INTER-LIFT LINERS IN COPPER HEAP LEACHING

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Pioneered in the 1980's by Chilean copper mines, placing thin geomembrane liners between lifts of oxide ore is becoming increasingly common in copper heap leaching. Originally used to reduced acid consumption, the practice is being considered for mitigation of low permeability zones and for ores with incompatible metallurgy such as sulphide ore stacked over oxide.

Geomembrane Selection

The base liner serves a dual purpose of metal recover and environmental protection. As such it should be designed to the same standards whether or not inter-lift liners are planned. The exception being the drainage system; generally this must maintain capacity for the peak process flow rates, plus a reasonable contingency for storm water, throughout the operating life of the heap. When inter-lift liners are used, the useful life of the base drainage system is only 1 lift, and it can therefore be designed for this shorter life and reduced loading condition.

Inter-lift liners are therefore not environmental liners. They serve strictly an economic role; leakage carries a financial penalty such as increased acid consumption but it poses no environmental threat. Because of this inter-lift liners are generally thin. In fact, the operations currently using this technology employ geomembranes with nominal thicknesses no greater than 0.5mm (20mil).

The limited performance data available indicates that a properly functioning thin inter-lift liner will allow up to 2% of the pregnant leach solution (PLS) through to lower lifts. Under some circumstances the cost associated with this leakage may warrant an upgrade to a conventional liner system, which should loose no more that about 0.1% of the PLS flow, much less if a composite system is used. (Smith and Welkner, 1995). However, these circumstances are expected to be rare.

The most commonly used geomembranes are low or medium density polyethylene (LDPE or MDPE, or visqueen), linear low density polyethylene (LLDPE) and polyvinyl chloride (PVC). Two of the older Chilean operations are using nominal 0.25mm (10 mil) LDPE with sewn-and-folded "J" seams. Newer operations tend to use thicker material, nominally 0.5mm (20 mil) with conventionally seams.

Both LLDPE and PVC have the advantage over LDPE and MDPE of higher flexibility, better puncture resistance, better installation survivability and higher tolerance of differential settlement (Ramey, et al, 1996). Sewn seams are both leaky and prone to tearing along the perforations, which can result in enormous leakage rates. Therefore, this technology is being replaced with glue (for PVC), tape or fusion welding (both for LLDPE).

Each of these two materials has certain advantages with respect to installation, which is generally performed by mine personnel. PVC can be pre-fabricated into panels of custom dimensions to minimize field seams. The dimensions are limited only by the total panel weight. However, PVC is generally not available in rolls, except for very narrow rolls, and some installations are much simpler with rolled liners.

LLDPE has a higher tensile strength than PVC of the same thickness, and it is also lighter, making the task of dragging panels around easier and causing the liner less damage in the process. Fusion welded seams are also several times stronger than PVC's glued seams, but they require a certain degree of expertise and some specialized equipment. High-strength double sided bonding table is available which will yield a seam similar in ease of fabrication and in performance to glued PVC.

To a great degree the best liner comes down to a matter of personal experience. In many cases it may be worth the effort of trying both types to determine which best lends itself to your particular needs and site conditions.

Foundation Preparation

Before a geomembrane can be placed the surface of the prior lift of ore must be graded to provide proper drainage; smoothed to eliminate stones and tight topographic changes that would damage the liner; and compacted to minimize differential settlement and provide proper support to the construction and stacking equipment. Most operations have found that a combination of ripping-and-compacting the spent ore (commonly called 'ripios' in South America) and placing select ripios over soft areas provides a suitable foundation.

Rather than specifying a minimum compaction as is generally done in earthworks construction, a method specification is often more appropriate. As a rule of thumb, a suitable surface is indicated when proof rolling with conventional construction equipment does not result in rutting. The equipment used to proof roll should provide a contact pressure similar to the highest loads which will be induced after the geomembrane is placed.

Where local zones of soft ore are present, a layer of more durable ripios from another area of the heap often provides suitable performance. Alternatively, consider select waste rock or pit run gravels, plated with finer ripios or clay.

The total thickness of the stabilized foundation will depend upon the properties of the spent ore and the magnitude of the post-construction loads. Around 600mm (2 feet) is typically adequate to provide a firm base. If the foundation material is too coarse to bed the liner, a thin veneer of fine soil will be required. Fine gravel, sand or clay are the best materials, and a thickness of 100mm is adequate for most applications. (Run of mine ore may require a thicker bedding layer.)

Drainage and Protective Layer

Proper drainage is essential to good metallurgical performance, heap stability and controlling leakage. All of these issues are amplified when inter-lift liners are used. Consider this, a conventional heap will develop a few centimeters to a meter of head over the base liner. Therefore, the phreatic surface is always within a meter of the base liner and it therefore does not significantly affect stability. However, with an inter-lift liner elevated, for example, 60m above the base, the phreatic head can now be 61m above the base liner; much higher if proper drainage is not provided.

For most projects using inter-lift liners the drainage system consists of the crusher-run ore augmented with perforated drainage pipes. The ore is stacked directly on the geomembrane, either concurrently with liner deployment so that the stacker is never working over the geomembrane, or with a walking-stacker working on top of the freshly-stacked heap. Pipes are generally 65mm to 100mm diameter perforated, corrugated polyethylene pipe such as ADS in the U.S. or Dren-e-flex in Chile, spaced every 2 to 6 meters. Both types of pipe have low crush strengths and are suitable only when construction and post-construction loads are low.

Where the ore is too course to place directly on the geomembrane, a conventional protective layer can be used. However, this will increase the cost considerably. Before making this choice thicker geomembranes should be considered.

Delivering the PLS from the upper lifts to the permanent collection system located at ground level can be difficult. Outfall pipes with drop boxes and energy dissipaters seem to be the design-of-choice until a better idea comes along.

Heap Stability

In addition to introducing phreatic surfaces quite high in the cross section, inter-lift liners are also zones of low shear strength. A heap using inter-lift liners will be less stable than a conventional heap, if all other factors are equal. This is especially critical if inter-lift liners are added after the geotechnical engineer performs the original analysis, where inter-lift liners are generally not considered in the stability analysis.

The most common way to provide adequate stability is the use of benches or set backs at each lift. For a 10m high lift, bench widths can range from 3 to 10m depending on the slope of the top of the lift, the strength of the ore and the strength of the geomembrane interfaces. Interface shear strength is the single most important parameter in controlling stability and it is important that the values be tested using site-specific materials; literature values are never suitable and usually result in either unreasonable conservatism or an unsafe slope (Smith and Criley, 1995).

Highly flexible geomembranes such as PVC and LLDPE will result in higher interface shear strengths than less flexible materials such as high density polyethylene, LDPE or MDPE.

Summary

Inter-lift liners have proven to be wise investments on may copper projects. Their use will likely expand; gold heap leach may offer some applications to extend this technology beyond its traditional basis in copper, especially for low permeability ores.

While offering solutions to certain metallurgical problems, inter-lift liners pose new design challenges to the civil and geotechnical engineers. If not properly addressed these problems could render the system dysfunctional. However, none of the challenges are significant if they are addressed at the proper point in the design and if the resulting design measures are properly implemented and maintained.

References

Ramey, T.V., M.E. Orman and M.E. Smith, "Designing Leach Pad Liners for Differential Settlement," *proc.* Of Randol International Gold Forum, Olympic Valley, CA, April 1966.

Smith, M.E. and K. Criley, "Interface Shear Strength is not for the Uninitiated," *Geotechnical Fabrics Report*, pg. 28-31, April 1995.

Smith, M.E. and P. Welkner M., "Liner Systems in Chilean Copper and Gold Heap Leaching", *Mining Engineering*, pg. 53-57, Jan. 1995.

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