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Leakage through Liner Systems

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Introduction

Leakage through geomembranes could originate from bad seams, mechanical attachments such as pipe boots and batten strips, punctures from sharp objects, and from damage caused by equipment during liner installation and placement of the cover soils. Leakage through a single line system, unless in pond applications where the liner is exposed, may not be easily detected until it shows up in the ground water monitoring wells. However, leakage in double-liner systems can easily be detected and monitored. The focus of this paper is to explore the leakage phenomena, discuss the current regulatory requirements for action leakage rates, and recommend techniques to minimize leakage through geomembranes.

Sources of Leakage

Of the twenty six (26) lined cells surveyed by Leak Location Services, Inc., ninety percent (90%) o leaks were located in the seams and ten percent (10%) were located in the sheet. The cells ranged from 0.4 - 4.9 hectares (1 - 12 acres) with an average of 15.7 geomembrane leaks per hectare (6.3 leaks per acre). However, before concluding that the liner in your landfill or pond is leaking, consider the fact that the fluid flowing into the leak detection system (LDS) could come from any one or a combination of the following sources:

1. Leakage through the top (primary) geomembrane.
2. Gravity drainage of rain and condensation water trapped in the leak detection zone during construction (compression water).
3. Water from consolidation of the primary compacted clay liner (consolidation water).
4. Ground water infiltration.

In studies by Bonaparte and Gross (1990, 1993), the measured flow rates attributed to consolidation water ranged from 20 - 840 liter/hectare/day, lphd (2 - 90 gallon/acre/day, gpad). Freeman and Maxson (1993) evaluated 41 double-lined landfill cells and reported the average monthly leakage, attributed to consolidation water, from 0 - 310 lphd (0 - 33 gpad). Another study by Workman (1993) supports the claim that in almost all cases the primary clay liner of the double liner system is the major source of leakage. The leakage rate due to consolidation water depends on the clay layer thickness, its properties, its original moisture content and dry density at the time of construction, and the overburden pressures during consolidation. The rate decreases significantly with time between the initial and the active periods of the landfill operation. The consolidation water normally shields any small leaks through the primary geomembrane.

The leakage source for a single liner system could be from number 1 and/or 4 as mentioned above. The leakage source for a double liner system consisting of a geonet sandwiched between two liners could be from number 1, 2, and/or 4. The most convincing evidence indicating leakage through the primary geomembrane is the discovery of a match between the chemical constituents of the leakage and the landfill leachate. The leakage rate through the top geomembrane depends on the size and number of holes, head pressure, and the materials in immediate contact with the liner. The worst liner leakage occurs when the liner is under a high head pressure and overlays a high permeability drainage layer such as a geonet or gravel. This could be the case in a double-lined pond.

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The EPA Action Leakage Rates

The Environmental Protection Agency does not specify maximum leakage rates for nonhazardous waste containment (i.e. municipal solid waste landfills and surface impoundments). This remains in the jurisdiction of the state and local governments. However, EPA requires owners or operators of hazardous waste landfills to establish an Action Leakage Rate (ALR) for each hazardous waste unit. The ALR is the leakage rate that requires implementation of a response action plan to prevent migration of hazardous materials out of the containment unit. Originally, EPA proposed an ALR of 47 - 187 lphd (5 - 20 gpad). As a result of reviewing comments and field data provided by the owners/operators, it was realized that the specified ALR is not appropriate all units. Subsequently, EPA is now requiring the owners or operators to propose an ALR for each unit based the maximum leakage rate that a leak detection system can transmit and remove under gravity flow without saturating the leak detection system. This is referred to as Rapid and Large Leakage rate (RLL). Based on the current minimum requirements and using a factor of safety of two (2), EPA recommends ALRs of 9,354 lphd (1,000 gpad) for surface impoundments and 935 lphd (100 gpad) for landfills and waste piles. Alternatively, the owner could propose a site-specific ALR for EPA approval.

Response to Leakage

The leakage source should be identified before a response action plan is implemented. In cases where the leakage is due to breach in the top geomembrane, several options may be considered depending on the type and stage of a project and severity of the leakage. For exposed liner applications, the liner installer should retest all suspect areas around pipe boots, T-seams, patches, specifically in the sump area where leaks are most likely to occur and repair the leaks. Alternatively, the entire lined area could be electronically tested to locate and repair the leaks. This test is very accurate because small pin holes which are not visible to the naked eye can be detected. This test can be performed for exposed as well as buried geomembranes under water o 60 cm (2 feet) of soil in single and double liner systems. The cost of this test in the U.S. ranges from $1.00 - $0.50 per square meter for projects ranging from 0.5 to 8 hectares ($0.10 - $0.05 per square feet for projects ranging from 1 to 20 acres). Other methods, such as construction of barrier walls or closure of the facility, may be necessary to isolate the leakage within the landfill area or to eliminate the source of leachate generation if the landfill is partially filled with waste or is near full capacity.

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Conclusion and Recommendations

Leakage in landfills and surface impoundments can initiate from different sources. Each possible source should be evaluated including the top geomembrane. A repair plan should be implemented to fix the leaks based on the nature of the project, severity of the leakage, or the site-specific ALR, if applicable.

The following are recommended for a good liner installation:

- **Subgrade Surfaces:** Make sure the subgrade on which the liner is to be installed meets the project specification and is free of loose rocks and sharp objects. If subgrade conditions are questionable, construct a small test pad to simulate the field conditions. Use the proposed construction equipment to place the cover soils. Then recover the liner and inspect it for any puncture or excessive deformations. If the liner is damaged by the subgrade material in this test, a layer of non-woven geotextiles may be used on the subgrade to cushion the liner.

- **Hot Shoe Welds:** The liner between the overlapped area must be dry and clean for a proper weld. The hot wedge welder must be clean and operated properly. A sharp edge on the welding machine touching the liner during welding can damage the liner. These cuts are not detected by the air pressure test since they are located outside the seam area in the lower sheet and are hidden under the flap.

- **Extrusion Welds:** Minimize extrusion seaming, specifically in the sump area. Test all extrusion welds for leaks, specifically at the T-Joints.

- **Pipe Boots:** If possible, avoid pipe penetrations through the liner. Penetrations are normally located in the sump area at the lowest point of the containment facility and are often where the leakage occurs. If the penetrations cannot be avoided, use a polyethylene pipe so that the pipe boot can be welded and clamped to the pipe. Double test all extrusion welds in this area.

- **Batten Strips:** Use the Poly-Flex PEC embed channel for all mechanical attachments to concrete structures, specifically those which are to be submerged. Make sure the PEC channel is installed correctly in accordance with the Poly-Flex specification. (i.e. weld all corners and sections of the PEC channel all around prior to its installation in concrete).

- **Installation Accidents:** Leakage can occur through the top geomembrane where it has been accidentally damaged by the installation crew, such as by a knife blade, or by dropping tools on the liner, etc. These activities should be avoided during installation.

- **Cover Material and Equipment:** The cover soil material in contact with the liner should no contain any particles larger than 1 cm (3/8 inch) or any sharp rocks. The initial layer should preferably be no less than 30 cm (12 inch) for equipment with ground pressures of less than 34.5 kPa (5.0 psi). The initial lift should be increased proportionally for heavier equipment. The cover placement should be monitored to ensure the liner is not damaged by the equipment. When cover soil material is questionable, a layer of non-woven geotextile may be used over the liner to cushion it.

- **Placement of Waste:** Finally, it is important that the initial layer of waste be free of large pieces of metal, wood, steel rebar, concrete, household appliances, and demolition waste. These objects could push through the cover soils and penetrate the geomembarne.

Geomembrane leak location and repair can be expensive and time consuming. Construction of a leak free liner system requires a competent design, liner installation and testing by trained technicians, and construction quality assurance by qualified inspectors who are independent of the liner manufacturer and installer.

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