

GEOMEMBRANES FOR TAILING IMPOUNDMENTSⁱ

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The reasons for employing geomembranes for containment facilities are all based on the reduction of leakage and the resulting reduction in “failure” risk that comes with better containment; with the definition of “failure” including structural failure, environmental contamination and inadequate water supply. For relatively benign wastes, such as flotation tailings from some copper, moly and phosphates plants as well as other ores and processes, factors other than environmental containment can also lead to a lined impoundment as the optimum approach. Whether for the protection of surface and groundwater or optimized water reclaim, geomembranes are often a cost-effective way to reduce leakage, especially when cost is considered from a risk-based net present value or “risked NPV” approach. No modern large-scale leach pads use soil-only liners and this is often driven as much by economics as environmental factors, as the value of the solution itself lost through clay liners can pay for the extra cost of constructing with a geomembrane as well as the cost of proper construction quality assurance (CQA).

In order to quantify the “leakage avoided” by a geomembrane, a simplified comparative analysis was performed and is meant to provide a comparison between geomembrane-lined and unlined tailings facilities located on sites with 1 meter of naturally occurring or compacted clay ($k = 1 \times 10^{-7}$ cm/sec) and a range of hydraulic heads. Defect size and frequency were estimated from published performance data considering three categories of liner installation: high quality, average quality and low quality representing respectively (i) excellent liner installation and CQA program, (ii) good installation with a CQA program, and (iii) poor installation without an effective CQA program. The following table summarizes the results.

head (m)	LEAKAGE RATES (liters/hectare/day)			
	geomembrane high quality	geomembrane average quality	geomembrane low quality	clay only (1m)
1	6	37	79	864
5	35	208	446	4,320
10	86	503	1,077	8,640
20	230	1,350	2,894	17,280

The leakage analysis shows that the installation of a geomembrane reduces liquid losses by 83% to 99% over clay alone. This approach gives a rough idea of the potential water savings when a geomembrane is employed in a tailings impoundment design. An important note regarding geomembrane liners with “low quality” installations: data and in-house surveys suggest that over 30% of such systems experience a failure that requires either a substantial reconstruction or complete replacement (or abandonment) of the system and this is not reflected in the leakage figures reported in the preceding tables (the failure rate of systems with “average” or “high” is negligible).

A high quality containment system also reduces the risk of structural failure due to a number of favorable factors. The reduced seepage in the embankment and foundation improves the stability of the slopes and reduces the risk of internal erosion (or “piping”) failure which is the cause of many dam failures including the well known cases of Los Frailes (Spain) and Omai (Guyana). A recent survey of tailings dam failures by the authors’ firm considered 122 documented failures and found the following causative events: seepage alone was the primary cause in 14% of the failures, slope instability 30%, foundations 11%, and earthquakes 20%. Slope instability, foundation failures and earthquake response are all significantly and negatively affected by higher phreatic surfaces in the embankment and foundation. Thus, a total of 75% of these failures were directly related to seepage and all would have been significantly less likely - and most probably avoided - with a good quality liner system. A liner system also allows the dam to be more aggressively designed - using steeper slopes, less complicated and less expensive embankment fill, and simpler construction methods which can offset the cost of the liner.

Taken in total, conventional tailings disposal presents one of the highest risks in mining and considering this in the design is well advised.

If design concerns include environmental degradation, water conservation or reduction of risk, then employing a geomembrane in the design of a tailings or residue storage facility could significantly improve its performance. As illustrated by a quantitative comparative analysis of leakage rates, constructing a tailings impoundment with a geomembrane can reduce leakage by up to 99%. In addition, the risk of failure is mitigated, substantially eliminating 75% of the cause of most tailings dam failures. Using average or high quality installation techniques further reduces the risk of failure of the geomembrane liner by at least 30%.

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