NFPA No.
329

LEAKAGE FROM

Underground Flammable & Combustible Liquid Tanks 1964

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Recommended Practices on

Leakage from Underground Flammable and Combustible Liquid Tanks

NFPA No. 329 — 1964

1964 Edition of NFPA No. 329

This recommended practice was prepared by the Sectional Committee on Maintenance and Repair, approved by the Committee on Flammable Liquids, and adopted by the National Fire Protection Association at its 1964 Annual Meeting held May 18–22 in Dallas, Texas.

Origin and Development of No. 329

This recommended practice replaces a manual on this subject issued in 1959. That manual was preceded by a report (NFPA No. 30B) on the same subject which was withdrawn from publication in 1950.

The major changes in this edition were made to comply with the new basic classification of flammable and combustible liquids. Other changes were made for clarification or were editorial in nature.

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NFPA No. 329

Foreword

Liquid shall mean, when not otherwise identified, both flammable and combustible liquids.

Combustible liquid shall mean any liquid having a flash point at or above 140° F (60° C).

Flammable liquid shall mean any liquid having a flash point below 140° F (60° C) and a vapor pressure not exceeding 40 lb. per sq. in. absolute at 100° F (37.8° C).

Flammable and combustible liquids for consumer uses are commonly stored in underground tanks. The majority of such tanks are at service stations; however this report is not confined to tanks at these places. It includes underground fuel oil tanks in connection with dwellings and business places, as well as underground tanks containing other flammable and combustible liquids at industrial properties. Millions of gallons of these liquids are stored in underground tanks and it is of vital importance, economically as well as from the potentially hazardous conditions such tanks may present, that proper methods of installation be understood and practiced.

The text outlines the proper methods for installing underground tanks, minimizing losses and detecting leaks, protecting contaminated areas and detecting sources of seepages and gives methods for their removal. These methods can be only general as each case encountered will have its own peculiarities.

CHAPTER 1

Recommended Safeguards for the Installation of Underground Tanks

General

Underground tanks provide a widely accepted method for storage of flammable and combustible liquids. Such storage is frequently under buildings or driveways, permitting other uses of the area above the tanks.

These liquids in underground tanks seldom become involved in fires even when buildings above them burn to the ground. However, when a tank is buried it is not, like an aboveground tank, accessible for inspection, maintenance and painting.

The labor of replacing an underground tank is often much greater than the cost of installation of the original tank or the value of the replacement tank. Therefore, securing maximum leak-free life from a tank is good economics. The entrance of water into a tank, or leakage of product out of a tank or its connected piping, can also cause serious economic loss and possible hazards to adjacent property.

Because visual inspection of underground tanks is impossible, minor leaks may go undetected for some time, particularly if inventory control is inadequate. The small quantities, which might evaporate harmlessly aboveground, may be protected from evaporation by ground cover. In well drained areas, such liquids usually dissipate harmlessly. However, where a high water table exists, or where the liquid follows natural or sewer drains, underground piping or conduits, escaping liquid may travel some distance underground.

A low flash point flammable liquid may create a hazard if it enters a basement, utility manhole or similar subgrade enclosure where vapors may accumulate and a source of ignition may exist. Fortunately, in occupied premises these vapors usually manifest themselves by odor at concentrations below the flammable range.

Fire prevention and economics both require high standards of fabrication and installation to extend the life of the tank and to prevent leakage. Therefore, operating methods which will detect leaks promptly should be employed. Reliable methods for locating the source of spillage or leakage should be employed and responsibility for such investigation should be established. An effective and safe method should be used for testing each individual tank suspected of leaking.

Installation

The excavation for an underground tank should provide a firm level base. Ledges or high spots which might stress the tank should be avoided. Care should be taken particularly when a tank is to be placed in filled or rocky ground. A bed of clean sand at least six inches in depth should be placed in the bottom of the hole.

The tank should be placed in the hole with care. In some cases the tank is equipped with lugs so cables can be attached for lowering the tank with a crane or shovel boom. A hoist on an auto wrecker is sometimes useful for small tanks. Dropping the tank or rolling it into the hole should be avoided. Such handling may break a weld or puncture or damage the tank metal, and may scrape off the protective coating if the tank has been coated. If no other method is available, however, and the tank must be rolled into the hole, ropes should be used to control movement of the tank while it is being lowered.

Piping should be installed free of leaks, and in a manner to prevent leaks from developing. Welded, screwed joints or approved connectors should be used. Flanged joints are not recommended for underground service but if used, they should be of steel. Threaded joints and connections should be made up tightly with a suitable lubricant or piping compound. Hard setting compounds, such as litharge or red lead are not recommended.

Pipes passing through concrete should be in pipe sleeves, mastic or be otherwise free. If not so protected, settlement, frost action, vibration, or traffic may break or loosen the piping.

After the tank is piped, both piping and tank should be tested. See Chapter II and Chapter IV of the Flammable and Combustible Liquids Code, NFPA No. 30.

In areas where a high-water table exists it may be necessary to fill the tank at once with water or product. In such case, in addition to air test on the lines, a before and after gage reading should be taken of the liquid in the tank. Because liquid will be forced into the suction line by the air pressure, it is desirable to first fill the tank with liquid and then test it hydrostatically. The immediate filling of the tank with water or product may be avoided if sufficient anchorage is attached to each end of metal straps laid over the top of the tank to overcome buoyancy.

A sand back fill at least six inches on all sides of the tank is desirable, but back fill may also be clean soil. No construction debris, cinders, stones or other foreign material should be allowed to get into the excavation. Back fill should be well tamped and, where subject to traffic, tank and piping should be protected by adequate cover.

NOTE: For further information on tank and piping installations see the Flammable and Combustible Liquids Code, NFPA No. 30.

Corrosion

The foregoing discusses the prevention of leaks from mechanical causes during installation. However, tank and piping meeting these recommendations can develop leaks through corrosion. In fact, all corrosion is electrochemical in nature. There are three principal causes for corrosion, any one or all of which may be present.

1. **The nature of some soils in which the tank is buried.** The nature of some soils in which the tank is buried is of the greatest importance. Two soils with different properties in contact with the tank or piping will set up corrosive action very rapidly. This is particularly true if construction debris, cinders, shale or other foreign matter is mixed even in very small quantities with the normal back fill. Every effort must be made therefore to keep all such foreign material out of the excavation. It is even more important that cinders, shale and other foreign matter be kept out of the 6 inches of clean sand or earth in which it is usually specified that a tank must be buried. It is this foreign matter that gives the service station industry its biggest corrosion problems.

Proper back fills, the use of necessary measures to exclude foreign matter from the excavations and back fills, and the use of properly applied protective coatings especially on the tank are means for prolonging the life of tanks and piping.

Coatings and wrappings are extensively used on underground piping and to a much lesser extent on buried tanks. A properly selected, well applied and well inspected coating will often provide years of excellent service. Coatings, however, have two or three major deficiencies that are difficult to overcome. These all result from the fact that a coating is no better than its weakest spot, just as a chain is no better than its weakest link. Many times, otherwise perfect coatings concentrate corrosion at a few holidays (breaks in the coating caused, for example, by air bubbles or rough handling of the tank) and consequently, actually accelerate corrosion.

Soils with low electrical resistance, such as might be found in filled land, are usually very corrosive. Soils which do not permit rapid drainage of water also are usually corrosive. When an excavation is made in a heavy impervious clay and sand back fill is used around a tank, the back fill may actually become a moisture holding pocket. If the moisture is rich in soluble salts, a very corrosive condition may result. This condition frequently occurs in clay soil areas where salt is used for snow and ice removal. The salt laden water seeps into the pocket around the tank and what was once a non-corrosive soil becomes a very corrosive environment.

Cathodic protection of tank and piping buried in such soils is usually the best action to be taken for prolonging the life of such tanks and piping. Cathodic protection is the application of a direct current flowing to the metal being protected that is of sufficient magnitude to prevent currents from leaving the metal. Cathodic protection is applied by two methods. Sometimes the required current flow is established by creating a battery in the ground which will force current in the proper direction. An anode of a more active metal is buried in the ground and electrically connected to the tank and pipes to be protected. The protected tank becomes the cathode of the battery and current flows toward it. Magnesium is now the most frequently used sacrificial or galvanic anode although zinc and aluminum are sometimes used.

In the other method of cathodic protection, direct current from an external source is forced from an artificial ground bed to the metal to be protected. Rectifiers are most generally used as the current source and carbon or scrap steel sections provide adequate ground beds. Cathodic protection systems should be de-energized during maintenance of the tank and piping, and this protection system should be operated at not over the recommended voltage. Suitable warning signs should be displayed where such protection is installed.

2. **The action of two dissimilar metals in the tank and piping system.** The corrosive action of two dissimilar metals in the tank and piping system occurs at points where valves and fittings of steel and brass, or other such dissimilar metals are connected. Obviously such combinations of metals should be avoided wherever possible.

3. **Stray currents.** Stray currents may set up corrosive action but their presence may be difficult to determine until after the action has progressed to the point where damage has been done to the tank or piping. When currents from an external source flow on buried metal objects and leak off of the metal to cause corrosion, the resulting deterioration is usually called stray current electrolysis. Stray currents can come from street car systems using the rails for a negative return, railroad signal systems, direct current generators, plating equipment, electric furnace equipment, elevators, electrolytic chemical process equipment and direct current industrial equipment. Even alternating current equipment such as resistance welders which allow direct current components to escape on metal grounds may be responsible for corrosion. Where stray currents are suspected a thorough investigation should be made and proper corrective measures taken.

CHAPTER 2

Methods to Minimize Losses and Detect Leakage

The Problem

When a tank is buried two or three feet underground or under a concrete pavement or slab, detection of leaks is difficult. Nevertheless there are effective methods to indicate whether such a tank is leaking. One or more of these methods should be used as a regular part of good business procedure. Others are employed when leakage is suspected. More extensive methods may be necessary when it has been established that there is leakage somewhere in a neighborhood and ordinary methods have failed to disclose the source.

Stock Control

A leaking tank may create a potential hazard if the vapors seep into sewers, manholes or basements, but many leaks are solely economic losses to the operator. Whether it be storage incidental to a big industry, or the principal merchandise inventory of a local gasoline dealer, leak control is economically important. Therefore, it is not surprising that direct economic methods are the most effective means of control.

Accurate inventory control should be maintained for each underground tank. A stick accurately calibrated in gallons, or a stick marked in inches accompanied by a gage chart for each particular tank, is an essential inventory tool. At the beginning of operations and at the beginning and end of each accounting period, accurate inventory should be made by "sticking" the contents of each underground tank. Mechanical gages or submerged gage pipes with check valves should be used for tanks under buildings.

Stock loss control can be accomplished by one of the following methods: (1) Gaging of tanks before and after bulk deliveries; (2) Checking the quantity of liquid through the open tank vehicle domes on arrival and again for complete emptying before leaving; (3) If delivery is by meter, the meter readings should be observed before and after each delivery.

An additional reason for gaging a tank before bulk deliveries is to determine whether the receiving tank has adequate unused capacity to hold the quantity to be delivered. Sometimes overflowed product may seep underground and appear in sewers, manholes or basements even quite some distance away, or some time later, and create a hazard or falsely indicate a leaking tank. If a spill occurs, the fire department should be called, the proper personnel in the company making the delivery should be notified, and a record should be made of the gallons spilled. The fire department should call the sanitation or other affected departments and take proper steps to eliminate or control the hazard.

Accurate gage readings taken at the end of each shift or day, together with the records of deliveries and sales, should disclose any liquid loss. Most service stations have dispensing pumps with totalizing meters. A station operator should check three ways: by gage stick for quantity removed from the tank; by meter for quantity delivered; and cash received. A discrepancy could mean a loss but not necessarily a leak.

Many underground tanks contain liquid for use rather than for sale, as in factories or fleet terminals. These present additional problems in inventory control, and procedures must be established to accurately measure and record products used. Cases of severe leakage have occurred in such installations and because the only records kept were of liquids delivered, the leak was not discovered for some time.

Any discrepancy between the recorded quantities received into and those removed from the tank should be investigated. Inaccuracy of either the delivery or dispensing device could cause a discrepancy.

Small discrepancies, however, may result from evaporation. Temperature changes also affect volume measurements and these should be calculated. One of the following methods can be used to determine the presence of a leak.

Overnight Tests

A simple test to determine the presence of a leak is to take an accurate stick reading when the station closes at night and another reading the following morning before opening for business. A loss during this period, when there has been no delivery or withdrawal of liquid, may indicate a leak. However, this test might not disclose a small leak, a leak near the top of the tank, or in the piping. To check these places, arrangements can often be made for a delivery to completely fill the tank into the fill or gage pipe just before closing of the station. When comparing any change in level the next morning it might be necessary to compute and allow for expansion or contraction of the liquid, if a considerable quantity was delivered to fill the tank, and the delivery temperature varied several degrees from the underground temperature.

Water Accumulation

There is another way in which stick gaging may disclose a leak. In many areas of the country where there is a high ground-water level, and almost anywhere in wet rainy weather, a leak may let water into the tank. If the end of the gage stick is periodically smeared with water-indicating paste, a sharp line between the two colors will show the presence of water in the tank. This inexpensive paste, obtainable from service station equipment suppliers, remains unchanged in gasoline or other petroleum product but changes color upon touching water.

The presence of water in an underground tank does not necessarily mean there is a leak. In wet weather, the water may be entering the tank through a defective or improperly tightened surface fill or gage cap. Operators should check these after every filling and gaging. Threads should be good, gaskets in place and in good condition and the caps fully tightened. Grease on the threads will permit tightening threaded fittings more easily and will also help seal out water.

Small accumulations of water may also result from condensation. Warm humid air drawn into tanks as product is pumped out may cause droplets to form on tank sides at cooler underground temperatures. Upon refilling, these will be washed to the bottom of the tank.

Leaks in Piping

A leak in underground piping is one of the most difficult to detect. A fill line leak can cause loss during each delivery but none in the intervals between. A leaky suction line to the dispensing pump is more easily detected. Air may be drawn through the leak when the pump is running and product leaks out when the pump stops. Although it might be merely a leak through the check valve in the suction line, air in the line on the first pumping operation in the morning or loss of prime between periods of operation could indicate a leak in the suction line.

CHAPTER 3

Tests and Procedures for Determining the Existence of Leaks in Underground Tanks and Piping

When it is suspected that an underground tank or its connected piping may be leaking, the following steps may be used to confirm or refute the leakage.

Suction Line Testing

To inspect dispensing units and aboveground piping for leaks, remove the panels of the dispensing unit to expose the pump body, air eliminator, meters and product piping. A close observation will reveal the existence or absence of leaks at joints and fittings. A vulnerable point in the product piping is in that section in the sump between the ground and the pump body.

The attendant at the service station should be questioned about the operation of the dispensing unit. If there is evidence of hesitation in delivery of product at any time after the nozzle is opened, or if the pump loses its prime, it usually indicates that the suction line is not full. This can be the result of either an improperly operating check valve, or of a leak in the suction line. The check valve should be checked and if necessary, put in proper operating condition. The check valve may be a foot valve located at the end of the suction line in the tank, an angle check valve located at top of the tank, or an in-line check valve located at the base of the pump in the dispensing unit.

It may be advisable to disconnect the suction line at the dispensing unit, to observe the liquid level in the line. This will require disconnecting the piping and electrical circuit and removing the dispensing unit from the island. With the piping full of liquid, observe the level for approximately 15 minutes. If the level drops steadily after it has been determined that the check valve is holding, there is probably a leak in the line.

It will then be necessary to uncover the suction line from the island to the check valve to determine the location of the leak, and appropriate steps to eliminate the leak should be taken.

Tank and Connected Pipe Testing

The following procedure will be useful where it is desired to check the tightness of any underground storage tank and its piping. The equipment is simple and easily assembled from readily available materials. There will be no need to uncover the tank unless leakage is indicated.

Equipment

1. A piece of clear plastic pipe or standard weight steel pipe approximately four feet long, three inches or four inches in diameter, threaded on both ends. For repetitive use, the steel pipe should be equipped with a boiler gage glass close to the upper end. If this is not readily available, readings of sufficient accuracy can be made by measuring from the top of the pipe down to the flammable liquid level with a measuring tape or ruler.
2. Threaded bell reducer (or coupling and bushing) to connect the test pipe to the fill opening of the tank.
3. Five gallon capacity safety cans.

Procedure

1. To permit maximum temperature equalization and to help eliminate entrained air, the tank should be filled shell full with the same product which is in the tank, 8 to 12 hours or more if possible, prior to making the test. The delay for temperature stabilization can be omitted if equipment and procedures are used by which accurate temperature measurements and volume adjustments can be calculated. For gasoline the adjustment factor of 0.6 gallons per 1000 gallons per one degree Fahrenheit temperature change during the test should be used. If two or more tanks are connected with siphons, all tanks so connected must be filled. Manifold connections between tanks should be disconnected and the lines capped.
2. Remove fill pipe cover and, if necessary, remove the fitting onto which it screws, exposing the pipe thread on the fill pipe. By means of a coupling, the bell reducer or bushings attach the test pipe to the fill opening. Threads must be in good condition and must be made up product tight using pipe dope if necessary. Tightly cap the fill pipe of all other tanks connected to test tank by siphons, as all tanks so connected will be tested as a unit.
3. Pumps to which this particular tank siphon is connected must be temporarily taken out of service, blanked off or disconnected. If the vent line from this tank is manifolded to that from any other tank, the vent line must be disconnected and capped; if the vent line serves this tank only, it need not be disturbed for the present.

4. Fill the test pipe by pouring product in the top until the level is close to the top of the gage glass, or within a few inches of the top of the test pipe. Make a preliminary inspection to see that there is no leakage at the point where the test pipe connects to the fill pipe of the tank, at the pump, or at any other point where piping is exposed.

5. After a period of 30 minutes or more, depending on the size of the tank, mark the liquid level on the gage glass, or accurately measure and record the distance from the liquid level to the top of the test pipe. This stabilizing period is to allow for additional temperature change, the release of entrained, absorbed, or trapped air bubbles, and the possible slight bulging of the head of the tank due to the increased pressure. The top of the test pipe should then be covered (not air tight) to prevent loss by evaporation.

6. Then constantly observe the liquid level in the test pipe, recording differences in level every 15 minutes. Temperature readings of the liquid in the tank also should be recorded every 15 minutes. If the drop in level with a constant liquid temperature is more rapid than approximately one inch in a four inch diameter test pipe, or two inches in a three inch diameter test pipe per hour and is continuous, a leak in the system is indicated. Where there is a change of liquid temperature, changes in liquid volume must be calculated before a conclusion is reached as to the tightness of the system. If a steady release of air bubbles is observed in the test pipe, and the drop in level per hour exceeds that shown above, it would be desirable to postpone the start of the test until the release of air has decreased or stopped altogether.

It will be noted that the tests to this point include not only the tank but also the fill pipe, vent line, and piping up to and including the pump. If significant leakage is found, it will be necessary to disconnect the piping and repeat the test in order to determine that it is the tank that is leaking and not the piping. Hence, if leakage is indicated, continue the test by taking the following additional steps.

7. Pump product out of the tank through the service station pump to lower the liquid level to the top of the tank. Uncover the tank and disconnect and cap the suction connection of the tank. Refill the test pipe and repeat the test. If no leakage is indicated, the leak must be in the suction line. If the leakage persists, it must be either in the tank or vent piping, and another step will be necessary.

8. Pump out product to lower the level in the test pipe, then disconnect and cap all piping at the top of the tank. Refill the test pipe and repeat the test. If leakage still persists, then it is the tank that is leaking and appropriate steps must be taken for removal or abandonment (see NFPA No. 30F, Abandonment or Removal of Underground Tanks). When two or more tanks have been tested as a unit, this final test must be made on each tank individually.

Table I

THERMAL EXPANSION OF LIQUIDS

	Volumetric Coefficient of Expansion, per Degree F.
Acetone	0.00085
Amyl acetate	0.00068
Benzol (benzene)	0.00071
Carbon disulfide	0.00070
Ethyl ether	0.00098
Ethyl acetate	0.00079
Ethyl alcohol	0.00062
Fuel oil	0.0004
Gasoline	0.0006
Methyl alcohol	0.00072
Toluol (toluene)	0.00063

Table II

CHART FOR COMPUTING LOSS OR GAIN IN STANDPIPE—IN GALS.

Inches of Change	Nominal Pipe Sizes*							
	1" Dia.	1¼" Dia.	1½" Dia.	2" Dia.	2½" Dia.	3" Dia.	3½" Dia.	4" Dia.
¼"	.0008	.0013	.0019	.0034	.0053	.0076	.0104	.0136
½"	.0016	.0026	.0038	.0068	.0106	.0152	.0208	.0272
¾"	.0024	.0397	.0057	.0102	.0159	.0228	.0312	.0408
1"	.0034	.0053	.0076	.0136	.0212	.0306	.0416	.0544
2"	.0068	.0106	.0152	.0272	.0424	.0612	.0832	.1088
3"	.0102	.0159	.0228	.0408	.0636	.0918	.1248	.1632
4"	.0136	.0212	.0304	.0544	.0848	.1224	.1664	.2176
5"	.0170	.0265	.0380	.0680	.1060	.1530	.2080	.2720
6"	.0204	.0318	.0456	.0816	.1272	.1836	.2496	.3264
7"	.0238	.0371	.0532	.0952	.1484	.2142	.2912	.3808
8"	.0272	.0424	.0608	.1088	.1696	.2448	.3328	.4352
9"	.0306	.0477	.0684	.1224	.1908	.2754	.3744	.4896
10"	.0340	.0530	.0760	.1360	.2120	.3060	.4160	.5440

*The internal diameter of different grades and types of pipe varies slightly from the nominal pipe sizes given. This variance, however, is not considered to be of sufficient significance to be a factor in the general use of this table.

CHAPTER 4

Protective and Remedial Procedures for Handling Underground Seepages

When a flammable or combustible liquid has seeped into a building, subway or tunnel, steps must be taken to protect the public from the danger of explosion and fire. The fire department or fire marshal's representatives should be notified immediately. (For information on flammable liquids in other underground structures, see Flammable and Combustible Liquids and Gases in Manholes, Sewers and Similar Underground Structures, NFPA No. 328.) To enter an area in which there is an undetermined concentration of some unknown vapor is to risk the possibility of fire or explosion, also an additional life hazard may exist because of toxic vapors or insufficient oxygen.

Specific procedure varies with individual cases where these liquids or their vapors are found in a building but the following general procedure is usually in order.

General Size-up of the Situation

Where these liquids are found in a building, the building should not be entered and evacuation of building occupants, at least in areas exposed, should be ordered. Construction and layout as well as occupancy are factors to be considered in ordering evacuation.

When flammable vapors are reported in a building, the sense of smell cannot be relied upon to determine the type or concentration of vapors. However, if odor is strong, entry should not be made until the vapor concentration has been checked with a combustible gas indicator. The use of a combustible gas indicator is the only positive method to determine the presence and extent of a vapor concentration. When vapors are found to be within or above their flammable range, the evacuation of the building may be ordered.

Eliminating Sources of Ignition

Smoking or other sources of ignition should not be permitted in the suspected area. After the presence of flammable vapors has been verified, the electrical and gas services to the building, where possible and feasible, should be disconnected or cut off outside the structure. The shutting off of electrical equipment in areas where flammable vapors exist has provided the source of ignition for fires and explosions. The shutting off of the gas service outside of the building removes the pilot lights and gas burners which may be sources of ignition.

Ventilation of Area

When the presence of flammable vapors in a building has been verified, immediate steps should be taken to ventilate the area. Natural ventilation, by opening windows and doors, may be adequate. Approved mechanical ventilating equipment may be necessary for the removal of vapors from subsurface areas. Prior to entry into the affected area, a combustible gas indicator should be used to determine the concentration of the vapors. This can be done by probing through some opening before entering and taking continuous readings as cautious entry is made. Ventilation should continue until the area no longer contains flammable concentrations of vapors as indicated by repeated tests at different locations and levels with the combustible gas indicator.

Locating Seepage into Building

When the area has been made safe for entry, it may then be examined to determine the source of the flammable vapors. If the place or places of entry of the liquid or vapors can be determined, appropriate steps should be taken to seal off such places. Untrapped drains, pipes or other openings through floors or foundations are common sources of liquid or vapor entry into a building.

Preventing Seepage into Building

Entrance of flammable vapors through drains, pipes, or other openings may be stopped by plugging such openings. If necessary to prevent additional liquid or vapors from entering the structure, a hole or trench should be dug or wellpoints installed between the structure and the source of the seepage. This hole, trench or wellpoint should be of sufficient depth to trap all seepage and of such size as to facilitate removal of the liquid which should be placed in drums or tanks. Suitable warnings and barriers should be placed around such a hole or trench. Experience has shown that seepage may continue over a long period of time and may reappear, particularly after a rain, warranting the hole or trench to remain open until seepage has been eliminated.