GEOSYNTHETICS : LESSONS LEARNED FROM FAILURES

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This short course handout was prepared for the sole purpose of fostering the exchange of information between professionals, with a view to enhance the state of practice in geosynthetics engineering and related disciplines. This short course handout should not be construed as expressing any preference for any type of product or system.

The case histories presented were selected by the authors who agreed to participate in the short course "Geosynthetics: Lessons Learned from Failures". The case histories presented do not represent the entire range of applications of and modes of failures of geosynthetics. Therefore, they do not provide any information of statistical nature regarding the number or probability of occurrence of the various modes of failures of structures incorporating geosynthetics.

The title of this short course handout should not be interpreted as implying that all of the failures presented in this volume are failures of geosynthetic products. In reality, the failure of a structure incorporating one or more geosynthetics does not necessarily result from the failure of a geosynthetic product.

The papers presented in this short course handout should not be used to claim that structures incorporating geosynthetics fail. In fact, only an extremely small fraction of the structures incorporating geosynthetics do fail. As demonstrated by thousands of publications, structures incorporating geosynthetics perform very well. The purpose of this short course handout is to further increase the safety of structures incorporating geosynthetics by informing potential users of mistakes that should be avoided, and by telling them how they can be avoided.

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LESSONS LEARNED FROM GEOMEMBRANE LINER FAILURES LOCATED WITH THE HIGH-VOLTAGE ELECTRICAL LEAK LOCATION METHOD

by D. L. Laine and G. T. Darilek

ABSTRACT: During the past ten years, the high-voltage electrical leak location test method has been used to detect and locate numerous geomembrane liner failures at more than 200 sites. These failures ranged in size from two-meter long rips located under 600 millimeters of soil to smaller punctures, cuts, and seam leaks. In many cases, these failures occurred and were not detected even though a formal written quality control and quality assurance program was implemented. Many of the leaks that were found could have been prevented by using better installation procedures, changing the installation design , or avoiding simple mistakes. This paper discusses the causes of some liner failures detected and located using the high-voltage electrical leak location method. Some of the brief case histories that are presented involve damage to liners caused during the placement of protective soil in landfills, mechanical damage to liners, seam leaks, and other leak problems. Recommendations and solutions are presented to help alleviate these types of problems in the future.

KEYWORDS: Geomembrane, Electrical Leak Location, Landfill, Surface Impoundment, Leak Detection, Leak, Failures, Quality Control, Liner Testing.

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I. INTRODUCTION

The high-voltage electrical leak location method uses advanced and sensitive electronic equipment to locate leaks in the geomembrane liners of surface impoundments and landfills. The development of the leak location method began in 1980 and the method has been offered as a commercial service since 1985. The liners that have been surveyed ranged in size from much less than 10 square meters to more than 60,000 square meters. These surveys were used as either the final quality control (QC) test of the liner prior to acceptance of waste material or to locate leaks in facilities with a known leakage problem.

The electrical leak location method detects electrical paths through the geomembrane liner caused by water leaking through the leaks. A voltage is connected to one electrode placed in the water or soil covering the liner and to a second electrode placed in the leak detection zone for double-lined systems or in earth ground for single-lined systems.

Electrical current flowing through the leaks in the liner produces localized anomalous areas of high current density near the leaks. These areas are located by making electrical potential measurement scans throughout the survey area.

With the proper implementation of equipment and survey procedures the electrical leak location method can detect and locate very small leaks. The leak signal amplitude is proportional to the amount of electrical current flowing through the leak. To maximize this current, a high voltage power supply with safety circuits is used that can provide up to 300 volts DC, depending on the current requirement. The high voltage power supply produces a proportionally higher leak signal to provide optimum leak detectability.

II. TYPES OF LEAKS LOCATED

The high-voltage electrical leak location method has been used to detect and locate many leaks that were not located using conventional test methods. The liner leaks located included leaks in extrusion fillet hand welds and to lesser degrees, leaks in double fusion weld seams and leaks caused by damage to the sheet. The leaks caused by sheet damage tend to be the largest, particularly when they are found in the geomembrane liners of landfills that are covered with a protective soil or drainage material.

A. Extrusion Fillet Welds

One of the most common leaks found is a leak where the extrusion fillet weld and the double fusion welds meet. These "tie-in" welds are typically found where destructive samples are removed from double fusion weld seams for laboratory testing of seam quality. These areas are repaired using a patch that is extrusion welded to the liner. These leaks can be prevented by paying careful attention to properly cutting back the overlap material flap and properly grinding the area. The patch can then be properly sealed using an extrusion fillet weld without leaving a leak in the old air channel.

It is time for the industry to rethink the practice of taking destructive samples out of double fusion weld seams that seldom fail and patching the sample points with an extrusion fillet weld that are notorious for failures. We must be sure that such tests do not cause more problems than they solve (Cadwallader et al. 1994).

A similar type of leak is found at tee welds placed over the fusion butt welds where three sheets are jointed together. Leaks in this area can be prevented if the liner technician trims back the material flap on the double-fusion weld and properly grinds the weld eliminating the short section of air channel at the butt joint. The extrusion fillet tee weld or patch is then placed over the butt joint sealing the liner without leaving a leak along the old air channels.

B. **Double Fusion Welds**

A double fusion weld is a weld where the two sheets are fused together with two parallel fusion welds, leaving a small air channel located between the welds and between the two liners. This air channel is used to air pressure test the integrity of the weld. A loss in air pressure over a specific length of time indicates a bad weld. This welding method is now the preferred welding method for joining the straight edges of the sheets. However, the method for testing this weld does not test the sheet adjacent to the weld.

The high-voltage electrical leak location method has found liner failures that are suspected to be caused by a sharp edge or burr on a part of the welding machine touching the liner, cutting the liner. These leaks measured from just a few centimeters in length to more than two meters in length. Figure 1 shows a picture of one of these leaks. The difficulty in detecting this type of leak is they are located on the bottom welded liner next to the weld and are covered by upper liner flap. Therefore, unless the upper liner flap is removed or temporarily lifted by hand this area cannot be visually inspected. Also, in removing the flap there is the potential for causing additional liner damage by cutting the liner.

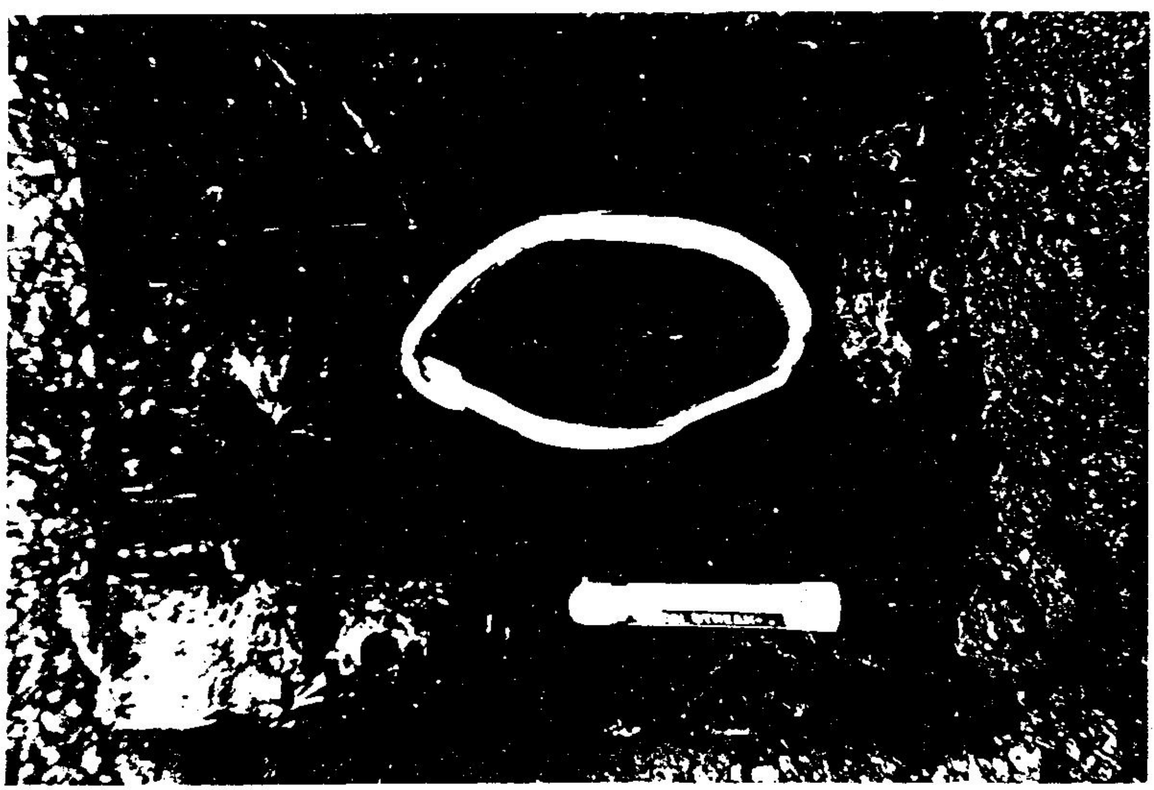

Figure 1. Photograph of Leak Caused by Sharp Edge on Double Fusion Welder

The double fusion welder should be inspected periodically to be sure that the parts that contact the liner do not have sharp surfaces. In addition, the wheels should be checked regularly to make sure that there are no metal burrs that could damage the liner.

A second type of liner failure associated with the double fusion weld is when sand particles or small sharp natural material becomes trapped under the liner flap when the weld is made. The particle is heated as the welding machine passes over it, causing the particle to melt through the liner. Once again these types of leaks cannot be detected using conventional test methods without first removing the upper liner flap. Careful attention must be paid to keeping sand or other particles off both sheets that are being welded.

C. <u>Leaks in the Liner Sheet</u>

Leaks in the geomembrane liner sheet are caused by knife cuts, mechanical damage from equipment, and from the mishandling of the liner sheet. The majority of these types of damage can be prevented by following proper QC procedures. However, even with good QC practices, large leaks can be missed (Laine et al. 1993).

Figure 2 shows a large leak located in the floor of a small landfill. The leak was caused when dump truck tires cut the liner during the placement of the protective soil cover. This damage was not noticed by the QC engineer because it was covered by the protective soil.

Figure 2. Photograph of Leaks in Primary Caused by Dump Truck Wheels.

A second site was inspected for damage that was caused by the dump truck "spinning" the rear tires when dumping the protective soil. The QC engineer and the dump truck operator marked the area for repair. The soil was removed and the damage was repaired. However, additional damage was not detected and the repaired area was covered with soil. A leak location survey was required to locate all the damaged area.

A small cut or deep score on the liner material can lead to future leakage problems. At one site a cut was located at the base of the entrance ramp to a newly constructed landfill. As the heavy trucks brought material into the landfill the liner was flexed allowing water to saturate the supporting clay sub-grade through the initial cut. As the sub-grade became water saturated the support for the liner material was lost and the cut was enlarged.

Figure 3 shows the results of this action. The initial cut was approximately 100 millimeters in length with the resultant tear measuring in excess of 1 meter. A geocomposite liner is shown protruding through the primary liner tear.

Figure 3. Photograph of Leak Caused by a Razor Cut and Tearing of the Sheet Under Load. (Note: Geo-composite Liner Protruding through the Tear.)

A very unusual liner failure was caused by the geonet drainage material punching a small hole in the primary liner. Figure 4 shows the backside of the primary 2 mm HDPE liner. The indentations and small hole were caused by the geonet pressing into the sheet. It is unknown how this failure occurred, but this may have been caused by a front-end-loader bucket pressing down on the soil covering the liner. The pressure of the bucket on the thin soil was so great that the geonet was extruded through the liner. This could have been prevented by using proper QC procedures.

Figure 4. Leak Caused by Geonet Cutting into the Liner Sheet

Many of the leaks caused by mechanical damage can be reduced by the proper use of written QC procedure. Razor cuts can be reduced by strict adherence to a QC plan that prohibits sharp pointed razors and other knifes on the lined area and allows only hook type razor knifes for cutting the liner sheet. Of course, the liner should never be used as a surface for cutting liner patches or other pieces of liner.

III. ENGINEERING AND SITE PROBLEMS

The electrical leak location survey was needed to solve leakage problem in two-40,000 square meter surface impoundments. The client had already implemented a comprehensive third party QC program including numerous laboratory tests of the welds and the liner material.

The electrical leak location survey found 50 leaks in the two ponds including several leaks in the double fusion welds. The lesson learned was that over reliance of conventional test methods can be a costly and ineffective process. An electrical leak location survey is a valid final test to assess the final performance of the liner.

At several landfill sites, after the final protective soil cover is placed over the liner material, water was detected in the leak detection zone after a heavy rainfall. The client at one site spent several months looking for leaks in the primary liner using dye tests, air pressure tests, and excavating portions of the liner cover material. The liner still leaked after all of these tests were conducted. Electrical leak location found twelve leaks in four days of testing at this site. The lesson leaned was the "we can solve our problems approach" can be costly, time consuming, and could jeopardize your good standing with your clients.

Liner installers are requested to install liner material in a variety of adverse weather conditions. If the client insists that the liner be installed in conditions that are unsuitable then the client should assume the consequences of a leaking liner. One example, two small liners were installed during adverse winter weather conditions. The client insisted that the liners be completed during the winter so the plant could become operational. During the previous eight years four electrical leak location surveys were performed after the liners were cleaned. Hundreds of leaks were found during each survey. The majority of leaks were associated with weak seams caused during the initial installation.

At one landfill project the Engineering design firm did not inform the owner of the availability of the electrical leak location test method until waste material was placed in the landfill cell. Subsequently the liner leaked and the engineers recommended an electrical leak location survey. The survey located several small holes in the liner but the major leak was located under the waste pile. Engineering and design firms who work on these types of projects must inform clients of relevant testing methods.

IV. CONCLUSION AND RECOMMENDATIONS

The high-voltage electrical leak location method has been used to locate many geomembrane liner leaks and failures that could not be located using conventional test methods. These have included tears under the flap of double-fusion weld seams, leaks in extrusion fillet welds, and leaks under the protective soil of landfills. Some of the leaks can be eliminated by modifying the quality control plan. However, as we have observed some leaks will occur even if a QC plan is used during installation. An electrical leak location survey can detect the leaks that can not be found using other test methods.

We have also discussed that the engineering design firm and the QC engineer have a responsibility to the owner of the facility to help them understand the limitations of the various test methods and to recommend those methods which can help achieve a near leak free facility.

V. REFERENCES

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