METHANOL REFUELING STATION COSTS

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INTRODUCTION

Background

Emissions from over 200 million cars, trucks, and buses on the road in the United States account for about half of all air pollution in the U.S., and for more than 80% in major urban areas. Since 1968 the federal government has regulated air pollutants in the exhaust of cars and light trucks, and has regulated the emissions from heavy-duty vehicles since 1990. These regulations have resulted in emission levels per vehicle-mile driven falling by about 80% since 1970. However, because of the dramatic increase in the number of vehicles and the number of miles driven, motor vehicles are still responsible for over 60% of the carbon monoxide (CO), and about one-third of the volatile organic compounds (VOCs).

Our reliance on petroleum-fueled vehicles also raises significant energy security concerns. More than one-fourth of the world's oil production is consumed in the U.S., which every year imports about one-half its oil, at a cost of about $60 billion to the American economy. With the transportation sector almost completely reliant on oil, future availability and possible price shocks are major policy concerns.

What is needed is a clean, efficient vehicle that provides the consumer with all the performance and convenience of today's automobile while reducing our dependence on oil. Fuel cell vehicles are now being developed and will soon be available to meet this challenge. Fuel cells are simple *electrochemical engines,* with no moving parts, that generate electricity by harnessing the energy in the reaction between hydrogen and oxygen to make water. Any hydrogen-rich material can serve as a source of hydrogen.

Methanol – a liquid fuel made from natural gas or renewable biomass resources – is a leading candidate to provide the hydrogen necessary to power fuel cell vehicles. The technical feasibility of using methanol fuel cells in transportation has been demonstrated in transit buses, and by 2004, or sooner, it is expected that a variety of cars and trucks in the U.S. and worldwide will be operating on methanol fuel cells. The commercialization of methanol-powered fuel cells will offer practical, affordable, long-range electric vehicles with zero or near-zero emissions while retaining the convenience of a liquid fuel.

Objective

Given the strong commitment to developing methanol fuel cell vehicles, the need for fueling infrastructure to serve these vehicles must be addressed. Consumers have come to expect near universal availability of fuel for their automobiles. As a consequence, the most likely scenario for developing a methanol fuel distribution system would involve utilizing the existing gasoline distribution system by adding methanol fueling capacity to existing retail gasoline outlets.

This study looks at the capital costs associated with various ways of accomplishing this objective.

REQUIREMENTS FOR METHANOL FUELING STATIONS

Station Description

The components in a retail methanol fueling station, illustrated schematically in Figure 1, include a double-walled fuel storage tank, a fuel dispenser, a vapor recovery system, and associated pipes, hoses, and fittings. The storage tank may be buried, as shown in the illustration, or if space and local codes permit, may be located above ground. The equipment and arrangement are essentially the same as those found in retail gasoline or diesel stations.

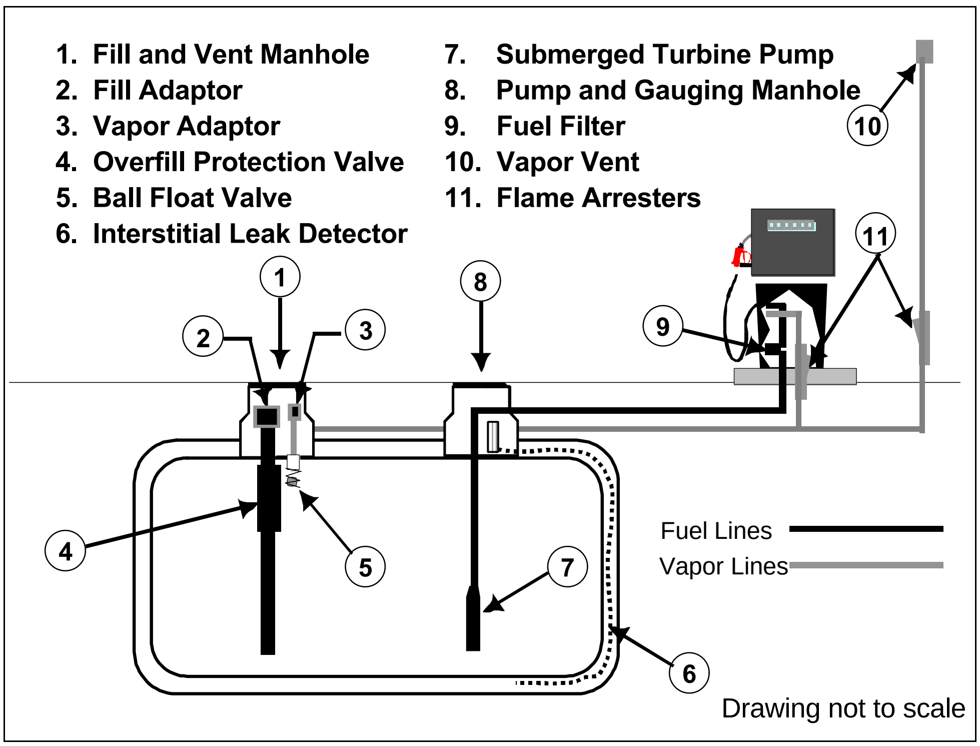

Figure 1. Schematic of methanol fueling station

Underground storage tanks (USTs) for methanol are classified as **chemical USTs** and are regulated by the Environmental Protection Agency (EPA). These regulations require that chemical USTs installed after December 1988 must have secondary containment and interstitial monitoring. Secondary containment may be provided in a number of ways, the most common of which is to place one tank within an another, making a double-walled tank. Interstitial monitoring devices detect the presence of a leak in the space between the two tanks.[1] Automatic systems to monitor tank inventory are also available, but not mandatory.

Since the chemical properties of methanol are different from than those of petroleum fuels, some materials commonly used to store and transport gasoline and or diesel may not be suitable for use with methanol. Several materials compatibility problems, in both the on-board fuel system and the fueling infrastructure, arose in the late '80s and early '90s when vehicles designed to operate on M85 (a fuel consisting of 85% methanol and 15% unleaded gasoline) were first introduced. A common problem was clogging of vehicle fuel filters with the residue from the reaction between methanol and some of the fuel-wetted parts. These problems were attributed to dissolution of aluminum and leaching of plasticizers and fillers (mostly zinc oxide) from dispenser hoses. These problems were resolved by nickel-plating aluminum components or replacing them with parts made of iron and steel alloys and by changing hose liner materials to eliminate the leaching of plasticizers and fillers.

Nearly 15,000 methanol vehicles have been operating for nearly a decade now in California, New York, and elsewhere, supported by a fueling infrastructure of 100 methanol fueling stations in California and many more across the country. Efforts to ensure that fuel contamination is not a problem and that fuel quality is kept at a high levels are continuing. Manufacturers of fueling equipment have benefited from these efforts and offer a wide range of equipment which is fully methanol compatible.

All components selected in this study are considered by their manufacturers to be fully methanol compatible. This implies that the materials will have a satisfactory service life when exposed to methanol and that any degradation of the materials will not adversely affect the quality or performance of the fuel. Test procedures have been developed for materials used in fabricating equipment for dispensing methanol and methanol/gasoline blends for use in internal combustion engines.[2]

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1. *Musts for USTs,* U.S. Environmental Protection Agency, Office of Underground Storage Tanks, EPA/530/UST-88/008, September 1988

2. Pending SAE Standards J1747, *Recommended Methods for Conducting Corrosion Tests in Gasoline/Methanol Fuel Mixtures,* and J1748, *Recommended Methods for Determining Physical Properties of Polymeric Materials Exposed to Gasoline/Methanol Fuel Mixtures*.

The methanol and automotive industries and government agencies are currently organizing a research consortium to determine methanol fuel specifications for fuel cell vehicles. Testing in fuel cell systems is also being conducted using various grades of methanol and potential fuel additives. Taken together, these efforts will be useful in determining the quality of methanol fuel that must be delivered to fuel cell vehicles.

Storage Tanks

Most retail fueling stations use underground tanks because they allow for greater commercial use of the available land. Above-ground tanks are common for fleet refueling facilities and may also be used in rural applications where land use is not an issue. Underground tanks are available in sizes from 500 to 50,000 gallons, while above-ground tanks are available in the range of 250 to 12,000 gallons. Acceptable tank materials for containing methanol include carbon steel, fiberglass, and stainless steel. Due to cost, stainless steel tanks are rare. Carbon steel tanks used underground must be protected against corrosion, usually by a fiberglass coating.

The crown of a buried tank must have a minimum covering of 36 inches of fill material or 30 inches of fill material with an 8-inch reinforced concrete slab. Fill material for fiberglass and fiberglass-over-steel composite tanks should be pea gravel; sand may be used for all-steel tanks. Adequate fill is required to ensure that the tank is not damaged by vehicles driving over it. Antiflotation tie-downs may be required if the local water table is high enough to interfere with the tank.[3]

Above-ground tanks are exposed to the elements and must be protected by coating with materials that are not degraded by the sun's ultraviolet radiation. Above-ground tanks require protective barriers to prevent impact with vehicles using the fueling facility. Since burning materials can come into contact with the exterior of an above-ground tank, and possibly result in detonation of the contained fuel, above-ground tanks are often covered with a fire-protective material such as concrete, providing a minimum 2-hour fire rating per UL 2085.

Reuse of Existing Tanks

For stations which are switching a portion of their gasoline capacity to methanol, the reuse of an existing gasoline storage tank, assuming it meets all current regulations and is

[3] *Methanol Fueling System Installation and Maintenance Manual*, California Energy Commission, March 1996 (Updated November 1998)

"methanol compatible," appears to be an economical alternative to installing a new tank. While the 1996 California Energy Commission's *Methanol Fueling System Installation and Maintenance Manual*[4] does not recommend the storage of M100 (neat methanol) in tanks previously holding gasoline or diesel fuel, CEC staff recently intimated that that exclusion is overly conservative. They concurred that given today's advanced tank cleaning techniques for removing fuel residues, past concerns over reusing existing gasoline diesel fuel tanks for methanol storage may not be warranted.[5]

Tank cleaning vendors suggested two techniques for cleaning USTs. In the first, personnel wearing self-contained breathing apparatus enter the tank and manually wash its inner surfaces. In the second, the tank is pressure washed from the outside. In both cases, the process leaves the tanks in a clean, "gas-free" state, indicating the absence of explosive vapors. The tanks may, however, contain some residual moisture, which can probably be removed by additional methanol rinses.

Another way to reuse existing tanks is to construct a new fiberglass tank inside the existing tank. Fiberglass panels, prefabricated at the factory to fit the contours of the existing tank, may be installed in an existing tank while it is still in the ground. All tank fittings are relocated to new manways and upgraded to current standards. This ReTank™ System, which was introduced in 1994, should be much more economical and less time consuming than tank replacement.

In the event that an existing tank is reused, all product and vapor piping leading to and from the tank should be replaced. Secondary containment will also be required for new product and vapor piping.

Venting and Vapor Recovery

Venting and vapor recovery systems for methanol refueling stations are nearly identical to those for gasoline and incorporate both Stage I and Stage II vapor recovery. Stage I systems recover vapors emitted during filling of the fuel storage tank and Stage II systems recover vapors emitted at the dispenser during vehicle refueling.

A Dual Point Stage I vapor recovery system employs two pipes to the storage tank – one

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[4] *Methanol Fueling System Installation and Maintenance Manual*, California Energy Commission, March 1996 (Updated November 1998)

[5] Peter Ward; Private communication, January 27, 1999

to carry the product and the other to return displaced vapors to the delivery truck. These systems employ a ball float valve in the tank at the end of the vapor return line to restrict flow in the event of an overfill situation. This allows the delivery driver time to discontinue tank filling. Coaxial vapor recovery systems allow delivery of fuel and return of vapors through a single riser pipe from the tank, but methanol compatible components for such systems are not currently available.

Pipes that vent methanol storage tanks to the atmosphere require pressure-vacuum vent caps to restrict escape of vapor during tank filling. Flame or detonation arresters must also be installed on both the vapor recovery pipe at the dispenser and on the tank vent line. These passive devices provide protection against an external flame source entering the tank's vapor space.

Pumps, Dispensers, Nozzles, and Hoses

Pumps to move methanol from the storage tanks to the dispensers can be located in the storage tank or in the dispenser. Submersible turbine pumps, located in the storage tank, are becoming the industry standard. Such pumps offer the advantage of being able to provide fuel to multiple dispensers, generally offer higher performance than suction pumps, and operate with lower power consumption. Residual pressure in the fuel line between the pump and the dispenser, even when the pump is not operating, facilitates the use of mechanical leak detectors to monitor and signal leaks in the product line.

Dispensers and nozzles used for petroleum products contain many aluminum components. For use with methanol these may be replaced with iron components or the aluminum parts may be protected against corrosion by electroless nickel plating. The dispenser should also contain a final fuel filter capable of removing 95 percent of 1 μm particles. Dispenser hoses are made with special polymer liners and synthetic rubber to assure that both the fluid and vapor lines are fully methanol compatible.

Provisions should also be made to prevent misfueling, i.e., putting methanol in the tank of a gasoline fueled car or gasoline into the tank of a fuel cell vehicle. Cardlock systems have been effectively used by fleets in California and elsewhere to control access. These systems, which require that the card remain with the vehicle and that the driver input an identification number at the time of refueling, may not be practical for the multi-car multi-driver situations encountered in general consumer use.

A unique spout configuration and matching access port on the vehicle, the system used when unleaded gasoline was introduced, may be an acceptable technique. Radio frequency identification (RFID) technology, with transducers on both the vehicle and the fuel dispensers, will allow future fuel cell vehicles to communicate directly with the fuel dispenser to assure that the appropriate fuel is dispensed into the vehicle.

COST OF METHANOL FUELING STATIONS

Scope

A site plan for a typical urban/suburban fueling station, located on a corner 110 ft x 110 ft plot, is shown in Figure 2. This station has three USTs for storage of three grades of gasoline, two pump islands, and four dispensers capable of refueling eight vehicles simultaneously. At an average fill-up of 13.5 gallons requiring six minutes, a station such as the one illustrated may service between 200 and 400 vehicles per day and have a gasoline throughput of 85,000 to 170,000 gallons per month. This type of station was considered a candidate for adding methanol fueling capacity.

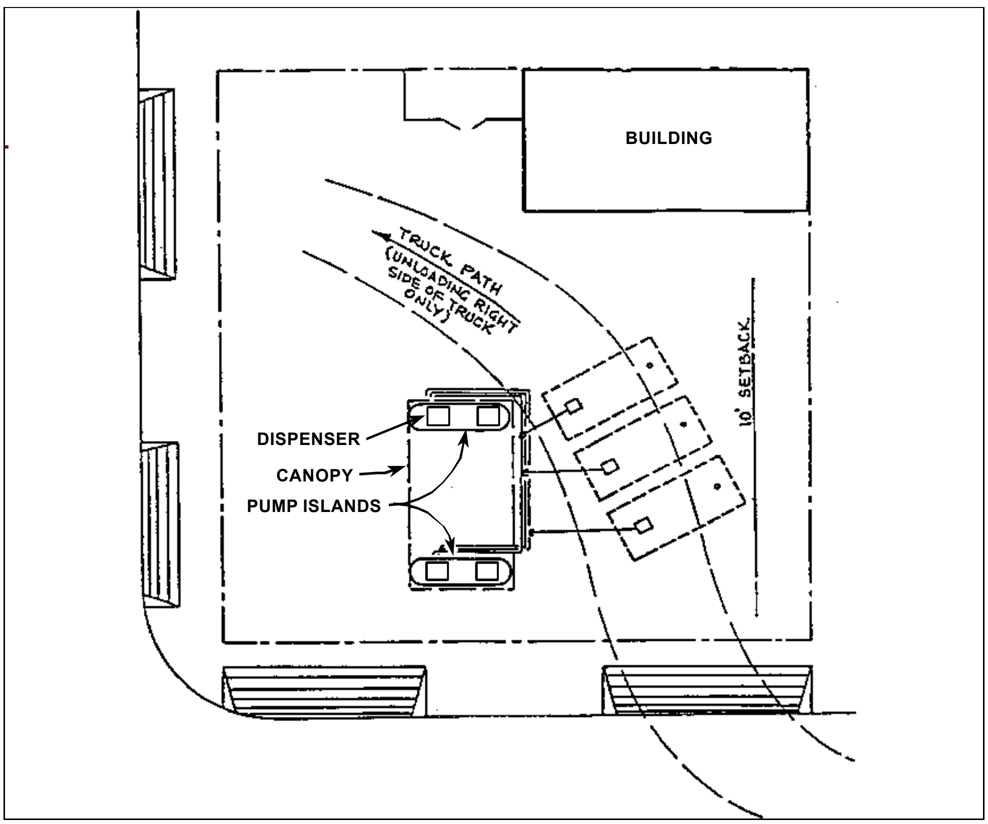

Figure 2. Site plan of a fueling facility (adapted from CEC Manual)

Scenario 1: Add Methanol Capacity to an Existing Station

In this scenario it is assumed that the capability of dispensing up to 33,000 gallons of methanol per month is added to an existing retail gasoline station, increasing the station's overall throughput. This may be accomplished by adding a new underground 10,000 gallon methanol fuel tank, remote from the existing tank field, for instance in the upper left hand corner of Figure 2. An above ground tank might be added where space and permitting allow. Above ground tanks must be located at least 25 feet from any major building, property line, or public way.[6] One single product, two-hose fuel dispenser is added, providing the capability to refuel about 20 vehicles per hour. All other fuel system components, such as product and vapor piping, pumps, etc. are new and methanol compatible.

The costs for installing such stations are detailed in Table I.

Table I

Increase Throughput of An Existing Station by Adding 33,000 gal./month of Methanol Capacity

	Urban Underground Tank	Rural Above-ground Tank
MATERIALS		
10,000 gallon double-walled storage tank	$17,553	$25,850
Interstitial leak detector probe	$1,200	$1,200
Fill & vapor adaptors, overfill, and ball float valves	$640	$640
1/3 hp submersible turbine pump w/ leak detector	$1,426	$1,426
Dispenser, nozzles, hoses, and fittings	$8,645	$8,645
Vent valve and flame arrestors	$1,580	$1,580
Download piping	$300	$1,000
Product and vent piping	$390	$650
SUB TOTAL	**$31,734**	**$40,991**
Contingency	$3,173	$3,963
TOTAL MATERIALS	**$34,907**	**$44,954**
LABOR		
Install tank, piping, vent system, etc	$25,000	$10,000
Labor contingency	$2,500	$1,000
TOTAL LABOR	$27,500	$11,000
TOTAL MATERIALS & LABOR	**$62,407**	**$55,954**

Notes:
1. Underground tanks are average for both fiberglass and steel models.

The cost for installing the underground storage tank includes all labor (including electrician) and equipment to excavate for the new tank, to dispose of excess soil, to connect piping, monitoring, and dispensing systems, to backfill, and to restore paved surfaces. The cost also includes soil samples and lab fees, permits, and tank testing.

6. NFPA Standard 30A, *Flammable and Combustible Liquids Code*, 1996 Edition.

Other assumptions made in deriving this estimate include:

- the tank is installed alone, and not adjacent to or within a tank field with multiple tanks;
- that no shoring or dewatering is required;
- no underground remediation is required at the site; and,
- that tank access is good and there is no interference from buildings or utilities.

The cost estimate for the above-ground tank includes the cost of a 10 inch reinforced concrete pad with spread footers and digging/restoring a trench for piping. It does not include the cost of vehicle barriers or any decorative enclosures. The estimated cost for piping for above-ground tanks is higher than for the underground tanks since it was assumed that the above-ground tank is located at a greater distance from the existing pump islands.

The time required to install a new underground tank was estimated to be about 10 days, while an above ground tank can be installed in about five days. The effect on station operations would, of course, depend on the location of the installations relative to commercial areas and vehicle driveways.

Scenario II: Methanol Displaces a Fraction of Existing Gasoline Storage Capacity

In this scenario it is assumed that a portion of the station's gasoline storage capacity is displaced by the 10,000 gallons methanol storage tank. Alternate ways of accomplishing this include:

- Eliminate one product from the mix of petroleum products and convert that storage capacity to methanol. This could be done by cleaning or upgrading one of the existing petroleum tanks and installing new methanol compatible piping and dispenser. The cost of this route is detailed in Table II, for both tank cleaning and installation of a fiberglass tank-within-a-tank utilizing the ReTank™ or equivalent process.
- Remove one of the existing petroleum tanks and replace it with a methanol compatible tank and upgrade the balance of the system. Removing an underground tank from a multi-tank field, however, generally requires that the entire field be excavated and the back-fill removed in order to prevent the other tanks from shifting. The costs for this option, then, are likely to be

higher than for installing a new methanol tank in a location remote from the existing tank field.

The cost estimates for displacing existing petroleum storage capacity by refurbishing an existing petroleum tank are detailed in Table II.

TABLE II

Refurbish an Existing 10,000 gal. Petroleum Tank

	Clean	ReTank
MATERIALS		
Interstitial leak detector probe	$1,200	$1,200
Fill & vapor adaptors, overfill, and ball float valves	$640	$640
1/3 hp submersible turbine pump w/ leak detector	$1,426	$1,458
Dispenser, nozzles, hoses, & fittings	$8,645	$8,645
Vent valve and flame arrestors	$1,580	$1,580
Product piping	$300	$300
Vent piping	$390	$390
SUB TOTAL	**$14,181**	**$14,213**
Contingency	$1,418	$1,421
TOTAL MATERIALS	**$15,599**	**$15,634**
SERVICES		
Refurbish 10,000 gallon underground tank	$3,250	$9,677
Excavate to expose top of tank		$4,000
Labor contingency	$325	$1,400
TOTAL LABOR	**$3,575**	**$15,077**
TOTAL MATERIALS & LABOR	**$19,174**	**$30,711**

The cost estimates for the tank cleaning processes assumes that the work can be through existing manholes. The excavation cost of $4,000 for the ReTank™ process assumes that the existing manholes are not large enough to accommodate the installation of the fiberglass liner and partial excavation to expose the top of the tank is needed.

Tank cleaning can be accomplished in less than a day, and installation of new piping and dispenser would require about one week. Placing a fiberglass liner in an existing tank would also require about a week.

SUMMARY AND CONCLUSIONS

While replacement of the internal combustion engines with fuel cell electrochemical engines represents a radical change in technology, developing a fueling infrastructure for these vehicles does not. Refueling stations for dispensing methanol will be very similar to today's gasoline fueling stations, having the same layout and employing the same types of equipment.

The capital costs to implement this new fueling infrastructure are also moderate. The capital costs for the scenarios evaluated in this study are summarized in Table III:

TABLE III

SUMMARY OF STATION COSTS

Scenario	Cost
Increase storage capacity at existing stations	
Add new 10,000 gal underground tank	$62,407
Add new 10,000 gal above-ground tank	$54,600
Displace existing gasoline storage capacity with methanol	
Clean existing 10,000 gal undrground tank	$19,200
Install fiberglass liner in an existing 10,000 gal tank	$31,000
Replace existing underground 10,000 gal tank	$70,000

Note: All scenarios include new dispensers, piping, etc.

The capital cost of increasing the throughput of an existing gasoline station by adding a methanol storage and methanol compatible piping and dispenser is about $62,400. This includes installing a new double-walled underground storage tank and methanol compatible product and vapor piping, dispenser, valves, etc. Where space is available and local codes allow, an above ground tank can be installed, and the overall cost reduced to around $54,600.

Replacing an existing tank in a multi-tank filed is a high cost option, due to problems associated with excavating near other tanks. To avoid problems of tanks becoming displaced, the entire field may need to be excavated or shoring provided. The cost for this option was estimated to be about $70,000.

Converting an existing petroleum storage tank to methanol and installing new piping, dispenser, etc., are lower cost options for converting petroleum capacity to methanol. An existing gasoline or diesel tank can be cleaned and the balance of the system furnished with new methanol compatible components for slightly less than $20,000. The cost for installing a new fiberglass tank-within-a-tank and furnishing new piping, dispenser, etc. is around $30,000.

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Modern Welding Company, Fresno, CA 93711. Mr. Rob Bartlett

Above-ground Storage Tanks

Hoover Containment, Inc., Glen Burnie, MD 21060

ITEQ Storage Systems (TRUSCO), Fresno, CA 93721. Mr. Tom Jacobs

Dispensers and Nozzles

Tokheim Corporation, Charles E. Thomas Company, Gardena, CA 90249. Mr. Don Petroni

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Valves and Fittings

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Pumps, Leak Detectors, and Tank Monitoring Equipment

FE Petro, Inc., McFarland, WI 53558. Mr. Troy Miller.

Marley/Red Jacket Pump Company, Davenport, IA 52802. Ms. Dale Allen

Veeder-Root Company, Simsbury, CT 06070. Mr. Sean Desmond

Flame/Detonation Arresters

The Protectoseal Company, Bensenville, IL 60106-1690. Mr. Keith Anderson

Tank Cleaning Services

Midwestern Services, Inc., Houston, TX 77017. Mr. Phillip Kimmel

Subsurface Technologies, Inc. Westminster, MD 21157. Mr. Bill Gereny

UST Installation Contractor

Subsurface Technologies, Inc. Westminster, MD 21157. Mr. Bill Gereny