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Standard Guide for Selection of Techniques for Electrical Leak Location of Leaks in Geomembranes[1]

This standard is issued under the fixed designation D6747; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide is intended to assist individuals or groups in assessing different options available for locating leaks in installed geomembranes using electrical methods. For clarity, this guide uses the term "leak" to mean holes, punctures, tears, knife cuts, seam defects, cracks, and similar breaches in an installed geomembrane (as defined in 3.2.6).

1.2 This guide does not cover systems that are restricted to seam testing only, nor does it cover systems that may detect leaks non-electrically. It does not cover systems that only detect the presence, but not the location, of leaks.

1.3 (**Warning—**The electrical methods used for geomembrane leak location could use high voltages, resulting in the potential for electrical shock or electrocution. This hazard might be increased because operations might be conducted in or near water. In particular, a high voltage could exist between the water or earth material and earth ground, or any grounded conductor. These procedures are potentially very dangerous, and can result in personal injury or death. The electrical methods used for geomembrane leak location should be attempted only by qualified and experienced personnel. Appropriate safety measures must be taken to protect the leak location operators as well as other people at the site.)

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4439 Terminology for Geosynthetics

D7002 Practice for Electrical Leak Location on Exposed Geomembranes Using the Water Puddle Method

D7007 Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earthen Materials

D7240 Practice for Electrical Leak Location Using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive-Backed Geomembrane Spark Test)

D7703 Practice for Electrical Leak Location on Exposed Geomembranes Using the Water Lance Method

D7852 Practice for Use of an Electrically Conductive Geotextile for Leak Location Surveys

D7953 Practice for Electrical Leak Location on Exposed Geomembranes Using the Arc Testing Method

D8265 Practices for Electrical Methods for Mapping Leaks in Installed Geomembranes

3. Terminology

3.1 For general definitions used in this guide, refer to Terminology D4439.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *conductive-backed geomembrane, n*—a specialty geomembrane manufactured using the co-extrusion process with an insulating layer in intimate contact with a conductive layer.

3.2.2 *conductive drainage geocomposite, n*—a specialty drainage geocomposite manufactured with one or several conductive geotextiles.

[1] This guide is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.10 on Geomembranes.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2.3 *conductive geotextile, n*—a specialty geotextile manufactured with an electrically conductive element or fiber or external treatment to make it electrically conductive.

3.2.4 *electrical leak location, n*—a method which uses electrical current or electrical potential to locate leaks in a geomembrane.

3.2.5 *electrically isolated conductive-backed geomembrane installation, n*—an installation of conductive-backed geomembrane that achieves a continuously conductive surface on the bottom layer while electrically isolating the bottom conductive layer from the top insulating layer of the entire geomembrane installation.

3.2.6 *leak, n*—for the purposes of this guide, a leak is any unintended opening, perforation, breach, slit, tear, puncture, crack, or seam breach. Significant amounts of liquids or solids may or may not flow through a leak. Scratches, gouges, dents, or other aberrations that do not completely penetrate the geomembrane are not considered to be leaks. Types of leaks detected during surveys include, but are not limited to: burns, circular holes, linear cuts, seam defects, tears, punctures, and material defects.

3.2.7 *poor contact condition, n*—for the purposes of this guide, a poor contact condition means that a leak is not in intimate contact with the sufficiently conductive layer above or underneath the geomembrane to be tested. This occurs on a wrinkle or wave, under the overlap flap of a fusion weld, in an area of liner bridging, and in an area where there is a subgrade depression or rut.

3.2.8 *substrate, n*—for the purposes of this guide, the sufficiently conductive layer directly underneath the geomembrane being testing for leaks.

3.2.9 *survey area, n*—for the purposes of this guide, the survey area refers to the geomembrane area subject to electrical leak location testing.

4. Significance and Use

4.1 Geomembranes are used as barriers to prevent liquids from leaking from landfills, ponds, and other containments. For this purpose, it is desirable that the geomembrane have as little leakage as practical.

4.2 The liquids may contain contaminants that, if released, can cause damage to the environment. Leaking liquids can erode the subgrade, causing further damage. Leakage can result in product loss or otherwise prevent the installation from performing its intended containment purpose.

4.3 Geomembranes are often assembled in the field, either by unrolling and welding panels of the geomembrane material together in the field, unfolding flexible geomembranes in the field, or a combination of both.

4.4 Geomembrane leaks can be caused by poor quality of the subgrade, poor quality of the material placed on the geomembrane, accidents, poor workmanship, manufacturing defects, and carelessness.

4.5 Experience demonstrates that geomembranes can have leaks caused during their installation and placement of material(s) on the geomembrane.

4.6 Electrical leak location methods are an effective and proven quality assurance measure to locate leaks. Such methods have been used successfully to locate leaks in electrically insulating geomembranes such as polyethylene, polypropylene, polyvinyl chloride, chlorosulfonated polyethylene, and bituminous geomembranes installed in basins, ponds, tanks, ore and waste pads, and landfill cells.

4.7 The principle behind these techniques is to place a voltage across a sufficiently electrically insulating geomembrane and then locate areas where electrical current flows through leaks in the geomembrane (as shown schematically in Fig. 1). Other electrical leak paths such as pipe penetrations, flange bolts, steel drains, and batten strips on concrete and other extraneous electrical paths should be electrically isolated

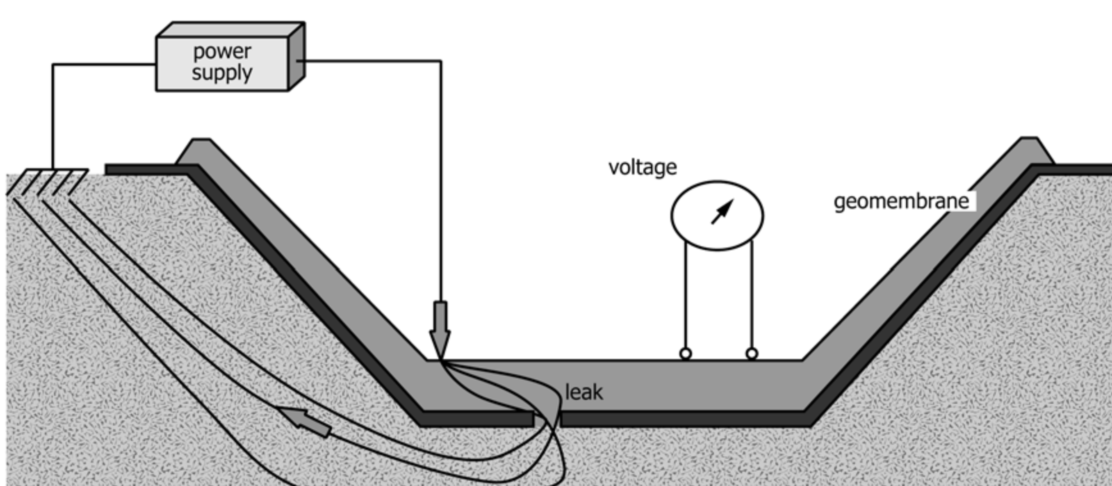

FIG. 1 Schematic of the Electrical Leak Location Method (Earthen Material-Covered Geomembrane System is Shown)

or insulated to prevent masking of leak signals caused by electrical short-circuiting through those preferential electrical paths. The only electrical paths should be through leaks in the geomembrane. These electrical detection methods for locating leaks in geomembranes can be performed on exposed geomembranes, on geomembranes covered with water, or on geomembranes covered with an earthen material layer.

5. Developed Methods

5.1 Electrical leak detection methods were developed in the early 1980s and commercial surveys have been available since 1985.

5.2 The principal conditions for the successful application of the methods are as follows:

5.2.1 There must be sufficiently conductive material above the geomembrane or the geomembrane should be clean and dry (extent depends on method),

5.2.2 There must be sufficiently conductive material underneath the geomembrane,

5.2.3 There must be good contact of the material above and below the geomembrane through the leak, and

5.2.4 The sufficiently conductive material above and below the geomembrane are to be in contact only through the leak locations.

5.3 Leak detection sensitivity is a function of site conditions and application of the testing methodologies. Site conditions include conditions local to a given leak including degree of saturation, perforation geometry, and contact with the underlying and overlying material(s). Functionality testing for each method is performed with an actual or artificial leak of a given circular diameter to verify that testing parameters are optimized for site conditions. Functionality testing should not be mistaken for leak detection sensitivity, which can only be determined by the field application of the testing method.

5.4 The methods can be organized into two categories depending on whether the geomembrane is bare or covered with a sufficiently conductive material. A short description of each of the methods that can be applied to these geomembrane conditions is presented in Sections 6 and 7.

5.5 Choosing which method is appropriate for a particular application will depend foremost on whether the geomembrane is bare or covered with water or earth. If the geomembrane is bare, multiple methods are effective. Each method has different features and limitations, as described in Section 6. If the geomembrane is covered, the method selection will depend on whether the material is covered with water or earth, and whether the method is to be performed as part of construction or as part of a permanent leak monitoring system, as described in Section 7.

5.6 For geomembranes that are to be covered with earthen materials, for a higher probability of locating all leaks, a bare geomembrane leak survey method can be performed before cover material is placed to locate the leaks caused during the geomembrane installation. Then after the earthen material is placed, the dipole method (Practice D7007 or D8265) can be used to locate any damage incurred during cover material placement.

5.7 A conductive-backed geomembrane is manufactured using a co-extrusion process with an insulating layer in intimate contact with a sufficiently conductive layer and can be used to overcome the substrate conductivity and hole contact limitations of the various leak location methods. However, if any method other than the spark testing method is to be performed, the conductive-backed geomembrane must be installed as an electrically isolated conductive-backed geomembrane.

5.8 Conductive geotextiles or conductive drainage geocomposites are geosynthetics that offer on one of their faces a conductive layer that can carry the current below the geomembrane being tested, overcoming the substrate conductivity limitations of the various leak location methods. The use of conductive geotextiles/geocomposites is detailed in Practice D7852.

6. Exposed Geomembrane Methods

6.1 *Comparison of Methodologies:*

6.1.1 Currently available methods include the water puddle method (Practice D7002), the water lance method (Practice D7703), the spark testing method (Practice D7240), and the arc testing method (Practice D7953).

6.1.2 All of the methods listed in 6.1.1 are effective at locating leaks in exposed geomembranes. Each method has specific site and labor requirements, survey speeds, advantages, limitations, and cost factors. A professional specializing in the electrical leak location methods can provide advice on the advantages and disadvantages of each method for a specific project and specific site conditions. Alternatives to a project's specified method should be accepted when warranted by site conditions, logistics, schedule, or economic reasons.

6.2 A summary of the comparisons of the exposed geomembrane electrical leak location methods is presented in Table 1.

6.3 *The Water Puddle Method*—This technique is appropriate to survey a dry, uncovered geomembrane placed directly on a sufficiently conductive substrate. Practice D7002 is a standard practice describing the water puddle method. The substrate is usually the subgrade soil and the upper sufficiently conductive layer is the water in an applied puddle. One electrode of a low voltage power supply is placed in contact with the substrate and another electrode is placed in a water puddle maintained by a squeegee or roller bar (as shown schematically in Fig. 2). Water is usually supplied from a water truck or other pressurized water source. For this technique to be effective in locating leaks, the water in the puddle or stream must come into contact through the leak with the electrical conducting material below the geomembrane. This completes an electrical circuit and electrical current will flow. Detector electronics are used to monitor the electrical current. The detector electronics convert a change in the current into a change in an audio tone. Functionality testing is performed with a 1-mm diameter actual or artificial leak.

6.3.1 *Features*—The main advantage of this method is the detection of leaks in geomembrane seams and sheets while the geomembrane installation work progresses during construction. The method does not require covering the geomembrane

TABLE 1 Summary of Comparisons of Exposed Geomembrane Leak Location Methods (typical)

Geomembrane Type	Water Puddle	Any nonconducting or conductive-backed geomembrane[A]
	Water Lance	Any nonconducting or conductive-backed geomembrane[A]
	Spark Tester	Conductive-backed geomembrane
	Arc Tester	Any nonconducting or conductive-backed geomembrane[A]
Substrate Conductivity	Water Puddle	Must be sufficiently conductive
	Water Lance	Must be sufficiently conductive
	Spark Tester	Not relevant: spark testing used exclusively on conductive-backed geomembrane
	Arc Tester	Must be sufficiently conductive
Water Source Requirement	Water Puddle	Required – low volume
	Water Lance	Required – high volume
	Spark Tester	Not required
	Arc Tester	Not required
Additional Labor Requirement for Movement of Water Supply Hoses	Water Puddle	May be required
	Water Lance	May be required
	Spark Tester	Not required
	Arc Tester	Not required
Power Supply	Water Puddle	Up to 36 volts DC or AC
	Water Lance	Up to 36 volts DC or AC
	Spark Tester	6000 to 35 000 volts DC, AC, or pulsed
	Arc Tester	6000 to 35 000 volts DC, AC, or pulsed
Effectiveness on Side Slopes and Vertical Walls	Water Puddle	Can be effective: slightly less effective on vertical walls
	Water Lance	Can be effective: less effective on vertical walls
	Spark Tester	Effective: not dependent on contact between geomembrane and substrate
	Arc Tester	Effective: less effective with separation from substrate
Setup and Calibration Time	Water Puddle	1 hour
	Water Lance	1 hour
	Spark Tester	30 min
	Arc Tester	30 min
Measurement Time	Water Puddle	A second or two
	Water Lance	A second or two
	Spark Tester	Instantaneous
	Arc Tester	Instantaneous
Operator Training Time Requirement	Water Puddle	1 day
	Water Lance	1 day
	Spark Tester	1 hour
	Arc Tester	1 hour
Typical Survey Speed (varies depending on equipment used)	Water Puddle	1000 m^2 per hour per operator
	Water Lance	900 m^2 per hour per operator
	Spark Tester	500 m^2 per hour per operator
	Arc Tester	900 m^2 per hour per operator
Tolerance to Wet and Dirty Geomembrane	Water Puddle	Tolerant to slightly wet and dirty sites
	Water Lance	Tolerant to slightly wet and dirty sites
	Spark Tester	Tolerant to slightly dirty but dry sites
	Arc Tester	Tolerant to slightly dirty but dry sites
Effectiveness in Locating Leaks in Poor Contact Conditions[B]	Water Puddle	Effective: however, depends on if water can get through leak and make contact with substrate[B]
	Water Lance	Effective: however, depends on if water can get through leak and make contact with substrate[B]
	Spark Tester	Effective
	Arc Tester	Somewhat effective: depends on arc length[B]

[A] If used, conductive-backed geomembrane must be installed as an electrically isolated conductive-backed geomembrane installation in order to allow it to be tested using all of the available electrical leak location methods.
[B] If conductive-backed geomembrane is being tested and it has been installed as an electrically isolated conductive-backed geomembrane installation, then all methods become effective at locating leaks in poor contact conditions.

with water other than the small puddle of water. Procedures can be used to differentiate smaller leaks from larger leaks in their vicinity. The electrical survey rate of approximately 3000 m^2/h per operator does not affect the installation work schedule and permits a rapid construction quality control of the geomembrane installers' finished work. The approximate setup time varies from 1 to 3 h. The method requires a minimal amount of training to be proficient.

6.3.2 *Limitations*—Unless a geomembrane manufactured with a conductive layer in intimate contact with the insulating geomembrane is being tested, leaks may not be detected in poor contact situations such as at the peak of a wrinkle and in any area where the substrate is not in intimate contact with the geomembrane, unless measures are taken to make the contact. This technique cannot be used during rainy weather or when the membrane is installed on an electrically nonconductive material, typically a desiccated substrate, and in the near vicinity of conductive structures that cannot be fully insulated or isolated. The detection of leaks in seams of repair patches is difficult and time consuming since it requires a potential lengthy water infiltration time. A constant water source is required for the application of the water puddle. The water applied to the geomembrane must not be allowed to flow off to the surrounding soil. The geomembrane must be reasonably

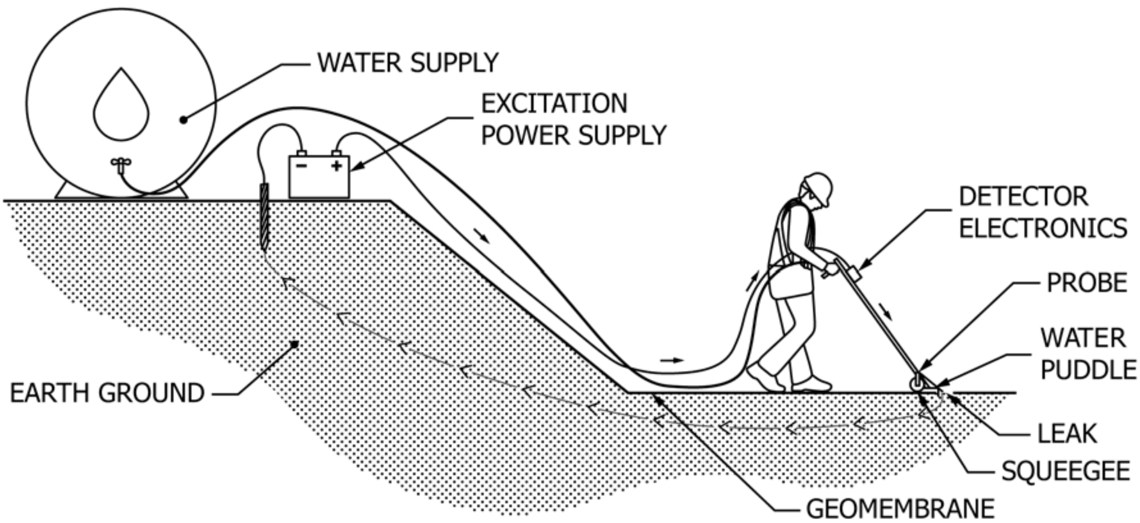

FIG. 2 Schematic of Water Puddle Method

clean and mostly dry at the commencement of the survey. Conductive objects such as concrete sumps, batten strips, or metal pipes connected to the conductive layer under the geomembrane must be electrically isolated from the water applied to the survey area and cannot be leak tested.

6.4 *The Water Lance Method*—This technique is appropriate to survey a dry, uncovered geomembrane placed directly on a sufficiently conductive substrate. Practice D7703 is a standard practice describing the water lance method. The substrate is usually the subgrade soil and the upper sufficiently conductive layer is the water in a stream of water. There are two ways to implement the water lance method setup, as detailed in Practice D7703. Fig. 3 shows one way to connect the power supply and sensor. The meter measures the voltage drop in a continuous stream of water. Another implementation is the same electrical setup as that used for the water puddle method previously shown in Fig. 2, except a continuous stream of water is used instead of a squeegee. Water is usually supplied from a tank, the sump or low spot of a survey area, or other pressurized water source. For this technique to be effective in locating leaks, the water in the stream must come into contact through the leak with the electrical conducting material below the geomembrane. This completes an electrical circuit and electrical current will flow. Detector electronics are used to monitor either the electrical current or the voltage between two points along the column of the water lance. The detector electronics converts a change in the current or voltage into a change in an audio tone. Functionality testing is performed with a 1-mm diameter actual or artificial leak.

6.4.1 *Features*—The main advantage of this method is the detection of leaks in geomembrane seams and sheets while the geomembrane installation work progresses during construction. The method does not require covering the geomembrane with water other than the water stream. Procedures can be used to differentiate smaller leaks from larger leaks in their vicinity. The electrical survey rate of approximately 900 m^2/h per operator does not affect the installation work schedule and permits a rapid construction quality control of the geomembrane installers' finished work. The approximate setup time varies from 1 to 3 h. When the water lance is set up to measure voltage potential along the water column in the water lance, it can be less susceptible to current short-circuiting, but the overall survey sensitivity would be less than when the lance is

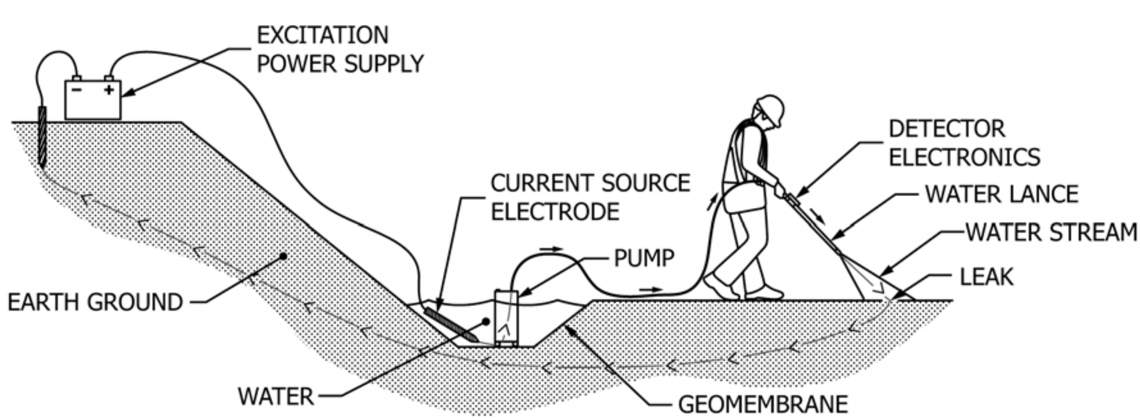

FIG. 3 Schematic of Water Lance Method

set up to measure current. The method requires a minimal amount of training to be proficient.

6.4.2 *Limitations*—Unless a conductive-backed geomembrane is being tested, leaks may not be detected in poor contact situations such as at the peak of a wrinkle and in any area where the substrate is not in intimate contact with the geomembrane, unless measures are taken to make the contact. This technique cannot be used during rainy weather or when the membrane is installed on an electrically nonconductive material, typically a desiccated substrate, and in the near vicinity of conductive structures that cannot be fully insulated or isolated. The detection of leaks in seams of repair patches is difficult and time consuming since it requires a potential lengthy water infiltration time. A constant water source is required for the application of the water stream. The water stream must be continuous to detect a leak. The water applied to the geomembrane must not be allowed to flow off to the surrounding soil. The geomembrane must be reasonably clean and mostly dry at the commencement of the survey. Conductive objects such as concrete sumps, batten strips, or metal pipes connected to the conductive layer under the geomembrane must be electrically isolated from the water applied to the survey area and cannot be leak tested.

6.5 *The Arc Testing Method*—This technique is appropriate to survey a clean (or slightly dirty), dry, uncovered geomembrane placed directly on a sufficiently conductive substrate. Practice D7953 is a standard practice describing the arc testing method. The substrate is usually the subgrade soil. One electrode is placed in contact with the substrate. Another electrode is introduced above the geomembrane as an electrically conductive probe with a very high voltage power supply (as shown schematically in Fig. 4). The test probe is swept over the upper surface to inspect for the presence of leaks. Where a leak occurs, a closed circuit is created and an electrical arc is produced. In addition to a visual arc, the equipment has an audible and visual alarm. Different types of test probes can be utilized with the equipment depending on the area to be tested. For example, small probes are used in confined areas and large probes can be used on large, open areas. Functionality testing is performed with a 1-mm diameter actual or artificial leak.

6.5.1 *Features*—The main advantage of this technique is that the technique is not dependent on the use of water. All slopes and vertical walls can be tested. The method can detect pinhole leaks. The electrical survey rate of approximately 900 m^2/h per operator does not affect the installation work schedule and permits a rapid construction quality control of the geomembrane installers' finished work. Repairs can be performed immediately upon location of a leak. The setup time required is approximately 30 min. The method requires very little training to be proficient.

6.5.2 *Limitations*—The maximum arc length for leak detection depends on the site conditions and equipment voltage. Unless a conductive-backed geomembrane is being tested, leaks will not be detected in poor contact situations such as at the peak of a wrinkle, under a seam overlap flap, and in any area where the substrate is not within the maximum arc length of the geomembrane, unless effort is made to improve the contact. This technique cannot be used during rain events. The geomembrane must be dry and clean (or slightly dirty). Conductive objects such as concrete sumps, batten strips, or metal pipes connected to the conductive layer under the geomembrane cannot be leak tested.

6.6 *The Spark Testing Method*—Co-extrusion technology made it possible to manufacture a polyethylene geomembrane that can be spark tested. Practice D7240 is a standard practice for this method. The material has a thin layer of electrically conductive material on one surface as an integral part of the geomembrane. This provides a way to spark test the installed geomembrane. The conductive-backed geomembrane is installed such that the nonconductive surface is on top. The testing utilizes a very high voltage power supply to charge an element such as an electrically conductive neoprene pad. The geomembrane acts as a dielectric of a capacitor that provides a low impedance through the geomembrane. Another conductive element is then swept over the upper surface to inspect for the presence of leaks. When the probe is scanned over a leak, the high voltage causes a spark through the leak to the co-extruded lower layer as shown in Fig. 5. To facilitate leak location, equipment must include an audible alarm. Different types of equipment are utilized depending on the area to be tested. For example, small, handheld detectors are used in confined areas and large detectors can be used on large, open areas. Functionality testing is performed with a 1-mm diameter actual or artificial leak.

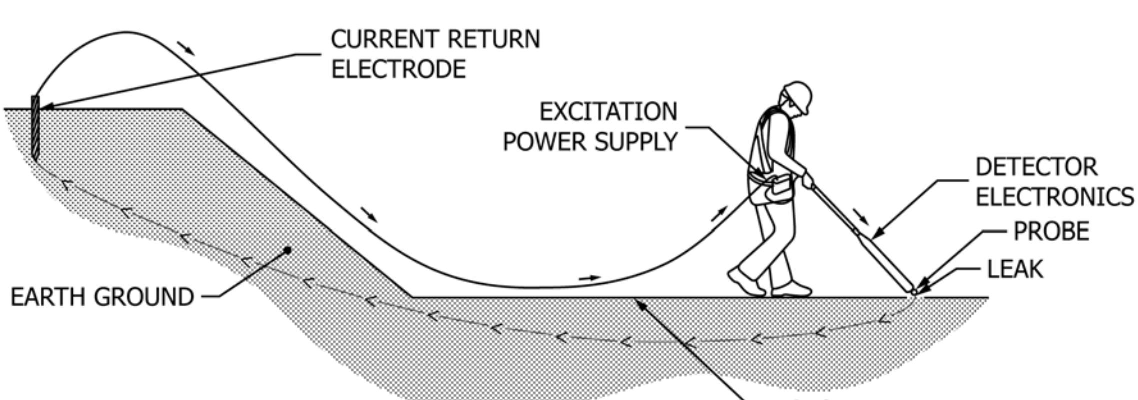

FIG. 4 Schematic of Arc Testing Method

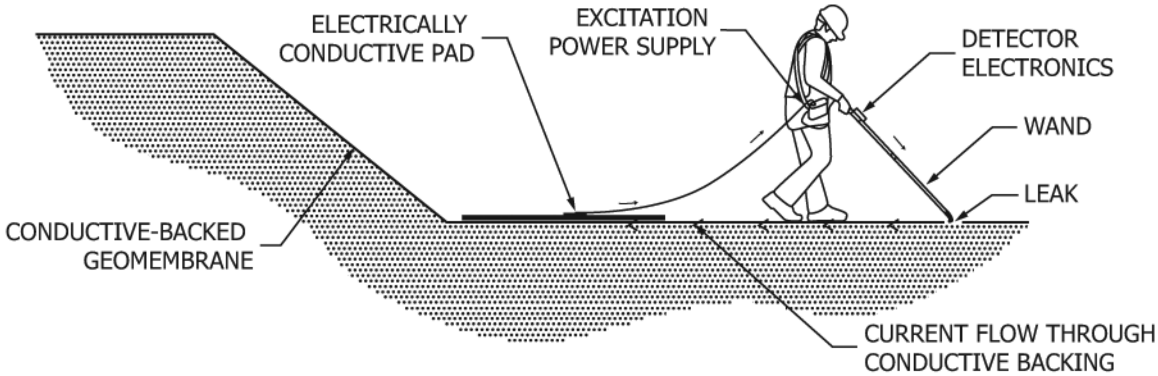

FIG. 5 Schematic of Spark Testing Method

6.6.1 *Features*—One advantage of this technique is that the technique is not dependent on the use of water. All slopes and vertical walls can be tested. The method can detect pinhole leaks. Since the geomembrane tested is manufactured with a conductive layer in intimate contact with the insulating geomembrane, the problems of insufficiently conductive substrate and poor hole contact are eliminated. This means that the technique can locate holes on wrinkles and waves and when the substrate is not sufficiently conductive. It can be performed while construction is ongoing. All slopes and vertical walls can be tested. The rate of testing depends on the type of equipment used. Using a 2-m wide brush, travelling at 3 to 5 km/h, the rate can be up to 500 to 1500 m^2/h. Repairs can be performed immediately upon location of a leak. The setup time required is approximately 30 min. The method requires very little training to be proficient.

6.6.2 *Limitations*—A conductive-backed geomembrane is required. The presence of wrinkles, waves, and steep slopes may reduce survey speed. This technique cannot be used during rain events, and it is only applicable for exposed conductive-backed geomembranes that are clean (or slightly dirty) and dry. If the geomembrane is not installed as an electrically isolated conductive-backed installation, the seams cannot be reliably tested for leaks. Conductive objects such as concrete sumps, batten strips, or metal pipes connected to the conductive layer under the geomembrane cannot be leak tested.

7. Covered Geomembrane Methods

7.1 *Description and Comparison of Methodologies:*

7.1.1 Currently available methods include mobile methods and the permanent monitoring system. The dipole method (Practices D7007 and D8265) is the most commonly used and the only formally standardized mobile method.

7.1.2 The difference between the dipole method and the permanent monitoring system is that the dipole method is a mobile survey method and does not require any permanent electrode installation, while the permanent monitoring system requires electrode installation as part of geomembrane lining system construction. The dipole method detects and locates leaks at the time of the survey, while the permanent monitoring system provides continuous leak monitoring for as long as the monitoring system components are designed to last.

7.1.3 The success of the covered geomembrane electrical leak location methods is highly dependent on site conditions (principles outlined in 5.2). Poor site conditions can adversely affect the leak detection sensitivity and in some cases prevent the method from functioning at all. The most important site condition is complete electrical separation between the cover material and the substrate. For existing facilities, this condition is not usually the case. It is therefore imperative that the methods are applied as part of a new construction project and are planned for, including an interim configuration that facilitates the mobile methods. The interim configuration typically incorporates an isolation trench along the entire perimeter of the containment facility, as shown in Fig. 6. Other geosynthetics on top of the geomembrane such as geotextile or geocomposite can remain intact through the isolation trench as long as they are dry. Isolation flaps can also be used, which are short sections of geomembrane welded to the base geomembrane and bisecting features that would connect the cover material to the substrate such as access roads. An example is provided in Fig. 7. Permanent monitoring systems must incorporate isolation as part of the final facility configuration.

7.1.4 For all covered methods, leak detection depends on current flow through a given leak. Since current will travel the path of least resistance, all current paths will affect the overall sensitivity of detecting a given leak. Perimeter isolation issues, as well as other leaks in the geomembrane, may compromise the detection of a given leak if that leak provides a more resistive current path than the other current paths present in the survey area. Multiple surveys may be required to locate all leaks present in a survey area. If initial leak detection sensitivity is poor but the survey area is well isolated, it is likely that significant leaks exist in the lining system and only the repair of the significant leaks will result in as survey with higher sensitivity.

7.1.5 The dipole method is not recommended for a deep soil fill configuration (greater than 3 m); method sensitivity decreases with increasing distance of the dipole probe from the surface of the geomembrane. For deep liquid fill, the inaccuracy level to pinpoint a leak anomaly may increase due to many factors such as length of survey line, depth of liquid, and site conditions.