LOCATING GEOMEMBRANE LINER LEAKS UNDER WASTE IN A LANDFILL

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ABSTRACT

An Electrical Leak Imaging and Monitoring (ELIM SM) survey was used to locate leaks under 2.5 meters of stabilized waste in an active geomembrane-lined landfill. The landfill is lined with two 2-mm thick HDPE geomembranes that are separated by a geonet drainage layer. The primary liner is covered with 600 mm of drainage sand and 2.5 meters of stabilized waste for a total cover thickness of more than 3 meters. The principle of the ELIM method is to apply a voltage across the geomembrane liner and then to measure the resultant electrical potentials at widely spaced points. The data is processed using specialized mathematical inversion algorithms to image the locations of the leaks. The processed data indicated a leak near the center edge of the landfill cell. The suspect area was excavated to reveal two 80-mm long cuts in the primary liner.

INTRODUCTION

A high-voltage electrical leak location survey method has been used to locate leaks at more than 400 geomembrane-lined facilities world-wide (Laine and Darilek, 1993; Colucci et al., 1996). This commercial, field-proven technology has located many leaks that were not previously detected using other test methods and inspections, or that were caused during the placement of the protective soil cover. The method and equipment can locate leaks after the protective soil cover is placed over the liner and is a very cost-effective way to check liner installation quality or quickly solve a leakage problem. However, these commercial surveys are conducted using closely-spaced measurements on the soil with less than 1 meter of soil and no waste on the liner. The ELIM method is an advanced extension of this basic method that was developed to allow leaks to be detected under a much deeper soil and waste cover. In addition, the ELIM method allows for collection of data on a much wider spacing, or around the perimeter of a landfill cell, eliminating the need to place numerous data collection electrodes in the landfill cell. The ELIM method can also be used as a monitoring system.

ELIM METHOD

The ELIM method detects electrical paths through an electrically insulating geomembrane liner caused by water or moisture in holes through the geomembrane liner. Electrical current is induced through the leaks by connecting a current source to one electrode placed in the soil covering the liner and a second current sink 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 current sources at the leaks. These points are located by making potential measurements around the perimeter of the landfill or with a widely-spaced grid of electrodes on the floor of the landfill. The data is then processed using specialized inversion algorithms to locate leaks in the geomembrane liner that are associated with the high current sources at the leaks. The inversion algorithms determine the distribution of current density that best reproduces the observed voltage data. This is achieved through a non-linear least squares fit to the data. The validity of the ELIM method was verified using a medium scale physical model of a geomembrane lined facility.

The Electrical Leak Imaging and Monitoring system can be used as a permanent monitoring system or to investigate active landfill cells. A major advantage of the method is the ability to collect data around the perimeter of the landfill cell without placing electrodes on the floor area. This allows the method to locate leaks in active landfills after waste has been placed on the floor area. The use of the method as a permanent monitoring method would enable landfill operators to evaluate long term performance of the landfill liner system. This is especially important for subtitle D landfills that have a single synthetic geomembrane liner. If a leak develops the ELIM system would alert the landfill operator of a leak and determine the location. A United States patent is pending for the ELIM survey method.

ELIM LANDFILL SURVEY

<u>Landfill Description.</u> This application of the ELIM method was at an active hazardous waste landfill for stabilized residue from a recycling operation and stabilized contaminated soil. The landfill had a known leakage problem that could not be solved using conventional test methods. The landfill has a depth of 18 meters with a surface area of approximately 4.4 hectares and a floor area of approximately 1 hectare. Figure 1 shows a cross section of the lining system for the landfill. The cell has two 2-mm thick HDPE geomembrane liners separated by a geonet drainage layer. The primary liner was covered with 300 mm of a clean drainage gravel. An additional 300 mm of a protective sand was placed over the gravel. The two drainage materials are separated by a thick geotextile. The stabilized soil waste was placed on the protective sand.

<u>Survey Procedure.</u> The ELIM survey was conducted in an area where 2.5 m of stabilized waste was placed in the landfill cell. Other areas of the landfill cell had as much as 5 m of waste covering the floor area. The top layer of waste was very solid so 20 mm diameter holes were drilled about 100 mm deep to support the measurement electrodes.

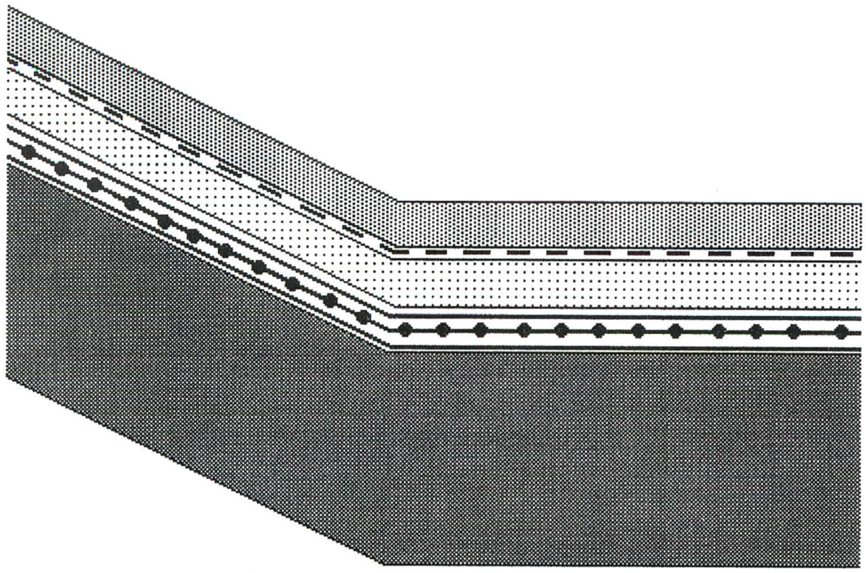

Figure 1. Cross Section of the Liner System

Figure 2 shows the survey layout. To create electrical flow through the liner, a low-frequency alternating current source was connected to one electrode placed in the leak detection layer with a current sink connected to a second electrode placed in the waste material covering the liner. The current source can provide up to 400 volts and 500 mA, depending on the load. A potential reference electrode was installed in a region of the landfill away from the area of suspected leakage. The location of the remote electrode is quite arbitrary, its purpose being to provide a common reference point for all of the potential measurements. As an alternative, the electrode can be put at some remote location away from the landfill. A synchronous voltage measurement meter with signal averaging capabilities was used to make potential measurements relative to this reference electrode on a 5 m by 5 m spacing over the part of the floor area that was covered with 2.5 m of waste. Data was collected over an area of 4,000 square meters. One-hundred sixty-eight data measurements were made.

Survey Results. Figure 3 is a shaded surface display of the processed data. To remove any effects of variations in the current magnitude that may occur with such measurements, the data is shown as transfer resistances, which are the ratios of measured potentials to the magnitude of the injected current. The data clearly indicates a distinct anomaly located at grid position 60 meters east and 10 meters north. The broad nature of the anomaly is a result of the waste thickness smearing the effect of the leak current source at the measurement points on the surface of the waste. This effect was confirmed by performing simulation trials using a three-dimensional finite element solution of the governing equations for this potential equation problem. For shallower waste the effect of the leak would be much more pronounced.

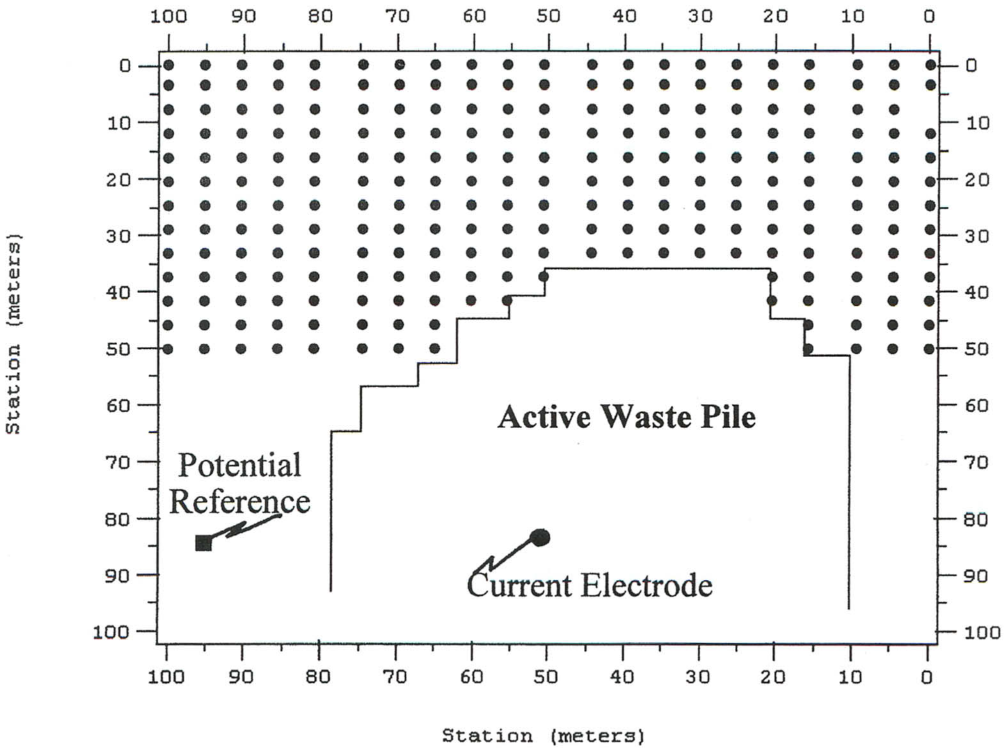

Figure 2. Survey Grid Showing Position of Current Electrode, Potential Reference Electrode, and Measured Potential Electrodes (black dots). The Second Current Electrode was Placed in the Leak Detection Layer.

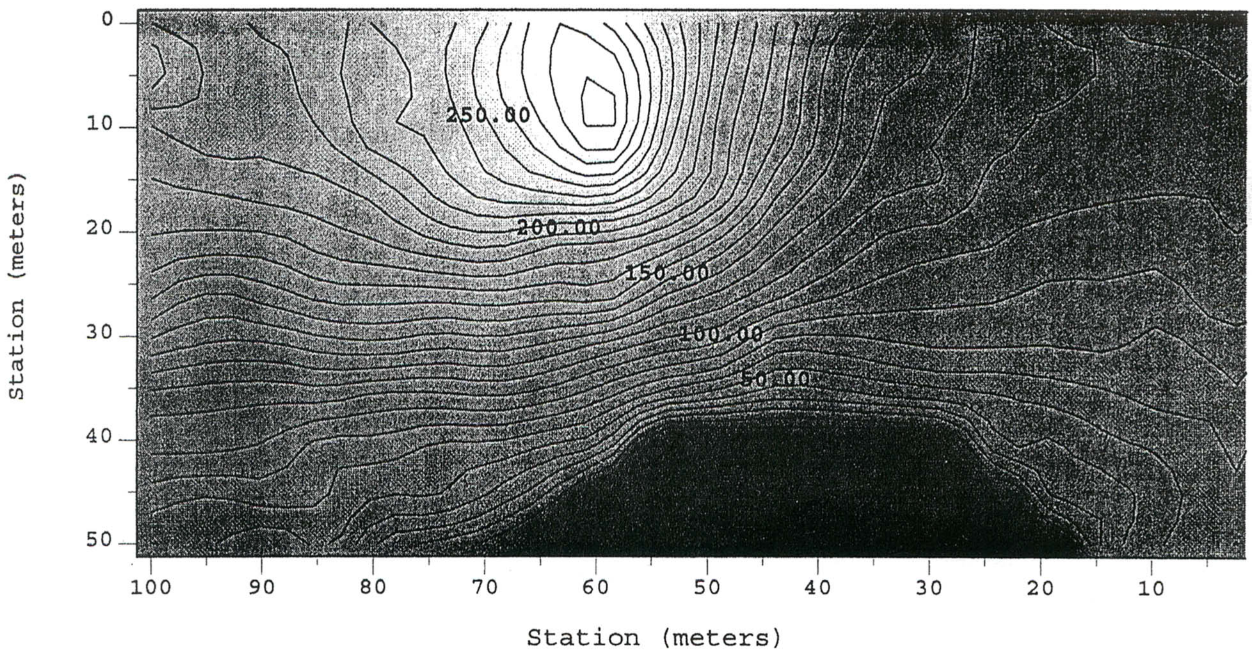

Figure 3. Contour Plot of Processed ELIM Data Collected Over Three Meters of Waste High Contour Value Indicates Leak Position

Based on the results of the ELIM survey, recommendations were made to the landfill operators to excavate the area of the imaged anomaly to identify the source of the signal. The feature was excavated to expose two closely-spaced cuts approximately 80 mm in length.

SUMMARY AND CONCLUSIONS

An ELIM survey was used to accurately locate two small leaks under 3 m of waste in a geomembrane lined landfill cell. This was the first application of the technique in an active landfill. Measurements were collected on the waste using a widely-spaced electrode grid. This allowed fewer data points to be collected, which saved time and money in identifying the leakage problem. The technique described does not rely on measurements on a regular grid, or in fact within the landfill cell. By using appropriate numerical inversion algorithms we are able to determine leak signals in a tomographic fashion, although sensitivity is reduced in comparison with using data collected within the cell.

REFERENCES

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