

Recommended Practices for Installation of Underground Liquid Storage Systems

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Recommended Practices for Installation of Underground Liquid Storage Systems

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FOREWORD

These *Recommended Practices for Installation of Underground Liquid Storage Systems* have been prepared as an industry service by the Petroleum Equipment Institute. This recommended practice is truly an industry document, as PEI members, environmental regulators, oil company engineers, oil marketing trade associations, etc., have had an opportunity to review and comment on the previous publication under the same name. The text represents the consensus views of the PEI Tank Installation Committee, comprised of the following members:

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This document supersedes and replaces the previous recommended practice entitled, *Recommended Practices for Installation of Underground Liquid Storage Systems*, PEI/RP100-2011.

All questions and other communications relating to this document should be sent only to PEI Headquarters, addressed to the attention of the PEI Tank Installation Committee.

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1. INTRODUCTION

1.1 Background. Studies conducted by a variety of environmental agencies and trade organizations reveal that one of the significant causes of leaks in underground liquid storage systems is improper installation. Installation of such systems is a specialized craft. Proper installation requires practical experience, combined with careful adherence to recognized good practices and procedures.

1.2 Purpose. The purpose of this document is to provide a concise reference that describes recommended practices for the installation of underground liquid storage systems.

This document is not intended to serve as a basic instruction manual. Because installation of underground storage systems is a specialized craft, it is assumed that persons using this publication for reference purposes will have a fundamental comprehension of the basics of essential procedures for pipefitting, earthwork, concrete placement, electrical installation and related construction techniques.

1.3 Scope. These recommended practices apply to underground, atmospheric and shop-fabricated tanks, associated piping, and equipment up to and including the emergency shear valve intended to dispense gasoline, diesel and related petroleum products into motor vehicles at retail, commercial and government vehicle fueling facilities. If this recommended practice is used as a guide to the installation of underground storage tank systems containing substances other than petroleum, the user must ensure that the storage system materials and components are compatible with and applicable to the substance to be stored.

This document does not address practices associated with the installation of storage systems for liquefied petroleum gases, liquefied natural gases or compressed natural gases.

The practices recommended in this publication are limited to installation procedures.

This document is not meant to provide interpretation of regulatory or legislative requirements related to underground storage systems, nor does it endorse or recommend particular materials, equipment, suppliers or manufacturers. The inclusion of procedures for the installation of equipment or devices is not meant to imply that such equipment or devices should always be used. Nothing in this document is intended to discourage the devel-

opment and implementation of new installation methods and procedures.

1.4 Sources. The specifications and procedures outlined here constitute a synthesis of recommendations published by such organizations as the American Petroleum Institute (API), Fiberglass Tank & Pipe Institute (FTPI), International Code Council (ICC), National Association of Corrosion Engineers International (NACE), National Fire Protection Association (NFPA) and the Steel Tank Institute (STI). In addition, some of the specifications and procedures are derived from instruction manuals issued by manufacturers of tanks, piping and related equipment.

In instances where there were differences or omissions in material available from the above sources, the Tank Installation Committee of the Petroleum Equipment Institute (PEI) has included its own consensus recommendations based on the practical experience of committee members with these systems. In addition, the committee has had the benefit of reasoned comments graciously submitted by state environmental officials, oil company engineers, equipment manufacturers and installation contractors.

The intent of the committee is to provide recommendations that will minimize the possibility of storage system failure. At the same time, the committee has endeavored to avoid recommendations that will needlessly increase installation costs. Manufacturers' instructions should be considered as the minimum acceptable standard to protect product warranties.

1.5 Use of Other PEI Recommended Practices. Underground storage systems may include vapor recovery piping and equipment. The user of this document should refer to PEI/RP300, *Recommended Practices for Installation and Testing of Vapor Recovery Systems at Vehicle Fueling Sites* for additional guidance in the installation of vapor recovery systems; PEI/RP500, *Recommended Practices for Inspection and Maintenance of Motor Fuel Dispensing Equipment* for information concerning the inspection and maintenance of motor fuel dispensers; and PEI/RP900, *Recommended Practices for Inspection and Maintenance of UST Systems*.

1.6 Importance of Competent Installers. Reliance on skilled, professional tank system installers is an important factor in avoiding storage system failures. The high incidence of leaks in piping, for example, is far less attributable to the failure of pipe and fittings than to poor installation practices, such as abrasion resulting from crossed lines, incompatible pipe fittings, the use of improper pipe sealant, inadequate testing and poor workmanship.

Similarly, premature storage system failures can be caused by debris and other foreign material carelessly left in tank and piping excavations. Failure can also result from improperly connected cathodic protection components, inadequately compacted backfill material and a variety of other improper installation techniques.

No amount of written instruction provided by manufacturers or regulatory agencies will serve to make an incompetent or under-supervised installer a competent craftsman. Installation of storage systems designed to contain flammable and combustible liquids is a unique undertaking. The ability to recognize and react to unexpected or abnormal conditions encountered during a tank installation requires experience, as well as skill.

In addition to proper system design and operation, the use of tank installers who have the experience and integrity to insist on doing the job correctly is the greatest protection against ultimate storage system failure and liability exposure. Participation in training programs is essential to improving the skills of installers and the quality of installations.

A certification process should be developed and established for the installers of storage systems, monitoring devices, cathodic protection, secondary containment and related equipment.

1.7 Written Plans. Written plans are required to obtain permits, solicit bids and provide precise guidance for installers. The plans should describe the property, identify the size and location of the tanks, indicate the liquids to be stored, and provide the location of the dispensers and piping. Plans should also specify the materials of construction, piping dimensions, location of electrical service components, and the dimensions and locations of vents, observation wells, vapor recovery systems and gauges or monitoring systems.

If hold-down pads or other anchoring devices are included in the tank system design, their dimensions and construction details should also be included in the written plans.

If appropriate, the plans should show cathodic protection component locations, tank hole lining specifications, manway positioning, electronic release monitoring device configuration and other components of the system.

Selection of equipment and materials compatible with one another and with the fluids being handled is necessary to help ensure long-term system operation and integrity. Installation checklists provide a convenient method of planning and documenting work.

1.8 Unexpected Conditions. Even a well-planned underground storage system may require revision during construction. For example, if soil tests are not available, the installer may encounter an unexpectedly high water table that will require anchoring of the tanks. Through consultation with experienced installers, the owner can anticipate the range of contingencies that might occur.

Again, by way of example, an installation plan may call for replacement of only one of several tanks at a jobsite. As the excavation progresses, however, deterioration may be discovered, making it advisable to replace other tanks in the same field.

Experienced installation personnel can anticipate, detect and adapt to these unexpected conditions.

1.9 Corrosion Concerns. Corrosion of certain metals exposed to diesel- and/or ethanol-blended fuels or vapors has become problematic in recent years in all types of underground storage tank (UST) systems. Refer to Appendix C for further guidance and information regarding this topic.

1.10 Regulations. Storage systems discussed in this recommended practice are usually regulated by federal, state or local agencies. While the general requirements of the regulations are similar, specific requirements may vary from jurisdiction to jurisdiction. PEI has not attempted to specify, override or interpret specific regulations by publication of this document.

All owners should ensure that the equipment to be installed meets all applicable regulatory requirements before beginning an installation. Consult the local authorities having jurisdiction (AHJs) before storage system plans are finalized or construction is initiated. Approvals may also be required from building code officials, environmental agencies, zoning boards, fire marshals or similar authorities.

2. MATERIALS HANDLING

2.1 Care in Handling Tanks. Although steel tanks and fiberglass-reinforced plastic (FRP) tanks are designed to withstand normal handling, they can be damaged during transportation or installation. Tanks must not be dropped, dragged or handled with sharp objects and, except for minimal movement necessary for inspection and testing, should not be rolled. If the tank is damaged, it must be repaired in accordance with the manufacturer's instructions.

WARNING: Handling tanks presents many safety considerations and should be conducted in accordance with 29 CFR Part 1926.753.

2.2 Unloading, Lifting and Lowering. The proper way to move a tank is by lifting it, using the lifting lugs installed by the manufacturer. Tanks should be carefully lifted and lowered using cables or chains of adequate length. When two lifting lugs are used, the angle between the lifting cable and vertical should be no more than 30 degrees. (See Figure 2-1.) Use a spreader bar where necessary. Maneuver tanks with guidelines attached to each end of the tank. If tanks must be relocated on a jobsite during installation, lift rather than roll them. Before any attempt is made to move tanks, establish that hoisting equipment has sufficient capacity and reach to lift and lower tanks without dragging or dropping.

WARNING: Never place chains or cables around the shell of the tank.

2.3 Tank Storage. Locate tanks in a secure area where the chance of accidental damage or vandalism will be minimized. Free the area from rocks and foreign objects that might cause damage. Chock tanks until ready for installation and, if high winds are expected and tanks could move, tie them down with at least ½-inch diameter nylon or other suitable rope secured to stakes of a size and number adequate for restraint.

2.4 Piping and Equipment Storage. Stockpile piping materials and equipment in a secure area on the jobsite, away from excavations, work areas and walkways. Take care to prevent any damage that could result in leakage or accelerated corrosion after installation.

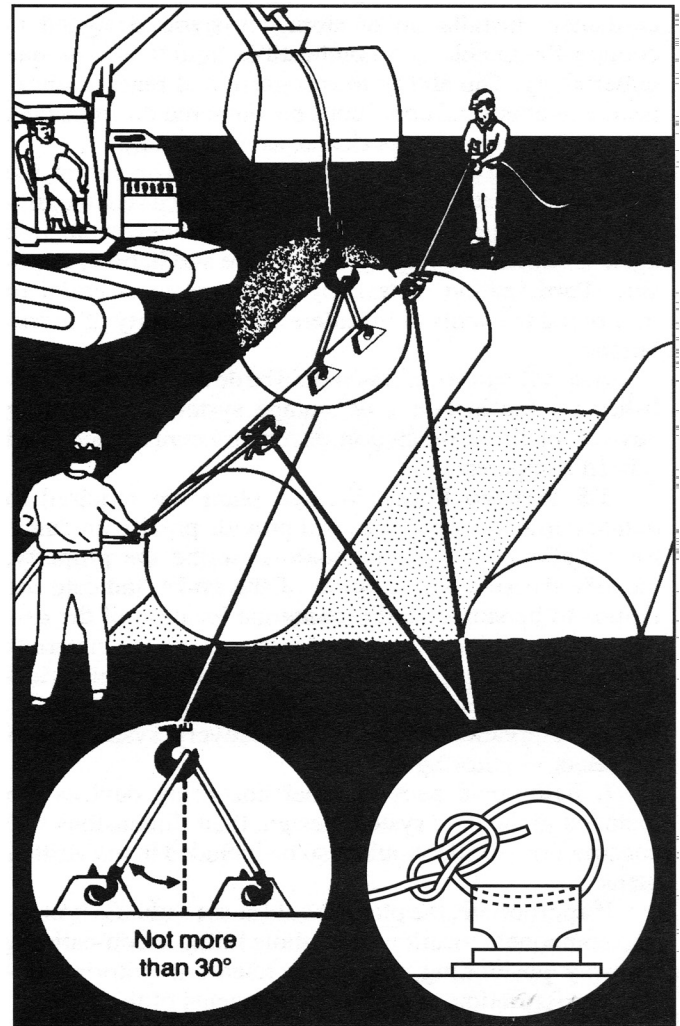


FIGURE 2-1. Handling tanks. Cables and chains should be attached to lifting lugs, and guidelines should be used to control movement of the tank. Equipment used for handling tanks must have sufficient capacity to lift and lower the tank without dragging. **NEVER PLACE CHAINS OR CABLES AROUND THE SHELL OF THE TANK.**

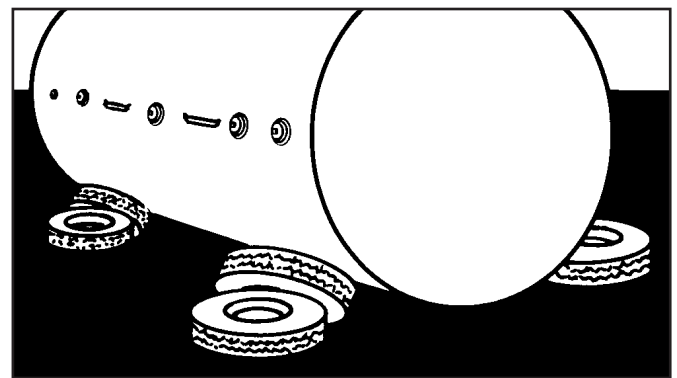


FIGURE 2-2. Storage and handling of tanks. Good project management includes the assignment of storage areas to minimize relocation of tanks and equipment as work progresses. Tanks require protection from rolling, accidental contact damage and vandalism.

3. PREINSTALLATION INSPECTION AND TANK TESTING

3.1 Preinstallation Inspection. Visually inspect tanks, equipment and piping materials before installation. Confirm adherence to specifications, report to the owner any detected damage that could result in leakage or premature corrosion and, if applicable, repair damage in a manner approved by the manufacturer.

3.2 Preinstallation Tank Testing. Remove, apply sealant to and reinstall factory-installed steel or cast iron plugs, taking care not to cross thread. Replace metal or plastic thread protectors with liquid-tight steel or cast iron plugs. Pressure test single-walled tanks with 3- to 5-psig air pressure, soaping all surfaces, seams and fittings while inspecting for bubbles.

WARNING: Air testing with over 5 psig (3 psig for 12-foot diameter fiberglass-reinforced plastic [FRP] tanks) is hazardous and may damage the tank. Do not air test a tank that has previously contained flammable or combustible liquids. Place warning barricades at the ends of tanks

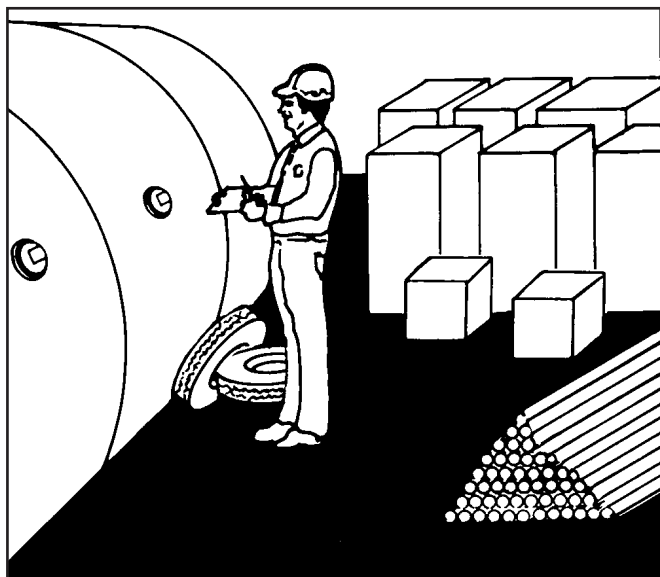


FIGURE 3-1. Preinstallation inspection. All equipment, materials, and components must be inspected before installation. Noncompliance with the specifications or detected damage should be brought to the attention of the owner and repaired or replaced, as appropriate.

being tested. Except to apply the soap solution and inspect for bubbles, avoid tank ends, manways and fittings while the tank is under pressure. Do not leave tanks that are under test unattended. Release pressure in the tank before disconnecting any gauges or test fittings. When testing double-walled and/or compartmented tanks, follow manufacturer procedures for correct sequencing of the pressurization and depressurization of containment and annular spaces.

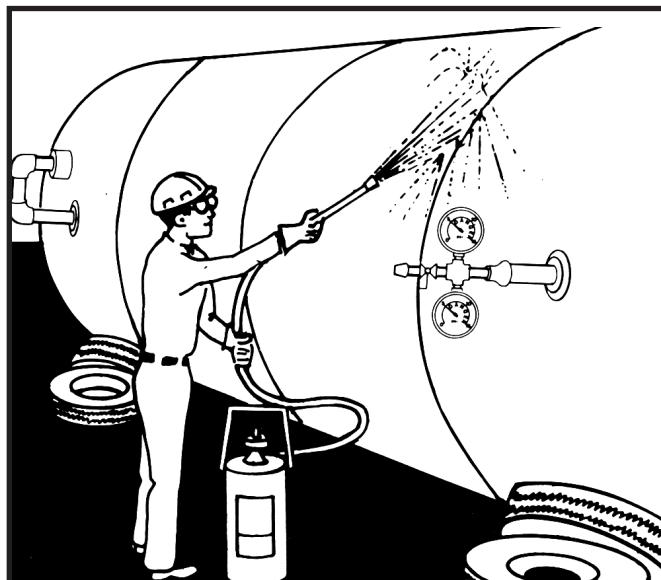


FIGURE 3-2. Preinstallation pressure test. Pressure test primary tanks at 3 to 5 pounds per square inch gauge (psig). Soap all surfaces, seams and fittings while carefully inspecting for bubbles. **NEVER TEST AT PRESSURES OVER 5 PSIG.**

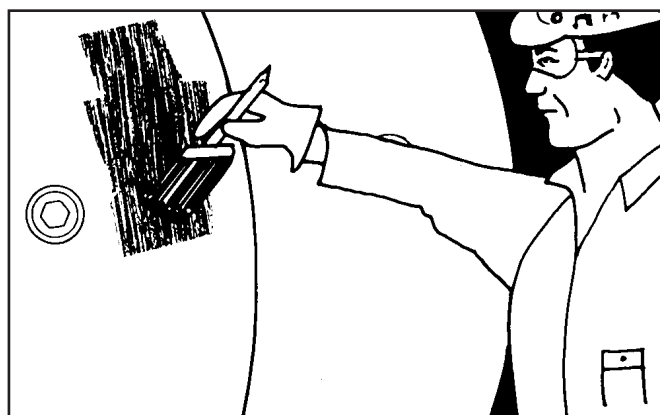


FIGURE 3-3. Field repairs. Field repairs are permitted by some manufacturers, provided the person making the repairs has been trained and qualified and does the work in accordance with the instructions of the manufacturer.

Comments

- Because manufacturer field test requirements vary, methods employed should comply with a specific manufacturer's instructions.
- Be aware that some tank manufacturers do not tighten fittings to allow for temperature changes during shipping and storage.
- Air tests are inconclusive without soaping and careful inspection for bubbles. Apply the soap solution uniformly with a mop or spray.
- Care in selecting the proper gauge for air testing is essential. Gauges must have a scale that will permit detection of small changes in pressure that might go undetected on gauges with a broader range. Since the best accuracy of gauges is at mid-range and test pressures must not exceed 5 psig, use a gauge with a maximum limit of 10 or 15 psig. Check gauges for operation and accuracy before use. The accidental use of vacuum gauges on pressure tests has caused serious accidents.
- Use two gauges to reduce the chance of over-pressurizing the tank due to gauge failure.
- Use a pressure relief device to prevent over-pressurization that may result from temperature

changes. The device should have sufficient capacity to relieve the total output of the air source at a pressure of not more than 6 psig.

3.3 Preinstallation Testing of Double-Walled Tanks.

To prevent damage from over-pressurization of the interstitial space between the tank walls, use the following procedure.

1. Pressurize the inner tank to a maximum of 5 psig. Seal the inner tank and disconnect the external air supply.
2. Monitor the pressure for a period of 1 hour. While air tests are generally inconclusive without soaping and careful inspection for bubbles, this step is recommended to detect a very large leak in the inner tank and to prepare for the next step.
3. Pressurize the interstice with air from the inner tank. Use a third gauge for measuring pressure in the interstice. (See Figure 3-4.)
4. Soap the exterior of the tank and inspect for bubbles while continuing to monitor the gauges to detect any pressure drop.
5. First release pressure in the interstice, then release pressure in the primary tank.

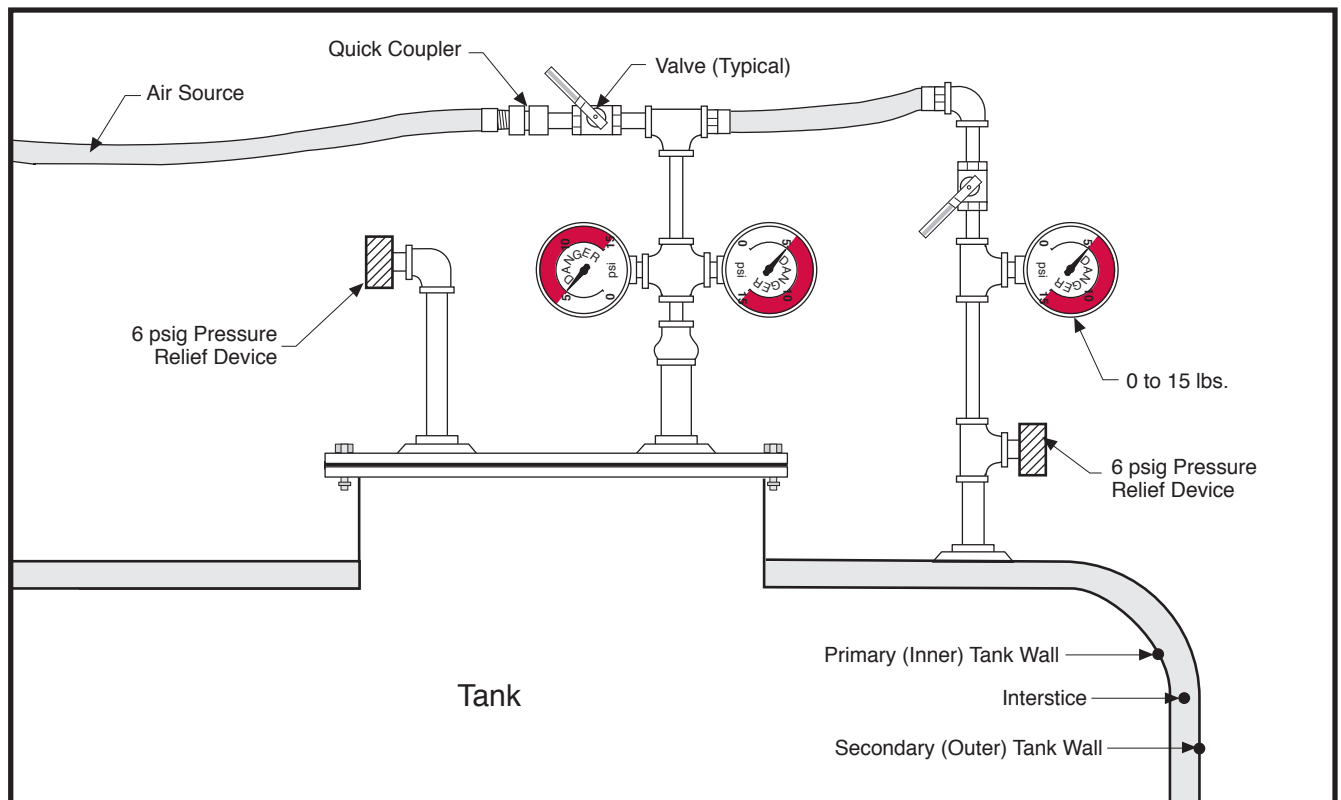


FIGURE 3-4. Air testing double-walled tanks. Pressurizing the interstice with air pressure from the inner tank, after disconnecting the outside air source, prevents over-pressurization. The manifold illustrated above is a useful method for accomplishing this.

WARNING: Pressurization of the interstice directly from an outside air source is dangerous and strictly prohibited. Never enter the inner tank while the interstice is under pressure. Release pressure in the tank and the interstice before disconnecting any gauges or test fittings.

Comments

- The capacity of the interstice is very small in relation to the capacity of the primary tank. Compressors commonly used for testing can over-pressurize the space in seconds, causing serious damage to the tank.
- A slight decrease in pressure in the inner tank may occur when the interstice is pressurized. A pressure drop of 0.3 psig or less is typical.
- The space between the inner and outer tank walls is variously referred to as the “annular space,” “annulus,” “interstitial space” or “interstice.” “Interstice” appears to be the most accurate term, and it is used throughout this text. The primary containment vessel is referred to as the “inner tank” and the exterior of the tank as the “outer tank.”

WARNING: Manufacturers field test requirements vary. At a minimum, methods employed should comply with a specific manufacturer’s instructions.

3.4 Preinstallation Testing of Compartmented Tanks. If a compartmented tank has single-walled bulkheads, test the compartments on different sides of the same bulkhead at different times. If the compartmented tank has double-walled bulkheads, compartments may be tested at the same time.

3.5 Alternative Interstice Tests. A tank shipped with a liquid-filled interstice, or with an interstice on which a vacuum is drawn, need not be subjected to the preinstallation air/soap test described in Sections 3.2 and 3.3, provided alternative test or inspection methods prescribed by the manufacturer are employed.

Comment

Alternative test procedures may not test primary tank openings, manways and risers. These should be tested at some point during the installation.

3.6 Double-Walled Tank With Liquid-Filled Interstice. Carefully inspect interior and exterior surfaces of a tank shipped with a liquid-filled interstice for signs of leakage. Check the level of liquid in the interstice reservoir. If the manufacturer’s recommended test procedure for a liquid-filled interstice includes air testing the inner tank, monitor the reservoir for the presence of bubbles as the air test proceeds.

3.7 Double-Walled Tank With Vacuum on Interstice. A double-walled tank shipped with a vacuum on the interstice need not be subjected to an air/soap test, provided the tank arrives at the installation site with the vacuum level within limits designated by the manufacturer and the manufacturer’s installation instructions specify that the vacuum reading may be used instead of an air test. If the vacuum level has changed significantly, consult the tank manufacturer.

WARNING: Factory-supplied vacuum levels and gauge operability should be verified prior to acceptance of tank delivery.

4. EARTHWORK

4.1 Earthwork. The excavation should provide adequate space for the tanks, piping and associated equipment, and for the placement and compaction of backfill materials, particularly under the circumference of the tank shell and ends. The slope of excavation walls is determined by soil conditions, depth of the excavation, shoring requirements and, if workers are required to enter the excavation, safety considerations. Prevent surface water from entering the excavation by constructing an earthen berm or other means.

WARNING: Determine the location of overhead and underground utilities before excavating.

Comments

- Consider the following factors in determining the size, shape and depth of the excavation:
 - tank manufacturer's installation instructions;
 - stability of the soil;
 - requirements for compacting bedding and backfill;
 - space for placing associated equipment;
 - depth of cover.
- Minimize problems by tightly scheduling critical phases of the work, including:
 - layout;
 - paving removal and excavation;
 - preparation of the base for the tanks;
 - setting the tanks and other system components;
 - backfilling and compaction to the top of the tanks;
 - piping, electrical and equipment installation;
 - completion of backfilling;
 - paving.

Factors that aggravate excavation problems include groundwater and surface water, unstable soil, adjacent backfilled areas, frost, presence of released product and vibration. Problems resulting from unstable soil or the infiltration of water may require the removal of tanks that are already set in order to clear fallen materials, or to correct tank movement caused by settlement or flotation. If such an event occurs, consult the tank manufacturer.

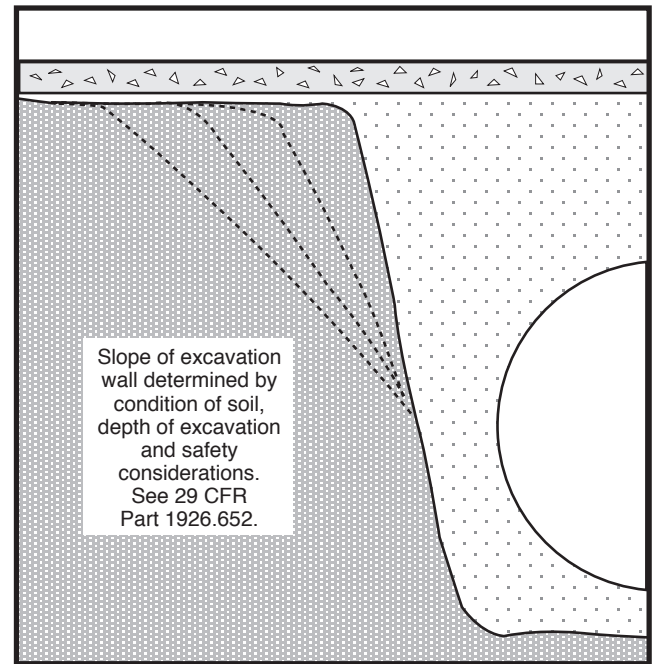


FIGURE 4-1. Excavation. Typical excavation considerations include the stability of the soil, tank bedding and backfill requirements, space for components, manufacturers' recommendations and safety. Cave-ins require more backfill, because fallen materials cannot usually be reused as backfill.

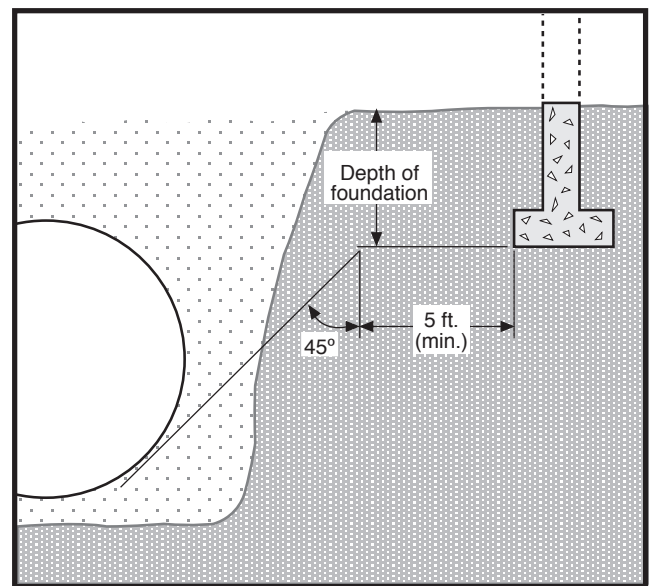


FIGURE 4-2. Clearance from existing structures. Care must be exercised to avoid undermining nearby structures during construction or afterward, permitting transfer of foundation loads onto the tank. The 45° factor illustrated will accomplish this in most cases.

An excavation that has caved in will require additional backfill because the materials that have fallen into the excavation typically cannot be used as backfill.

4.2 Location of Excavation. Excavation for underground tanks should be made with due care to avoid undermining foundations of existing structures. In the absence of local building codes or regulations, use the minimum distance to the base of adjacent structures or property lines depicted in Figure 4-2. Additional distances may be required to ensure that downward forces from loads carried by the foundations and supports are not transmitted to the tanks.

4.3 Excavation Depth, Bedding and Backfill. The total depth of the tank excavation is determined by the tank diameter, bedding thickness, hold-down pad (if required), depth of cover, and slope and length of piping. Much of the tank's support is derived from compacted backfill material, which permits the downward forces present to be dissipated uniformly over a large area. To provide a firm foundation, set the tank on a bed of backfill material 1 foot thick that extends 1 foot beyond the ends and sides of the tank. Place at least 2 feet of backfill between adjacent tanks and between tanks and excavation walls.

Steel tank manufacturers specify that when a bottom hold-down pad is used under a steel tank, the thickness of bedding material between the tank and the pad can be reduced to 6 inches.

WARNING: Placement of a tank directly on a hold-down pad, on a pad smaller than the total tank area or on intermediate supports (saddles) will cause uneven distribution of loads. This may contribute to structural failure and is never permitted.

4.4 Cover in Areas Subject to Traffic. In areas that are subject to vehicle traffic, cover may consist of at least 30 inches of compacted backfill and 6 inches of asphaltic concrete, or 18 inches of compacted backfill and 6 to 8 inches of reinforced concrete. Paving over tanks in traffic areas should extend at least 1 foot beyond the perimeter of the tank.

Comment

At most facilities, fully loaded transports can be expected to pass over the tank area. While some authorities require a minimum of 6 inches of reinforced concrete paving, at least 8 inches is recommended.

4.5 Cover in Areas Not Subject to Traffic. Cover in non-traffic areas should be at least 2 feet thick and consist

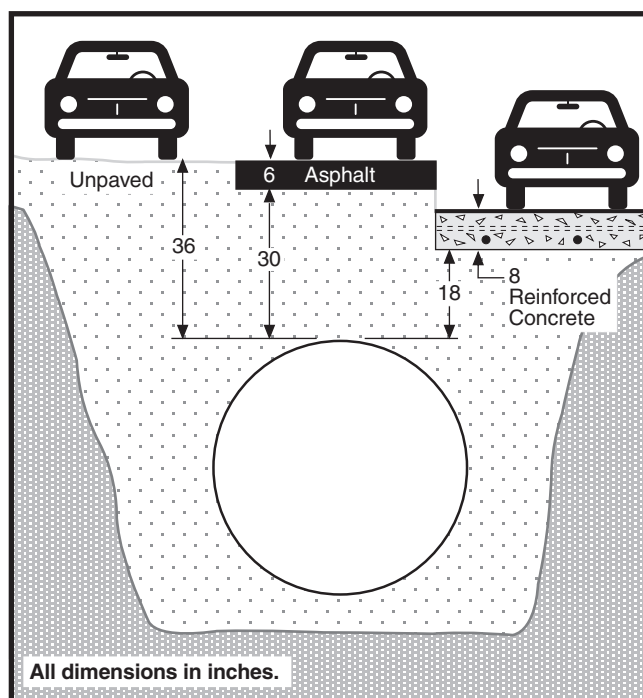


FIGURE 4-3. Depth of cover in areas subject to traffic. The majority of tanks are located in areas that are subject to vehicle traffic. Backfill helps dissipate traffic loads and offset buoyancy.

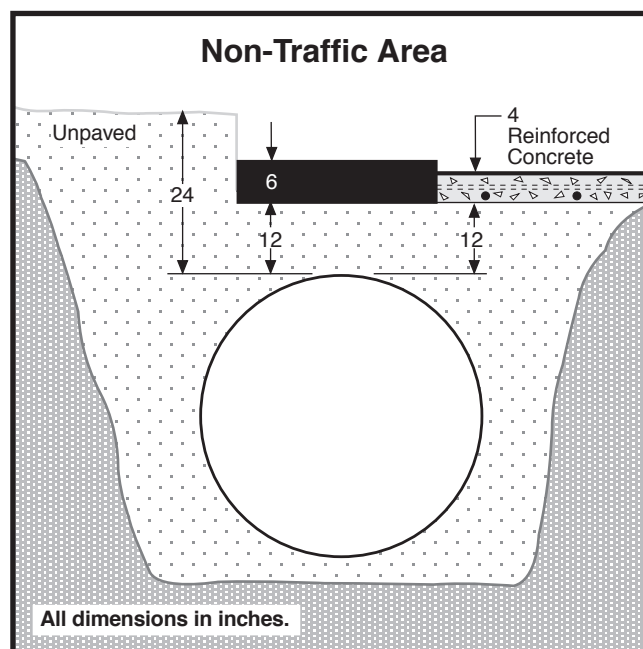


FIGURE 4-4. Depth of cover in areas not subject to traffic. In areas that are not subject to vehicle traffic, cover requirements may be reduced. However, a reduction in cover depth may not prevent tank floatation if groundwater or surface water enters the excavation during flooding events.

of a minimum of 1 foot of backfill covered by filter fabric to prevent migration and a minimum of 1 foot of earth. An acceptable alternative is 1 foot of backfill material and at least 4 inches of reinforced concrete or 6 inches of asphalt paving.

4.6 Maximum Burial Depths. Maximum burial depths, measured from the top of the tank, are established by tank manufacturers and independent testing laboratories.

Seven feet is the standard maximum burial depth for fiberglass tanks. Consult with the fiberglass tank manufacturer if a deeper burial depth is required.

Five feet is the typical burial depth for steel tanks. The maximum burial depth for each steel tank is marked on the tank.

The planned burial depth should not exceed the manufacturer's recommendation.

4.7 Handling of Excavated Material. Excavated material that cannot be immediately removed from the site should be safely stockpiled at least 2 feet away from the edge of the tank excavation. Unless approved for use as backfill, keep excavated material separate from approved backfill material and remove as soon as practical.

4.8 Work Area Safety. Keep work areas clear of stockpiled materials. In areas with unstable soil, if per-

sonnel are required to enter the excavation, slope or shore excavation walls. Barricade work areas to protect both the public and installation personnel and to prevent accidental damage from vehicles and equipment. Members of the installation crew should wear personal protective equipment and have fire extinguishers and first-aid supplies on hand.

Comment

Excavation safety requirements are defined in U.S. Department of Labor 29 CFR Part 1926, Subpart P.

4.9 Excavation of Used Tanks. Used underground tanks should be made safe before removal. Product retained in the tank and piping, as well as released product, should be recovered, removed and disposed of in an approved manner. Monitor tanks frequently during removal because, even after the tanks have been completely emptied, liquid can reenter the tank. There is significant danger of fire or explosion due to the existence of vapors in the tank or the reentry of oxygen or previously released product into the tank.

Comment

These procedures are covered in detail in American Petroleum Institute's (API's) Recommended Practice 1604, *Removal and Disposal of Used Underground Petroleum Storage Tanks*, Third Edition, March 1996; Reaffirmed November 2001.