boxes at Stage I vapor recovery risers.	x		
Implement dry breakaway connections for all dispenser hoses.	x		
Implement automatic shutoffs for all fuel dispensing nozzles.	x		
Research and development to further reduce vapor loss from all UST components,			x
Post-installation tightness testing of overfill containment sumps. Development of associated testing protocol.		x	
Design and implement more reliable overfill protection systems (e.g., not easily disabled, less likely to malfunction).			x
Phase-out float-ball valves as primary overfill protection devices.	x		
Implement integrity testing of secondary containment systems. Develop associated protocol.		x	
Conduct compatibility/permeability testing of select UST components for use with MTBE-enriched gasoline.		x	

Category: Service Station Site Design	Additional Knowledge Needed for Implementation		
	Some[A]	Moderate[B]	Extensive[C]
Design service stations are to minimize potential for contaminated stormwater runoff.	x		
Design all catchments on-site to drain to oil-water separators.	x		
Implement high visibility signs warning against 'topping off" on all dispensers.	x		
Ensure that all signage at service stations is clearly visible, including signs for emergency shutoff switch and labels for fill pipes.	x		
Complete documentation kept on-site at all times, including spill response plan, emergency contact information, site plan, O&M records and manuals, etc.	x		
Label all drains within facility boundary to indicate drainage to oil/water separator, sanitary sewer, or storm drain.	x		

Table 5 *(continued)*
Suggestions for Improved UST Practices

Category: UST System Installation	Additional Knowledge Needed for Implementation		
	Some*	Moderate*	Extensive[C]
Expand the training and certification for all personnel involved in UST installation activities.		x	
Implement qualified third-party oversight for all aspects of UST system installation.		x	
Develop and implement requirements for comprehensive QA/QC documentation including materials and equipment used equipment performance certifications, installation personnel, and installation procedures."		x	

Category: Leak Detection Systems	Additional Knowledge Needed for Implementation		
	Some*	Moderate[B]	Extensive[C]
Ensure that an appropriate system is carefully selected (e.g., third-party oversight, documentation).	x		
Ensure that testing/monitoring results are interpreted and reported by qualified personnel.	x		
Train UST personnel on the importance of following manufacturers' and industry maintenance protocols.	x		
Ensure that appropriate documentation and reporting are completed during all phases of installation, maintenance, and testing of leak detection systems.	x		
Determine if existing leak detection systems are adequate and if they-are sufficiently sensitive to find small/subtle leaks (particularly if using generally recalcitrant compounds like MTBE).			x
Develop and implement improved environmental sensors (e.g., for ground water) for selectively identifying the presence of released petroleum.			x

Category: Customer Education	Additional Knowledge Needed for Implementation		
	Some*	Moderate*	Extensive[C]
Develop training program to educate public and full-service attendants on proper refueling techniques and related UST issues.		x	

Table 5 *(continued)*
Suggestions for Improved UST Practices

Category: UST System Inspection and Maintenance	Additional Knowledge Needed for Implementation		
	Some[A]	Moderate[B]	Extensive[C]
Expand training and certification programs for all personnel involved in UST system maintenance and testing.		X	
Implement qualified third-party oversight for all aspects of UST system maintenance and testing.		X	
Develop requirements for comprehensive QA/QC documentation and reporting during all phases of maintenance and testing of UST systems.		X	
Ensure that maintenance testing results are interpreted and reported by qualified/ certified personnel.	X		
Perform periodic inspections of fill riser spill containment boxes for liquid leak tightness. Develop protocol for inspection and quantification of leakage.		X	
Develop well-defined protocols for maintenance, inspection, and testing of the various types of UST equipment. Ensure that appropriate protocols for specific systems are used.'		X	
Exnand training for proper handling and disposal techniques for used gasoline filters.	X		
Increase required testing frequency for overfill protection systems.	X		
Expand the implementation consistent/timely monitoring and maintenance of corrosion protection systems.	X		
Expand the implementation of inspection and maintenance protocol for dispensing nozzles at all pumps.	X		
Ensure that joints and cracks in paving at UST sites are periodically sealed/caulked to reduce potential for infiltration.	x		
Ensure that a current spill response plan is maintained on-site at all times.	x		
Ensure that spill cleanup supplies are maintained regularly. Ensure that used sorbent materials are handled/disposed properly.	x		
Utilize good "housekeeping" practices to minimize contamination of stormwater runoff. Spot clean drips regularly with appropriate materials.	x		
Develop system-specific "best management practices"' document for each individual site, and keep it on-site at all times."		X	
Avoid use of cleanup and spill response methods that involve water to minimize additional waste disposal requirements. Ensure that any washdown water is collected and disposed of properly.	X		
Expand periodic collection and analysis of ground-water samples at sites with monitoring wells in-place.	X		
Expand periodic inspection and cleanout of storm drain inlets and catch basins within facility boundary.	X		

Table 5 *(continued)*
Suggestions for Improved UST Practices

Category: Owner/Operator Certification and Training	Additional Knowledge Needed for Implementation		
	Some*	Moderate[B]	Extensive[C]
Expand training program that addresses: importance of their role; spill response and reporting; site maintenance and cleanup; inventory control; overfill protection; operation of leak prevention and alarm systems; and, requirements for third-party oversig		x	
Ensure training for all UST personnel upon hiring and annually thereafter on proper handling and disposal of waste materials.	x		
Implement certification program for service station attendants (e.g., Oregon program).		x	

Category: Tanker Driver Certification and Training	Additional Knowledge Needed for Implementation		
	Some*	Moderate[B]	Extensive[C]
Expand the training programs for all tanker drivers, including sections on: importance of driver's role; spill response and reporting; tank gauging; overfill protection devices; spill boxes; vapor recovery systems; and, health and safety."		x	
Develop training certification requirements for all tanker drivers.		x	
Implement periodic third-party oversight during product delivery, particularly for newly-trained drivers.	x		

Category: Regulatory Enforcement	Additional Knowledge Needed for Implementation		
	Some*	Moderate[B]	Extensive[C]
Expand and improve regulatory agency inspection and enforcement procedures.		x	
Consolidate regulations to reduce overlap and improve clarity.			x
Expand and provide uniform training for regulatory agency inspectors.		x	

Notes:

A: These items require some refinement or additional development.

B: These items require further development, analysis, or cost-benefit analysis to determine the most appropriate and beneficial implementation.

C: These items require extensive research to evaluate feasibility and the potential benefits before they can be definitively recommended for implementation.

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