GeoAmericas 2016
3RD PAN-AMERICAN CONFERENCE ON GEOSYNTHETICS
10-13 APRIL 2016 • MIAMI BEACH • USA

STATISTICS ON ELL SURVEYS COMPARED TO THE OVERALL GEOMEMBRANE COVERED AREA IN THE PROVINCE OF QUEBEC IN 2014

C. Charpentier, T. Jacquelin, A. L. Rollin and H. Bremner, Groupe Alphard, Montreal, Canada

ABSTRACT

In recent papers related to construction quality assurance or leak location on geomembranes, a statistic published in January 2010 was discussed thoroughly: about two percent (2%) of all installed geomembranes in North America were tested for leaks with electrical leak location (ELL). Groupe Alphard decided to gather pertinent information on the present situation (for the year 2014) in the province of Quebec, Canada. Since this paper is written in the summer of 2015, only statistics from 2014 will be included. Installers of geomembrane in Quebec were contacted to collect estimates of installed geomembrane (poly-ethylene and bituminous) throughout 2014. Thanks to the companies' collaboration, the areas installed have been estimated. Thanks also to ELL companies that worked in Quebec, we were able to gather the amount of surface that has been tested and the amount of holes detected. Please note that this paper does not compare ELL methods in any way, and that only ASTM standardized methods were considered at ELL.

As a result, it is fascinating to add all received information and calculate the high percentage of installed geomembrane being tested by a ELL technique. That percentage is considered from an installed geomembrane point of view, regardless of the number of methods used on it. A square meter that has been tested with multiples methods (say water puddle or/and dipole) will just count as 1 square meter of tested geomembrane. After that, statistics about the percentage of total installed geomembrane that has been tested by different techniques such as water puddle, dipole, arc testing, and both water puddle and dipole were analyzed.

Other statistics will be derived from gathered data, such as how many leaks has been repaired in the surveyed surface, that could be extrapolated to the un-verified surface installed in 2014, and thus how many leaks may not have been found. Other ratios like percentage of each damage type found, types of geomembranes, CQA on site or not, and a handful of other statistics will be included in the paper.

1. INTRODUCTION

Electrical leak location on geomembrane installations has been conducted for well over 20 years. During this time, technology and standards have continuously improved in order to deliver better and better surveys, to enhance the precision of various methods, and to find new ways to ignore or bypass background noise, false positives, and other error-inducing parameters. Thanks to these improvements, and to the experience and skill of those in the leak location industry, the ELL market is growing year after year, but is still marginal when compared to the overall installation of geomembranes. Why is that?

From the author's point of view, ELL surveys are performed due to a short list of reasons, either:

- ELL is mandatory by law on a specific type of impervious work;
- a leakproof system sealed with geomembrane is leaking more than the allowable leakage, and remediation work is required;
- the owner wishes to pay for ELL in order to have a good environmental reputation;
- a contractor wants to make sure the job is well done, so that he will not be held responsible for future leaks; or
- the owner and/or the designer know the value of ELL, and decide to go with available pro-active methods to lower the risk of leaks in their geomembrane installation.

All of the above reasons contribute to whether an electrical leak location surveys is performed. According to a recent paper related to construction quality assurance and leak location on geomembranes, probably only two percent (2%) of all installed geomembranes in North America is surveyed using electrical leak location (Darilek and Laine. 2010). That estimated statistic was quoted a few times in the 11th International Conference on Geosynthetics, held in Portland in 2015, and teased the audience quite a bit. It raised the question of whether that 2% also applies to the Province of Quebec, where leak location professionals have been active for 15 years, educating the industry about leak location, and pushing it forward. The 2014 season was chosen as it was the most recent, mostly all of the data was available at the time of writing this paper (summer 2015), and it was also a good year for ELL.

This paper will summarize the data collection methodology, the results of the percentage of tested geomembrane in all of Quebec, and will also provide additional statistics from Groupe Alphard's own leak location surveys. These values are based on the three common leak location methods that were conducted in Quebec in 2014. Only ASTM standardized methods were considered as ELL for the purposes of this paper; any "last minute improvised testing" or head pressure tests are excluded.

2. ELECTRICAL LEAL LOCATION METHODS

2.1 Description of the Water Puddle Method (Leak Location on Exposed Geomembrane)

The water puddle geoelectrical method (ASTM D7002) relies on the intrinsic insulation properties of geomembranes for the detection of small perforations (<1 mm^2) in the geomembrane, generally produced at the time of installation (see Figure 1).

A continuous DC voltage is applied into the metallic water puddle structure, and a grounding electrode is placed outside of the limits of the geomembrane. In the presence of a leak, the current will pass from the metallic structure, through the defect, into the subgrade, and to the grounding electrode. A visual and auditory signal will be produced, indicating the presence of a leak to the technician. This technique requires only a thin film of water on the surface of the geomembrane, and provides a validation of the entire exposed surface surveyed.

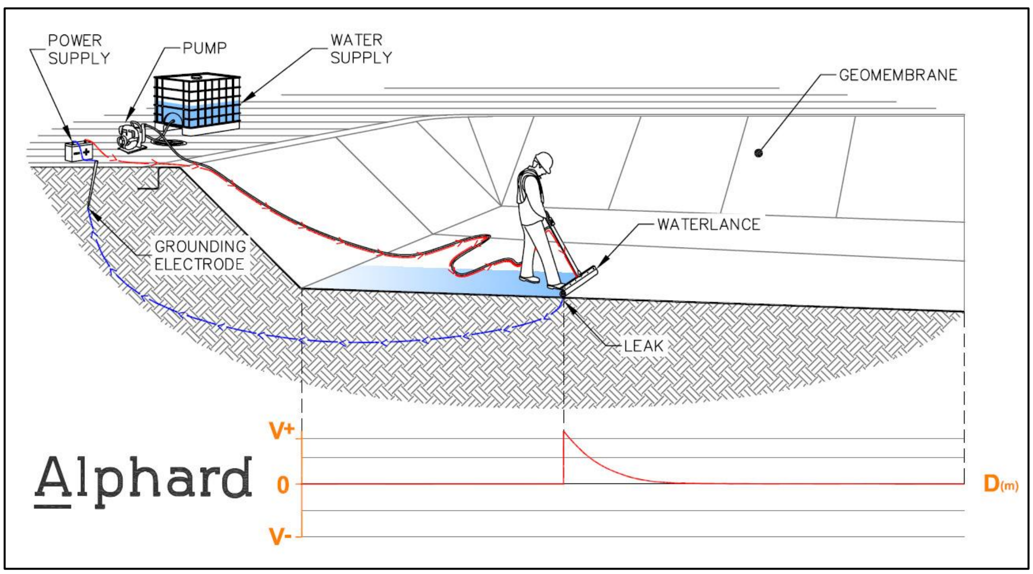

Figure 1. Water puddle schematic

2.2 Description of the Arc Test Method (Leak Location on Exposed Geomembrane)

The arc test method (ASTM D7953) relies on the intrinsic insulation properties of geomembranes for the detection of small perforations (<1 mm^2) in the geomembrane, generally produced at the time of installation (see Figure 2).

A high voltage is applied to the arc test wand, and a grounding electrode is placed outside of the limits of the geomembrane. No conductive medium, such as water, is required when performing the survey. In the presence of a leak, the current will create a spark from the wand, through the defect, into the subgrade, and will then pass into the grounding electrode. An auditory signal will be produced, indicating the presence of a leak to the technician. This method provides a validation of the entire exposed surface surveyed. Since the contact between the wand and the subgrade is achieved with a spark, there is no slope limitation as it may be the case with a water based leak location.

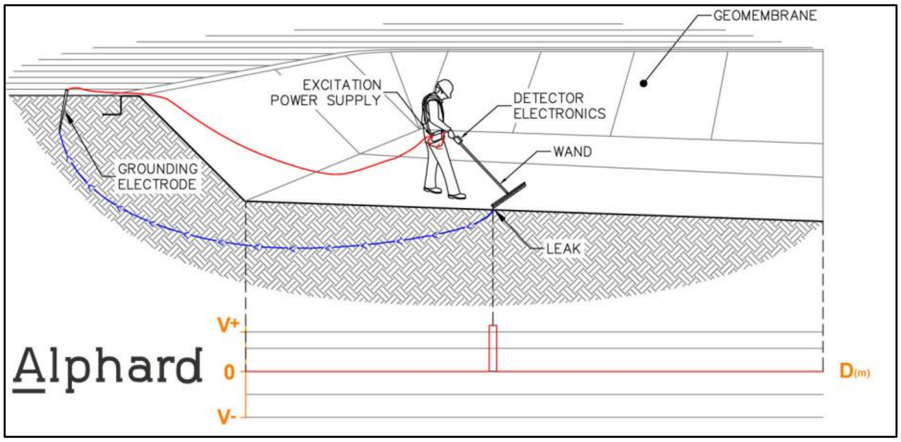

Figure 2. Arc testing schematic

2.3 Description of the Dipole Method (Leak Location on Covered Geomembrane)

The dipole geoelectrical method (ASTM D7007) relies on the intrinsic insulation properties of geomembranes for the detection of perforations that were created during the installation of the cover material (see Figure 3).

A current of up to 550 V is injected into the cover material, and a grounding electrode is placed outside the limits of the geomembrane. If a defect is present, the current will pass through the hole to reach the ground (electrode), which then generates a distinct electrical signature that can be identified and located by a specialized technician.

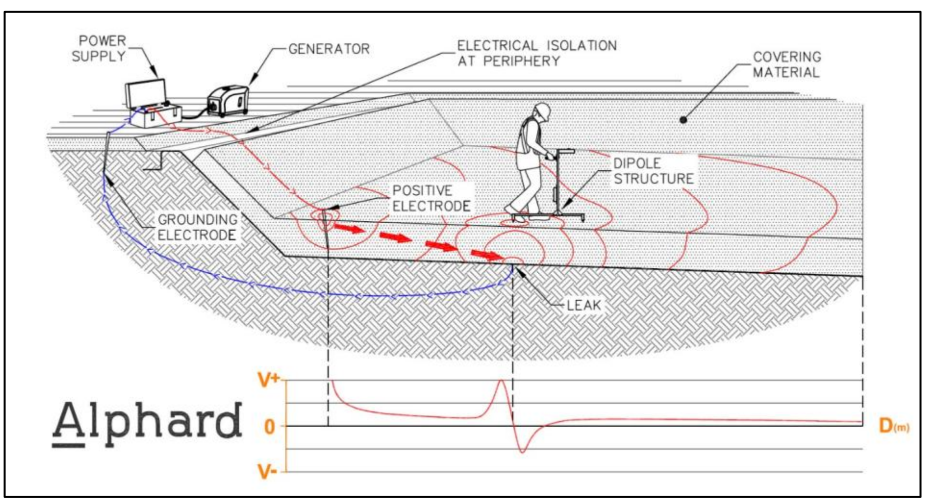

Figure 3. Dipole schematic

3. DATA COLLECTION METHODOLOGY

3.1 Geomembranes Requiring Specialized Installation

Initially, it was thought that the geomembrane manufacturers should be contacted in order to obtain the amount of installed geomembrane in Quebec in 2014, however, it was quickly decided that it would be best to contact the installers directly. Geosynthetics are frequently delivered to a site a few months before the actual installation, or sometimes the installer will use geomembrane rolls already stored onsite. Additionally, there is often either wastage onsite, or alternatively, excess material delivered onsite to ensure sufficient quantities to complete the project. Six companies installed geomembranes that required specialized installation (PVC, LLDPE, HDPE) in 2014. It was therefore feasible to contact them all in order to gather the necessary data. Each installer provided their totals—which will not be disclosed—so that the overall quantities of installed liner could be calculated. In 2014, only HDPE was installed in this category of liners.

3.2 Geomembranes Requiring Generalized Installation

The above approach could be used to calculate installed quantities for geomembranes requiring dedicated installers with specific tools, but for bituminous liners a different approach needed to be used. As not all of the qualified contractors were known, the manufacturers were contacted directly for their sales in Quebec in 2014. Although this method still leaves some uncertainty in terms of materials installed that had been previously delivered, it was possible to include measurements from sites where Groupe Alphard was present and BGM was installed. Using the collected data, a rather precise total area installed could be obtained, but there may still be room for error, due to uncertainties.

Concerning ELL, many specialized companies have worked in Quebec in the past; however, in 2014, there were only three. The two other companies that provided ELL collaborated by providing their values for area tested (irrespective of the number of jobs performed) for each type of geomembrane, for each method they provide, as well as the number of leaks found. It was then possible to draw a full portrait of the geomembrane installation, and the percentage of testing applied to it.

4. LEAK LOCATION STATISTICS

4.1 Percentage of Tested Liner

The main statistic of interest was the percentage of installed liner tested, which could then be compared with the 2% estimation. After many years of promoting ELL, and making it part of standard good practice design, seeing anything over 2% would be terrific.

The percentage of installed liner tested using ELL was calculated to ensure that there was no "double counting". Once one square meter of liner had been tested (regardless of the method) it was added to "area surveyed". If the same area was tested again using another method (e.g. first tested using the water puddle method, and then again with the dipole method) that area was not added again to the tally, as it had already been considered as "tested".

It is possible to show the percentage of geomembrane tested using each individual method, as well as the percentage of geomembrane tested by both methods (first the water puddle method and then the dipole method). Although those are all derivatives from the basic goal of this paper, they are detailed below for informational purposes.

Based on the information kindly shared by all of the geomembrane installers and BGM manufacturers in Quebec, a total of 2,037,538 m² of liner was installed in Quebec in 2014. Based on the data also kindly shared by the other two firms offering ELL in Quebec in 2014, added to Groupe Alphard's data, 436,144 m² of liner was tested using ELL. The percentage of geomembrane installed in Quebec in 2014 that was tested using any ELL method is 21.41%. Please note that this may not be representative of other years, as about half of this 21.41% is due to a single job (255,000 m² tested with the water puddle method AND then again with the dipole method).

Table 1 shows the areas tested using the different methods. ARC stands for arc testing, WP for water puddle, DIP for dipole, WP+DIP for areas tested using both methods (water puddle followed by dipole), and ELL for an area tested using any of the methods, without double-counting (the main percentage).

Table 1. Percentage of three ELL methods surveyed in Quebec, 2014

Method	Area surveyed (m²)	% of installed liner
ELL	436 144	21.41%
ARC	45 091	2.21%
WP	331 815	16.29%
DIP	374 453	18.38%
WP+DIP	312 515	15.34%

If the areas surveyed for each of the three methods are summed, a total surface survey area of 751,359 m² is obtained. Groupe Alphard provided 700,268 m² of leak location in Quebec only in 2014, which represents more than 95% of all ELL that occurred during that time frame.

4.2 Leaks Found, and Leaks NOT Found

4.2.1 Leaks Found as Seen from a Leak Location Point of View

It's great to talk about the area of liner tested, but what was the outcome of the tests? A whole range of leaks was found, from pin-hole sized to giant tears from heavy machinery. The types of leaks detected are depicted in Figure 4, however, it is important first to look at the bigger picture: 105 leaks were found and repaired in Quebec in 2014. This results in a low average of 1.4 leaks per hectare, which is way smaller than the numbers found in several papers. This is likely due to a large part of that 751,359 m² of ELL coming from a single job that was 255,000 m² of water puddle and dipole (510,000 m² total). On large installations such as this, the leaks per hectare value is generally low due to the simplicity of the installation:

- large flat area to deploy full rolls;
- almost no extrusions area needed, maybe just for air channel tests;
- no circulation on the geomembrane.

Additionally, over time the number of leaks tends to decrease, as each participant in a project improves with time and learns from past mistakes. This includes installers, designers, and contractors, who all play a crucial role in the quality of the geomembrane installation. ELL also plays a part in the overall amelioration of leakproof works since it clearly shows where failures are and what they look like.

4.2.2 Leaks not Found as Seen from an Installed Liner Point of View

When considering that 105 leaks were found on the 21% of installed liner that was tested, it statistically means that there may be roughly 400 leaks in the remaining 79% of brand new geomembrane installed in 2014 that was not tested. So what does that mean? Liners leak, and each project is different, with a different set of tolerances. Was the 21% that was tested the most critical jobs? Hard to tell, but it's unlikely. Part of that 79% might not have known of ELL, and the other part may have known about it, but did not think it was worth the investment. Based on our own experience, electrical leak location is about 1% of the global cost of a project, often less.

4.3 Defining the Leaks Found By Groupe Alphard

The other ELL companies were not asked to provide details on the types of leaks that were found, and this section will not address the number of leaks found by Groupe Alphard. Rather, this section will address the types of leaks found by Groupe Alphard in Quebec in 2014: 70% of the leaks found were with the water puddle method, 30% were with the dipole method, and no leaks were found using the arc test method. Most of the surveys performed included both water puddle and dipole testing, so those dipole statistics show only the damages that occurred during placement of the cover material, which lowers the amount of leaks found with dipole. The damage type repartition pie-chart (Figure 4) shows the more common leaks, and includes leaks found with either the water puddle or dipole method.

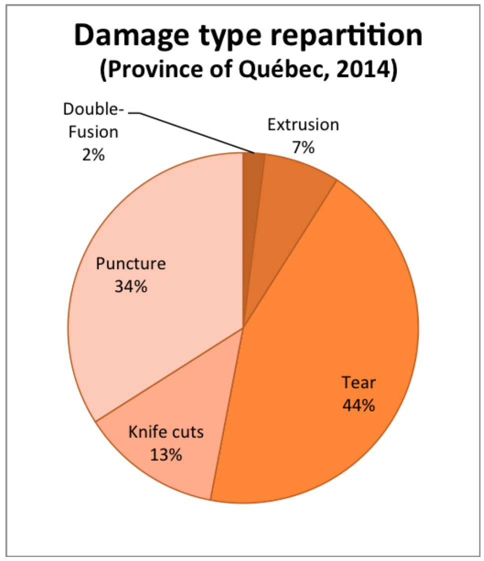

Figure 4. Damage type repartition

Leaks in double-fusion seam? How is it possible? Likely the defect is due to a problem just next to a welding track, under the overlap. Those defects are not detectible with the air channel test and are invisible to the bare eye, but can be detected easily with the water puddle equipment. It is also possible to have a blocked air channel that prevents the whole seam from being tested. It is always recommended to pierce the air channel at the far end of the seam, to make sure air pressure was present up to the end of the seam.

Extrusion leaks are common, and should ideally be detected during the vacuum box test, but there are limits to that quality control procedure. There are physical limits that prevent an acceptable seal from being formed all around the vacuum box (toe of the slope or around a penetration, for example), and there are limits to concentration after vacuum testing for an extended period of time. Thirteen percent for knife cuts in 2014 is surprisingly high. Even knowing that those leaks are generally tiny and do not leak much, installers need to be more careful. Main causes are tools dropped on the liner, loose blades not disposed of properly, and mainly accidents while cutting patches over the geomembrane and cutting through the patch AND the installed geomembrane.

Tears and punctures are the most common damages. Sharp rocks can perforate the geomembrane—they can be present in the subgrade and, with the pressure applied from heavy machinery, pierce the liner. On exposed geomembrane, most of these leaks are found by the installer and are repaired before the ELL starts (or are at least marked with chalk or paint). If there is sand and/or dirt on the geomembrane, however, those damages can sometimes be impossible to see. The puncture category also includes forgotten stakes that were driven over, and direct machinery contact, such as a bulldozer's blade, or an excavator/bobcat bucket.

4.4 ELL Demand by Sectors

To illustrate the demand in 2014 in Quebec, the ELL provided by the three companies was regrouped into four (4) different sectors (as seen in Figure 5):

- mining wastes, which also includes any facilities, built on a mining site;
- industrial wastes and contaminated soils;
- domestic wastes (landfills); and
- water storage and treatment.

No leak location survey was performed on any domestic waste landfill in Quebec in 2014, but it seems unlikely that any was performed in previous years either, as there are no requirements for it in any law or construction guide. The large mining project previously described is mostly responsible for the 66% mining wastes; otherwise it is generally closer to 10%. Industrial wastes and contaminated soils are usually the main sectors where ELL is required, seconded by water storage and treatment.

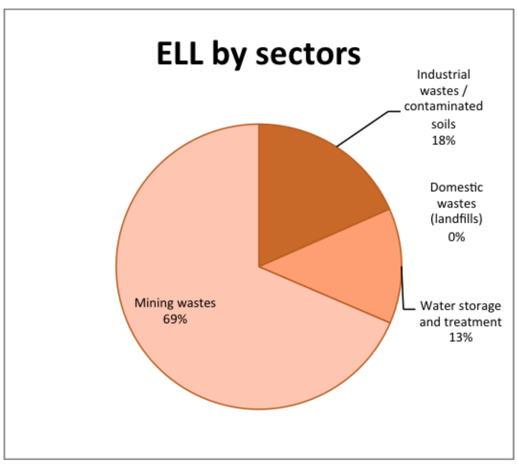

Figure 5. ELL by sectors in Quebec, 2014

5. CONCLUSION

Electrical leak location professionals have been pushing forward ELL methods in Quebec for 20 years, making it better known, more convenient, and allowing for solutions to be developed to deal with climactic difficulties and social behavior specific to that area. Water puddle method was born in Quebec and is widely used now.

It is important to say that 2014 was a really good year, for geomembrane installation and for leak location, and does not represent every year (especially not 2015). However, it has been a great surprise to discover that 21% of all geomembrane installed in Quebec in 2014 was tested with leak location. Additional time and effort will be invested to make it even more popular, so it becomes second nature and part of standard good practices, whatever the containment needs. If it is worth the time and money for quality design and geosynthetics, it is probably worth the 1% investment to include electrical leak location.

As previously stated, certain limitations were inherent in this study. For one, it is possible that more bituminous liner was installed in 2014 than what was noted. Additionally, these results are for one year only. The 2014 values are skewed in favor of the one large mining project, where 255,000 m^2 of HDPE liner was tested using both the water puddle and dipole methods. These values should be tracked over the upcoming years, in order to have more representative values, and also to see the progression and evolution of leak location over the upcoming years.

It would be interesting to gather information on the drainage material over and under each leak, and have an estimate of the operation head-pressure, to have a rough idea of the global leachate flow prevented by finding and repairing those 105 leaks in 2014, and then extrapolate to a possible existing leachate flow on the 79% of un-tested liners.

REFERENCES

ASTM D7002. Leak Location on Exposed Geomembranes Using the Water Puddle System, *American Society for Testing and Materials*, West Conshohocken, Pennsylvania, USA.

ASTM D7007. Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials, *American Society for Testing and Materials*, West Conshohocken, Pennsylvania, USA.

Forget, B. et al., (2005). Lessons Learned from 10 Years of Leak Detection Surveys on Geomembranes, Sardinia Symposium, Sardinia, Italy.

Beck. (2014). *Designing to minimize geomembrane leakage*, Geosynthetics Magazine, August/September Issue.

Darilek, G.T. and Laine, D.L. (1999), *Performance-based specification of electrical leak location surveys for geomembrane liners*, Geosynthetics '99, Boston, Massachussetts, USA, April 28-30 1999, p. 645-650.

N. Touze Foltz. (2002). *Méthodes de détection et de localisation de défauts dans les géomembranes*. Ingénieries - E A T, 2002, p. 17 - p. 25. <hal-00465455>

Thiel, R., Beck, A. & Smith, M.E. (2005). *The Value of Geoelectric Leak Detection Services for the Mining Industry*, *Geofrontiers*, ASCE, Waste Containment and Remediation. pp. 1-

Darilek, G.T. and Laine, D.L., (2010). *Leak Location Surveys, The Past, The Present, The potential,* GSI Annual Meeting 2010