The Technical Background and Successful Field Experience of Spark Testing a Conductive Liner

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Abstract

Construction Quality Assurance (CQA) plays an important role in producing a quality containment system. Electrical Leak Surveys are CQA non-destructive tests that help locate leaks/defects after the installation of the geomembrane is completed. Spark testing of an insulating geomembrane with an underlying conductive layer is the electrical leak survey method in which this paper will be focused. Conductive Geomembranes typically include a 2 to 3 mil thick coextruded layer of polyethylene containing a conductive carbon black on the bottom surface of an insulating geomembrane which allows it to be spark tested for defects. The advantage of the conductive geomembrane in regards to spark testing is that the conductive layer is in intimate contact with the geomembrane, and it allows the geomembrane to be 100% spark tested in the field per ASTM D7240 (*Standard Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique*). This paper is intended to discuss the intricacies of field spark testing a conductive geomembrane. It will include the equipment used and the calibration of the equipment for site specific conditions. It will also discuss the process in spark testing the geomembrane and spark testing underneath the weld flap.

Introduction

The purpose of geomembranes is to be containment barriers for liquids and/or gases in environmental and industrial applications. The design engineer of a project uses the physical and/or chemical properties of a specific geomembrane to determine if it is appropriate for use in their specific application. Geomembranes can be damaged during shipping, handling, poor subgrade conditions, installation, traffic, and cover material. This may alter the material from the prime material manufacturing state. Thus, engineers rely on or should rely on good CQA to alleviate and/or detect any damage to the geomembrane and to provide a quality installed geomembrane containment system.

The objective of CQA is to ensure that the liner is built according to the project specifications, with the best possible workmanship, and within the constraints of the budget and schedule. CQA does not ensure a perfect lining system. If the liner is poorly designed, CQA will ensure that that poorly designed liner is properly installed. There are several different methods to incorporate CQA in to the post installation of a project to assure the quality of the geomembrane system in an application. Visual inspection, destructive testing of seams, non-destructive testing of seams, leak location using electrical potential which is performed with water/soil on top of geomembrane, and the spark testing of a conductive geomembrane which is performed on an exposed conductive geomembrane are some different techniques used as CQA of geomembrane systems. This paper examines the CQA technique of spark testing a conductive geomembrane using the capacitance effect on the geomembrane panels and the conductive geomembrane underneath the fusion weld flap.

Conductive Geomembrane

Spark (Holiday) testing was originally developed to inspect coatings on steel pipe. A high electrical potential (voltage) of negative polarity (ground) is applied to the metal pipe to be tested. An electrode (wand or brush) of opposite (positive) polarity is passed over the coating. Any voids in the coating will establish electrical continuity and allow a spark to pass between the metal pipe and the electrode.

Geomembrane manufacturers use this type of electrical spark testing of synthetic polyethylene geomembranes for defects during the manufacturing process. The next logical step was to then take this proven technology from the factory to the field. This move was accomplished with the development of a specialty coextruded geomembrane with an integral outer layer of conductive material. A conductive geomembrane typically comprises of a 2 to 3 mil layer of a special conductive carbon black (Figure 1) which provides the geomembrane with an intimate conductive layer.

Figure 1: Coextruded Conductive Geomembrane Cross-section

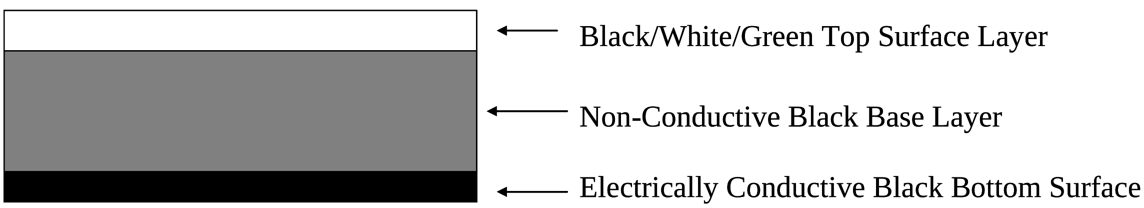


Figure 1: Coextruded Conductive Geomembrane Cross-section

Spark Testing

The electrical leak location test using the spark test of a conductive geomembrane containment system can involve the spark test of two areas of the installed geomembrane system. The first area is the spark test of each individual geomembrane panel between the fusion welded seams, and the second area is the spark test underneath the fusion weld flap. The spark tests on each of these areas are similar, but each test should be setup and calibrated separately. The spark test on the wide geomembrane panel is typically done with brass brush electrode (Figure 2) that is typically 4 foot wide. The spark test performed on the conductive layer on bottom of the fusion weld flap is typically done with a conductive neoprene electrode (Figure 3) which is usually flat so that it can slide underneath the flap.

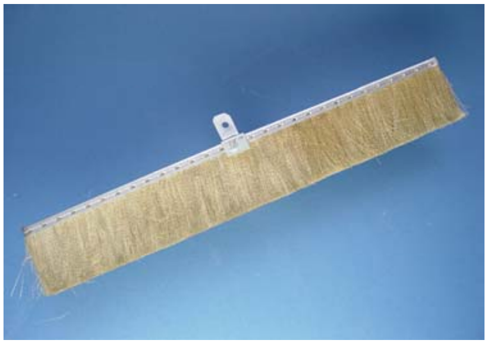


Figure 2 – Brass Brush Electrode

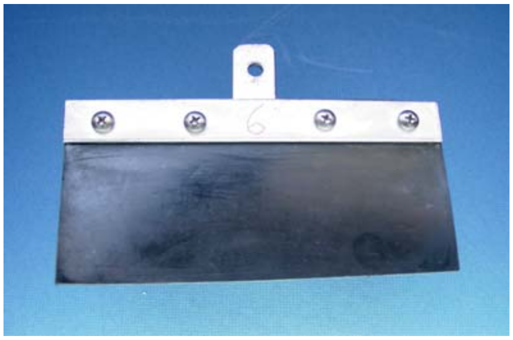


Figure 3 – Neoprene Electrode

The spark testing of a conductive geomembrane typically utilizes a high voltage spark tester "Holiday Detectors" – typically those over 5KV – these operate by generating a narrow pulse of high voltage. These pulses occur between 30 and 150 times per second. Any holes (or holidays) in the material being tested will allow this high voltage to arc across to the ground side of the circuit. This current flow is detected and indicated (by visual and audible signals typically). While this pulse of voltage does not "alternate", it does act like an AC voltage in many respects. One of these is that the material being tested – in this case a conductive geomembrane – acts like a capacitor. A capacitor is an electrical device in which two electrically conductive materials are separated by an insulating layer (Figure 4). By moving a conductive rubber ground pad with the spark test electrode, the electrode acts like one side of the capacitor, the grounding pad-to-liner-to-electrode acts like the insulator of the capacitor, and the ground pad is the opposing side of the capacitor. A small current will pass through this "capacitor" even when no defect is present in the geomembrane. This allows the use of a ground pad with a short cable to detect any defects in the liner material. The spark testers used for leak location on conductive geomembranes typically range from 15,000 volts to 35,000 volts with a sensitivity adjustment (Figure 5). The range in voltage and sensitivity allows the operator to adjust the spark tester for the site specific material and conditions.

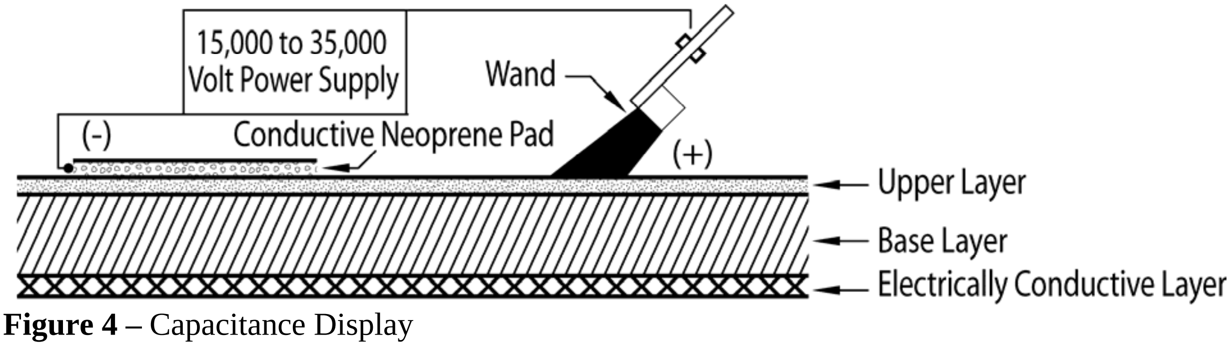
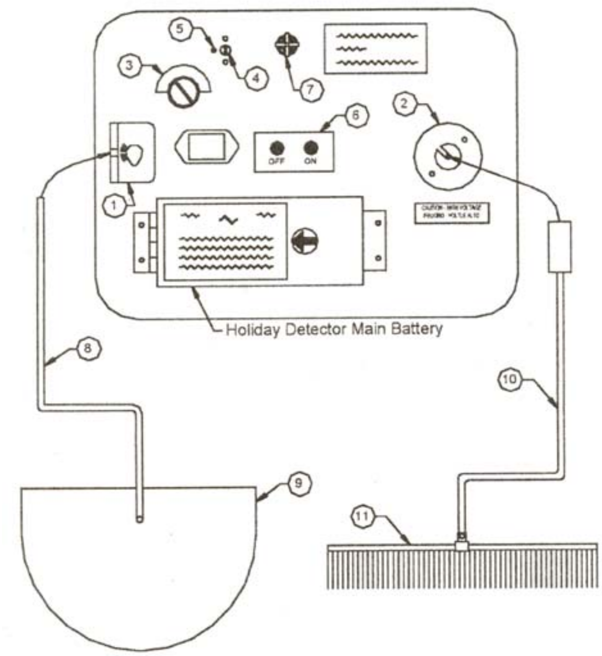


Figure 4 – Capacitance Display



Legend for Spark Tester Diagram

1. Ground Terminal
2. High Voltage Terminal
3. Sensitivity Dial
4. Voltage Dial
5. Voltage Adjusting Screw
6. Main Power Switches
7. Alarm Buzzer
8. Ground Lead
9. Electrically Conductive Grounding Pad
10. High Voltage Lead
11. Wand (Electrode)

Figure 5 – Typical High Voltage Spark Tester

The procedure for spark testing starts by determining a grid pattern that the technician will follow during testing the individual geomembrane panels. The technician begins the survey with the test wand contacting the surface of the geomembrane, and he continues until the entire surface of the geomembrane panel has been spark tested. Sometimes engineers are concerned with potential flaws that may occur underneath the fusion weld flaps where two different panels have been seamed. Unless the operator is able to get the electrode within a few millimeters of the flaw it will not be detected. The GSE conductive layer on the bottom of the flap solves this problem by propagating the high voltage along the conductive layer beyond just the area directly touched by the electrode. Because there is a loss in the conductive layer adjusting the sensitivity of the Holiday Detector will allow the Holiday Detector to detect any flaw as far away as a few meters or as closely as a few centimeters.

Pipeline Inspection Company’s Holiday Detectors, when used with a GSE conductive liner, are typically adjusted to maximum voltage (about 35KV) and the sensitivity is adjusted such that when the electrode is touched to the underside of the top layer of a seam (the flap) a brief “holiday detected” signal may be received. This is due to the “capacitor” becoming charged, thus more current is flowing. Once this effect is over the “holiday detected” signal goes off. The operator now moves the electrode along the flap. As they get near a flaw the “holiday detected” signal sounds. Once they have moved beyond this flaw some distance the signal goes off. Midway between the signal first sounding and then end of it is the location of the flaw. If this distance is too large to identify the exact location of the flaw, then the sensitivity adjustment may be turned down (less sensitive) and the area probed again try to find the exact location, or the operator may just look under flap for a visual detection.

Field Testing of a Brine Pond

Spark testing of a conductive geomembrane was performed on a 20 acre, 30 foot deep Brine Pond in Texas. The pond containment system consisted of a secondary 40 mil GSE conductive geomembrane, geonet, and a primary 60 mil GSE conductive geomembrane with a protective geotextile between the subgrade and secondary liner on a portion of the project. A Pipeline Inspection Company Ltd. Spark tester Model Number(s) 735 and 790 with sensitivity adjustments were used for spark testing the conductive geomembrane on this project. A field technician of EnviroCon Systems, Inc. performed the spark testing with a third party inspector overseeing the leak detection testing. The entire secondary and primary liners were spark tested during the construction phase, and the primary liner was spark tested a second time after all construction was completed. The electrical spark testing of the pond located approximately 6 to 7 defects per acre in the double lined brine pond. The defects were primarily on the secondary 40 mil conductive layer.

Spark testing of the individual geomembrane panels was performed using a grid system agreed upon by the installer and third party CQA representative. Approximately 70% of defects detected were on the individual panels that were due to dragging 40 mil conductive liner over subgrade with gravel embedded into the subgrade. As the geomembrane rolls were dragged over subgrade, the gravel would come loose and introduce indentations in the geomembrane. These indentations were slightly thinner and would trigger the spark tester audio alarm indicating a potential defect. About half way during installation of the secondary liner, a protective geotextile was installed underneath the secondary liner to solve this problem.

Spark testing of the conductive geomembrane underneath the fusion weld flap was performed. Approximately 30% of the defects were located under the fusion weld flap, and the defects were due to weld heat separation of the bottom overlap during welding of the seams. The spark testing underneath the flaps located these defects.

One hurdle to overcome was the continuous false audio alarms that were triggered by the spark testers on one end of the pond during spark testing underneath the weld flap. Investigation was performed on the sensitivity adjustment of the spark tester at different locations throughout the pond. The author noticed that on one end of the pond, the spark testing underneath the fusion weld flap worked without false alarms at a specific sensitivity adjustment. However, the author noticed when we got to the north end side of the pond the spark tester started producing false audio alarms, and we had to adjust the sensitivity of the spark tester to successfully take out the false alarms. The only explanation that was determined for the increase in sensitivity was the near location of a high voltage power lines running parallel within 100 feet of the north end side of the pond (See Figure 6). The conductive geomembrane was successfully installed and spark tested and after one month of filling the pond with brine at level of 20 feet, no leakage has been observed in the leak detection layer of this brine pond.

Figure 6 – Brine Pond with High Power lines

Conclusion

Geomembranes are exposed to all types of external forces during the construction phase of a project. Therefore, a good CQA program is crucial to the successful installation of a quality geomembrane system, and Electrical Leak Surveys have become valuable CQA post installation tests that help engineers achieve their goal of a leak free geomembrane barrier system. The experience with the brine pond project mentioned above and numerous other projects have shown that spark testing of a conductive geomembrane is a proven, successful technique for the location of defects on exposed geomembranes. Based on field experience, the author believes that this procedure should be considered by designers for all critical containment applications where leak free construction is important.

References

ASTM D7240 Standard Practice for Leal Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test)