Post Installation Leak Testing of Geomembranes

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ABSTRACT: Much progress has been made by geomembrane manufacturers, installers, and third party quality control inspection companies to assure quality materials and construction in geomembrane systems. Comprehensive on-site quality control procedures have also been established for the control of seaming and welding of the geomembrane systems including destructive and nondestructive seam testing for weld quality and leakage. A new trend has emerged which extends the concept of quality materials and construction to enable the verification of leak-free systems over the entire lined surface after deployment and installation of the geomembranes. These systems utilize new technology associated with co-extruded layers made electrically conductive and therefore spark testable over 100% of the surface. Or they incorporate computer graphics and interpretive computer software to analyze electrical sensors in a grid precisely locating the position of abnormalities associated with seepage through a damaged liner. These recent developments in quality assurance are explained in this paper in the context of case histories where the materials and techniques have been applied internationally.

CO-EXTRUDED ELECTRICALLY CONDUCTIVE MEMBRANE FOR SPARK TESTING

Co-extrusion is a method of polymer film manufacture which allows the combination of integrally fused layers, each providing an individual function in the film. Multiple layered dies form the molten polyethylene into a sheet of film while retaining the individuality of each different layer. Such production enables the use of different colors, different materials, different additives, different mixing action, etc. in the different layers as molten polymer comes together. Today textured surfaced membrane, light colored membrane, and multi-density polyethylene combination liners are all available through the technology of co-extrusion. And what has also become available are electrically conductive carbon black layered geomembranes which enable complete spark testing with standard spark test equipment over the entire geomembrane post installation (Thiel and Cadwallader, 1993).

Conductive spark testable liners have been used in a wide variety of applications including, as illustrated by the following case history, in the mining industry.

Management of process water and runoff at a large copper mining operation in the U.S.A. required a lined containment for stormwater surge storage to protect groundwater. A double liner system with leak detection drainage layer between two flexible membrane liners was, therefore, installed at the copper mine to construct this reservoir for stormwater and snow melt runoff. Conductive HDPE geomembrane was installed for both primary and secondary liners, enabling 100% spark testing of the area for leaks after installation. The conductive liner incorporates an underside co-extruded layer, within the material, of special high purity, high concentration carbon-black stabilized polyethylene. The electrically conductive layer enabled the liner to be spark tested after installation with 100% reliability.

A 1.5 mm secondary HDPE geomembrane, HDPE drainage net, and a primary liner of white-surfaced 2.0 mm HDPE liner made up the double liner and drainage layer. The co-extruded white surface stabilized liner temperature, thereby stabilizing thermal expansion and contraction, and improved visual detection of surface scoring and other impact damage. Each liner layer comprised of 82,000 square meters. Collected stormwater runoff in the containment is recycled back to the leach pad operations or used as process water elsewhere at the mine.

Once the liner was deployed and seamed, it was ready to be spark tested. For this, Gundle Lining Construction Company of Houston, Texas, USA, used a 340 kg six-tired All Terrain Vehicle (ATV) which pulled a spark testing unit mounted on a trailer. The spark testing unit consisted of a batter and transformer that generated a 30,000 volt cha to a sliding neoprene contact pad, and a 1.8m wide brass brush testing a 1.8m wide strip of liner as the ATV moved forward at two to three miles per hour. In this way, the entire lined area was tested ensuring that all leaks were detected and repaired.

To induce a charge in the conductive underside of the liner, the neoprene pad was mounted with the battery and transformer on the vehicular test unit and contacted the liner directly ahead of the brass brush. The neoprene pad, being electrically conductive, brought the voltage to the surface of the sheet and induced an electrical charge in the co-extruded conductive underside layer of the liner through electromagnetic induction. As the brass brush encountered a leak or penetration, the charge transmitted through from the conductive underside to the brush, completed the circuit, created a spark, and set off an alarm. The charged neoprene pad slid along the membrane as the vehicle moved forward, so that it was always in close proximity to the brass brush.

One Gundle technician operated the vehicle mounted test unit and a Third Party Inspector from S.H.&B. Agra of Reno, Nevada, USA, walked behind the unit as it tested the liner for leaks. When a leak was found, the equipment sparked, and an audible alarm registered. The unit was then stopped and a small hand-held wand was attached to the test system to verify the leak location, which was then marked by the inspector for subsequent repair.

The owner's project personnel purposely created small holes, the locations of which were recorded by the inspection firm to check the reliability of the spark testing method. All such purposely created holes were detected, although their location was completely unknown to testing personnel. Spark testing with the conductive liner was highly successful, locating leaks in welds, knife damage in geomembrane panels, and other damage in both panels and seams.

Construction with the 100% spark testable co-extruded conductive liner is taking place worldwide including at another mining project in Uzbekistan where gold solution ponds are receiving the benefit of a thorough and repeatable leak testing system.

ELECTRICAL SENSORS IN COMBINATION WITH COMPUTER SOFTWARE.

There is also growing interest in a system which can detect accidental damage to geomembranes occurring during the application of protective soil cover, and monitor liner system performance in the long term.

A grid system of electrical sensors in combination with special computer software has been developed which can be used to fulfill these requirements. The system consists of a grid of sensors placed permanently in the subgrade prior to the installation of the liner system. The sensors are connected with special insulated wires to a central control box normally located on top of one of the embankments. After completion of the installation of the liner system and the protective layer, an active electric source is placed in one location on the upper surface of the liner system and an electric field applied. The sensors beneath the liner measure the level of signal coming from the active source. The current density of the field depends on the integrity of the liner system. The measured data is processed using graphic presentation software and special interpretive software. Analysis of the results gives precise information on the position of any abnormalities in the liner.

A mobile system is available as well, for projects already completed in suitable situations. In this case no wires are used. A mobile electrical probe is positioned by the operator across the upper surface of the protective soil cover at predetermined grid points. An active electric source is placed in a suitable location and the current density is measured and abnormalities are interpreted with software. The position of damaged areas can be precisely located and repairs made after removal of the protective cover.

To illustrate the system, the following case occurred at a lined landfill in France. After the liner had been installed and covered with protective soil, and after having rained, it was found that water was pouring into the monitoring well from the drainage layer between the two liners in the double lined landfill. The upper HDPE liner had been covered with a 500mm layer of sand, and it was thought that some damage must have occurred during the spreading of the layers. The problem was to locate the damaged areas without having to remove all 20,000 square meters of protective soil, an extremely expensive operation. A mobile electrical sensor system was applied to the surface of the protective layer and a series of readings were taken on a predetermined grid measuring electric current from a source electrode placed between the two liners. An interpretation of the data enabled the engineers to pinpoint the location of the damaged liner. On digging down through the soil to the liners in the pinpointed locations, the damaged material was exposed and repaired. Several large holes had been made by the bulldozer spreading the soil, and by the end of the survey over 40 holes had been discovered, made by marking stakes inserted in the sand to control its depth during soil cover operations.

Although use of the mobile system after the lining operation was effective, the survey process takes time and a more effective system is to place sensors in the subgrade prior to lining the excavation.

On software-generated three dimensional computer graphic contour diagrams, leaks show up as "peaks". Interpretation of the peak's positions permits the precise location of abnormalities arising from seepage through the damaged liner. This can then be related back to the actual position on site where the damage location can be determined to within ±150 mm. Digging away the protective layer in this location, taking appropriate care not to further damage the liner, will expose the area of damage which can then be cleaned and repaired using a patch and the extrusion welding process. After repair, the small excavation is carefully refilled with protective cover material.

After completion of all repairs, a site is resurveyed to insure that there are no remaining damaged areas which may have been "masked" by previous damage. A Clear Field Report of Integrity (CFRI) is issued to the client on completion of the survey.

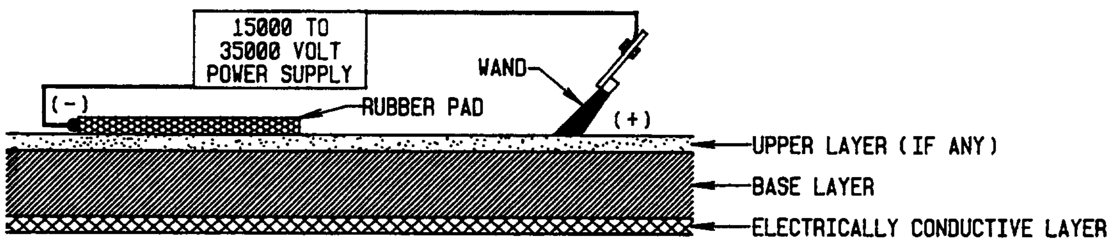
The system enables the integrity of a lined containment to be surveyed at any subsequent time depending on the design. Usually the probes and wires used are effective for a minimum of two years but longer life sensors can be made available if required.

CONCLUSION

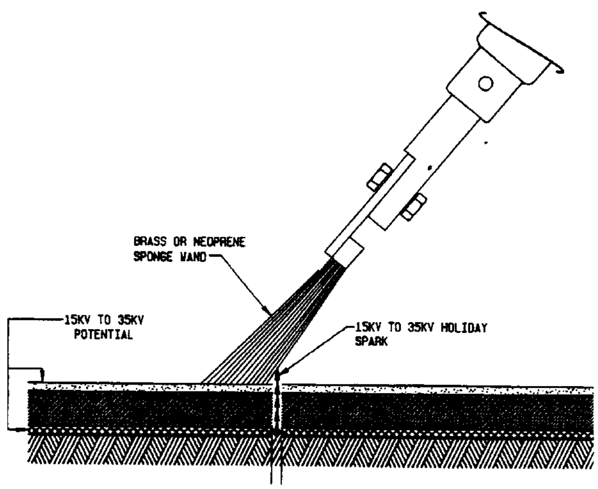
In addition to more traditional flood testing and electrical resistance surveys of ponds, technological innovation has led to new methods for complete leak testing of geomembranes. Modern co-extruded geomembrane manufacturing methods and computer technology now offer design engineers and regulators improved options for assessing and monitoring the quality of geomembrane construction.

REFERENCES

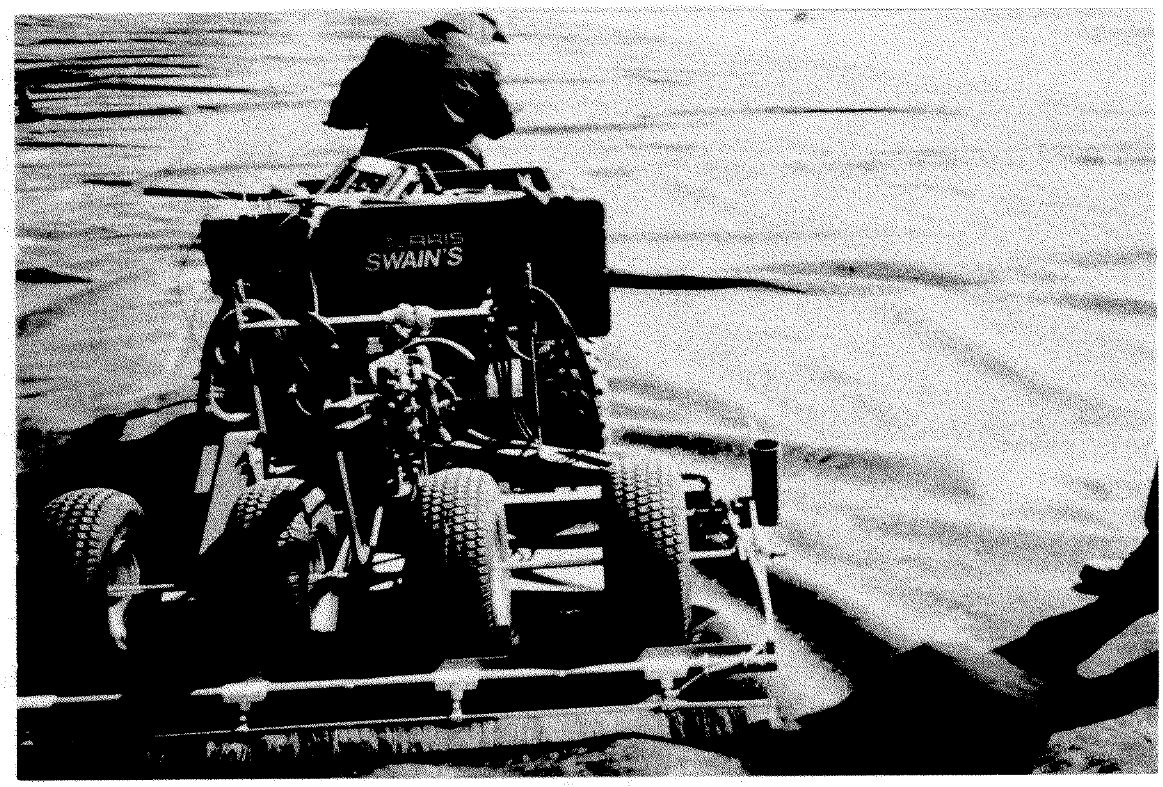
Thiel, Richard S. and Cadwallader, Mark W. (1993) Innovative Applications of Co-Extruded Geomembranes, *Proceedings of the 7th GRI Seminar on Geosynthetic Liner Systems: Innovations, Concerns and Designs*, 32-45.



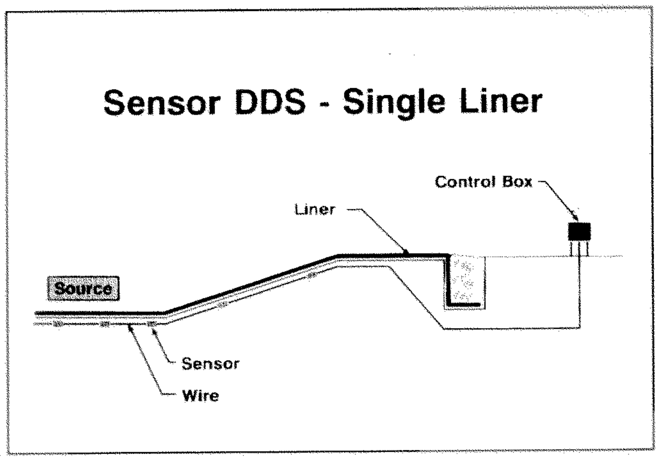
Spark Testing of Co-Extruded Conductive Geomembrene By Electromagnetic Induction of Charge In The Electrically Conductive Layer

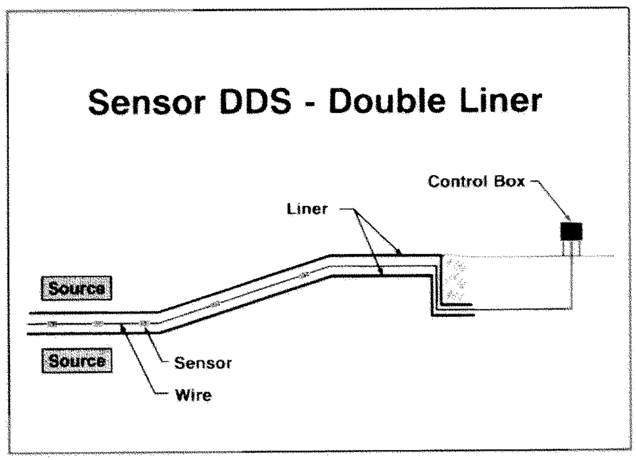


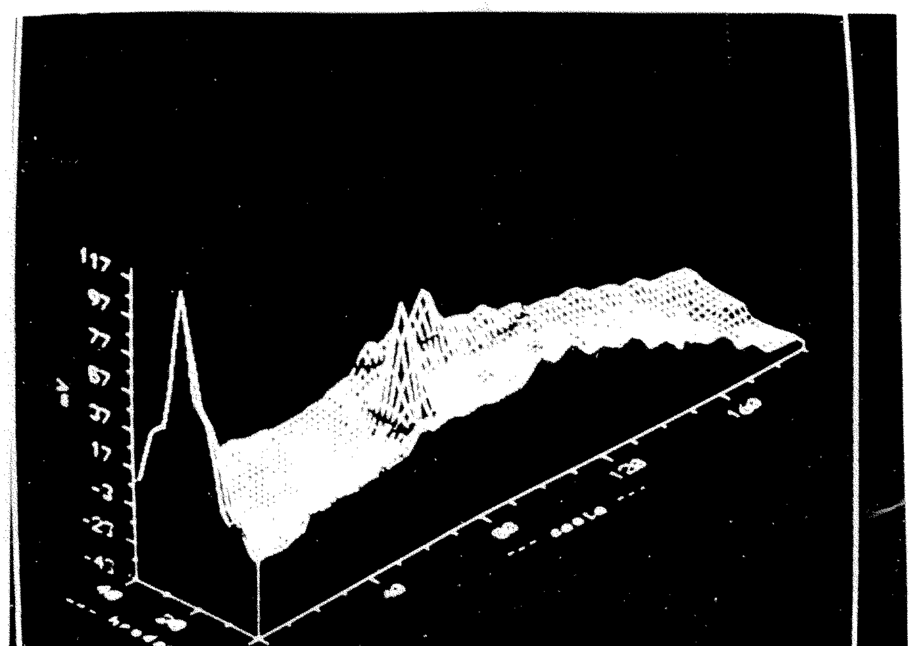
Electric Spark Emitting From Charged Conductive Layer To Wand Detecting Hole in Liner



Vehicular Spark Testing Unit In Operation







The 3D Diagram Interpretation of Current Density Anomalies