Designation: ~~D7007 – 16~~ D7007 – 24

Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earthen Materials[1]

This standard is issued under the fixed designation D7007; 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 These practices cover standard procedures for using electrical methods to locate leaks in geomembranes covered with water or earthen materials. For clarity, this practice uses the term "leak" to mean holes, punctures, tears, knife cuts, seam defects, cracks, and similar breaches in an installed geomembrane (as defined in ~~3.2.5~~3.2.9).

1.2 These practices are intended to ensure that leak location surveys are performed with ~~demonstrated~~ a standardized level of leak detection capability. To allow further innovations, and because various leak location practitioners use a wide variety of procedures and equipment to perform these surveys, performance-based ~~operations~~protocol are also used that specify ~~the~~ minimum leak detection ~~performance for the equipment and procedures.~~criteria.

1.3 ~~These practices require that the leak location~~ The survey shall then be conducted using the demonstrated equipment, procedures, and survey ~~parameters used are demonstrated to result in an established minimum leak detection distance. The survey shall then be conducted using the demonstrated equipment, procedures, and survey parameters.~~parameters. In the absence of the minimum signal strength during leak detection distance testing, a minimum measurement density specification is provided. Alternatively, the minimum measurement density may simply be used.

1.4 Separate procedures are given for leak location surveys for geomembranes covered with water and for geomembranes covered with earthen materials. Separate procedures are given for leak detection distance tests using actual and artificial leaks.

1.5 Examples of methods of data analysis for soil-covered surveys are provided as guidance in Appendix X1.

1.6 Leak location surveys can be used on geomembranes installed in basins, ponds, tanks, ore and waste pads, landfill cells, landfill caps, and other containment facilities. The procedures are applicable for geomembranes made of materials such as polyethylene, polypropylene, polyvinyl chloride, chlorosulfonated polyethylene, bituminous material, and other ~~electrically-insulating~~ electrically insulating materials.

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

1.8 (**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 earthen material and earth ground, or any grounded conductor. These

[1] These practices are under the jurisdiction of ASTM Committee D35 on Geosynthetics and ~~is~~are the direct responsibility of Subcommittee D35.10 on Geomembranes.
Current edition approved ~~Jan. 1, 2016~~March 1, 2024. Published ~~January 2016~~March 2024. Originally approved in 2003. Last previous edition approved in ~~2015~~2016 as ~~D7007~~D7007 – 16.~~–15.~~ DOI: ~~10.1520/D7007-16.~~10.1520/D7007-24.

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.)

1.9 *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 and health~~safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.10 *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
D6747 Guide for Selection of Techniques for Electrical Leak Location of Leaks in Geomembranes

3. Terminology

3.1 For general definitions related to geosynthetics, see Terminology D4439.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *artificial leak, n*—an electrical simulation of a leak in a geomembrane.

3.2.2 *conductive-backed geomembrane, n*—a geomembrane that is manufactured with one surface that is conductive.

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

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

3.2.5 *current source electrode, n*—the electrode that is placed in the water or earthen material above the geomembrane.

3.2.6 *dipole measurement, n*—an electrical measurement made on or in a partially conductive material using two ~~closely-spaced~~ closely spaced electrodes.

3.2.7 *earthen material, n*—sand, gravel, clay, silt, combinations of these materials, and similar materials with at least minimal moisture for electrical current conduction.

3.2.8 *functionality testing, n*—for the purposes of these practices, functionality testing is a demonstration that a testing circuit is installed in order to detect an artificial or actual leak using the proposed equipment settings and survey procedures. Functionality testing may be used to determine the measurement density through the use of leak detection distance testing.

3.2.9 *leak, n*—for the purposes of these practices, 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.

~~3.2.6 *leak detection distance, n*—The distance that a leak location equipment and survey methodology are capable of detecting a specified leak. The leak is usually specified as a circular leak with a specified diameter. For surveys with earthen materials on the geomembrane, the leak detection distance is usually measured from the surface projection of the leak.~~

3.2.10 *noise, n*—the unwanted part of a measured signal contributed by phenomena other than the desired signal.

[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.

3.2.11 *pole measurement, n*—an electrical measurement made on or in a partially conductive material using one measurement electrode and a remote reference electrode.

3.2.12 *potential, n*—electrical voltage measured relative to a reference point.

3.2.13 *site response current, n*—the value of current, typically expressed in milliamps, resulting from applying a voltage to a current source electrode inserted into the material covering the geomembrane in the survey area with the current return electrode connected to the underlying conductive layer.

4. Significance and Use

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

4.2 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.

4.3 The most significant causes of leaks in geomembranes that are covered with only water are related to construction activities, including pumps and equipment placed on the geomembrane, accidental punctures, and punctures caused by traffic over rocks or debris on the geomembrane or in the subgrade.

4.4 The most significant cause of leaks in geomembranes covered with earthen materials is construction damage caused by machinery that occurs while placing the earthen material on the geomembrane. Such damage also can breach additional layers of the lining system such as geosynthetic clay liners.

4.5 Electrical leak location methods are an effective final quality assurance measure to detect and locate leaks. If any of the requirements for survey area preparation is not adhered to, then leak sensitivity could be diminished. Optimal survey area conditions are described in Section 6.

5. Summary of the Electrical Leak Location Methods for Covered Geomembranes

5.1 The principle of the electrical leak location method is to place a voltage across a geomembrane and then locate the points of anomalous potential distribution where electrical current flows through leaks in the geomembrane. Additional information can be found in Guide D6747.

5.2 *General Principles:*

5.2.1 Figs. 1 and 2 show diagrams of the electrical leak location method for a geomembrane covered with water and for a geomembrane covered with earthen materials, respectively. One output of an electrical excitation power supply is connected to a current source electrode placed in the material covering the geomembrane. The other output of the power supply is connected to an electrode in contact with electrically conductive material under the geomembrane.

5.2.2 When there are leaks, electrical current flows through the leaks, which produces high current density and a localized anomaly in the voltage potential distribution in the material above the geomembrane. Electrical measurements are made to locate those areas of anomalous signal at the leaks.

5.2.3 Measurements are made using a dipole or pole measurement configuration. Various types of data acquisition are used, including audio indications of the signal level, manual measurements with manual recording of data, and automated digital data acquisition.

5.2.4 Direct current and alternating current excitation power supplies and potential measurement systems have been used for leak location surveys.

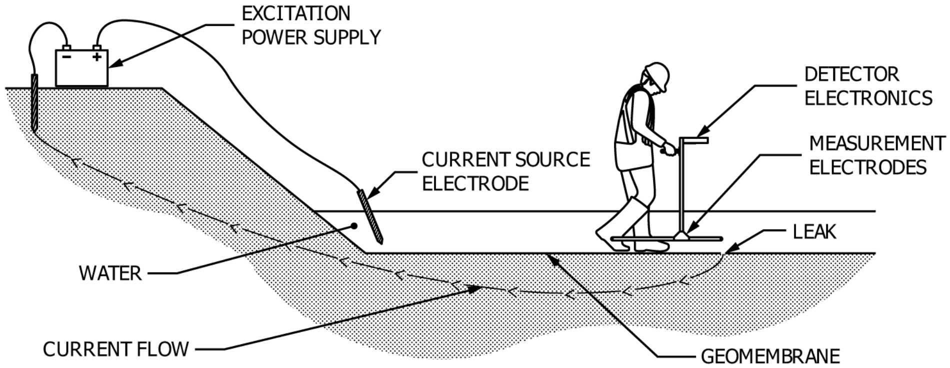

FIG. 1 Diagram of the Electrical Leak Location Method for Surveys with Water Covering the Geomembrane

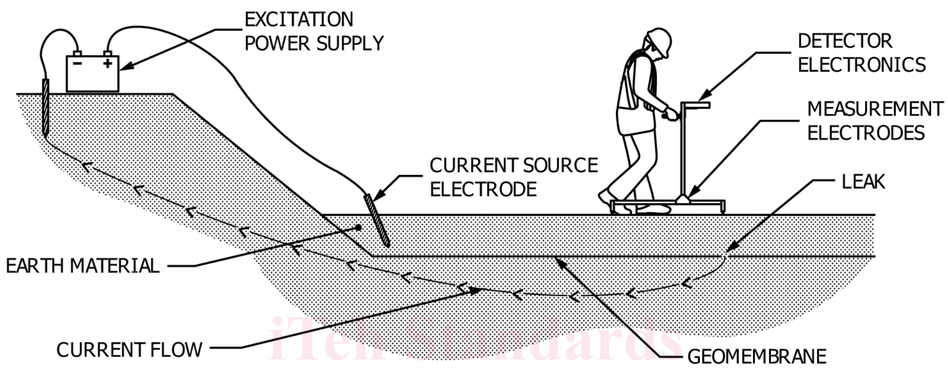

FIG. 2 Diagram of the Electrical Leak Location Method for Surveys with Earthen Material Covering the Geomembrane

5.3 *Leak Location Surveys of Geomembranes Covered with Water:*

5.3.1 Leak location surveys for geomembranes covered with water can be conducted with water on the geomembrane or with water covering a layer of earthen materials on the geomembrane.

5.3.2 For leak location surveys with water on the geomembrane, usually a dipole probe is systematically scanned through the water covering the geomembrane to locate the points of anomalous potential distribution. The dipole spacing is typically 0.2 to ~~1 m.~~3 m.

5.3.3 Various types of probes can be used to perform the surveys. Some are for when the operator wades in the ~~water;~~water, some are for towing the probe back and forth across the ~~geomembrane;~~geomembrane, and some are for raising and lowering along vertical or sloping walls.

5.3.4 The probe ~~is typically~~can be connected to an electronic detector assembly that converts the electrical signal from the probe to an audible signal that increases in pitch and amplitude as the leak signal increases.

5.3.5 When a leak signal is detected, the point with the maximum signal is then determined. This point of maximum signal corresponds to the location of the leak. The location of the leak is then marked or measured relative to fixed points.

5.3.6 The leak detection distance depends on the leak size, the electrical contact through the leak, the conductivity of the materials within, above, and below the leak, the electrical homogeneity of the material above the leak, the output level of the excitation power supply, the design of the measurement probe, the sensitivity of the detector electronics, the survey area configuration and isolation, and the survey procedures. Leaks as small as 1 mm in diameter have been routinely found, including tortuous leaks through welds in the ~~geomembrane. Leaks larger than 25 mm in diameter can usually be detected from several metres away.~~geomembrane, when site conditions are favorable.

5.3.7 The survey rate depends primarily on the spacing between scans and the depth of the water. A close spacing between scans is needed to detect the smallest leaks.

5.4 *Leak Location Surveys of Geomembranes Covered with Earthen Materials:*

5.4.1 For leak location surveys with earthen materials covering the geomembrane, point-by-point measurements are made on the earthen material using either dipole measurements or pole measurements. Dipole measurements are typically made with a spacing of 0.5 to 3 m. Measurements are typically made along parallel survey lines or on a grid pattern.

5.4.2 The survey procedures are conducted by systematically taking measurements of voltage potential in a grid pattern. Leaks can be located during the performance of the voltage measurements, but the voltage data must be collected for post-survey evaluation. The measurements and positions can be recorded manually or using a digital data acquisition system. Appendix X1 details the two main methods of data analysis and the advantages and disadvantages of each.

5.4.3 The data ~~is~~are typically downloaded or manually entered into a computer and plotted. Sometimes data ~~is~~are taken along survey lines and plotted in graphical format. Sometimes data ~~is~~are taken in a grid pattern and plotted in two-dimensional contour, shade of gray, or color contour plots, or in three-dimensional representations of the contours. The data plots are examined for characteristic leak signals.

5.4.4 The approximate location of the leak signal is determined from the data plots, and additional measurements are made on the earthen material in the vicinity of the detected leak signal to more accurately determine the position of the leak.

5.4.5 The leak detection distance depends on the leak size, the electrical contact through the leak, the conductivity of the materials within, above, and below the leak, the electrical homogeneity of the material above the leak, the design of the measurement electrodes, the output level of the excitation power supply, the sensitivity of the detector electronics, the survey procedures, the survey area configuration and isolation, and the data interpretation methods and expertise. Usually leaks as small as 5 mm in diameter can be located under ~~600 mm~~ 600 mm of earthen material. Leaks ~~larger than 25 mm~~ as small as 1 mm in diameter can ~~usually be detected from several metres away.~~be found, including tortuous leaks through welds in the geomembrane, when site conditions are favorable.

5.4.6 The survey rate depends primarily on the spacing between the measurement points, the type of data acquisition, and whether data interpretation is accomplished in the field. ~~A close spacing between measurement points is needed~~Optimal survey area conditions are described in Section 6~~to adequately replicate the leak signals and to detect smaller leaks.~~.

6. General Leak Location Survey Procedures

6.1 The following measures shall be taken to optimize the leak location survey:

6.1.1 Conductive paths such as metal pipe penetrations, pump grounds, and batten strips on concrete should be isolated or insulated from the water or earthen material on the geomembrane whenever practical. These conductive paths conduct electricity and mask nearby leaks from detection, as well as compromising the overall survey quality.

6.1.2 In applications where a single geomembrane is covered with earthen materials that overlap the edges of the geomembrane, measures should be taken to isolate the edges. If earthen materials overlap the edges of the survey area to earth ground, electrical current will flow from the earthen material to earth ground, compromising survey sensitivity. Isolation can be accomplished by ~~either:~~either performing the leak location survey before the edges of the geomembrane are ~~covered;~~covered, removing the earthen materials from a narrow path around the perimeter of the ~~geomembrane;~~geomembrane, or allowing the edge of the geomembrane to protrude above the earthen materials.

6.1.3 There must be a conductive component on the bottom surface of the geomembrane or material directly below the ~~electrically-insulative~~ electrically insulative geomembrane being tested. Typically, leak location surveys on a ~~properly-prepared~~ properly prepared subgrade will have sufficient conductivity. Under proper conditions and preparations, geosynthetic clay liners (GCLs) can be adequate as conductive material. There are some conductive geotextiles or other conductive materials with successful field experience which can be installed as part of or beneath the geomembrane to facilitate electrical leak location survey (that is, on dry ~~subgrades,~~subgrades or as part of a planar drainage geocomposite).

6.1.4 For lining systems where an ~~electrically-insulative~~ electrically insulative geomembrane is overlain by a drainage geonet geocomposite, if the drainage geocomposite is not saturated or is not manufactured to be conductive, only leaks that penetrate both geosynthetics can be ~~detected;~~detected, as a dry drainage geonet geocomposite is ~~electrically-insulative.~~electrically insulative. Drainage geocomposites without an electrically insulative core may not be subject to this limitation.

6.1.5 For lining systems comprised of two geomembranes with only a geonet or only a drainage geocomposite between them, ~~the~~ it is recommended to use either a conductive-backed geomembrane or conductive geosynthetic between the geomembranes. If the drainage geocomposite or geomembrane is not electrically conductive, the volume between the geomembranes shall be filled with ~~water~~ a liquid to provide the conductive material. The ~~water~~liquid level in the area between the geomembranes should be limited so that it exerts a pressure less than the pressure exerted by the ~~water~~liquid and any earthen materials on the primary geomembrane. When the head pressure of the ~~water~~liquid under the geomembrane exceeds the downward pressure exerted by the weight of the ~~water~~liquid and any earthen materials on the geomembrane, the primary geomembrane will begin to float. For surveys with only ~~water~~ a liquid on the geomembrane, the survey area will be limited to the area of the geomembrane that is covered with ~~water.~~liquid. For surveys with earthen materials on the geomembrane, the survey area can be calculated from the relative density of the earthen materials, the thickness of the earthen materials, and the slope of the geomembrane. Additional area can be surveyed by placing ~~water~~ a liquid on the earthen material on the primary geomembrane.

6.1.6 For surveys with earthen materials on the geomembrane, the earthen materials shall have adequate moisture to provide a continuous path for electrical current to flow through the leak. Earthen materials usually have sufficient moisture at depth, but sometimes the surface of the earthen materials becomes too dry. This dry material shall be scraped away at the measurement points, or the surface shall be ~~wet~~wetted with water. The earthen materials do not have to be saturated with water. The amount of moisture required depends on the earthen material, the equipment, and procedures.

6.1.7 If it is suspected that existing numerous or large leaks in the geomembrane may be causing poor leak detection sensitivity, it is recommended that more than one survey be performed, the first to locate and uncover the large leak(s) and the subsequent survey(s) to perform the method at the desired sensitivity.

6.2 After the survey circuit is installed, a functionality test is performed using an actual or artificial leak, which may include leak detection distance testing as described in the annexes. The measurements obtained over the actual or artificial leak are used in tandem with the site response current to assess the site's conduciveness to testing and verify functionality of the testing circuit.

7. Leak Location Survey Procedures for Surveys with Water Covering the Geomembrane

7.1 The leak location survey shall be performed by scanning the leak location probe along the submerged geomembrane. The maximum distance between adjacent scans shall be determined by a leak detection distance test using an artificial or actual leak. The advantages and disadvantages of using the artificial or actual leak are listed in Table 1. A leak detection distance test shall be conducted on each geomembrane being tested for each set of equipment used before the set is used on that geomembrane. Periodic leak detection distance tests are specified in ~~7.8~~7.7.

7.2 *Artificial Leak Procedures*—Annex A1 contains the procedures for using an artificial leak to conduct a leak detection distance test and determine the detection distance for surveys with water on the geomembrane.

7.3 *Actual Leak Procedures*—Annex A2 contains the procedures for using an actual leak to conduct a leak detection distance test and determine the detection distance for surveys with water on the geomembrane.

7.4 *Leak Location Survey*—The leak location survey shall be conducted using procedures whereby the leak location probe passes within the detection distance of all locations on the geomembrane being surveyed for leaks. Because the probe detects leaks within the detection distance on both sides of the probe, the distance between leak detection sweeps can be no more than twice the

TABLE 1 Comparison of Artificial Leaks versus Actual Leaks for Leak Detection Distance Test with Water on the Geomembrane

Factor	Actual Leak	Artificial Leak
Repairs	Geomembrane must be repaired after test	No geomembrane repair
Mobility	Moving location requires another actual leak to be made and repaired.	Can be easily moved without needing geomembrane repair
Test adequacy of the conductivity of the material under the geomembrane	Yes, could be important for double geomembranes	Yes for single geomembranes, yes for double geomembranes if the artificial leak current return path corresponds to actual site survey conditions
Convenience	Must drill hole, sometimes under water, position is difficult to determine	Artificial leak is just placed in the water, can usually see the position