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US Regulations on Solid Waste Containment Facilities

Aigen Zhao, PhD, PE
Tenax Corporation
4800 East Monument Street, Baltimore, MD21205, USA
Tel: (410)522-7000, fax: (410)522-7015
email: azhao@us.tenax.com

Gregory N. Richardson, PhD, PE,
G.N. Richardson & Associates
14 N Boylan Avenue, Raleigh, NC 27603, USA
Tel: (919)828-0577, fax: (919)828-3899
email: greg@gnra.com

Introduction

Over 600 million metric tons of solid waste was generated within the USA last year. These solid wastes (both hazardous and non-hazardous) must be properly disposed of in an environmentally safe manner. Despite many of the innovations and technology advancements in recycling and composting of solid waste materials, landfilling is still the most economic means to dispose of solid waste. This will be especially true for developing countries. This paper presents USA regulations for solid waste landfill liner and cover systems, for the readers to assess and compare with their local practice. This paper excludes such solid wastes as radioactive materials that are regulated separately.

USA Regulatory Requirements on Solid Waste Landfills

In the United States, all landfills are regulated at the federal level under the Resource Conservation and Recovery Act (RCRA) promulgated in 1976. RCRA wastes include (1) hazardous wastes, (2) municipal solid wastes (MSW), and (3) industrial wastes not covered under other land disposal restrictions. RCRA wastes do not include radioactive wastes or polychlorinated biphenyls (PCB) wastes.

Hazardous Waste Disposal

Since 1984, hazardous waste landfills are regulated under RCRA Subtitle C. Under Subtitle C, hazardous waste landfills are required to have two liners and two lateral drainage systems. A hazardous waste is defined as follows:

1) a listed (40 CFR251) material defined as a hazardous waste; or
2) waste mixed with or derived from a hazardous waste; or
3) waste not excluded (some wastes, such as municipal solid waste, are specifically identified and excluded as non-hazardous waste); or
4) waste possessing any one of four characteristics (a) ignitability (flash point 60 C^{o}), (b) corrosivity (2>Ph>12); (c) reactivity; and (d) toxicity as determined by the toxicity characteristic leaching procedures (TCLP) test.

For hazardous waste, a double liner system with leak detection capability is required, as shown in Figures 1 and 2. The lower liner system is always a composite liner consisting of a geomembrane over a compacted clay liner(CCL).

Double-liner systems have proven to provide the greatest environmental protection for municipal solid waste (MSW) and hazardous waste landfills. Currently in the United States, 100% of hazardous waste and 24% of municipal solid waste landfills require double–lined systems (Koerner, 2000). The leakage detection system (LDS) is arguably one of the most critical components of double-lined landfills, and must designed to satisfy the following objectives: (1) provide rapid detection of a major breach in the primary liner system, and (2) limit the head acting on the secondary liner to less than the thickness of the LDS. An acceptable level of leakage (ALR) into the LDS is established during the permitting process. This rate of leakage must not saturate the LDS, that is produce a head greater than the thickness of the LDS. To minimize the impact of excessive leakage into the LDS, many hazardous waste landfills use a composite barrier in the upper (primary) liner system. This generally consists of a geomembrane over a geosynthetic clay liner (GCL). Federal regulations outline construction quality assurance (CQA) testing that must be performed during the construction of each landfill cell.

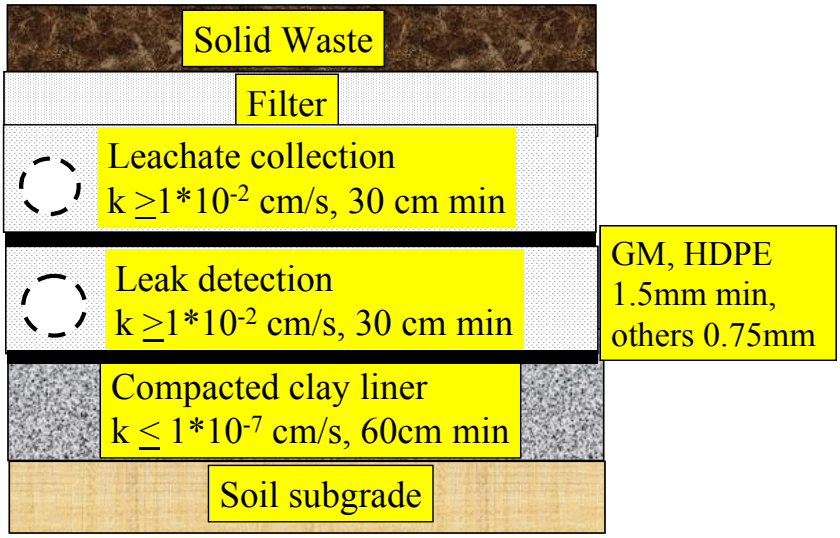

Figure 1. U.S. EPA MTG Subtitle C-Hazardous Solid Waste (Liner System)

For landfill closures, current Federal regulations require that the final covers on RCRA Subtitle C landfills must limit the infiltration through the cover to a rate less than the leakage rate of the liner system (40 CFR 264.310). Typical RCRA Subtitle C final covers incorporate a composite barrier consisting of a geomembrane and 600 mm of $1*10^{-7}$ cm/sec CCL. Note RCRA Subtitle C final covers rarely have slopes greater than 5-8% such that stability problems are not a concern.

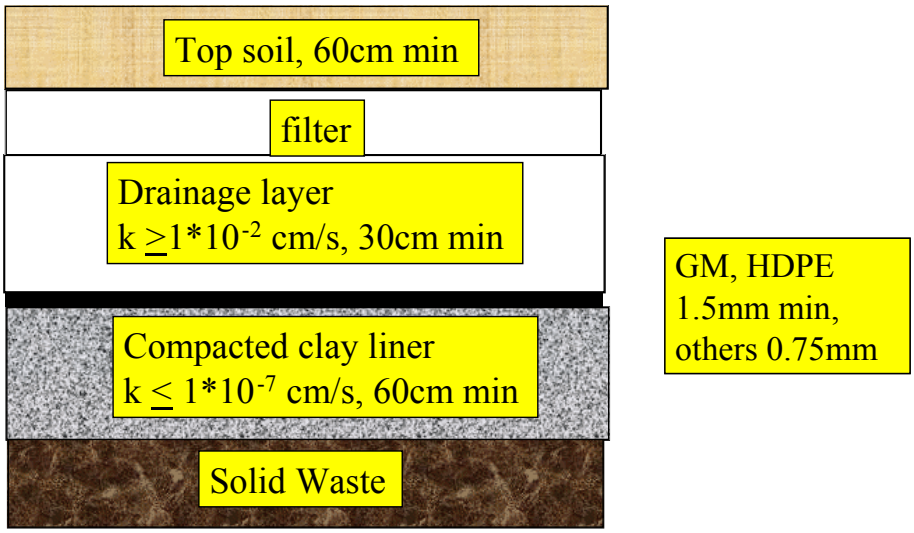

Figure 2. U.S. EPA MTG Subtitle C-Hazardous Solid Waste (Cover System)

MSW Disposal

There are two common types of non-hazardous solid wastes, municipal solid waste (MSW) and industrial waste. MSW landfills are regulated under RCRA Subtitle D. Since 1993, this has required that all new MSW landfills be lined with a single composite liner consisting of a geomembrane plus a clay liner(CCL or GCL). Note that individual States can set more stringent requirements than established by Federal law. Currently, seven States require double liner systems for MSW landfills. While industrial waste regulations are still ambiguous, most States are requiring these facilities to meet RCRA Subtitle D criteria.

Minimum Technology Requirements for Subtitle D non-hazardous wastes liner systems are shown in Figure 3. This minimal liner system is composed of (from bottom up):

1. Prepared soil subgrade foundation layer
2. A compacted clay liner (CCL) on the soil subgrade, with a minimum thickness of 600mm and maximum hydraulic conductivity of $1*10^{-7}$ cm/sec;
3. A geomembrane of 0.75mm or thicker, with a minimum thickness of 1.5mm for HDPE geomembranes. A geomembrane over a CCL forms a composite liner;

4. A leachate collection layer with a minimum thickness of 300mm and minimum hydraulic conductivity of $1*10^{-2}$ cm/sec;
5. A leachate removal system, i.e., perforated pipe network, is located within the leachate collection layer. The maximum head of leachate on the liner system must be less than 300mm; and
6. A filter between the leachate collection and removal system and the waste.

Minimum Technology Guidance concurrently developed by the Federal government provide a minimum program of construction quality assurance (CQA) testing that must be performed during the construction of each landfill cell. The CQA document, commonly referred to as the certification document, must be submitted to the permit authority before the landfill can be operated. The individual States are the permit authority for all MSW landfills.

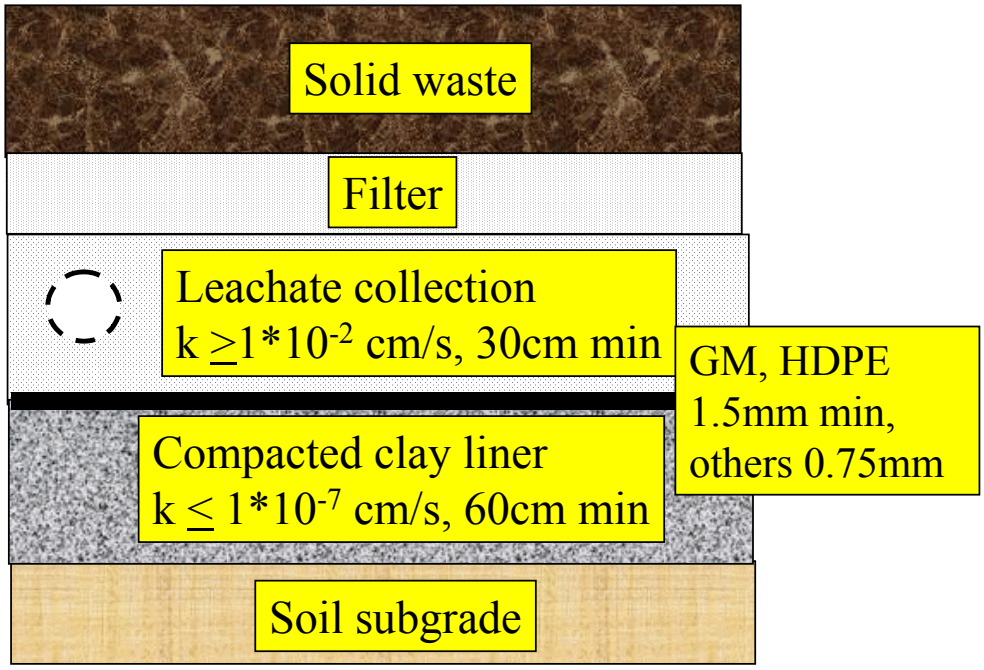

Figure 3. U.S. EPA MTG Subtitle D-Nonhazardous Solid Waste (Liner System)

For landfill closures, current Federal regulations require that a final cover be constructed within one year after the last lift of waste is placed. The final covers on RCRA Subtitle D landfills must limit the infiltration through the cover to a rate less than the leakage rate of the liner system (40 CFR 258.60). The EPA interpreted this requirement by requiring that final covers include a composite barrier consisting of 450mm of a compacted soil barrier having a hydraulic conductivity of less than $1*10^{-5}$ cm/sec overlain by a geomembrane. A nominal 150mm erosion control layer placed over the geomembrane completed the minimum regulatory profile (see Figure 4). This profile is considered a minimal system. In reality this 150mm erosion control layer is inadequate for survival

and is rarely incorporated alone. A typical erosion control layer must provide sufficient water storage capacity to allow the cover vegetation to survive periods of drought. Except for arid and semi-arid regions of the USA, this typically requires a 450-600mm layer of vegetative support soil beneath a 150mm top soil layer.

Additionally, RCRA Subtitle D final covers are commonly constructed having 25% to 33% slopes. Stability requirements at these slopes require the addition of a lateral drainage layer immediately atop the geomembrane to eliminate excess pore water pressures cause by precipitation induced seepage,

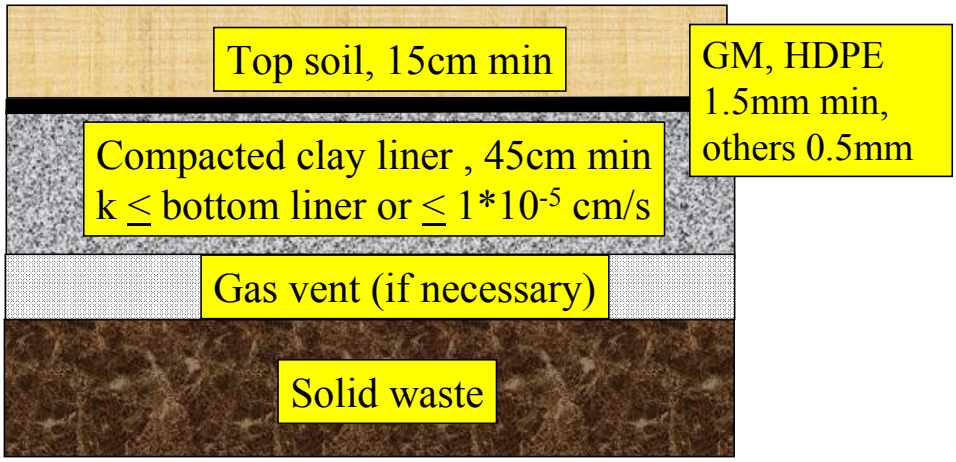

Figure 4. U.S. EPA MTG Subtitle D-Nonhazardous Solid Waste (Cover System)

20-Year Perspective

With more than twenty years of liner installation experience, the current liner trends in the USA are of interest to those beginning such work. Key liner trends during this time frame include the following:

1) HDPE smooth and textured liner systems have dominated the RCRA landfill applications. Textured HDPE liners have been able to achieve excellent slope stability in steep canyon facilities and when the waste height is significant (>100m).
2) The quality of geomembrane installation has improved dramatically in part due to more sophisticated double-wedge welding machines that produce quality seams.
3) Composite liners incorporating a GCL have become as popular as those that incorporate a CCL. Performance data actually shows that the GCL composite liners outperform the CCL composite liners.
4) The hydraulic capacity required of the geosynthetic lateral drainage composites has increased dramatically in both liner and final cover applications. This increase has been the result of failures and abnormal

weather patterns. Requited transmissivities are now routinely in the 10^{-3} $m^3/s/m$ range.

Current development is heavily focused on improving the design and geosynthetic materials used in final closures systems placed over the landfills. MSW landfills, in particular, commonly require these covers be placed on 33% slopes with a required service life of 30+ years. As with liner systems, a new generation of geosynthetics will be developed to solve these problems economically.

Concluding Remarks

US regulations for solid waste landfills were implemented before all geosynthetic components now used in their construction were available. Fortunately, the geosynthetic manufacturers have been able to successfully respond to the challenge and developed components that exceed the industry's original expectations. Their success has allowed greater flexibility in landfill design and an increasing economy in landfill construction. Today's landfill liner system cost less to construct than those built 20-years ago. Few industries can make that claim.

China has the opportunity to learn from the success (and failures) of the last twenty years of landfill construction in the USA. With the development of their geosynthetics industry, there is no reason that they cannot improve upon the performance and economy of the landfills constructed to date.

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