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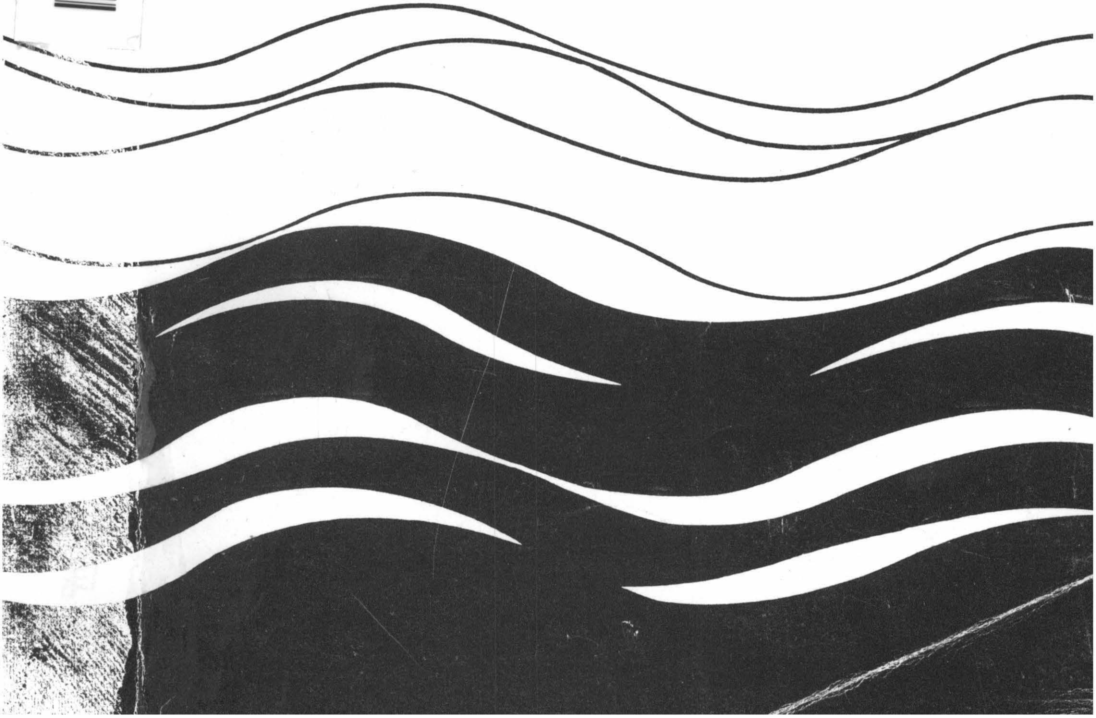

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# Underground Storage Tank Disposal: Alternatives, Economics, and Environmental Costs

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## ABSTRACT

Alternative technologies are examined for the disposal of disused underground storage tanks that once contained petroleum products or other hazardous chemicals and the effects of hazardous waste laws on disposal are discussed. Disposal options for the large population of old vessels are considered in terms of currently required and available technologies, the benefits and problems associated with various strategies, and the means available to a tankowner for utilizing these options through either a full or partial contracting of commercial services. Actual disposal costs charged by firms offering the service in or near Virginia are compared and the environmental impacts associated with cleaning wastes and tanks discarded according to each strategy are addressed. Additional information about pertinent regulations and the characteristics of the national UST population are provided in the Appendices.

**Key Words:** Underground Storage Tanks, Abandonment, Removal, Disposal, Costs, Environmental Impacts, Resource Conservation and Recovery Act, Comprehensive Emergency Response, Compensation, and Liability Act.

# INTRODUCTION

The disposal of old and unwanted underground storage tanks (USTs) used to be handled in a relatively straightforward, if somewhat environmentally, questionable manner. It has become more problematic as both the number of tanks requiring disposal and the regulations affecting the practice increase. Recent legislative and media attention on the dangers and probabilities of leaks from aging tanks has resulted in greater awareness among tank owners of the need for sound storage systems. However, the uncertainty regarding future regulations as well as the expense of complying with current requirements has created a dilemma over the appropriate "final fate" of vessels already taken out of service. To many, it seems that the puzzle of final disposal gets bigger while the solutions become fewer; while not entirely accurate, this view illustrates the need for a thorough understanding of both the sources of the problem and the options available to deal with it.

This report illustrates the dynamics of the problem by describing changing disposal technologies and the characteristics of the commercial disposal market under the strictures of current regulation. Information was gained from both the literature and extensive discussions with representatives of government, industry, and the associated trade unions. The reasons for the large population of old vessels are explained and the effect of hazardous waste laws on disposal considerations is briefly described. Disposal options are explored: the currently required and available technologies; the benefits and problems associated with various strategies; and the means available to a tank owner for utilizing these options, through either a full or a partial contracting of commercial services. A summary of actual disposal costs, as reported by commercial firms in or near Virginia, is presented and the environmental costs associated with cleaning wastes and tanks discarded according to each strategy are addressed. Additional information about pertinent regulations and the characteristics of the national UST population is provided in the Appendices.

## THE PROBLEM

At the aggregate level, the current situation can be seen as the result of two somewhat related components: an unusually large number of tanks that now or soon will require disposal, and a strict and expanding set of hazardous waste regulations that tend to reduce, at least in the short term, the variety of disposal options available. A number of factors contribute to the increase in out-of-service vessels; while institutional incentives for proper closure have always existed in some form, a wider recognition of their potential impact combined with disturbing new statistics about the current tank population have emphasized the need for prompt attention to the disposal question.

Important reasons for tank closure include:

**Tank Age:** With an average non-leaking lifespan of about 15-17 years (U.S. EPA 1986), many of the tank systems (tanks plus piping) that were installed during the growth decades of the 1950s and '60s have now reached or exceeded the end of their serviceable lives. Although the risk of leakage from corrosion increases considerably with age, poor installation, the storage of incompatible liquids, or other errors can cause releases in as little as five years. While many older tanks have already been closed in some way, those remaining on site still present an environmental liability that many owners seek to avoid through removal and off-site disposal.

**Liability:** As an increasing number of court cases has shown, tank owners remain financially liable for damages resulting from spills or releases from their facilities, regardless of whether they were aware of the release or the tank was currently in service. Liability is reduced or often eliminated if tanks are removed and properly disposed of off-site.

**Current or Pending Regulation:** Federal legislation passed in 1984 required all owners of UST's to notify designated officials (in Virginia, the State Water Control Board) of the existence and location of their tanks. For many owners, this was incentive to pull up their old tanks before the May 7, 1986, registration deadline. The cost and difficulty of subsequent disposal has resulted in many tanks being left in temporary storage above ground until owners become able or are required to proceed with final disposal. Those who did not pull their vessels may be unwilling to do so until the regulations oblige them to; these regulations will soon be promulgated and the number of owners in this position is thought to be quite large. The possibility of a fee being levied on all underground tanks, whether in service or not, provides additional incentive for their removal. Table 1 provides a breakdown of the UST population by industrial sector.

**Insurance Requirements:** Old tanks present a lasting liability, and thus are costly and difficult to insure. Because insurance premiums are based partially on the condition of the tanks and can run as high as $2,500/year for even a new system, it is generally in the best interest of the owner to remove unused tanks that may increase premium rates further or even make insurance impossible to obtain. Since upcoming regulations will require owners to carry insurance for sudden and non-sudden releases of stored material, the early removal of abandoned tanks may help tank owners obtain coverage at the lowest possible cost.

**Property Value:** Because of the environmental and financial risks associated with buried tanks, an abandoned vessel may have a negative effect on the economic value of the property on which it is buried. Current Virginia law recommends that records be kept of the location of the tank and passed to new owners of the property; some states require that it be written into the property deed. Because of liability and restrictions on subsequent land use, even a properly closed vessel remains a constraint.

**On-Site Dangers:** While the cost of proper disposal is high, the dangers and liabilities of improper closure are becoming increasingly apparent. A poorly closed on-site tank can be used for illegal storage or disposal, or accidentally filled with an incompatible substance, or re-used for storage of potable water or other consumable liquids. In addition, the explosive nature of tank fumes present a continuing danger: individuals unaware of the tank's presence may light matches near the vent pipe or contractors may accidentally hit the tank with heavy equipment during excavation, causing sparks and the release or igniting of flammable gases. An unfilled or improperly filled tank is also subject to collapse, causing fracture or subsidence of the overlying surface (N.Y. Department of Environmental Conservation 1985).

Once the decision is made to close a tank, state and federal statutes can have a strong influence on the choice and implementation of disposal strategies. State laws, which include building codes, stipulate recommended procedures and notification requirements, and specifically restrict the abandonment of tanks to limited situations. Of more importance are the federal laws governing hazardous waste management; since the sludge occasionally found in the bottom of motor fuel and oil tanks often proves to be hazardous because of ignitability or a high lead content according to federal definitions, tank owners and cleaners must follow procedures more complex and usually more expensive than those previously acceptable.

Two federal acts have particular relevance to underground tank disposal. EPA's Resource Conservation and Recovery Act (RCRA), administered in Virginia by the Dept. of Waste Management, is the primary federal act governing both the handling of hazardous industrial waste and the promulgation of standards for new and existing underground storage tanks. Under the tenets of RCRA, any hazardous waste generated during the cleaning process and shipped off-site for disposal must be: 1) "manifested", that is, accompanied by an EPA document that verifies proper transport and disposal; 2) transported only by a company in possession of an EPA identification number; and 3) treated and disposed of only at a facility also specifically permitted for hazardous waste management. For some tank owners, this complicates the disposal process since they may no longer transport unclean tanks on their own vehicles or take uncleaned tanks to sanitary landfills or industrial ones not permitted for hazardous waste disposal unless the tank contents are verifiably non-hazardous. It must be noted that some sanitary landfill operators who are unaware of the current laws may still accept underground tanks, but this is not likely to continue.

The second pertinent federal act is the Comprehensive Emergency Response, Compensation, and Liability Act (CERCLA, or Superfund), which holds that tank owners, as the "generators" of the waste, are ultimately responsible for any environmental damage caused by toxic residues ("strict liability") regardless of when it occurs or in whose possession the waste happens to be at the time; although liability is shared among the involved parties, owners are not entirely freed of responsibility when they give their tank to a professional firm for disposal. Thus, financial liability can serve as an effective incentive for tank owners to follow recommended disposal procedures.

However, while financial liability may be an incentive for compliance by tank owners, it is often a disincentive for disposers not accustomed to or permitted for the handling of hazardous materials. An example of this is the metal recycling industry. Whereas scrap metal processors formerly would purchase tanks that were simply safe to handle and free of contaminants to subsequent steelmaking, the fact that they can now be held liable for the contents of the tanks they buy has made many unwilling to run the risk by accepting USTs onto their property. The Institute for Scrap Iron and Steel (ISIS), which represents the industry, advises its members not to buy tanks unless they are certified clean and lead-free, suggesting that the loss of business may be preferable to the legal risk presented by an unclean tank. Yet the cost of such cleaning — typically $350-$400 for a 5,000 gallon tank — is many times the value of the scrap steel ($25-$125), and recyclers report that few owners choose this option, although it is generally considered the most environmentally sound one.

Although both Acts have other widespread effects, the points briefly outlined here are those having the greatest impact on tank closure and the choice of disposal technology must now be considered and evaluated in light of these regulations as well as against the standard criteria of technical effectiveness and cost. Disposal options that are no longer easily available, such as sanitary landfill, are those least acceptable from both the environmental and the public health standpoints; while the present alternatives may be more expensive, they provide a more effective solution to the problem. The following sections of this report describe in detail the state of these technologies and the ways in which tank owners can acquire proper service.

## THE OPTIONS

### I. Disposal Technologies

The available means for underground tank disposal are represented by a well-established set of technologies operating within tight and changing regulatory and industrial constraints. While innovative developments have refined some aspects of cleaning waste treatment and disposal, the available options for underground tank disposal consist of two general sequences, defined here as strategies: 1) abandonment-in-place; and 2) tank removal, followed by either landfilling or recycling. Although differentiated largely by the final disposal location or treatment of the used vessel, both are preceded by a certain amount of tank conditioning consisting of pumping, cleaning, vapor-freeing, and any other necessary steps. The dangers of the procedures, the relative inaccessibility of the tanks, and the strict requirements for waste management make the operation fairly expensive, and generally necessitate the use of experienced, specialized disposal firms.

Both abandonment and removal have been defined by various trade and representational organizations to include certain standard procedures that, when coupled with the waste management requirements of RCRA legislation, provide an apparently straightforward sequence of operations. However, since these recommended procedures vary somewhat among organizations and do not all carry the force of law, an understanding of the purpose and function of each step as well as the comparative qualities of the strategies they produce is an important first step in assessing the capabilities of both the private tank owner and the commercial disposal industry.

#### A. Tank Conditioning

Most forms of disposal (with the exception of a hazardous waste landfill, in some cases) require that the tank be emptied and cleaned to an extent, depending on the final disposal site of the closed vessel. For all tanks, excess product must be pumped out and the interior space rendered gas free; sludge, if found, must be removed and disposed of according to RCRA regulations for all tanks except those destined for a permitted hazardous waste landfill. Recycling usually requires, further, that the metal in contact with the sludge be scraped clean and that any scale or rust also be eliminated.

As a potentially hazardous waste, petroleum sludge — particularly that from leaded gasoline — is often the most problematic of the usual storage tank-cleaning wastes. Consisting of a combination of insoluble deposits wetted with water and hydrocarbons containing organic lead, the material is considered hazardous because of its high content of lead or other toxic elements and must be disposed of in a manner that will either prevent the mixture from entering the environment or will convert the organic lead to a less toxic inorganic form. Sludge formation is a highly variable phenomenon dependent on such factors as the quality and throughput of product; presence of water; and degree of previous tank maintenance and, as a result, does not occur in many cases. When sludge is present, however, it is important that it be kept separate from other waste liquids since their combination may cause the whole mixture to be classified as a hazardous waste.

1. Cleaning

Tank cleaning is preceded by a thorough removal of the excess product, usually accomplished by a vacuum truck or — if no sludge is present — by filling the tank with water and pumping the floating product off the top. For tanks that have been removed from the ground and/or can be entered, sludge can be collected manually by individuals inside the tank provided that vapors are reduced to safe levels and proper protective clothing and respiratory devices are used. Although some mixing of sludge and product is inevitable during external pumping, once the sludge clearly becomes the predominant component it should be diverted to suitable hazardous waste containers and handled accordingly; since it has different characteristics from the petroleum supernatant, it usually requires different treatment. Properly drummed, this sludge may be left on the site for up to 180 days before removal and disposal.

Tanks that contained unleaded gasoline or those free of sludge and scale from leaded gasoline, generally require no further cleaning. For tanks that do require cleaning for any reason, however, three technologies are available: commercial steam cleaning, sandblasting or abrasion cleaning, and chemical treatment.

Steam cleaning, usually carried out in centralized facilities because of the requirements for specialized equipment and good runoff collection, uses the abrasive action of high pressure, high temperature steam to dislodge sludge and scale from tank walls. In one steam cleaning operation, the empty, vapor-free tank is transported to the site and punctured if no holes exist already. During cleaning, a hose that has been inserted through one of the holes and anchored, violently discharges 400° steam at 300 psi; the thrashing of the hose under pressure ensures that the internal surfaces are uniformly subjected to the scouring action of the high-velocity steam. Excess product and dislodged sludge and scale flow out of the holes, with the potentially hazardous material then separated from the rinsewater and eventually manifested and treated according to RCRA regulations. After a final vapor check, the tank can be safely cut up and is sufficiently clean to be salable to a scrap metal dealer.

Sandblasting or other forms of abrasion cleaning may occasionally be necessary for tanks with resistant deposits or those that have linings or coatings. If tanks can be entered, scraping can be done by hand with a stiff wire brush; otherwise pressurized sand or other abrasive material may be necessary.

A third technique for tank cleaning currently marketed by a firm in North Carolina involves the use of a nitric acid rinse to chemically leach lead from scale and rust adhering to the inside of vessel walls. In this process, ventilated tanks are drained of residual product and sludge before being exposed to the strong acid solution, which is followed by a final retesting of the steel for lead contamination to ascertain the effectiveness of the treatment. In most cases, the steel is sufficiently free of lead to go to a scrap dealer without further cleaning.

2. Vapor-freeing

Because of the explosive and toxic nature of gasoline fumes, their removal constitutes a particularly important aspect of tank disposal (American Petroleum Institute 1985). For the purposes of preventing explosion, fume concentrations must be either below the "lower flammable limit" of 1 percent hydrocarbon vapor by volume in air, the point at which the mixture is too lean to propagate flame, or above the upper limit of 10 percent, where it is too rich. Because of local variations in concentrations the minimum value is preferred, with a 90 percent safety margin; for gasoline, a 0.1 percent vapor level is thus considered safe for torch work. However, this level is still toxic and requires the use of protective equipment. For sustained work inside the tank, levels should be reduced to below the threshold limit value (TLV), the concentration below which most individuals will not suffer adverse health effects from the inhalation of fumes.

Three methods are recommended by the American Petroleum Institute (1981) for the removal of vapors from storage tanks. They are:

> i Inert with carbon dioxide (dry ice). Crushed dry ice is distributed evenly on the bottom of the tank, and forces out flammable fumes and oxygen as it vaporizes. Contractors surveyed for this report said this method was the most commonly used.
>
> ii. Forced ventilation with air. A small gas exhauster operated with compressed air is connected to an opening at one end of the tank and will draw air in through a suitable opening provided at the other end. The vapor concentration in the tank can be checked with a combustible gas indicator (CGI) to determine when the tank is gas-free.
>
> iii. Fill with water. As the tank fills, flammable gases will be expelled through other openings. The contaminated fill water is then disposed of in an appropriate manner. (Note: because of the large amounts of contami-

nated wastewater generated, API is reconsidering its recommendation of this method.)

With all methods, expelled fumes will tend to accumulate near the ground in the vicinity of the tank, posing a significant safety threat and requiring that all possible sources of ignition be eliminated from the work area. After degassing, the vapor concentration in the tank can be checked with a CGI to determine if additional treatment is required. Because tanks with any residual product in them will tend to quickly resaturate the vapor space, the interior should be rechecked before initiating torchwork.

B. Abandonment in Place

Abandonment in place is a relatively straightforward means of disposal that avoids the expense and difficulty of tank removal and transportation off-site. Although obviously involving the commitment of land to long-term storage of the out-of-service vessel, it is often the disposal strategy of choice in those cases where removal is difficult, unsafe, or otherwise unsuitable.

According to the National Fire Protection Association (NFPA) Fire Codes (1986), on-site tank closure should consist of the following four steps:

1. Remove all liquid from tank and connecting lines.

2. Disconnect suction, inlet gage, and vent lines.

3. Fill completely with an inert solid material. Cap remaining vent lines.

4. Keep a record of tank size, location, date of abandonment, and method used for placing tank in a safe condition.

These codes are referenced into the Virginia Uniform Statewide Building Codes and, as such, apply as law to all Virginia localities. A more complete description of the process is provided by the API's Bulletin No. 1604 and includes the following steps:

1. Drain and flush the piping contents into the tank.

2. Remove all flammable liquid which can be pumped out. The use of a hand pump may be necessary.

3. Dig down to the top of the tank. (Note: this step may not be necessary if the tubes can be securely plugged from the surface.)

4. Remove the fill tube. Disconnect the fill, gauge, and product lines, and cap or plug open ends of lines which are not to be used further. The vent line should remain open until the tank is filled.

5. Fill the tank to overflowing with water to purge off all product. Siphon off the floating product into a suitable container for disposal, and continue filling to overflowing. This step serves to both purge the tank of vapors as well as remove excess product, but generates large quantities of contaminated rinsewater. If the use of water is impractical or undesirable, vapors may also be purged by adding crushed dry ice (carbon dioxide) to the empty tank (see *Tank Conditioning*). If sludge is present, product removal by pumping rather than water filling is advisable to prevent mixing.

6. After water has overflowed the tank, cut one or more large holes in the tank top. Pump out the water and dispose of it properly, then drive several 3/4"-1" holes in the bottom of the tank.

7. Introduce a solid, inert material through a hole in the top of the tank.

8. Disconnect and cap the vent lines.

9. Keep a permanent record of the tank location, date of abandonment, and method of conditioning the tank for abandonment. As "good business practice," new owners or operators should be informed of the presence of the tank when the land is transferred. It may be desirable to obtain an acknowledgement or release from the original property owner.

In these recommended procedures, the abandoned tank is filled with a solid material to prevent eventual tank collapse and subsidence of the overlying surface. Sand has traditionally been the filler material of choice because of its ready availability and low cost, although mixtures of sand and earth or sand and rock have also been used. Typically, some water must be added during filling to spread the mixture throughout the tank and prevent coning beneath the fill hole.

In recent years, however, alternatives to sand have been developed that offer various advantages over the use of natural materials. Although more expensive than sand and not approved for use by all states, their improved absorbancy, higher density, or other distinctive characteristics extend the range of situations in which abandonment in place can serve as an environmentally acceptable strategy. These fillers are composed of both natural and man-made materials.

*Flowable fill,* also known as lean mix concrete, controlled density fill, flowable mortar, or controlled low strength materials (ACI Committee 229), is a variable mixture of portland cement, water, and selected aggregate materials, typically fly ash and sand. Although the proportions of these components can be adjusted to achieve desired characteristics of strength and compactability, the amount of cement is comparatively small so that the finished product is neither a low-strength concrete nor a soil cement, but has properties similar to both.

The primary advantages of flowable fill for underground tank closure are its ease of handling and high density. Because the material is initially introduced as a slurry, it fills the tank evenly and completely without the use of additional liquid and leaves no residual water to promote rusting after the filler sets. In addition, the relatively high strength of the hardened fill prevents compaction and settling even after the confining walls of the tank rust away; however, excavation can still be accomplished with conventional equipment. Initial costs may be higher than natural materials, although savings in labor may help offset this. A form of concrete slurry is required and widely used in many parts of Virginia.

*Polyurethane Foam* is a light, inert material that is used where the excess weight of sand or concrete fill is undesirable. Already approved for use in some states, it is insoluble in water and most organic solvents. According to the specifications of one manufacturer, the tank should be certified clean and "gas-free" before the foam is used; however, a limited amount of absorbant material may be introduced to remove any residual condensation, water, mud, or sludge and to ensure complete filling. According to the manufacturer, the foam may be marketable as flotation material if the tank is ever exhumed; in other cases they may buy back the tank and foam themselves.

*Absorbant foams* also offer possibilities for use as filler material for abandoned tanks. One type recently developed by a Belgian firm is currently under consideration for domestic import. It is composed of a ureum and formaldehyde resin that is mixed with a hardener on-site and allowed to set within the tank. By altering the constituents of the components the foam can be made to vary in hardness and tailored to chemicals of a given specific gravity or which contain heavy metals; absorbancy is high for oil, chlorinated hydrocarbons and other organics, and a large number of additional compounds. Rather than bonding in a permanent way with the absorbant, however, these chemicals are simply soaked up as into a sponge, and while they are then resistant to flushing they can be squeezed out of the foam by compression. The pollution implications of this characteristic are as yet unknown.

Regardless of the type of material selected to fill an abandoned tank, recommended procedures still require removal of remaining product and proper disposal of residue. Cleaning and pumping techniques will be discussed later.

## C. Removal and Disposal

In most cases, local ordinances, land use imperatives, or preferred management practices necessitate the complete removal of the old tank from the site, followed either by backfilling or replacement with a new vessel. Although some of the pumping and cleaning steps are the same as abandonment, the need to excavate, elevate, and transport the tank makes this process more expensive, technically complex, and potentially dangerous. Once the tank has been withdrawn from the ground, it is either recycled at a scrap metal dealer or disposed of at an industrial or hazardous waste landfill.

### 1. Removal

Tank removal techniques are covered by both NFPA codes and API recommendations; at this point, Virginia building codes simply require the acquisition of a permit. NFPA codes define the removal process consisting of these steps:

1. Remove all flammable or combustible liquids from the tank and connecting lines.

2. Disconnect piping at all tank openings. Remove sections of connecting lines which are not to be used further and cap or plug all tank openings.

3. Remove the tank from the ground.

4. After removal, the tank may be gas-freed on the premises if it can be done safely at that location, or may be transported to an area not accessible to the public and the gas-freeing completed there.

5. For disposal, the tank should be retested for flammable vapors and, if necessary, rendered gas-free. A sufficient number of holes or openings should be made in the tank to render it unfit for further use.

As with abandonment, the API description of the same process is a more detailed set of recommended procedures similar to those covering abandonment in place. After flushing, isolating, and exposing the tank as described in steps 1-4 of that section, the procedure continues:

5. Temporarily plug all tank openings, complete the excavation, and remove the tank, placing it in a secure location. Block the tank to prevent movement. Before undertaking degassing measures, it is normally necessary to remove the tank from the ground since product which may have previously leaked into the ground could reenter the tank. Extreme caution should be used during this procedure.

6. Render the tank vapor-free (see *Tank Conditioning: Vapor-freeing*)

7. After degassing and before moving the tank from the site, plug or cap all holes, including corrosion holes. One plug should have a 1/8" vent hole to allow internal and external pressures to equalize during transport. The presence of product residues in the tank maintains a saturated air space and so reduces the flammability of the tank. (see *Tank Conditioning*).

8. Secure the tank on a truck for transportation. The 1/8" vent hole should be oriented on the uppermost point of the tank.

9. Because vapor may be released from residual liquid in the scale or sediment of the tank over time, degassed vessels should be transported promptly or rechecked for vapors after standing.

2. Tank Disposal: Recycling

For many reasons, the recycling of old steel vessels as scrap metal is the most desirable form of tank disposal. However, because of the demands of the steelmaking process it is also the form that has the most stringent standards for tank conditioning, often imposing an extra demand on the tank owner that will factor significantly in the selection of a disposal strategy. A brief examination of the factors important in metal recycling will help to elucidate the position of both the scrap metal dealer and, consequently, the tank owner.

The scrap metal industry essentially consists of two components: the processor, who buys, separates, and generally delivers scrapmetal; and the steel mills and foundries, who melt down the scrap for recasting into new products. Because of both quality controls on the finished products and stack emission limitations imposed by air pollution standards, steelmakers are fairly strict about contaminating elements in their supply of purchased scrap. Some contaminants, such as copper, tin, and nickel, will negatively affect the properties of the recast steel while others, such as lead, zinc, and aluminum will oxidize in the furnace and require removal by expensive air pollution control equipment, which in turn produces a hazardous sludge. Since steelmakers will not buy scrap that is apt to cause problems in their manufacturing process, processors must incorporate these restrictions into their specifications for metal purchased from the public.

For the petroleum tank owner, these restrictions impact on cleaning costs in two ways: linings and lead-containing sludge or scale must be cleaned from the inside of the tank, while coatings must be removed from the outside. Tetraethyl lead from leaded gasoline tends to accumulate in scale and rust deposits as well as in residual bottom sludge, so most processors require that these components be removed and the vessel surface in contact with sludge scraped down to a bare metal surface. Although some scrap processors will clean purchased metal to varying degrees on their premises, such services will result in a lower purchase price for the tank owner. Owners contemplating recycling must thus weigh the advantages of tank sale revenues and financial liability reductions against the added expense of reducing the tank to almost bare steel; however, since many older tanks are of bare steel to begin with, this factor may be of less importance now than in the future. It is interesting to note that many of the features now installed on new tanks to reduce corrosion, such as zinc anodes and epoxy coatings, will subsequently make them unsuitable for disposal as scrap metal because of excessive conditioning costs.

In addition, because of the danger involved in cutting and handling empty gasoline tanks, many scrappers require tank owners to cut up their vessels before delivery. Those who don't usually require proof that the tank has been vapor-freed of explosive fumes.

Despite these constraints, recycling as a disposal technology for underground vessels remains a viable and appropriate option, especially for uncoated steel tanks that are free of rust and scale. It should be mentioned that there is also a market for old aluminum tanks, but that the same restrictions against coatings, linings and surface contamination of the metal will apply.

3. Tank Disposal: Landfilling

In some cases, where the condition of the tank or distance to the scrap dealer discourages recycling, tank disposal by deposition in an industrial or hazardous waste landfill may be the preferred option. Although the tank then remains a rusting source of potential contamination for many years, a well-designed landfill is built to at least mitigate and contain the effects of all deposited substances, many of which are more harmful than gasoline residues. For tanks of material other than steel or that have contained substances that render the steel unsuitable for recycling, landfilling is often the only option for disposal. The requirements for tank cleaning and conditioning are rather less stringent for landfilling than for recycling. For industrial landfills (those permitted to accept industrial, but not hazardous, wastes) tanks must be drained of liquid and free of hazardous sludge; if sludge is present it must be shown by analysis to be non-hazardous. Because of space and safety considerations, operators often require that tanks be cut up or that the ends be cut off to facilitate compacting. A hazardous waste landfill will accept both the tank and the sludge, if present; an absorbant filler is often then poured into the tank to immobilize the residues and prevent collapse of the structure. Disposal fees for a hazardous waste landfill tend to be high (see *Disposal Economics*). Industrial and hazardous waste landfills are differentiated from sanitary landfills by the nature and extent of waste containment measures. In both, a layer of plastic lining material or compacted clay to reduce the movement of liquids and pollutants is a standard feature; however, industrial/hazardous waste facilities usually have additional components such as leachate collection systems, groundwater monitoring wells, and thicker layers of compacted clay. They are also more closely regulated and are supposed to be more carefully managed, in deference to the greater toxicity of the contents.

Sanitary landfills are designed primarily to handle domestic trash and limited amounts of industrial waste. Although they were commonly used as disposal sites for old underground tanks before the advent of the current waste management laws, landfill operators are now becoming increasingly wary of anything that might jeopardize their facility and result in unwanted publicity or legal problems. As a result, the availability of the sanitary landfill as a disposal option is diminishing, although some landfill owners will still occasionally accept cut-up vessels. Because of the lower level of environmental protection offered by these facilities, however, they are not generally considered an appropriate disposal location for used tanks.

A comparison of disposal strategies is presented in Table 2.

## II. Market Organization and Strategy Selection

Despite the recent changes in the waste management field that have restricted the disposal options available to tank owners, the review of the acceptable technologies illustrates that there are sufficient technological means remaining to safely close underground tanks. The greater problems are often logistical and economic for the tank owner: finding out exactly what is required; what is available; how much it will cost; and how to make the necessary arrangements. Economic estimates of the various disposal strategies will be discussed later; this section reviews the organization of the commercial disposal industry, as well as the way a tank owner might go about selecting a disposal strategy and a commercial firm to undertake it completely or partially.

### A. Preliminary Considerations

Because of the expense and potential for environmental damage associated with tank closure, a thorough consideration of all the factors bearing on the disposal decision is an important first step in the closure process. Since many of these factors are site-specific, few general statements can be made about the relative advantages of any strategy for more than a defined set of conditions.

A breakdown of the choices in disposal alternatives is shown in Table 3. Important considerations affecting the specific course of action are:

1. Local Ordinances

In Virginia, the Uniform Statewide Building Code includes sections on both tank abandonment and removal. These regulations, which apply to all tank owners, require that any tank out of service for more than a year be removed from the ground and the site restored in an approved manner. However, under certain circumstances the fire official or building inspector may rule that removal is not necessary, so owners contemplating abandonment must first consult with local authorities about the suitability of their site. A permit must also be obtained from the fire official for any work to "remove, abandon, place temporarily out of service or otherwise dispose of any flammable or combustible liquid tank". The full text of these regulations is provided in Appendix I.

2. Location of Disposal Facilities

Because transportation costs can factor significantly in the total bill, the location of both disposal facilities and contracted firms should be determined before deciding on a course of action. Low disposal fees may be offset by high transportation costs, so site proximity is often an important consideration.

3. Location of Tank

Ease of accessibility to buried tanks will further affect closure costs. For example, tanks under asphalt or near buildings may be cheaper to abandon in place because of the high cost of repaving, provided no new tank is to be installed and local approval can be obtained.

4. Condition of Tank

Because of the amount of cleaning required of a tank destined for recycling, vessels with thick coatings or heavy deposits of scale and rust may be cheaper to abandon or landfill than to recycle. Some knowledge of the tank's condition is helpful in determining the most appropriate disposal route (Table 4).

5. Projected Land Use

Old tanks buried on site may interfere with subsequent land use and may affect the property value at the time of resale. Whether or not excavation is expected in the future can influence the decision between abandonment and removal.

The particular relationship of these elements to a given situation is likely to indicate what strategy is most appropriate for the tanks in question. The next step is to arrange for a commercial disposal service that is economical, environmentally sound, and legally correct.

## B. Commercial Disposal Services

### 1. Disposal Options

Because of the highly explosive nature of the gasoline fumes common in and around empty petroleum storage tanks, tank cleaning and removal is usually carried out only by specialized firms with proper equipment and a knowledge of safe procedures. These firms may be qualified to do the entire job or only certain parts; the tank owner must decide which firm(s) and how much to contract.

The acquisition of disposal service can be approached in two ways, depending on the amount of energy, time, and money the tank owner wishes to commit to the selection of contractors. One way involves the hiring of a single full-service disposal firm which will perform the entire operation, while another approach consists of contracting the services of two or more different companies ("split service"), each specializing in a different aspect of the procedure. Although full-service contracting is more convenient and simplifies the chain of responsibility, splitting the job among different companies allows use of the most economical alternative at each stage of the removal-disposal process. Examples of ways in which the procedure may be divided are given in Table 3.

Full-service firms can be divided into three general categories, according to their primary business orientation. Tank installers, the first category, will often provide removal and waste disposal services in addition to tank installation; these companies are the obvious choice when a new vessel is desired in the same location as the old.

Hazardous waste disposal firms are a second category. Some Virginia companies are active in both tank removal/disposal and abandonment activities in addition to their normal array of hazardous waste services. Because of the diversity of their waste management practices, hazardous waste management firms are well-connected to a variety of treatment, storage, and disposal (TSD) facilities, and can tailor treatment to the specific needs of the waste or tank owner.

Often, however, large TSD facilities such as landfills and solvent reclamation plants will offer full, "turnkey" waste management service to businesses that wish to use their technology. These facilities will supply or arrange for equipment to excavate and transport a used tank to their site, where it will be disposed of according to their particular technique. Tank owners considering using a particular landfill or other facility may wish to inquire about whether this service is offered before contracting with other disposal companies who may ultimately send their wastes to the same place.

Splitting services among contractors can be arranged (Table 3) according to which firms can most efficiently handle the responsibilities of tank pumping, removal, transport and disposal, and liquid waste transport and disposal. Some steps, such as excavation, the owner may perform if the necessary equipment and expertise are available, and the tank is drained and preferably vapor-freed beforehand. Care must be taken to coordinate steps, particularly removal, since the backhoe used to exhume the tank is also needed to load it onto the transport vehicle, so both must be at the site on the same day. Likewise, drummed hazardous waste must be picked up from the site within 180 days of the removal date to avoid RCRA storage regulations, and arrangements made ahead of time with the waste transporter, since deliveries to some TSD's must be scheduled months in advance. In return for this extra effort, considerable savings can be realized in some instances by using tank cleaners or industrial, as opposed to hazardous, waste landfills not usually included in the treatment schemes of professional disposal firms.

Companies that service underground storage tanks are listed in the telephone Yellow Pages under "Tanks." Directories for larger cities are useful since businesses will often serve regions in which they do not advertise. Scrap metal dealers are listed under "Scrap", "Junk", or "Recycling."

2. Contractor Selection

Problems in recent years with unscrupulous businesses making profits off substandard treatment of hazardous or industrial wastes make it advisable for tank owners requiring service to carefully review the credentials of disposal firms. Some financial liability for environmental damages remains with the tank owner even if the contracted firm is believed to be competent, so investigation may help to avoid costly litigation later on.

There are several points a tankowner might wish to investigate about a disposal service prior to contracting. Depending on the treatment scheme, these include:

*The amount of experience the firm has in handling gasoline tanks.* Many tank cleaners work mostly with fuel oil or petroleum, and may be less familiar with the procedures required for gasoline. A good knowledge of the applicable waste regulations is particularly important.

*The full sequence of cleaning and disposal procedures used, including the final fate of all components.* For cleaning and degassing, procedures consistent with those recommended by API or similar organizations are one indication of responsible service. The relevant API publications include:

i. No. 1604: "Recommended Practice for Abandonment or Removal of Used Underground Service Station Tanks" (1981)

ii. No. 2015: "Cleaning Petroleum Storage Tanks" (1985)

iii. No. 2015A: "A Guide for Controlling the Lead Hazard Associated with Tank Entry and Cleaning" (1982)

iv. No. 2202: "Guidelines for Protecting Against Lead Hazard When Dismantling and Disposing of Steel from Tanks that Have Contained Leaded Gasoline" (1982)

*The names, addresses, and legal status of all firms involved in the operation.* If hazardous sludge is expected, those transporters and facilities designated to handle it must have an EPA ID number and, for facilities, an operating permit as well. For transporters and in-state facilities, this requirement can be checked by contacting the Virginia Hazardous Waste Hotline, (800) 552-2075; for out-of-state facilities, the appropriate state government should have the same information. Facilities to which non-hazardous components will be sent can be contacted directly to verify their technical and legal ability to process the material in question.

*The willingness of the firm to certify or guarantee its work in writing.* A written certification that the tank is clean and lead-free is often necessary if the tank is to be recycled.

The goal of these investigations is to guarantee that the contracted firm is technically competent and will, in fact, dispose of the tank and its contents in a legal manner. Too often in the past, large fees have been paid in good faith to disposal firms which then dumped the material down the nearest manhole; knowing that the tank owner is scrutinizing the procedure is likely to discourage such practices. A summary of these and other suggested enquiries is listed in Table 5.

# DISPOSAL ECONOMICS

Although disposal options for underground storage tanks are fewer than in previous years, for most tank owners the difficulty of disposal arises from the high cost of services rather than a serious lack of them. While companies with many stations will achieve some economy by large-scale contracting of tank removal or replacement, independent owners can face bills of several thousand dollars to properly close old tanks, and still not be completely free of the liability associated with them. Trends in the disposal service market and the magnitude of actual costs an independent tank owner might incur were determined through interviews with numerous members of the industry.

## I. General Trends in the Tank Disposal Market

Several general observations can be made about the disposal market that have significance for both tank owners and others involved in the UST issue. The "disposal market" is here defined as both full-service tank disposal contractors and the specialized industries, such as recycling and waste treatment, that support them.

The current market is one very much in transition, and displays a characteristic fluidity as the impact and awareness of the regulations ripple through the various segments. Especially affected are the recyclers, some of whom are turning away used tanks or requiring extensive documentation of cleaning because of liability questions. Of those that do accept used tanks, not all require the same amount of cleaning, and at least one major scrapyard in Virginia requires no removal of scale or rust at all. Likewise, at least one municipal landfill was found that would take a cut-up tank, even if residual (and potentially hazardous) sludge were still present.

Similarly, this inconsistency is manifested in a wide variation in prices charged by different contractors for similar services. Depending particularly on the treatment and disposal procedure for the tank itself, prices can vary more than 100 percent both between options — recycling, landfilling, abandonment — and between firms using the same option (Table 6). This could have unfortunate consequences for owners who don't "shop around" for contractors, or who base their strategy decisions (which include illegal abandonment for owners who didn't register their tanks) on the first quoted price.

Full-service disposal contractors will usually try to minimize their expenses by altering their treatment scheme according to which option is cheapest for the waste in question. While many owners specifically request the incineration of sludges, the rising cost of landfilling is rendering alternative thermal or physical-chemical treatments more cost-effective. For this reason, in part, contractors often maintain active accounts with a number of TSD facilities.

In some cases, economies of scale can be realized that would help to reduce the cost of services contracted through separate firms (as opposed to full-service treatment). This is particularly true for liquid waste and sludge transportation and sludge analysis, but is not always the case for treatment and disposal. At least one full-service contractor indicated a willingness to reduce the price if given a multi-job contract. Such opportunities argue for a coordination of tank disposal efforts as one means of alleviating the economic burden on independent tank owners.

Most commercial enterprises expressed concern over the current disposal situation, and some are gearing up their service potential in anticipation of increased demand. Others, however, maintain the capability to service tanks but say they receive few calls, or that often tank owners withdraw after hearing the quoted cost of disposal procedures. The subsequent course of action of these owners is unknown.

In general, the elimination or reduction of legal liability continues to be a driving force behind the selection of disposal strategies. Owners will pay more for incineration services because of the elimination of risk, and some oil companies will treat their sludge by no other means. This motive, combined with the increasing cost and restrictions of landfilling may shift the disposal preference to the more environmentally sound alternatives.

**II. Factors Influencing Disposal Costs**

Estimates of the actual costs associated with each disposal option were obtained from representatives of a number of disposal firms. The associated discussions provided valuable insight into some factors affecting the total cost, as well as ways in which these costs might be reduced.

Costs were highly dependent on site-specific characteristics, with some company representatives considering a site inspection necessary before giving more than a ballpark figure. Factors mentioned as affecting the cost of disposal include: tank dimension, tank age, nearness to structures that would interfere with removal equipment, number of connecting pipes, and presence and extent of soil contamination. In addition, repaving can add as much as $1,500-$2,000 to the cost, depending on the type and thickness of asphalt or concrete desired; less pavement is required to bear traffic than when a hold-down capability is desired for replacement tanks partially submerged in the water table. The cost of paving is strong incentive for owners to install new tanks at the same time old ones are taken out, and the trend is to put in large tanks — 10,000 gallons or more — rather than the same number of the original smaller ones.

The partial contracting of individual firms specializing in separate steps may provide more economical service. For example, a local contractor may be used to exhume the tank, thereby reducing equipment mileage fees; or one company may be hired to exhume, pump and dispose of liquid waste while the tank itself is transported, cleaned, and recycled by a different firm that offers lower rates.

Proximity of facilities also influences disposal cost as much as direct service price in some cases. A flatbed truck can cost $45 or more per hour to hire, and the facilities contacted charge from $1.65 to $4.00 per-loaded-mile for tank transport. Drum transport is often included in disposal costs by full-service firms.

In part because of the cost of transport, the use of RCRA Subtitle D-authorized industrial landfills is sometimes an economical alternative for the disposal of tanks that do not contain hazardous sludge. Although less desirable environmentally than recycling, space in industrial landfills may be one-third or less of the price of space in hazardous waste landfills, making this an attractive option for relatively clean vessels.

### III. Comparative Costs

In order to obtain specific figures for tank disposal, a hypothetical standard tank system was devised that is considered to accurately represent a large percentage of the tanks actually being taken out of service. The characteristics of this tank system are:

tank: single 5,000 gallon steel

burial: under 6 inches of concrete and 30 inches of compacted fill

contents: 50 gallons of leaded gasoline and 50 gallons of sludge

location: tank and backfill entirely above water table

A "best case" situation was imposed as necessary for more detailed characteristics; specifically, no contamination, free access to the site, etc. The estimates for disposal obtained from several firms is presented in Table 6.

## ENVIRONMENTAL COSTS

For disposal purposes, tank wastes can be seen as consisting of two largely separate streams: the contents of the tank, both liquid and solid, and the tank steel itself. Even though these entities may both eventually be deposited in a landfill, either separately or while still intact from removal, their chemistry and environmental interactions remain sufficiently disparate to warrant separate treatment schemes. For this reason, this section will consider first the pollution potential of the various components of a typical tank system, both liquid and solid, then evaluate qualitatively the relative environmental cost of each strategy.

### I. Pollution Potential of Tank System Components

A. Lead

Because of the serious consequences of heavy metal accumulation in biological systems, the environmental problems of tank and cleaning waste disposal often revolve around the chemistry and toxicology of lead. A basic understanding of its pertinent reactions and health effects is therefore an important precursor to a more general evaluation of disposal techniques.

Two forms of lead are important in tank disposal: tetraethyl lead (TEL), the organic form added to gasoline as an anti-knock compound; and inorganic lead Pb(+2), which, as a charged species, will readily, and generally irreversibly, bind to clay or iron oxides, or combine with other compounds to form insoluble phosphates, carbonates, or hydroxides. The goal of treatment is to convert (oxidize) the more mobile organic form into the relatively immobile Pb(+2). Fortunately, this conversion occurs readily in the presence of oxygen and will take place automatically in dilute solution (Veerschueren 1983).

The most serious health risk from lead occurs during tank conditioning, when dust and lead vapors from the cutting and cleaning of tank walls can easily be inhaled. Inhaled lead in any form is readily absorbed by the lungs and distributed throughout the body, where sufficient concentrations can cause a variety of physical and neurobiological effects. Gasoline fumes also contain vaporized tetraethyl lead. For these reasons, face masks, good ventilation, and other safety measures are strongly recommended (API 1982).

B. Liquid Wastes

Liquid wastes are the contents requiring disposal after tank cleaning and consist generally of waste product, rinsewater and, in some cases, bottom sludge. Despite somewhat different chemistry, these materials often are sent for the same treatment if the final mixture is suitably ignitable.

Waste product consists of whatever was in the tank and whatever contaminants, if any, make it unsuitable for reuse. For gasoline tanks, the contaminant is often water from condensation or leaks along with solid material from the tank walls or accumulated from poorly filtered product shipments. Leaded gasoline itself consists of a diverse mixture of more than 276 aromatic, cycloparaffin, and branched paraffin hydrocarbons, along with tetraethyl lead.

Contaminated rinsewater is generated either when a tank is rinsed to remove settled material or water-filled as a means of vapor expulsion. The water-to-product ratio varies with the quantity of product and will, in part, determine subsequent treatment.

Bottom sludge is a complex mixture of sediments and insoluble mixed hydrocarbons produced in part by the microbial degradation of petroleum in the presence of water. When occurring in tanks used to store leaded gasoline, it may have an organic lead concentration high enough to qualify as a hazardous waste. By no means a consistent phenomenon in gasoline tanks, sludge formation is most common in poorly maintained tanks, those with a low flow-through rate or those that frequently receive poor quality product. It occurs more often in tanks storing diesel fuel, kerosene, jet oil, and other heavier products.

Since excess petroleum product normally still has a fairly high content of hydrocarbons unless badly contaminated, several options are available for its treatment for disposal. Options to lower pollution impacts include incineration, reclamation, and blending with other products for alternative uses, such as wash solvent.

Rinsewaters and water-contaminated product can be purified by air stripping, distillation, or similar processes that utilize the difference in physical properties between hydrocarbons and water. When rinsewater is rendered sufficiently free of gasoline or other target contaminants it can be safely discharged to a public sewer, since the biological activity of secondary treatment will degrade most petroleum residuals.

With a lower BTU content and often very high heavy metal concentration, sludge is usually landfilled, land-applied or, if possible, incinerated. Because of the reduction in volume, toxic hydrocarbon content, and hazard in general, incineration is preferred over land disposal whenever possible and economically feasible. In either case, the heavy metal content of both the raw sludge and the ash and the air pollution wastes that result from incineration presents the largest environmental liability, especially under acid conditions when metal solubility in general is increased. Although the oxidized form of lead is normally of low mobility in soil — due to its conversion to precipitates or retention by clay mineral or metal oxides — the presence of high concentrations of it or other species such as cadmium remains a focus of concern and an argument for extremely careful management of land disposal sites. Alternatively, high-sludge wastes can be solidified into cement or glass-like products and either landfilled or used as a construction material; although leaching of metals is reduced, this technology has not yet been widely implemented.

C. Lead-containing Solid Wastes

The rust and scale scraped from the walls of tanks destined for recycling consist mostly of iron with residual amounts of oxidized, inorganic lead.

As elements, the lead and iron components of tank scrapings cannot be altered significantly by treatment processes, and are usually disposed of in landfills. Because of the tendency of lead to oxidize and precipitate or bind with iron oxides and clay, leaching from a land disposal site is not expected unless the lead is present in high concentrations or is exposed to acidic leachate, which will increase the solubility of bound metals.

D. Tank Steel

The steel used in tank construction is described in the industry as "mild steel" and consists almost entirely of iron and less than 0.25 percent carbon along with trace amounts of silicon, manganese, phosphorus and sulfur. While the intense conditions of steelmaking can force the iron atoms into the crystalline structure known as steel, under natural conditions they will revert to the original oxidized state more characteristic of ores; this is the phenonomenon of rust.

Oxidized iron in groundwater is primarily of concern as a taste and odor contaminant. Its removal is a normal part of many water treatment plant processes, and can be further enhanced by purification devices added on to the tap. Although generally of low mobility, the most likely point of concern would be with abandoned tanks located partially below the water table and in proximity to drinking water wells.

**II. Pollution Impacts of Disposal Strategies**

The discussion of disposal strategies focuses on the fate of tank steel since, in each case, most of the product and sludge is supposed to be removed beforehand and treated separately. Petroleum contamination arises from residuals left in the tank after pumping.

A. Abandonment in Place

Because of the amount and type of material that is or may be left in the ground, tank abandonment presents probably the largest environmental threat of the various disposal choices. Under ideal circumstances — that is, when a tank is located above the water table and is completely freed of product and sludge before filling — this environmental threat will be fairly small and consist mainly of rusting steel.

More serious impacts are likely from tanks partially submerged in the water table that still contain some residue after pumping. Most fillers used in abandonment (sand, slurry, etc.) do not absorb petroleum derivatives and consequenly material could be released directly into groundwater, once the tank's integrity is breached, with a resulting threat to nearby wells. Even for tanks located above the water table concern still remains, since tanks' bottoms can be at a depth of 11 feet or more beneath a paved surface, largely isolated from the biodegradative action of hydrocarbon-utilizing soil microbes more abundant near the top.

These considerations may argue for restrictions on abandonment for tanks that either contain unpumpable sludge or that are located partially or wholly within the water table. If removal is impossible, the use of absorbant filler may be required to prevent migration of residues.

B. Landfilling of Tanks

The landfilling of tanks and their contents presents risks essentially the same as those associated with any hazardous waste landfill: primarily, the production of potentially toxic or hazardous leachate. The main components of potential contamination are sludge or product residuals and oxidized iron. Because RCRA regulations prohibit the deposition of free liquids in landfills, absorbant fillers are usually used to reduce the migration of residuals; however, the long time periods involved and the potential for eventual interaction of different kinds of leachate may give rise to unexpected and unpredictable results. For this reason, many tank owners avoid landfilling as a disposal alternative.

C. Recycling of Tanks

The recycling of tank steel is the most environmentally desirable method of tank disposal, since the steel is never, in fact, land-disposed but is melted down for recasting into other products. Heavy metals that may be of concern in land disposal become air contaminants in the steelmaking furnace; these are removed before emission and are treated as part of a hazardous solid waste.

## III. Conclusions

Tank disposal must be considered from the separate standpoints of tanks and contents. When treated separately, it is possible to reduce the hazard associated with combustible product and toxic sludge and toxic product reasonably well, although some components eventually will end up in a landfill. Since tank steel itself does not present large liabilities when land-disposed, the major concern focuses on untreated product and sludge that is either left in an abandoned tank after pumping, landfilled without treatment, or disposed of intact within a landfilled vessel. The most environmentally sound method is incineration or reclamation of product and sludge, followed by recycling of the tank steel.

# TABLES

**TABLE 1**
**Tank Population by Industrial Sector**

| | % of all UST Systems | % of all Facilities |
|---|---|---|
| Retail motor fuels | | |
| refiners and jobbers | 23.5 | 18.2 |
| convenience stores | 2.3 | 2.9 |
| independent chains | 1.3 | 0.1 |
| open dealers | 20.3 | 15.6 |
| Petroleum storage | | |
| wholesale and retail trade | 9.8 | 12.7 |
| agriculture | 6.2 | 10.5 |
| manufacturing | 5.4 | 5.9 |
| government | 10.6 | 10.2 |
| other | 15.0 | 18.9 |
| Petroleum storage: Total | 47.0 | 58.2 |

*Source:* April 17, 1987 Federal Register (52 FR 12662).

**TABLE 2**
**Comparison of Tank Disposal Strategies**

| | Advantages | | Disadvantages | |
|---|---|---|---|---|
| | Owner | State | Owner | State |
| Abandonment | does not require tank removal<br>may not require removal of pavement | saves landfill space | may be illegal: requires prior approval by building inspector;<br>threat of liability from env. damage remains;<br>may reduce property values;<br>may interfere with property use | potential for ground-water contamination from unpumped residuals |
| Removal, General | removes environmental threat from site;<br>no official approval necessary;<br>frees property for other uses | identifies nuisance: threat no longer hidden underground | excavation disturbs site;<br>repaving a major expense | may eventually involve some state liability: tank ownership no longer associated with site |

| | | | | |
|---|---|---|---|---|
| a. Landfilling | industrial landfills may be cheaper than other treatments; hazardous waste landfills require less tank cleaning | centralizes location of environmental impact | still liable for environmental damage; option increasingly expensive; option availability decreasing; generally requires that tank be cut up | relatively high risk of environmental damage, which state may eventually assume; shortage of landfill space |
| b. Recycling | eliminates liability; possible revenue from tank steel | conserves resources; saves landfill space; eliminates environ-mental risk | may require additional tank cleaning | |

**TABLE 3**
**Disposal Alternatives**

I. Disposal Strategy
   A. Abandonment in Place
   B. Removal/Disposal

II. Contractor Selection and Partitioning
   A. Full Service
      1. Tank Installer
      2. Hazardous Waste Management Co.
      3. TSD Facility Service
   B. Split Service
      1. Tank pumping, removal/liquid transport and disposal/tank transport and disposal
      2. Tank pumping and removal, liquid transport and disposal/tank transport and disposal
      3. Tank pumping and removal, liquid transport and disposal, tank loading onto transport vehicle/tank transport/tank disposal

III. Tank Disposal
   A. Recycle: steam clean
   B. Recycle: chemical clean
   C. Recycle: no cleaning (if unnecessary)
   D. Landfill: hazardous waste
   E. Landfill: industrial

IV. Liquid Disposal
   A. Incinerate
   B. Landfill
   C. Reclaim/Reuse

**TABLE 4**
**Tank Contents and Disposal Options**

| Tank Contents | Disposal Alternative |
|---|---|
| sludge and/or scale | whole tank to hazardous waste landfill |
| | remove sludge (and/or scale);<br>recycle<br>industrial waste landfill |
| no scale or sludge | recycle |

*Note:* Not all recyclers require the removal of rust and scale.

**TABLE 5**
**Contractor Evaluation**

These enquiries help to evaluate the credentials of disposal contractors

1. Are they licensed and permitteed to operate in Virginia?

2. Are they thoroughly familiar with the federal, state, and industrial regulations and guidelines for the proper handling and disposal of the product in question?

3. Do they have an EPA Identification Number?

4. Do they use only treatment, storage, and disposal (TSD) facilities or subcontractors permitted by EPA or an authorized state agency?

5. Do they take care of the manifesting paperwork?

6. Will they separate sludge from product prior to treatment?

7. What is the total treatment scheme: can they arrange for the incineration of sludge if desired?

8. Will they provide a written certification or guarantee of their work?

9. Are their employees trained in the essential safety precautions that apply to work with tanks that have contained flammable or combustible liquids?

## TABLE 6
## Reported Costs of Disposal Services

I. Full Service

| Firm | Option | Cost |
|---|---|---|
| 1 | removal; recycle | $2,200 - $2,700 |
| 2 | removal; recycle | $2,550 |
| 3 | removal; recycle | $9,000 |
| 4 | removal; landfill, hazardous | $5,000 |
| 5 | removal; landfill, hazardous | $6,915 |
| 6 | abandon in place | $2,800 - $5,250 |
| 7 | abandon in place | approx. $5,000 |

II. Partial Contracting; Tank Cleaning and Disposal[1]

| Firm | Technology | Cost |
|---|---|---|
| 1 | chemical clean and recycle | $350 |
| 2 | steam clean and recycle | $350 |
| 3 | steam clean and recycle | $400 |
| 4 | landfill, hazardous | $3,150 |
| 5 | landfill, hazardous | $390 |
| 6 | landfill, industrial | $2,150 |

[1] Costs are for vessel delivered to facility.

# APPENDICES

# APPENDIX ONE

## SUMMARY OF APPLICABLE LAWS AND REGULATIONS

### I. The Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA), passed by Congress in 1980 and amended in 1984, delineates a strict set of regulations governing the storage, transport, treatment, and disposal of hazardous wastes. Since the sludge occasionally found in the bottom of gasoline and oil tanks as well as in the rinsewater produced in the cleaning of them often is — or is assumed to be —hazardous according to the RCRA definitions, tank owners and disposers must make sure that their activities are in compliance with the regulations promulgated under Subtitle C of the Act.

The RCRA strategy focuses on two techniques to ensure safe waste handling: a manifest system to track waste from generator to final disposer ("cradle-to-grave" monitoring); and a set of permits and standards which apply to all those who generate, store, transport, treat, or dispose of hazardous waste. What exactly constitutes a "hazardous waste" is explicitly identified and numbered in a series of lists based on waste characteristics (ignitability, corrosivity, reactivity, or toxicity), industrial source, or specific chemical type. According to one of these lists, for instance, the bottoms of leaded gasoline tanks used by the petroleum refining industry are hazardous; this listing does not, however, apply specifically to retail outlets.

The manifest system is a strategy to provide a verifiable paper track of a hazardous waste from the time it is generated to its point of final disposal. A "manifest form," which identifies the type and quantity of waste and all those who will subsequently handle it, is filled out by the generator and signed by both the transporter(s) and treatment facility as they handle the waste, with the completed original returned to the generator ("round-trip" manifesting) as verification of proper disposal. A professional tank cleaning and disposal firm usually takes care of the manifesting paperwork.

All those involved in the waste disposal process are required to obtain an operating permit and/or identification number from the EPA. The granting of a permit for the storage, treatment, or disposal of hazardous waste is contingent upon compliance with specified technical and administrative requirements, which are designed to ensure that the waste is handled responsibly by knowledgeable personnel.

In brief, the regulations require that the tank owner or any contracted agent who handles a potentially hazardous waste must:

- determine whether the waste is classified as hazardous under the regulations and, if so:

- obtain an EPA Identification number;

- store hazardous waste on-site for no more than 180 days, or 270 days if it must be transported more than 200 miles for treatment;

- offer the waste only to transporters and facilities with an EPA identification number;

- comply with applicable Dept. of Transportation (DOT) packaging and labeling requirements for waste shipped off-site;

- use a multi-part "round-trip" Uniform Hazardous Waste Manifest to accompany the waste to its final destination; and

- maintain copies of manifests for three years.

**II. The Uniform Statewide Building Code**

Tank removal, abandonment, temporary closure and similar safety-related issues are regulated at the local level by the Uniform Statewide Building Code (USBC), which is a version of the Building Official and Code Administration (BOCA) codes that have been modified for application in Virginia. For tank closure, the USBC references as law both the BOCA Fire Prevention Codes (Articles 28 and 29) as well as the National Fire Protection Association's (NFPA) fire codes (Section 30), giving these guidelines the weight of legally enforceable standards. These laws are enforced at the local level by local building inspectors; where there is a divergence between codes, either may be followed. These codes apply to all Virginia localities and may not be superseded by local ordinances; however, local zoning laws may be used to achieve more rigorous regulation. Copies of the BOCA codes are available at the local building inspector's office, while the NFPA Fire Codes are at larger public libraries.

## APPENDIX TWO

## SUMMARY OF NATIONAL UNDERGROUND MOTOR FUEL STORAGE TANK SURVEY

In 1986, the EPA Office of Toxic Substances published the results of a national survey on underground motor fuel storage tanks. Based on a sampling of 890 establishments and a total of 2,445 tanks, the survey used direct personal interviews, inventory data, and physical tank testing to provide estimates of: (1) the total number of underground motor fuel storage tanks; (2) the number of establishments with underground motor fuel storage tanks; (3) the number of tanks that leak; and (4) characteristics of tanks and tank establishments. A summary of the findings is presented below; the complete report, as referenced in the Bibliography, is available from the EPA.

**Number:** There are an estimated 796,000 underground motor fuel storage tanks in the U.S. located on a total of 326,000 establishments. Subtracting those found on farms (which, because of their low frequency were excluded from subsequent analysis) leaves a working value of 638,000 tanks on 247,000 commercial, industrial, government and military establishments.

Note: EPA has significantly revised these estimates since this survey was completed; see Table 1 or the April 17, 1987, Federal Register.

**Location:**

- more than half of underground storage tanks are in the northeast and southeast
- about half the tanks are located at gasoline stations, although gasoline stations account for only about one-third of all establishments that have underground tanks (*see* Table 1)
- 21 percent of tanks are located wholly or partially within the water table
- 73 percent of all tanks are located beneath pavement (84-95 percent for gasoline stations)

**Mean Age:** 12 years

**Mean Capacity:**

- national average, all tanks: 5,405 gallons

- gas stations owned by major petroleum companies: 6,821 gallons
- gas stations owned by other companies: 5,093 gallons

**Contents:**

- leaded gasoline: 33 percent
- unleaded gasoline: 42 percent
- diesel fuel: 21 percent

**Details of Construction:**

- 89 percent of steel
    - 12 percent of bare steel
    - 5 percent cathodically protected
- 11 percent of fiberglass

**Number of Tanks per Establishment:** 2.4 for national average; 3.5 for gas stations

**Abandoned Tanks:** 14 percent of establishments reported one or more abandoned tanks on-site.

**Farms:** An estimated 3 percent of farms have USTs.

## APPENDIX THREE

## ORGANIZATIONS AND THEIR PARTICULAR INTERESTS

A number of private and public organizations are involved in the underground storage tank issue. A list of some of these organizations and their particular interests is provided below.

U.S. EPA
RCRA/Superfund Hotline
800-424-9346

The RCRA Hotline provides on-the-spot information on specific questions relating to any part of the Resource Conservation and Recovery Act and the CERCLA (Superfund).

U.S. EPA
Office of Underground Storage Tanks (WH-562A)
401 M St. SW
Washington, D.C. 20460
703-382-5628

As the EPA office charged with the regulation of underground tanks, the Office of Underground Storage Tanks can provide current information on the status of its regulatory program as well as technical information about the various requirements. The office also distributes a number of useful guidance and explanatory reports that are available to the public.

U.S. EPA
Office of Toxic Substances (TS-792)
401 M St. SW
Washington, D.C. 20460

The Office of Toxic Substances publishes several UST-related documents, including the National Survey of Underground Motor Fuel Storage Tanks.

Virginia Water Control Board (VWCB)
2111 North Hamilton St.
Richmond, VA. 23230
804-257-6685

The VWCB is responsible for implementing the UST program at the state level.

National Fire Protection Association (NFPA)
Batterymarch Park
Quincy, MA. 02269
617-328-9230

The NFPA publishes the recommended procedures for tank management that are ultimately incorporated into the Virginia Uniform Statewide Building Code. Copies of the Fire Codes are available at public libraries.

Building Officials and Code Administration International
4051 W. Flossmour Rd.
Country Club Hills, IL. 60477

This organization is the source of the BOCA building codes used to govern underground tanks.

American Petroleum Institute (API)
1220 L St. NW
Washington, D.C. 20005
202-682-8000
Publications: 202-682-8375

As the major trade association representing the petroleum industry, API maintains an active interest in the UST issue and publishes numerous guidance documents on underground tank management. A list of API's publications or copies of specific ones can be obtained from the Publications Dept., listed above.

Institute of Scrap Iron and Steel (ISIS)
1627 K Street, NW
Suite 700
Washington, D.C. 20006

ISIS represents the iron and steel recycling industry.

Steel Tank Institute (STI)
728 Anthony Trail
Northbrook, IL. 60062
312-498-1980

STI is an association of underground steel storage tank fabricators and suppliers of the industry. STI sets the standards for the widely-used "STI-P3" corrosion protection design for underground tanks.

Petroleum Equipment Institute (PEI)
PO Box 2380
Tulsa, OK. 74101
918-743-9941

PEI publishes various guidance documents as an industry service.

University Center for Environmental
and Hazardous Materials Studies
Dr. W. David Conn, Associate Director
Architecture Annex
Virginia Polytechnic Institute & State University
Blacksburg, VA 24061
703-961-7508

The University Center for Environmental and Hazardous Materials Studies at VPI&SU carries out interdisciplinary research on environmental problems and helps government, industry, and the public use this information effectively. Among other publications of the Center are a series of reports intended to inform local governments about issues relating to hazardous waste management. The reports were prepared using funds from the Virginia Environmental Endowment.

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**The Virginia Water Resources Research Center** is a federal-state partner agency attempting to find solutions to the state's water resources problems thro careful research and analysis. Established at Virginia Polytechnic Institute and S University under provisions of the Water Research and Development Act of 1 (P.L. 95-467), the Center serves six primary functions.

- It studies the state's water and related land use problems, including their ecological, political, economic, institutional, legal, and social implications.
- It sponsors, coordinates, and administers research investigations of these problems.
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- It provides training opportunities in research for future water scientists enrolled at the state's colleges and universities.
- It provides other public services to the state in a wide variety of forms.
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