LAYFIELD GEOSYNTHETICS

TECHNICAL PAPER

Development of a Conductive Textile and its Uses in Electrical Leak Location (ELL) Survey of Geosynthetic Containment Systems

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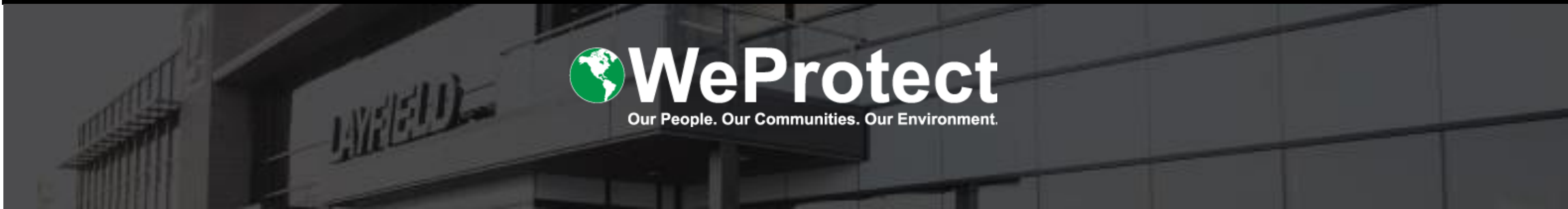
ABSTRACT

Electric Leak Location (ELL) surveys have proven to be a reliable method to evaluate construction integrity of containment systems. The challenge often encountered with this method is providing a consistent conductive layer beneath the geomembrane to facilitate an effective survey. Factors affecting a consistent conductive layer include: a non-conductive subgrade, inconsistent seams with conductive sheet, multi-layer containment systems with non-conductive intermediate layers, spray applied liners, and several others. This paper details the development and testing of a unique conductive composite of nonwoven geotextile and a thin conductive film to overcome these issues by providing a consistent conductive layer that can be used under any non-conductive sheet, or between geomembranes where drainage layers may be present. Multiple scenarios replicating the cases noted above were simulated and tested and are featured in this paper. The author found that testing sensitivity of the exposed/bare ELL methods was extremely reliable when using the new material and the equipment could find holes less than 1mm in diameter. Testing sensitivity was proven to be effective, and holes were successfully detected at applied test voltage between 15-35 kV.

INTRODUCTION

The Electrical Leak Location method is a sensitive technique that accurately locates leaks in geomembrane liners in landfills or other impoundments. This field-proven method has located many leaks not previously found using conventional methods. Leak location surveys are effective for both exposed and backfilled geomembranes. ELL testing on single lined systems is very effective where the geomembrane is in direct contact with a conductive soil subgrade such as compacted clay, a GCL, or other fine-grained native soil. If the subgrade is not conductive (frozen, poorly graded gravel, or too dry), a conductive medium is required to perform the ELL testing.

In double lined systems, the ELL testing can be challenging due to absence of a conductive medium under the primary geomembrane. However, the ELL testing can be performed with flooding the interstitial space or by using a conductive geomembrane. Both these methods come with challenges. Flooding of the interstitial space requires water to be hauled to site, it takes a while to flood the space between primary and secondary geomembrane depending on the size of the containment. The other challenge is to remove this water prior to putting the pond in service. Polyethylene (PE) geomembranes that are created using co-extrusion technology can be made conductive by adding carbon black in the outer layer. In recent discussions with 3rd party ELL contractors, it was mentioned that the potential issue with a conductive PE geomembrane is the isolation of bonded seams, the seams must be isolated to ensure efficient ELL testing. The conductive squeeze out from seams must be grinded and every seam



isolated prior to ELL testing. This can be both labour intensive and costly in large projects. Just one non-isolated seam can show up as a large leak during the ELL testing and can impact the efficiency and accuracy of the survey. For both single and double lined ponds one method is to lay a conductive geotextile.

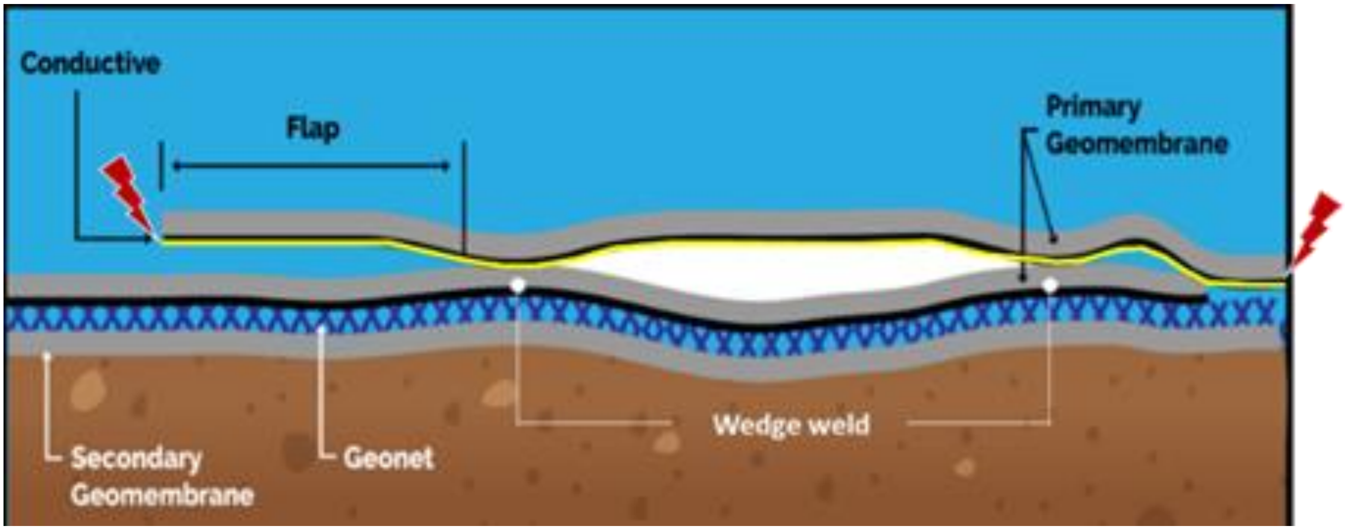


Figure 1. Schematic of spark testing on a conductive liner.

Conductive geotextile is easy to deploy and does not require isolation of seams. This white paper presents the development of conductive geotextile and case studies of installation and testing of conductive geotextile in the field using Electrical leak location techniques.

DEVELOPMENT OF A CONDUCTIVE TEXTILE COMPOSITE

Electrical conductivity is a material property that indicates the amount of electrical current a material can carry or how an electrical current can move within a substance. For a material to conduct it needs to receive and transmit electrical signals, Geosynthetics are planar materials hence the surface resistivity can be used to measure and identify their electrical behavior.

Figure 2. Arc testing on a 3-mil conductive film.

Most geomembrane and geotextiles are insulators meaning they cannot move electrical current. Since a conductive layer was needed the first phase of this project was to investigate existing conductive textiles. Our initial search results showed a variety of smart textiles which were conductive and flexible. The use of these materials was limited to high performance clothing. Containment applications are mostly industrial, and the costs of smart textiles made them unfit for large environmental applications. We then reached out to staple(short) fiber manufacturers that were supplying to non-woven geotextile manufacturers. A quote was obtained from a manufacturer of conductive fiber non-woven geotextile which was a blend of conductive fibers and regular staple fibers, the price was about 5 times more expensive compared to regular grade non-woven geotextile and the surface resistivity tested using a multimeter showed higher resistance meaning less conductivity. Other options researched included a narrow width foil based non-woven. Traditional nonwoven geotextile is 14.5' wide but the foil-based fabric was only 6 ft wide and had to be sewn to maintain conductivity across the seams. Our primary idea was to use a conductive film and to needle punch it with the non-woven fiber web making a composite conductive. One of the challenges we faced was extruding a very thin film with conductive properties and laminating/needle punching it to the non-woven fiber web. After many deliberations, we made some samples of different thicknesses and tested them for surface resistivity. The results showed good conductive properties at a 3-mil thickness. Our next step was to mimic the spark testing in a field setting. The spark trials were successful, and the technicians were able to spark test a leak through geomembrane. Picture 2 show a standard non-woven on the floor, followed by a 3-mil conductive film and a geomembrane placed on top and arc tested.

Next phase of the project involved needle punching the conductive film to a non-woven matrix. The composite material was re-tested to ensure electrical conductivity. The needle punching process perforated the film which resulted in holes in the conductive film making the composite permeable. The needle punching was primarily done to create a bond between the conductive film and nonwoven geotextile. We performed some physical tests on the conductive textile composite which yielded good results showing good mechanical properties. Water flow tests were performed using the ASTM D4491which is the standard test method for water permeability of geotextiles by permittivity.

Property	ASTM Test Method	Typical Values
Weight	D5261	6 oz/yd^2 200 gsm
Tensile	D4632	100 lbs 445 N
Elongation	D4632	50%
Trapezoidal Tear	D4533	50 lbs 222 N
CBR Puncture	D6241	340 lbs 1500 N
AOS	D4751	70 sieve 212 microns
Water Flow	D4491	20 gal/min.ft^2 810 l/min.m^2

Table 1. Tested properties.

Salient features of a conductive geotextile:

1. Provides a uniform conductive medium under any non-conductive barrier.
2. Does not require water for ELL testing.
3. One layer of conductive textile provide both conductivity and protection functions.
4. 15’ wide sheet for faster deployment.
5. Compatible with electrical leak location methods.

RECENT CASE STUDIES:

This section provides recent projects that used conductive textile in various containment applications.

1. Secondary Containment Tank Farm (2020-2022):

An environmentally sensitive project in western Canada required secondary containment to contain the potential release of hydrocarbons from existing and new above ground storage tanks. The design of the secondary containment system included concrete walls built around the secondary containment facility.

A secondary containment liner system was chosen to be an integral part of the concrete wall. Due to the complexity of installation a spray applied liner was selected to overcome challenges with multiple penetrations on the concrete wall. A non-woven geotextile is a preferred substrate to be sprayed with polyurea (PU), the geotextile was attached to the concrete wall and sprayed with the polyurea to create a containment system. During the design phase, it was decided to perform electrical leak location survey on the spray on liner.

However, with a standard non-woven geotextile it was not practical to conduct this survey as the standard non-woven does not have conductive properties. The conductive textile supplier proposed spraying directly on the conductive textile. After initial trials it was approved by the engineer for use as a substrate material. The electrical leak location testing was found to be very effective and holes up to 1mm were found by the lining contractor.


Figure 3. Spray applied PU liner on earthen berms and vertical wall lined with conductive textile.

2. Aboveground Synthetically lined Tank- Double lined system (2021)

A liner contractor was awarded supply and installation of a 150' diameter and 32' high above ground synthetically lined system (AWSS). An 80 mil thick HDPE primary and secondary geomembrane were selected to line the steel walls and bottom of the tank. The wastewater contained a variety of organic and inorganic compounds. As part of the project scope, liner installer was asked by the facility owner to perform ELL testing on the primary geomembrane. The containment system required a conductive medium between the primary and secondary geomembrane. ELL testing was performed on the primary geomembrane using the newly developed conductive textile.

During ELL testing, one defect (puncture) was detected in the primary geomembrane liner of the tank. The defect was located on the wall area of the tank, approximately 15 feet up from the tank's floor and 1 foot from the welded seam.

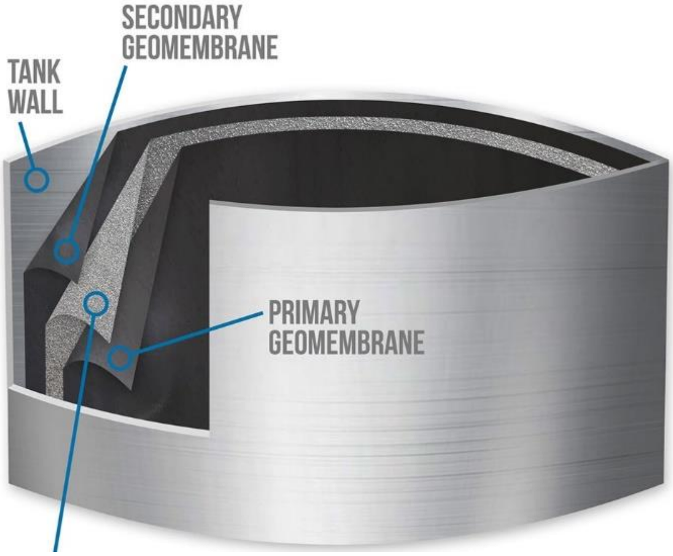


Fig 4. Schematic of aboveground tank lined with geosynthetics.

3. Wastewater Treatment Facility (2022)

Originally constructed in 1960, the Humber treatment plant is Toronto's second-largest wastewater treatment plant and services approximately 680,000 residents with an annual capacity of 473,000m3. The facility underwent extensive upgrades to improve air quality and odor issues which included the addition of biofilters to clean the emissions from the plants. During a recent inspection at the plant, it was determined the biofilter media has reached its end of life and required change out. During the removal of the biofilter media and tank clean-out, it was decided to improve the integrity of the containment and install a geomembrane lining system within the tank as an added level of protection against any leakage which may occur in the concrete tank. The concrete biofilter tank was lined by the installation team with a continuous layer of conductive textile. Seams were overlapped to create a continuous conductive surface. Following the installation of the conductive textile, a flexible geomembrane was installed. Geomembrane seams and penetrations were fusion welded and liner was mechanically attached at the top of the tank using a typical mechanical attachment consisting of an SS316 ¼"x2" bar & gasket. All conductive elements were isolated prior electric leak survey. Arc method (ASTM D7953) was chosen for performing the ELL survey.

CONCLUSION

The development of conductive textile can largely benefit non-conductive geomembranes that do not contain a conductive backing. All type of polymeric non-conductive barriers like PVC, EIA, Elvoloy's, Propylene's and CSPE can be tested using this new innovative conductive textile. This new technological innovation will benefit the overall construction quality assurance and will lower the risk of a leakage in both primary and secondary containment systems. The various case studies presented in this paper shows the diverse range of applications this product can be used and tested.

The next step for the author is to try and laminate this material on a geonet so it can used as a conductive geocomposite suited for ELL testing of the primary geomembrane in a double lined application.

Figure 5. Technician performing arc testing on the primary liner.