The End of Heap Leach Solution Loss

Abigail Beck, PE and Mark E. Smith, PE, GE[i]

A promising new technology is rapidly entering the mining scene that ensures a defect-free geomembrane lining system while typically paying for itself. Developed in the United States in the 1980's, geoelectric leak location surveys can detect holes in installed geomembranes after construction and construction quality assurance (CQA) activities have been completed, either before or after placement of the overliner (or both). These surveys have been in commercial use since 1985, but have typically only been used for waste containment facilities based on environmental concerns. Apart from avoiding environmental degradation and related liability and public relations issues, the cost of a geoelectric survey of a gold or copper leach pad liner is typically paid for simply by the value of solution that would otherwise have been lost through undetected holes in the liner. This article discusses the two geoelectric survey types used for leak location and the technical and financial benefits of employing each or both as part of the construction process for heap leach facilities.

Geoelectric surveys employ electrical conductivity measurements to pinpoint holes, non-destructively testing up to 100% of the liner area. Recent statistics show that 70% of the holes found in a liner after installation occur mid-panel rather than at the seams (Forget et al, 2005). This is both a testament to the success of conventional CQA measures on ensuring seam integrity, and a call to action for improved methods for ensuring containment of the bulk of the installed area.

There are two types of geoelectric surveys which can be used to locate holes in electrically isolative liners including HDPE. The water lance or water puddle method is used on exposed geomembrane and is capable of pinpointing holes so small that they are invisible to the naked eye. This survey is performed after liner installation and before placement of the overliner. After the overliner is placed, a dipole survey can be performed. This method is much less sensitive than the water lance method but it is essential for finding large construction damage caused by the machinery placing the overliner material, as many believe that overliner placement is the cause of most leaks. In addition, dipole surveys can be conducted in full ponds.

The water lance method (ASTM D7002-03) works by spraying water systematically onto the exposed geomembrane, which is charged with electricity. The ground underneath the liner is grounded to the negative electrode of the power source. In the presence of a hole, water passing through the hole creates a connection. A detector connected in series with the circuit alerts the lance operator by way of visible and audible signals of the movement of current through the lance. This method is dependent on the contact between the geomembrane and the material underneath it. It is typically less sensitive on side slopes, where water tends to flow down the slope rather than through a small hole.

The dipole method (ASTM D7007-03) can be performed on a liner covered by conductive material such as water or earth. Surveys on liners covered with water are much more sensitive than those covered with earth. The sensitivity of a dipole survey on earth depends on the depth of the material and its conductivity, which typically depends on moisture content and mineralogy (especial salt content). When cover thicknesses exceed 1 to 3 m the accuracy becomes unreliable. To perform the survey, the earth or water on top of the liner must be isolated from the surrounding ground. A high voltage source charges the cover material, while the ground underneath the liner is connected to the negative electrode of the power source. A dipole instrument is used to take voltage potential measurements of a fixed distance in a grid pattern throughout the survey area. In the case of a hole, current flows through the hole from all directions. As the operator travels across the hole location, the voltage potential increases sharply and then dips sharply below zero before returning to the original background values, creating a distinct sign wave pattern. Anomalies can also be created in the voltage potential measurements by things other than holes such as large rocks, changes in the cover system layers, pipes, and steel objects. This method is much more subjective than the water lance method and requires much expertise in distinguishing between holes and other anomalies.

To assist in choosing which method (or both) to use in the construction of a heap leach facility, the benefit to cost ratio analysis used by Smith et. al (2005) was modified with current prices for gold and copper and the most recent hole size and frequency statistics available. The hole size and frequency statistics are provided for sites with and without CQA activities (Forget et. al, 2005). Though greatly simplified from the probabilistic approach taken by Smith et. al (2005), this analysis shows the relative financial benefits of performing the different types of surveys at a heap leach facility, including differentiating between a PLS pond survey and a survey on the heap leach pad itself. The following table shows the parameters used to analyze the benefits of choosing either the water lance method, dipole method, or both, and the resulting benefit to cost ratios for both gold and copper heap leach facilities. The survey cost for the ponds is higher than a heap leach pad due to the typical survey size. The price of gold is taken to be $600 USD/oz. and the price of copper is taken to be $2.80 USD/lb. All assumptions and parameters not shown in the table are the same as used by Smith et. al (2005).

	Hole Freq./ha						
	10 mm^2	**1500 mm^2**	**Head**	**Survey Cost/ha**	**Leakage Avoided**	**B/C Au**	**B/C Cu**
pond (no CQA)	22	0	5 m	$5,382	17,630 L/day/ha	39.9	45.6
pond (w/ CQA)	4	0	5 m	$5,382	3,205 L/day/ha	7.3	8.3
Pad w/ both (no CQA)	22	1	1 m	$6,458	2,971 L/day/ha	5.6	6.4
Pad w/ both (w/ CQA)	4	0.5	1 m	$6,458	606 L/day/ha	1.1	1.3
Pad w/ W.L. only (no CQA)	22	0	1 m	$3,229	2,764 L/day/ha	10.4	11.9
Pad w/ W.L. only (w/ CQA)	4	0	1 m	$3,229	502 L/day/ha	1.9	2.2
Pad w/ Dipole. Only (no CQA)	15	1	1 m	$3,229	2,091 L/day/ha	7.9	9.0
Pad w/ Dipole. Only (w/ CQA)	3	0.5	1 m	$3,229	481 L/day/ha	1.8	2.1

This analysis shows that in high head applications such as PLS ponds, the benefit to cost ratio can be extremely high, making a geoelectric survey an obvious final step in

PLS pond construction or the upgrading of existing ponds. What this table does not show is the inherent risk in only performing a water lance survey on a heap leach pad. Though the average hole size found during a dipole survey is taken to be 1500 mm^2 for this analysis, in reality construction damage from a dozer can easily be ten times larger for isolated incidents, creating additional leakage that can easily double all of the leakage corrected during a water lance survey. On the other hand, if only a dipole survey is performed, the holes that are missed are typically the extremely small ones. In areas with relatively low head, the small hole leakage is relatively insignificant. Performing both water lance and dipole surveys on a heap leach pad coupled with CQA activities results in the lowest benefit to cost ratio. However, this scenario would create a far superior lining system, while still typically paying for itself during the life of the heap leach pad.

Including a geoelectric survey at the end of heap leach pad or pond construction does not significantly increase the overall project cost and will typically pay for itself during the first year of pad operation. When a hole is discovered in a leach pad after operations begin, it is typically several dozen meters under ore and thus too late to fix. Mine shut downs can and have occurred when leakage rates exceeds allowable flows. The likelihood of a major breach going undetected when both methods are used is essentially nil for surveyed areas, avoiding regulatory compliance issues and immediately increasing the net profitability of the project.

---

[i] Ms. Beck is a civil engineer with Vector Engineer, Inc., in Grass Valley, California.
beck@vectoreng.com
Mark E. Smith is president of Vector Engineering, Inc. and lives in Lima, Peru.
smith@vectoreng.com

The Mining Record, May 2006