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REVIEW OF LINER AND CAP REGULATIONS FOR LANDFILLS

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ABSTRACT

The U.S. Environmental Protection Agency, through its research and field experiences, has developed control strategies for hazardous and municipal solid waste landfills and surface impoundments. These control strategies include liner and cover systems. The liner systems include double liners for hazardous waste and a single composite liner for municipal solid waste. The purpose of each individual component will be discussed with options for using natural in-situ materials or geosynthetics. Although natural soils are used as various components, emphasis has been placed on the use of geosynthetics, including geomembranes, geonets, geotextiles, and plastic pipes. Cover systems for both hazardous and municipal waste facilities are based on a multi-layer design. The multi-layer component characteristics, including performance, thickness and material type will be discussed. These designs include both natural soils and geosynthetics.

It has been demonstrated with field data that the development of construction quality control/quality assurance will improve the performance of the disposal facility. Current programs and techniques used in the United States will be discussed.

Information on design and construction has been assembled into technical resource and guidance documents. The documents present summaries of state-of-the-art technologies and evaluation techniques determined by the Agency to constitute good engineering designs, practices, and procedures. The availability of the documents will also be discussed.

INTRODUCTION

Waste is generated at all levels of society. This waste may be either industry related or municipally generated. Both types of wastes may contain a variety of potential pollutants. In the United States of America these wastes are managed by landfills, surface impoundments and waste piles. The U.S. Environmental Protection Agency through its research and field experiences have developed control strategies to prevent potential pollutants from escaping into the environment.

The control strategies for waste management facilities include liner and cover systems. These systems are designed for long-term performance. In addition, for those containment systems for hazardous and toxic wastes, redundancy is designed into the containment systems to help ensure against major releases to the environment.

Field experience has clearly demonstrated that the development of construction quality control and quality assurance programs will improve the waste management facility performance.

This paper will present current designs for bottom and top containment systems, ideas and concepts for quality control/quality assurance programs and available technical guidance documents to support the designs and programs.

BOTTOM CONTAINMENT DESIGNS

The basic bottom liner design, for hazardous waste landfills, is two or more liners with a leachate collection sys-

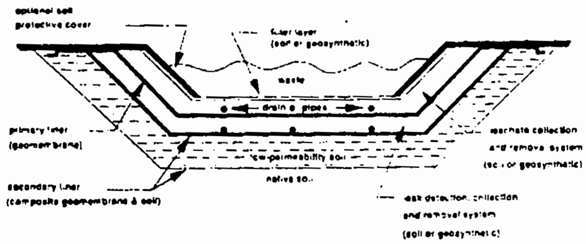

FIG. 1 SCHEMATIC OF DOUBLE LINER SYSTEM.

tem above and between the liners. The redundancy aspect of the design is that if the top liner does not perform as designed, then the second leachate collection system will alert appropriate personnel while corrective actions are implemented. The bottom liner in this design is assumed to contain the waste until the corrective action is in place. The design was reviewed and modeled in saturated and unsaturated hydraulic flow conditions. The result of these studies is the current recommended design of a double liner which has a bottom composite liner and a top geomembrane, Figure 1. The composite bottom liner is one that consists of a geomembrane in intimate contact with a compacted, low permeability natural soil. The composite liner design has been determined to be more hydraulically efficient than the geomembrane or natural soil liner working independently.

Liner Systems for Hazardous Wastes

The liner system currently being used by most hazardous waste management facilities incorporates in descending order a filter layer, followed by a primary leachate collection and removal system (LCRS), a primary geomembrane, a leak detection, collection and removal system (LDCRS), and a composite liner above the native soil foundation (EPA, 1987). The composite liner is defined as a geomembrane and a compacted, low hydraulic conductivity ($k < 1 \times 10^{-7}$ cm/sec) natural soil.

In bottom liner systems for construction and field seaming purposes, the geomembrane is to be at least 0.75 mm (30 mils) thick or 1.12 mm (45 mils) thick if left exposed to the elements for more than 30 days. These thicknesses may not be suitable for all geomembrane materials. The required geomembrane thickness will depend on the site-specific design, installation/construction concerns, seamability, and long-term durability.

Liner Systems for Municipal Solid Wastes

Liner systems for municipal solid wastes may have different designs based on site specific considerations including geology, hydrology and climatic conditions. Two basic approaches are used in the United States. The first is a generic design. This design has a composite liner system that is designed and constructed to maintain less than

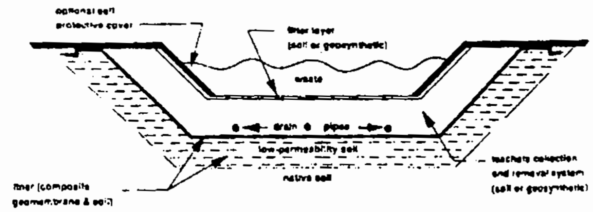

FIG. 2 GENERIC LINER DESIGN FOR NONHAZARDOUS WASTE FACILITY.

30-cm (12-in) depth of leachate over the liner. The second approach based on performance consists of liners and leachate collection systems to ensure that the concentration values of selected chemicals will not be exceeded at some point on the owner/operator's property.

Generic Design. A composite liner is shown schematically in Figure 2 and is defined as consisting of two components; the upper component is a geomembrane with a minimum of 0.75 mm (30 mil) thickness, the lower component consists of at least a 60 cm (24 inches) layer of compacted soil with a hydraulic conductivity less than or equal to 1×10^{-7} cm/sec. The required geomembrane thickness will depend upon the site specific design, installation/construction concerns, seamability and long-term durability. The geomembrane must be installed in direct and uniform contact with the compacted soil component so as to minimize the migration of leachate through potential defects in the geomembrane. A leachate collection and removal system (LCRS) should be located immediately above the composite liner to control the level of leachate on the liner.

Performance Based Design. The second design allows the owner operator of the proposed municipal solid waste landfill (MSWLF) to demonstrate that the design is protective of human health and the environment with respect to ground water quality down-gradient from the landfill. The nature of the demonstration is essentially an assessment of the landfill leachate characteristics, the potential for leakage from the landfill of that leachate to ground water and an assessment of the anticipated fate and transport of those constituents to the proposed point of compliance at the facility. Inherent to this type of approach, is the need to obtain sufficient site specific data to adequately characterize the pre-existing ground water quality and the pre-existing ground water regime (flow direction, horizontal and vertical gradients, hydraulic conductivity, specific yield and aquifer thickness). Th will be used to compare with data once the landfill has initiated activity.

TOP COVER SYSTEM DESIGNS

Proper closure is essential to complete a landfill. I search has established minimum requirements needed meet the stringent, necessary, closure criteria for both hazardous and nonhazardous waste landfills in the United States. In designing the landfill cover, the objective is to limit the infiltration of water to the waste so as to limit creation of leachate that might possibly escape to ground-water sources.

The cover system must be devised at the time the site is selected and the plan and design of the landfill containment structure is chosen. The location, the availability of low-hydraulic conductivity soil, the stockpiling of good topsoil, the availability and use of geosynthetics to improve performance of the cover system, the height restrictions to provide stable slopes, and the use of the site after the post-closure care period are typical considerations. The goals of the cover system are to minimize further maintenance and to protect human health and the environment.

Cover System for Hazardous Wastes

The closure of a hazardous waste landfill will normally have as its main criteria the minimization of moisture into the facility. Allowing moisture into a hazardous waste facility will subject the waste to leaching of potentially toxic pollutants into the leachate. Minimizing leachates in a closed waste management unit requires that liquids be kept out and that the leachate that does exist be detected, collected, and removed. Where the waste is above the ground-water zone, a properly designed and maintained cover can prevent (for practical purposes) water from entering the landfill and, thus, minimize the formation of leachate.

The current recommended design, Figure 3, is a multi-layered system consisting of, from bottom to top:

- *A Low-Hydraulic Conductivity Geomembrane/Soil Layer.* A 60-cm (24-in.) layer of compacted natural or amended soil with a hydraulic conductivity of 1×10^{-7} cm/sec in intimate contact with a minimum 0.5 mm (20-mil) geomembrane liner.
- *A Drainage Layer.* A minimum 30-cm (12-in.) soil layer having a mnimum hydraulic conductivity of 1×10^{-2} cm/sec, or a layer of geosynthetic material having the same hydraulic characteristics.
- *A Filter Layer.* A geotextile may be used to prevent soil clogging of drainage layer. This is designed based on soil size and vegetation layer.
- *A Top, Vegetation/Soil Layer.* A top layer with vegetation (or an armored top surface) and a minimum of 60 cm (24 in.) of soil graded at a slope between 3 and 5 percent.

Because the design of the final cover must consider the site, the weather, the character of the waste, and other site-specific conditions, these minimum recommendations may be altered. Design innovation is encouraged to meet site specific criteria. For example, in extremely arid regions, a gravel top surface might compensate for reduced vegetation, or the middle drainage layer might be expendable. Where burrowing animals might damage the geomembrane/low-permeability soil layer, a biotic barrier layer of large-sized cobbles may be needed above it. Where the type of waste may create gases, soil or geosynthetic vent structures would need to be included.

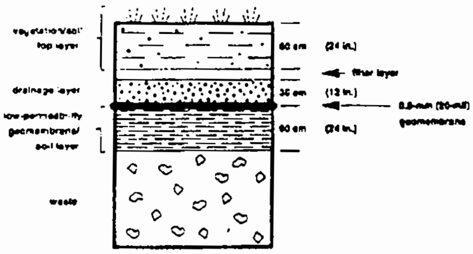

FIG. 3 USEPA-RECOMMENDED LANDFILL COVER DESIGN.

Cover Systems for Nonhazardous Waste

The cover system in nonhazardous waste landfills will be a function of the bottom liner system and the liquids management strategy for the specific site. If the bottom liner system contains a geomembrane, then the cover system should contain a geomembrane to prevent the "bathtub" effect. Likewise, if the bottom liner system is a natural soil liner, then the cover system barrier should be hydraulically equivalent to or less permeable than the bottom liner system. A geomembrane used in the cover will prevent the infiltration of moisture to the waste below and may contribute to the collection of waste decomposition gases, therefore necessitating a gas collection layer.

There are at least two options to consider under a liquids management strategy, mummification and recirculation. In the *mummification* approach the cover system is designed, constructed, and maintained to prevent moisture infiltration to the waste below. The waste will eventually approach and remain in a state of "mummification" until the cover system is breached and moisture enters the landfill. A continual maintenance program is necessary to maintain the cover system in a state of good repair so that the waste does not decompose to generate leachate and gas.

The *recirculation* concept results in the rapid physical, chemical, and biological stabilization of the waste. To accomplish this, a moisture balance is maintained within the landfill that will accelerate these stabilization processes. This approach requires geomembranes in both the bottom and top control systems to prevent leachate from getting out and excess moisture from getting in. In addition, the system needs a leachate collection and removal system on the bottom and a leachate injection system on the top, maintenance of this system for a number of years (depending on the size of the facility), and a gas collection system to remove the waste decomposition gases. In a modern landfill facility, all of these elements, except the leachate injection system, would probably be available. The benefit of this approach is that, after stabilization, the facility should not require further maintenance. A more important advantage is that the decomposed and stabilized waste may be removed and used like compost, the plastics and metals could be recycled, and the site used again. If properly planned and operated in this manner, fewer landfill cells could serve much of a community's waste management needs for many years.

CONSTRUCTION QUALITY CONTROL AND QUALITY ASSURANCE

Field data studies have clearly indicated that with the development of a Construction Quality Assurance/Construction Quality Control (CQA/CQC) program that the performance of the waste management facility will improve over a facility constructed without a good CQA/CQC program.

CQA consists of a series of planned observations and tests required to insure that the final product (the waste management facility) will meet the project specifications. CQA is a management tool and the plans, specifications, observations, and tests are all used to provide a quantitative means of acceptance of the final product. CQC consists of a series of actions which provide a continuing means of measuring and controlling the characteristics of the product in order to meet the specifications of the finished product. CQC is the production tool that is employed by the manufacturer of materials and contractor installing the materials at the site.

TECHNICAL GUIDANCE DOCUMENTS

The U.S. Environmental Protection Agency, in support of hazardous and nonhazardous waste management facilities, developed three types of documents. The intent of these documents was to assist designers of facilities and reviewers of permits for these facilities. One document, the permit guidance manual, addresses the type of information required for a permit. The other two documents, the Technical Resource Documents and the Technical Guidance Document, contain information useful to designers.

The Technical Resource Documents present summaries of state-of-the-art technologies and evaluation techniques determined by the Agency to constitute good engineering designs, practices, and procedures. They describe current technologies and methods for waste facilities, or for evaluating the performance of a facility design. Although emphasis is given to hazardous waste facilities, the information presented in these TRDs may be used for designing and operating nonhazardous waste treatment, storage and disposal facilities.

The Technical Guidance Documents present design and operating parameters or design evaluation techniques that, if followed, would demonstrate compliance with the United States regulations. This paper has presented the current cover and liner regulations for hazardous waste (Subtitle "C") and non-hazardous (Subtitle "D").

In addition to the documents described above the Agency presents detailed seminars throughout the U. S. Seminar publications, developed from these seminars, provide additional information useful to designers, operators and owners of waste management facilities. A listing of currently available documents is provided in the reference section.

SUMMARY

Management of hazardous and nonhazardous wastes will require the development of liner and cover systems that will minimize the release of potential pollutants to the environment. These systems, as designed and constructed in the United States, will contain mixtures of geosynthetics and natural soil materials. These designs have been generally described.

To insure that the facilities are constructed as designed, the development of a CQA/CQC plan is recommended. Specific objectives as well as key elements of the plan have been provided.

Finally, the technical knowledge, presented through a series of documents and publications have been identified.

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16. ABSTRACT
The U.S. Environmental Protection Agency through its research and field experiences has developed control strategies for hazardous and municipal solid waste landfills and surface impoundments. These control strategies include liner and cover systems. The liner systems include double liners for hazardous waste and a single composite liner for municipal solid waste. The purpose of each individual component will be discussed with options for using natural in-situ materials or geosynthetics. Although natural soils are used as various components, emphasis has been placed on the use of geosynthetics, including geomembranes, geonets, geotextiles, and plastic pipes. Cover systems for both hazardous and municipal waste facilities are based on a multi-layer design. The multi-layer component characteristics, including performance, thickness and material type will be discussed. These designs include both natural soils and geosynthetics.

It has been demonstrated with field data that the development of construction quality control/quality assurance will improve the performance of the disposal facility. Current programs and techniques used in the United States will be discussed.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Liner/Cap Regulation	Waste		
Landfill	Solid Waste		
Construction QA/QC	Surface Impoundment		
Disposal Facility	geosynthetics		
Design	Geonets		
State-of-the-art Technology	Geotextles		
Field data			

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