STORAGE OF HAZARDOUS SUBSTANCES INCLUDING PCBs:

SPECIAL CONSIDERATIONS

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Western Canadian Storage Tank Management and Environmental Liability: The Canadian Institute, December 1 and 4, 1989

Introduction

The presently daunting array of regulated chemicals, both waste and non-waste material, only promises to grow larger as previous and present regulatory measures evolve to encompass a wider spectrum of environmental concerns and situations. In the interim however, handling and storage of these hazardous substances must continue with environmental integrity. Storage of hazardous or special waste has not typically been underground; in fact, less than 4% of all underground storage tanks contain hazardous chemicals (1), although one could convincingly argue that many of the compounds found in petroleum products (benzene, napthalene etc.) certainly qualify as hazardous substances. This fact does not negate concern over environmental dispersal of hazardous material from storage tanks. Recent reports from Silicon Valley in California suggests that more than 75% of all contaminated groundwater is a result of leaking storage tanks. These contaminants were primarily trichloroethene (TCE, a solvent used in the cleaning of silicon chips) and methylene chloride. Similarly, contamination of soil and groundwater is a characteristic of an estimated 700 creosote treatment facilities in the U.S., primarily from leaking tanks, leachate from holding ponds and drippings from treated lumber (2). Clearly the regulatory demands placed on the handling and storage of hazardous material(s) is not unwarranted. Special consideration should thus be given, not only to the compatibility of the hazardous substance with the storage tank, but also to the inevitable situation of a leak. Moreover, the soil/sediment and groundwater characteristics should be considered strongly in the planning of a storage tank or facility. The chemical and physical properties of the soil and groundwater will have a major influence on the severity, degree of dispersal and eventual remediation of a leaked hazardous substance. However, before these points are highlighted a satisfactory definition of "hazardous waste" is essential.

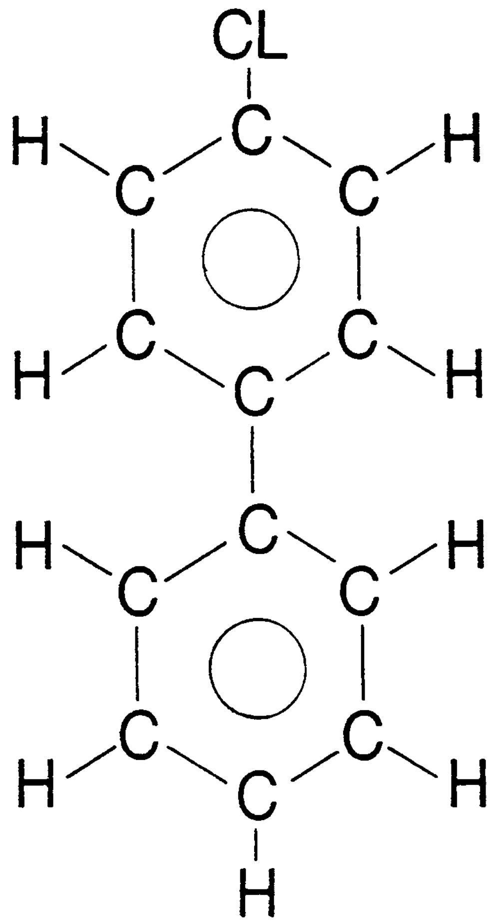
Definition of Hazardous Waste and PCBs

Hazardous wastes are a sub-set of all the waste generated in an industrial society. The classification of "hazardous" is applied to particular waste(s) due to chemical reactivity, flammability, corrosiveness, toxicity to man and/or wildlife, environmental persistence and bio-accumulative nature (3). It follows that any substance possessing any one or several of the above properties must also have special handling and storage requirements so as to avoid uncontrolled entry into the environment. Perhaps the most commonly sited example of a hazardous substance is that family of compounds known as PCBs (polychlorinated biphenyls). PCBs are synthetically produced by replacing the hydrogen atoms with chlorine atoms on a biphenyl molecule (Figure 1). As can be seen, up to 10 chlorine atoms may be replacing hydrogen atoms giving 209 possible PCB isomers. The extent of chlorination strongly affects the physical and chemical properties of PCBs (4). In general, as the degree of chlorination increases water solubility, vapour pressure and flammability decrease. Also with greater chlorine substitution the resistence to decomposition increases. Although long term studies of PCB related health problems are unavailable, the highly recalcitrant and persistent nature of the compound is part of the rational behind the widespread concern. Similarly, PCBs are hydrophobic compounds that are virtually insoluble in water but very soluble in fat, hence their tendency to bio-accumulate up the food chain. It should be realized that PCB solubility in natural waters (groundwater, seawater) will be directly proportional to the dissolved organic carbon content. The general scientific concensus is that PCBs are not immediately hazardous (5), however, protection against burning of PCBs must be guaranteed as the highly toxic dibenzo-p-dioxins and dibenzo furans are by-products of low temperature combustion.

Storage of PCBs

Polychlorinated biphenyls have strict storage regulations and for a complete review of these regulations the reader is referred to the Transportation of Dangerous Goods Act and Regulations as well as their respective provincial guidelines (e.g. B.C. Waste Management Act: Special Waste Regulations). However, certain aspects of these regulations can be summarized and are provided as a basic guideline. Firstly, it must be clear that the owner of the PCB wastes (transformers, capacitors) is solely responsible for their proper and authorized storage. Often PCB solids, liquids and/or PCB equipment can be stored in sealed steel containers. These containers provide extra protection against fire as well as prevention of spills or leaks. To this end it is recommended that the inside of the container be lined with a durable plastic bag and that the bottom of the bag be filled with vermiculite to a depth of approximately 4 cm. Vermiculite is a non-flammable, swelling clay and is therefore an excellent absorbant. Previous suggestions/regulations of using peat moss or sawdust have since been amended. Peatmoss or sawdust could conceivably burn despite their inherent properties which make them excellent adsorbers/absorbers of PCB. Regulations also state that any PCB equipment shall also be individually wrapped and sealed in plastic bags. If space

Figure 1: Molecular Structure of PCBs



Physical Properties:

(1) non-volatile at normal temperatures (below 40°C)

(2) low flammability

(3) solubility in fresh water 0.3-3.0 mg/L

(4) density > water

(5) do not conduct electricity

requires that the material be stacked, it cannot be stacked more than two high in the container. The container is to be back filled with vermiculite and the main plastic bag sealed after inclusion of an inventory sheet listing, in detail, the contents of the container. Another inventory sheet shall be placed in a plastic bag on the top of sealed drum, one (1) copy is to be distributed to the local fire department and at least one (1) copy of the inventory shall be kept in the office of the owner. The container is then sealed with a close fitting removable steel lid and the whole container placed on a pallet and labelled as ATTENTION/PCB. All drums are to be placed on individual pallets and stacked not more than two drums high. The rational for the pallets is to ensure that rapid removal with a forklift is possible in the event of a fire. In addition to the immediate containment of the PCB liquids or equipment, the actual storage facility must also meet specific quidelines. A concrete, epoxy sealed floor is recommended with curbing or sides sufficient to contain twice the volume of PCB liquid being stored. Access to the sight shall be restricted (e.g. chain-link fence, separate locked door) preferably to one individual. It is not surprising, given the above recommendations, that government inspection is mandatory. Although most sites can comply with storage regulations failure to pass inspection often results from a lack of a prudent contingency plan and demonstration of aptitude for dealing with PCBs. Both of these common shortcomings can be easily avoided. Firstly, it is highly recommended that at the time of inspection, a draft of the strategy plan for immediate actions in the event of a fire or spill be readily available. Secondly, the individual whom has access to the PCB storage facility must be properly trained with respect to the uses and handling of PCBs. The "training" of an individual can be accomplished by having read and available the Handbook of PCBs in Electrical Equipment printed and available from Environment Canada. Besides strict regulations of PCBs other regulations are being implemented for the storage of other hazardous materials. Provided are some recent storage tank regulations and recommendations to ensure safe and lawful storage of the hazardous material.

Storage Tank Recommendations

Although it is unlikely that underground storage of hazardous substances will set a precedence, there is recent legislation for underground storage of some chemicals that are considered as hazardous or special wastes. Virtually by definition, classification of storage sites for hazardous substances will be considered as Class A sites (most sensitive). As such the Environmental Code of Practice for Underground Storage Tank

Systems states that secondary containment facilities shall be employed at all new installations at Class A sites. The purpose of secondary containment is primarily twofold: (1) to provide added protection against contaminant leakage into the environment, and (2) to facilitate effective interstitial monitoring. As an example, new B.C. regulations (effective November 1, 1989) are in effect to control chlorophenol and anti-sapstain chemicals used in the wood treatment industry (6). Regulations for underground storage of the above requires that a double wall containment tank, with both walls impervious, be in place. There must also be in place a means of determining leakage into the interstitial space. In addition, a fixed roof shall be present as well as guard rails (or equivalent) surrounding the tank area to prevent any vehicle compaction.

Obvious alternatives to underground storage facilities are above ground tanks. Similarly to PCBs, above ground tanks shall be located in an impervious containment area provided with curbing or siding that will hold at least 120% of the total volume in the largest storage tank. It is recommended that the curbing also prevent surface runoff from entering the containment area and that the floor be sloped so as to facilitate removal of spilled material via pumping. As with an underground tank, an above ground tank will also be provided with a fixed roof and the necessary structures to prevent vehicle access. Obviously, design of the tank material and impervious material is contingent upon the chemical properties of the hazardous material. Further to these regulations, we suggest characterization of adjacent soil and groundwater conditions and properties as an added precaution. Despite precautions and insurances taken against the leakage of hazardous substances, such events do occur. Discussed below are some of the processes that occur after a leak or spill. Understanding these processes could conceivably aid in the remediation process and should be considered at the incipient stages of planning for storage tank location in order to minimize contaminant dispersal. Specifically, factors such as contaminant solubility, volatility, density and the soil/sediment adsorption capabilities must be considered.

Many hazardous compounds are relatively insoluble in water and when leaked will remain as a distinct independent phase. The subsurface migration of this distinct liquid through moist or saturated geologic strata is often referred to as "immiscible flow". The subsurface behavior of the immiscible liquid is dependent on a complex combination of factors including its physical and chemical properties, its physical and chemical interaction with water, and the physical and geochemical properties of the soil and rock through which the liquid moves. This section illustrates some of these complexities and indirectly highlights the difficulty and expense in tracking and recovering a leak.

A primary physical property determining the subsurface migration of an immiscible leaked or spilled liquid is its density relative to the soil aqueous phase as well as that of the groundwater. A less dense liquid will typically remain above the water table. However, there are exceptions to this general rule such as when water-table fluctuations cause some light liquid to be retained below a rising water table. Generally, if the liquid is less dense than the water, one would expect ponding on top of the saturated zone, whereas a more dense liquid such as TCE and PCB would be expected to penetrate the water table and flow downwards until a relatively impermeable layer is encountered. However, properties of the water and the sediment/rock greatly complicate this simplistic concept. For example silica grains have a larger hydration shell than does clay, hence, adsorption of hydrophobic organics to sand material is very weak.

The sorptive behavior of both the compound and the surfaces to which it comes in contact with are of considerable interest in determining the movement of a contaminant in the soil and groundwater. Sorption will also strongly affect, and possibly aid, in the degradation of the compound as surfaces are sites of microbial adhesion and growth as well as for chemical degradation processes (7). Despite the inherent variability and heterogeneity of sediment systems, estimation of the sorptive behavior of the hydrophobic pollutant can be estimated from a knowledge of: (1) the particle size distribution of the soil/sediment, (2) the organic carbon content of the soil/sediment, and (3) the octanol-water partition coefficient(s) of the substance(s). The octanol-water partition coefficient indicates the affinity of the compound to associate with the organic phase versus that of the aqueous phase. The lower the octanol-water partion coefficient the greater the aqueous solubility. Although the rule is not without exceptions, generally increased organic carbon content results in increased sorptive capacity, particularly with reference to the more hydrophobic pollutants (8, 9). Increased sorptive capacity will effectively reduce the amount of contaminant dispersal and act as a natural containment facility. Depending upon the type(s) of material being stored, choosing a storage site with soil/sediment characteristics condusive to containment is possible and should be strongly considered.

Concluding Remarks

Frequent changes in government regulations regarding hazardous substances requires that continued compliance becomes more difficult and liabilities more probable. As such, prevention of leaks from both underground and above ground storage tanks takes an even greater precedence. Some less than obvious considerations have been discussed with reference to the ultimate location of storage facilities for hazardous substances. These considerations will hopefully be a useful adjunct to the already in-place guidelines in minimizing the impact of what should be considered inevitable in any storage tank management plan.

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