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THE ENVIRONMENTAL PROTECTION AGENCY'S MUNICIPAL SOLID WASTE LANDFILL LINER DESIGN CRITERIA

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INTRODUCTION

The soon to be published non-hazardous land disposal regulation, RCRA sub title D (40 CFR Parts 257 and 258) must achieve three objectives. The first is to be protective of human health and the environment, second to be flexible so as not to stifle innovative designs, and third to allow individual states the latitude to develop state specific regulations. The containment systems (liners) currently under consideration will achieve these three goals. This paper will briefly discuss the approach to the liner design. Additional information will be forth coming as final decisions are made.

Statement of Proposed Regulation

While the regulations are still being finalized, the containment systems are being focused on two approaches. The first is a generic design. This design has a composite liner system that is designed and constructed to maintain less than 30-cm depth of leachate over the liner. The second approach consists of liners and leachate collection systems to ensure that the concentration values of selected chemicals will not be exceeded at some point of compliance. Both of these approaches require additional discussion to define terminology and to provide guidance on how to comply with the two approaches.

A composite liner shown schematically in Figure 1, is defined as consisting of two components; the upper component is a flexible membrane (FML) with a minimum of0.75mm (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 thickness will depend upon the site-specific design, installation/ construction concerns, seamability and long-term durability. Taking these factors into account, the EPA recommends the following minimum FML thickness for landfill bottom liners: polyvinylchloride (PVC)-0.75mm (30 mil), chlorinated polyethylene (CPE)-0.75mm (30 mil), reinforced chlorosulfonated polyethylene (CSPE-R)-0.9mm (36 mil) and semi- crystalline polyethylene (PE)-1.5mm (60 mil). The FML component 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 FML. A leachate collection and removal system (LCRS) should be located immediately above the composite liner to control the level of leachate on the liner.

The point of compliance is defined as that point in the uppermost aquifer at the waste management unit boundary. The Director of an approval state may re-define the point of compliance after considering the hydrologic characteristics of the facility and surrounding land, the quantity and quality of the leachate, the quantity , quality and flow of the groundwater, the proximity of groundwater users, the practical capability of the owner/operator and the public health and the environment.

Generic Design Considerations

As mentioned previously the generic design has two major components: the leachate collection and removal system and the composite liner system. The leachate collection system should be designed to meet the performance criteria standard of maintaining less than a 30 cm head above the liner. Leachate refers to any waste contacted by water including rainfall and snowmelt that combines with liquid in the waste and moves by gravity to the bottom of a landfill facility. Leachate quality, defined by the concentration of its constituents and water quality parameters (such as COD, BOD, pH, and eH), changes with time as the landfill matures. During the course of landfilling activities, waste characteristics may also change, producing profound changes in the type of leachate produced. As such, leachate is both site specific and waste specific with regard to both its quantity and quality.

Leachate is generally collected and removed from the landfill through sand blanket drainage layers, synthetic drainage nets, and perforated plastic pipes. Each LCRS consists of the following components:

- A low-permeability base which is either a soil liner , composite liner, or flexible membrane liner (FML);
- A high-permeability drainage layer constructed of either natural granular materials (sand and gravel) or synthetic drainage material (geonet) which is placed directly on the flexible membrane liner, or its protective bedding layer;
- Perforated leachate collection pipes within the high-permeability drainage layer to collect leachate and carry it rapidly to the sump or collection header pipe;
- A protective filter material surrounding the pipes, if necessary, to prevent physical clogging of the pipes of perforations;
- A leachate collection sump, sumps, or header pipe system where leachate can be removed;
- A protective filter layer over the high-permeability drainage material which prevents

physical clogging of the material; and
- A final operational protective layer of material that provides a wearing surface for traffic and landfill operations.

The recommended bottom liner slope is two percent at all points in each system. This slope is necessary for effective gravity drainage through the entire operating and post-closure period. The settlement estimates of the foundation soils performed during design should set this two percent grade as a design objective. It may be necessary to initially design the slopes steeper than two percent to allow for settlement.

The high-permeability drainage layer is placed directly over liner or its protective bedding layer. Often the selection of drainage material is based upon the availability of natural granular materials at the site. In some regions of the country, hauling costs may be very high for sand and gravel or appropriate materials may be unavailable and the designer may elect to use geosynthetic drainage nets (geonets) or synthetic drainage materials as an alternative. Frequently, geonets are substituted for granular materials on steep sidewalls since maintaining sand on the slope during construction and operation of the landfill is difficult.

FML Component

The design of the FML component of the composite liner system considers the technology guidance, material stress consideration, structural details and panel fabrication.

<u>Technology Guidance:</u> To achieve EPA guidelines for minimum leakage, the liner should not leak at a rate greater than the action leakage rate (ALR) stated in the site's response action plan as determined by the owner/operator and the permit writer. The minimum thickness of FML is set at 0.75mm (30 mils). State requirements may be more stringent than EPA guidelines; the more stringent requirements must be followed in design. It should be noted that increasing the liner thickness can greatly increase the cost. Increasing the liner thickness of the same material from 0.75mm to 1.5mm (30 to 60 mils) can double the per acre cost of the FML, the actual increase will depend on the polymer type.

<u>Stress Considerations:</u> Stress conditions must be considered for both the bottom and the side slopes of a landfill. For side slopes, the weight of the FML itself and the weight of the overburden and waste must be reckoned with. Because the geosynthetic must be able to support its own weight on the side slopes, the specific gravity, thickness, and yield stress of the material and the friction angle must be known to calculate self-weight. For exposed FMLs, uplift forces caused by wind is another critical loading condition. For FMLs covered with a layer of soil, the tendency of the soil to slide down the slope is a critical loading condition and should be evaluated. For FMLs at the bottom of the facility, the FML should be evaluated against

two different mechanisms by which loads can be applied. The first mechanism is due to compression or consolidation of the foundation soil supporting the landfill. The second mechanism is due to compression or consolidation of the overburden and waste.

Structural Details: Anchorage, access ramps, collection standpipes, and penetrations are all structural details that warrant attention, especially in double liner systems.

In anchorage trenches, the geosynthetic can be ripped or pulled out during construction, filling, and closure. The pullout capacity for various anchorage configurations (e.g., trenches with box or V-shape) can be calculated. Research is currently being conducted at Drexel University's Geosynthetic Research Institute to evaluate this design approach.

Most facilities have access ramps to bring waste into the landfill. With double liner systems, the continuity of both liners must be maintained over the entire surface. Construction activities such as traffic induced damage and site drainage must be addressed in the design. Vertical collection standpipes are used to access the primary leachate collection sumps. As waste settles the standpipe can be affected by downdrag and the primary FML beneath can be punctured. ASTM D-2435 is one dimensional consolidation test that could be used to measure the consolidation properties of the waste. From these properties, the settlement of the waste can be calculated. This calculated settlement is used to calculate the downdrag forces acting on the stand pipe. The settlement of the standpipe due to the downdrag forces can then be calculated to determine the impact on the FML. Remedies could include coating the standpipe with a viscous or low-friction coating or encapsulating it with multiple layers of low friction resistance material. A flexible foundation or spread footer design beneath the standpipe could provide a more gradual transition and spread the distribution of contact pressures over a larger portion of the FML than would a rigid foundation design. Manufacturers have recently developed polyethylene standpipes that are light weight, sealable, have low side wall friction and good chemical resistance.

Panel Layout: The layout of FMLs in the landfill should be planned so that seams run up and down the slope and that the length of field seams is minimized whenever possible.

Soil Component

The soil component of the composite liner must be at least two feet thick with a hydraulic conductivity of no more than 1 x 10^{-7} cm/sec. To meet the 1 x 10^{-7} cm/sec requirement, other factors including the actual construction of the soil liner (density, strength, etc.), slope stability, settlement and bottom heave; and long-term integrity of the liner and controls for liner failure may need to be considered.

Chemical Resistance

Chemical compatibility or chemical resistance to the waste or leachate has been and continues to be a major factor in selecting construction materials for a waste disposal facility. The Agency has a long standing policy that all construction materials coming in contact with leachate must be chemically resistant to that leachate. The Agency uses EPA Method 9090 or EPA Method 9100 as the procedure to evaluate the candidate materials.

Quality Assurance/Quality Control Testing

A quality assurance/quality control program has two principal components. The first is the Construction Materials Quality Control, which is designed to ascertain that materials used meet specifications. The second component is the Construction Quality Assurance Program which is designed to ensure that all methods used in testing, construction and placement of materials follow and exceed accepted practice criteria. Combined, these element constitute the QA/QC Plan. Quality control testing performed on materials used in construction of the landfill include source testing and construction testing. Source testing defines material properties at the point of manufacturer to ensure the properties used in the design are being met. Construction testing ensures the appropriate material was delivered at the site.

Activities of the construction quality assurance (CQA) officer are essential. The CQA Officer's responsibilities, and that of the CQA's staff members, include the following:

- communicating with the contractor;
- interpreting and clarifying project drawings and specification and recommending acceptance or rejection by the owner/operator of work completed by the construction contractor;
- submitting blind samples (e.g), duplicates and blanks) for analysis by the contractor's testing staff or one or more independent laboratories as applicable;
- notifying owner/operator of construction quality problems that need to be resolved on-site in a timely manner;
- observing the testing equipment, personnel, and procedures used by the construction contractor to check for detrimentally significant changes over time.
- reviewing the construction contractor's quality control recording, maintenance, summarization and interpretations of test data for accuracy and appropriateness.

Performance Standard Based Design

For approval of design not conforming to the minimum technology standards of a composite liner system, the owner and operator or the proposed municipal solid waste landfill (MSWLF) must demonstrate that the design is protective of human health and the environment with respect to ground water quality downgradient from the landfill. The nature of the demonstration is essentially an assessment 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 to existing ground water quality, the pre-existing ground water regime (flow direction, horizontal and vertical gradients, hydraulic conductivity, specific yield and aquifer thickness). The assessment must consider the effects construction of the MSWLF may have on the groundwater system. The major consideration here, for shallow groundwater systems, is the local capturing of precipitation that normally would have infiltrated as a source of groundwater recharge. An assessment of leakage from the proposed liner and leachate collection design should be based on empirical data from other existing operational facilities of similar design that have the capability of leak-detection monitoring. In lieu of the existence or availability of such information analytical approaches based on conservative assumptions may need to be conducted to estimate anticipated leakage rates. Given known source concentrations, groundwater and soil parameters, and the hydraulic gradients, a simple and hopefully conservative assessment of downgradient concentration at specific times and distances from the source can be conducted. Either on dimensional or two dimensional advection/dispersion contaminant transport methods may be used. The analysis should be performed by qualified professionals and may entail hypothetical computer simulations of groundwater flow and transport.

SUMMARY

The proposed municipal solid waste landfill liner regulations are focusing on a generic design and a performance design that will be protective of human health and the environment, flexible enough to allow design innovative and flexible enough to allow individual states to develop state specific guidance. The generic design incorporates a single composite liner with a leachate collection and removal system. The performance design is based on selected landfill leachate constituents not reaching the boundary (point of compliance) of the waste management unit. Additional information and technical guidance on the liner systems will be provided when final decisions are made and the regulations are published.

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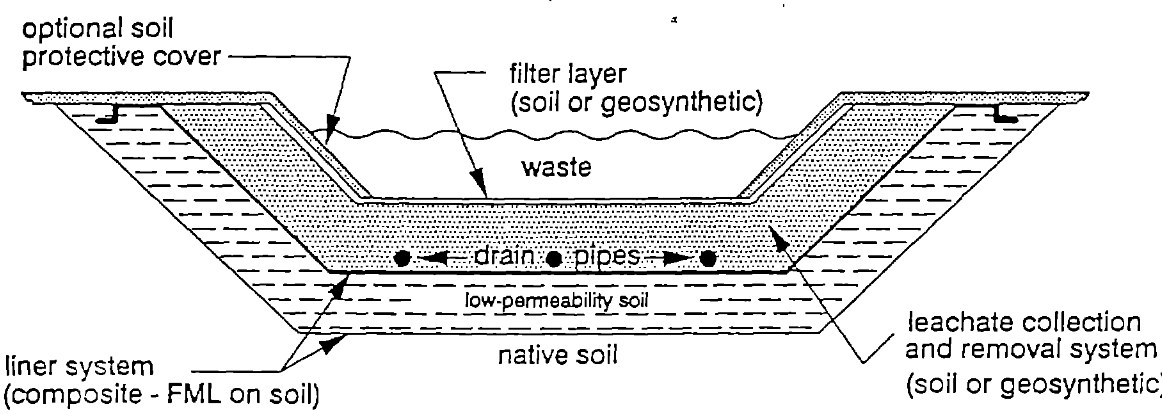
optional soil
protective cover
filter layer
(soil or geosynthetic)
waste
drain pipes
low-permeability soil
native soil
leachate collection
and removal system
(soil or geosynthetic)
liner system
(composite - FML on soil)

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16. ABSTRACT

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