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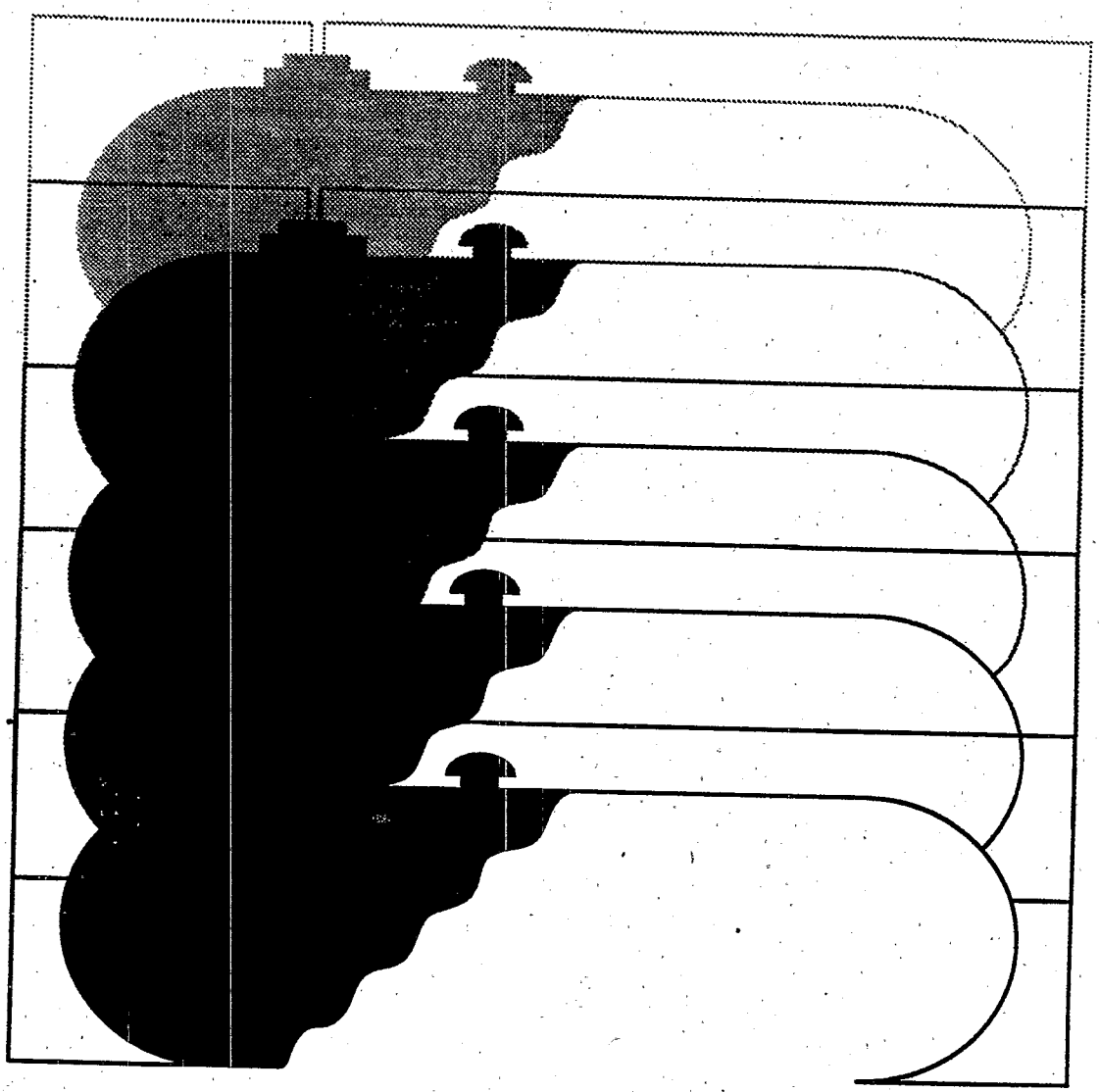
Underground Storage Tanks

EPA

Tank Issues

Design and Placement of Floating Liquid Monitoring Wells



A series of informative articles of interest to tank owners and consultants concerned with management of underground tanks for storage of fuel.

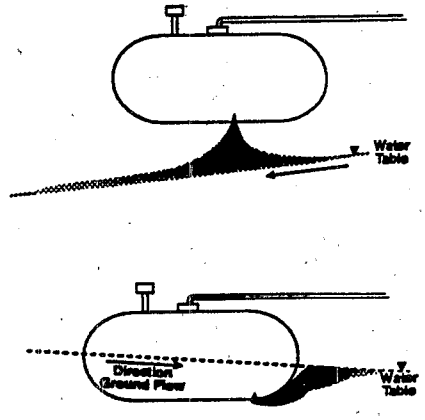
Introduction

Liquid product monitoring is the predominant method of external leak detection where the water table is within the zone of excavation. This paper discusses the use of liquid product monitors at new and old tank installations for detecting leaks from underground hydrocarbon storage tanks. This paper discusses the site conditions under which liquid product monitors can be effectively used, conditions which may mitigate or prevent the effective use of liquid product monitors, and the construction and placement of liquid product monitoring wells. Liquid product monitors are not used to determine the rate of tank leak. The rate of tank leak can be determined by other methods such as inventory or internal monitoring methods. Effective use of liquid product monitors or any other method of leak detection requires training and experience on the part of the user.

Migration of Liquid Product From Underground Leaks

- *Liquid product monitors are useful devices for measurement of leaks*
- *Liquid product monitors detect liquid hydrocarbons floating on the water table*
- *Liquid product monitors detect leaks, not leak rates*

Fuel hydrocarbons leaking from an underground storage tank are initially released as the product liquid. The liquid product tends to migrate toward the water table. If the product is released in the vadose zone, it begins to infiltrate downward to the water table and to partition between the vapor, aqueous, and solid phases. As the liquid product nears the water table, the plume of liquid spreads out, initially entering the capillary zone above the water table, then when the capillary zone reaches capacity, the excess liquid becomes part of the saturated zone. Fuel leaking directly into the saturated zone from a storage tank will tend to rise to the water table. Fuel hydrocarbons in the saturated zone (below the free surface or level of atmospheric pressure) are free to enter monitoring wells perforated at the water table. Floating product is readily detected by specialized instruments. Liquid monitors are relatively easy to install and are suitable devices for monitoring underground storage tanks in many situations.



A leak above the water table infiltrates downward to the capillary fringe and water table and migrates downgradient with ground water. A leak below the water table tends to rise to the water table and move downgradient with the ground water.

Natural and Engineered Site Conditions for Liquid Product Monitors

- *Liquid monitors are effective where water table is less than about 20 feet below grade and greater than 2 to 5 feet below land surface*
- *Backfill should be coarse-grained, permeable material*
- *Liquid monitors detect product on the water table*

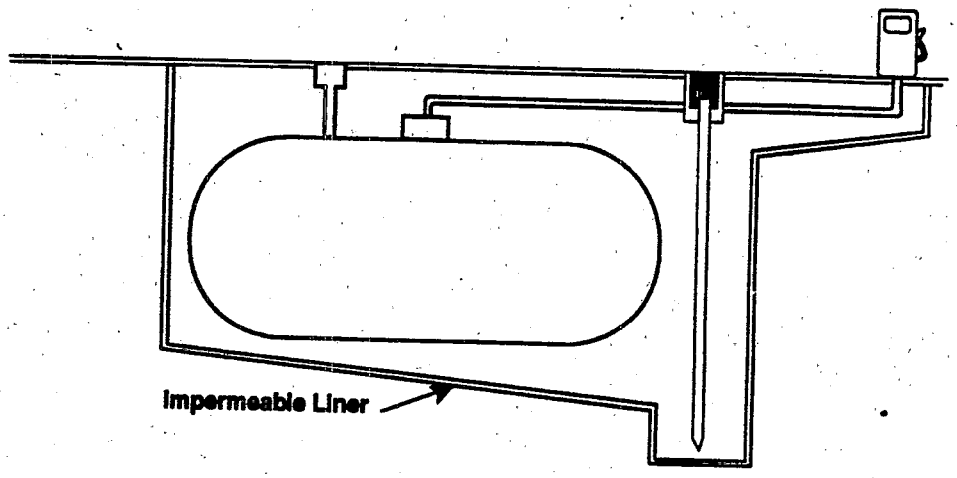
Liquid product monitoring is effective where the water level is below the bottom of the tank excavation if the native material is coarse grained and very permeable. If the native material is coarse grained and very permeable, the depth to water should not be greater than about 20 feet below grade. At greater depths, the time of percolation of product to the water table is considered too long to provide timely detection of a leaking tank.

Because the well should be sealed to a depth of 2 feet or more to prevent infiltration of liquids from the surface, it is not possible to detect liquid product within this depth of water table.

Sites that are contaminated by previous leaks or large surface spills may not be amenable to liquid monitoring because of high background content of hydrocarbon and the difficulty of detecting new leaks and discriminating between new leaks and surface spills. Liquid product monitoring wells can be located upgradient from the tank installation to detect liquid product migrating from off site. The backfill material in which the monitors are located must be relatively permeable to allow the hydrocarbon to spread rapidly on top of the water table. Old tank installations may be difficult to monitor because of both or either the low permeability of the backfill or the presence of high content of residual hydrocarbons from previous spills or leaks.

SURFACE SPILLS AND OFF SITE CONTAMINATION—Background levels of hydrocarbons from surface spills and liquid product from off site sources may affect the monitoring method, the suitability of various monitors, and the location of monitors. It is important to know the existing hydrocarbon levels at a new or existing site before the method of monitoring is chosen and before the instrumentation is installed. In addition, the detection of hydrocarbons from off site and the discrimination of surface spills from tank leaks should be a factor in the design and selection of monitors for the site. The major cause of spills is overfilling of the tank during liquid transfer operation. This problem can be minimized by using in-tank level sensors, dry couplings on transfer lines, spill containment devices, and barriers to product migration around fill pipe manways.

SECONDARY CONTAINMENT—Several types of secondary containment have been used in underground storage tank systems. Secondary containment refers to containment of hydrocarbons that have leaked from an underground storage tank to prevent migration of the product beyond the near-tank area before remedial action can be taken. Secondary containment can be afforded by double-walled tanks and product lines, by lining the tank excavation with clay or synthetic membrane liners, and by placing tanks in concrete vaults.



Monitoring wells can provide leak detection for tanks and distribution lines where secondary containment liners are used.

A double-walled tank is a tank within a tank, with a very small space separating the two tanks. Double-walled tanks can be monitored within the annular space between the two tanks and monitoring beyond the outside tank is generally not considered necessary.

Synthetic membrane liners consist of a rubber or polymer mat used to line the tank excavation. Tanks and backfill are placed within the lined excavation. Liquid product monitoring wells are generally placed in the lined excavation to provide leak detection. Liners are susceptible to chemical and physical degradation and should not be considered to perpetually contain tank product leakage. Although the useful life of liners may not be known, the life should be conservatively estimated and other types of monitoring should be implemented beyond the estimated useful life of the liner.

Some states require that, under certain conditions, underground storage tanks be contained in concrete vaults. Because concrete is not impermeable to liquid product migration and vapor transport, the vault should be lined or coated.

INSTALLATION OF EXTERNAL MONITORS AT NEW SITE VERSUS OLD SITE—The successful operation of external monitors is greatly dependent upon the proper selection and installation of monitors. The proper selection and installation is, in turn, almost wholly dependent upon the natural and man-made characteristics of the site. Site characteristics are most readily perceived and to a great extent can be controlled during the construction and installation of a tank system.

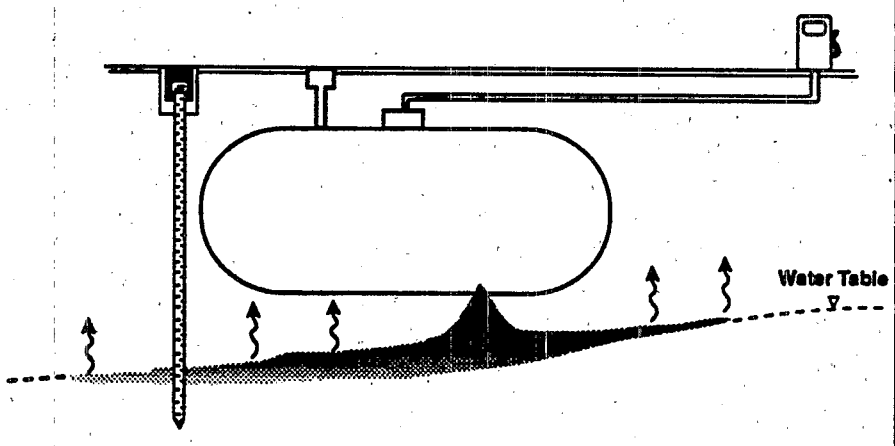
Liquid Product Versus Vapor Monitoring

Fuel hydrocarbons leaking from an underground storage tank are commonly released as the liquid product. The liquid product volatilizes in the soil air and the gas migrates through the unsaturated zone by diffusion. The hydrocarbon gases in the soil can be detected by vapor monitors. The liquid product tends to migrate to the water table where, when the voids are filled to capacity, the liquid product can be detected in wells screened at the water table.

Liquid Product Monitoring

- *Depth to water should be less than about 20 feet*
- *Liquid product monitoring is useful where secondary containment is employed*

Liquid product monitoring is not effective where the water level is below the bottom of the tank excavation unless the native material is coarse grained and very permeable. If the native material is coarse grained and very permeable, the depth to water should be within about 20 to 30 feet of grade. At depths below about 20 feet, depending upon the rate of percolation of product to the water table, the time delay in the product reaching the water table is considered too great to provide timely detection of a leaking tank. As an alternative, if the depth to water is greater than 20 or 30 feet, the trench could be lined to provide secondary containment of leaked product. If the water table is at shallow depths, less than 2 to 5 feet below the surface, it is not possible to monitor liquid floating product where the water table is above the perforated portion of the well casing. Because the well should be sealed to below the frost line to prevent infiltration of liquids from the surface, it is not possible to detect liquid product within this depth of water table. Because water may enter the tank in excavations with high water levels, the external leak detection system should be augmented by monitoring the water layer in the tank as a part of inventory control.

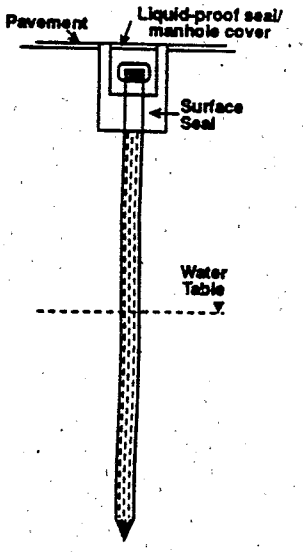


The vapor monitor will detect hydrocarbon gases in the soil air collected from above the water table. The liquid monitor will detect hydrocarbons floating on the water table.

Fine-grained backfill such as fine-grained sand, silt, and clay may be of such low permeability that the migration of hydrocarbons to the water table are greatly impeded. Above the zone of saturation, fine-grained material may hold much of the fuel in the capillary fringe above the water table (Johnson and others, 1989). Fuel released in the saturated zone migrates very slowly toward the water table in fine-grained material or may be trapped below the water table.

Liquid Product Monitoring Wells

- *Install liquid product monitoring wells to tap water table*
- *Perforate well casing continuously from bottom to surface seal*
- *Install in permeable backfill of excavation*



Materials — Liquid monitoring wells constructed of PVC (polyvinyl chloride) provided with slots for hydraulic connection with product on the water table is usually the cheapest material and is quite adequate. However, many materials have been used in construction of wells including stainless steel, PVC coated steel, cast iron, galvanized iron, polyethylene, polypropylene, fluorocarbon resins, and Teflon. Wells are typically from 2- to 6-inch I.D. (inside diameter) pipe.

Installation — The casing may be installed by hydraulic ram or any of several drilling methods including auger or hydraulic rotary to a depth of several feet below the lowest fluctuation of the water table. If a hydraulic rotary method is used, drilling mud should not be added to the drilling fluid or a viscosity reverting type of drilling fluid should be used to prevent clogging of the perforations in the well. Wells at new installations can be installed by backfilling around the pipe set in place rather than by drilling after backfilling. The casing should be perforated continuously from the top of the plug in the bottom of the casing to the surface seal of the casing. The casing is sealed to below the frost line, about 2 to 5 feet below the surface, to prevent entry of liquids through the well bore annulus. The top of the casing should be fitted with a waterproof cap which is capable of being locked. When the monitoring well is installed and before it is put into service, the well should be pumped to clear the fine-grained particles clogging the perforations. Periodic maintenance should be performed annually by pumping of the monitoring well to assure that the perforations are clear and will admit fluid from the saturated zone.

Location of Liquid Product Monitoring Wells

- *Locate wells in high permeability backfill*
- *Use two wells for one tank*
- *Use three or more wells for multiple tanks*
- *Use additional wells for backup, to locate leaks, to monitor piping systems, and to detect product from other tank installations*

The number of wells needed to monitor a storage system of one or more tanks in a single excavation may range from two to four or more. A minimum of two wells is recommended for a single tank ex–cavation. Three or more wells are recommended for an excavation of two or more tanks. Multiple wells at a tank excavation would provide backup capability in case of a well failure and might provide a means of locating the leak based on the time of arrival of hydrocarbons.

The liquid product leaking from an underground storage tank will migrate in the direction of ground water flow. Where the direction of ground water flow is known, one or more monitoring wells should be located within the backfill of the tank excavation on the down–gradient side of the tanks. Monitor wells should also be located on the upgradient side of the excavation, because the direction of the ground water gradient may change in time. Monitor wells can be locat–ed off site and upgradient from the excavation to detect the migration of product from off site sources. Because the native soil in the vicinity of a tank excavation may be of low permeability, vapor leak detection devices in each excavation should be considered as separate and independent systems.

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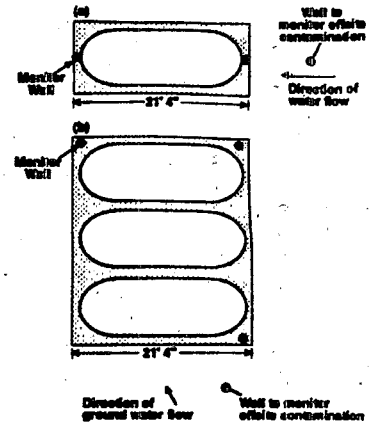
- *Use additional wells to track dispersion between leaks and surface spills*
- *Instrument each excavation separately*
- *Locate wells on the downgradient side of excavations*

At an existing tank, there may be insufficient space in the excavated zone to install monitor wells without danger of drilling into the tank. At existing installations, liquid monitor wells can be installed near the excavation where native soils are sufficiently permeable.



(a) Layout of monitor wells for detecting leaks in a single tank excavation; (b) Layout of monitor wells for detecting leaks in a 3-tank excavation.

Reference

Johnson, Richard L., McCarthy, Kathleen A., Perrott, Matthew and Hinman, Nancy, 1989. Direct comparison of vapor-, free-product-, and aqueous-phase monitoring for gasoline leaks from underground storage systems: Oregon Graduate Center Report, Beaverton, Oregon, 11p. *Also in:* National Water Well Association, Houston Conference Proceedings, 1989.

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"Tank Issues" are short articles of information on the current state-of-the-art on management of underground fuel tanks. These articles provide recommendations but are not regulations; neither the U.S. Environmental Protection Agency nor the Environmental Research Center, University of Nevada, Las Vegas may be held responsible for consequences of following recommendations in these articles. All appropriate state, local, and federal regulations should be followed in installation and operation of leak detection devices and in management of underground storage tanks.

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