Designation: D8265 – 20

Standard Practices for Electrical Methods for Mapping Leaks in Installed Geomembranes[1]

This standard is issued under the fixed designation D8265; 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 describe standard procedures for using electrical methods to locate leaks in geomembranes covered with liquid or earthen materials, which can be watered to cause leakage through the geomembrane. For clarity, these practices use the term "leak" to mean holes, punctures, tears, knife cuts, seam defects, cracks, and similar breaches in an installed geomembrane (as defined in 3.2.7).

1.2 These practices are intended to ensure that leak location surveys are performed to the highest technical capability of electrical methods, which should result in complete liquid containment (no leaks in geomembrane).

1.3 Not all sites will be easily amenable to this method, but some preparation can be performed in order to enable this method at nearly any site.

1.4 The geomembrane must be covered with water or as wet as practical. Earthen materials or sludge, or both, may also be present over the geomembrane. The main requirement is that a hydraulic gradient exist across the geomembrane so that if a hole or breach exists in the geomembrane, it will actively leak during the testing. If ideal testing conditions cannot be achieved, the method can still be performed, but any issues with site conditions are documented.

1.5 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 sufficiently electrically insulating materials.

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

1.7 The electrical methods used for geomembrane leak location should be attempted only by qualified and experienced personnel. Appropriate safety measures should be taken to protect the leak location operators, as well as other people at the site. A current limiter of no greater than 290 mA should be used for all direct current power sources used to conduct the survey.

1.8 *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.*

1.9 *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

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 *anomaly, n*—electrical measurement caused by some aberration in the survey area, which may or may not be a leak.

3.2.2 *conductive-backed geomembrane, n*—a specialty geomembrane manufactured using co-extrusion technology featuring an insulating layer in intimate contact with a conductive layer.

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

[1] These practices are under the jurisdiction of ASTM Committee D35 on Geosynthetics and are 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.

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

3.2.5 *earthen material, n*—sand, gravel, clay, silt, combinations of these materials, and similar materials.

3.2.6 *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.

3.2.7 *leak, n*—for the purposes of this standard, a leak is any unintended opening, perforation, breach, slit, tear, puncture, crack, or seam breach. Liquid must 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.

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

3.2.9 *primary geomembrane, n*—the uppermost geomembrane in a lining system containing multiple geomembranes.

3.2.10 *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.

3.2.11 *survey, n*—for the purposes of this standard, a survey is an electrical evaluation of a geomembrane-lined containment facility to check for leaks in the geomembrane.

3.2.12 *survey area, n*—the portion of the geomembrane-lined containment facility subjected to an electrical leak location survey.

4. Significance and Use

4.1 Geomembranes are used as impermeable barriers to prevent liquids from leaking from landfills, ponds, and other containment facilities. 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 used to detect and locate leaks for repair. These practices can achieve a zero-leak condition at the conclusion of the survey(s). If any of the requirements for survey area preparation and testing procedures is not adhered to, then leaks could remain in the geomembrane after the survey. Not all of the survey area requirements are possible to achieve at some sites, but the closer the site can come to the ideal condition, the more successful the method will be.

5. Summary of the Electrical Leak Location Methods

5.1 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. This creates a voltage differential between the material over the geomembrane and the material under the geomembrane.

5.2 When there are leaks in the geomembrane, 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 high current density corresponding to the presence of leaks.

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

5.4 Various types of probes can be used to perform the surveys. Some are for placement upon earthen materials, some are for when the operator wades in water, some are for towing the probe back and forth across a filled pond, and some are for raising and lowering along vertical walls of a tank.

5.5 Measurements are typically made along parallel survey lines or on a grid pattern. They are recorded and then organized into an electrical map of the survey area.

5.6 Electrical measurements must be made as close to the geomembrane as possible. The thickness of earthen cover materials, including impenetrable sludge or concrete, should not exceed approximately 1 m, though this thickness is highly site specific.

5.7 An electrical map created from the electrical measurements is adjusted in order to clearly display a characteristic leak signal, and the survey area is analyzed for the presence of any signals characteristic of a leak.

5.8 The approximate location of a leak signal is determined from the electrical map, and additional measurements are typically made in the vicinity of the detected leak signal to more accurately determine the position of the leak, if possible.

5.9 The leak detection sensitivity depends primarily on the survey area conditions. Optimal survey area conditions are described in Section 6. The leak detection sensitivity is also a function of 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 detector electronics, the distance away from the leak during measurement, the survey procedures, the presence of other leaks in the survey area, and data interpretation methods and expertise.

5.10 The survey rate depends primarily on the spacing between the measurement points, the type of data acquisition, the ease of contact with the cover material, and the method of data analysis and time required for leak pinpointing.

5.11 One intent of these practices is to produce documentation of a zero-leak condition, so multiple surveys may be required if leaks are found during the initial survey. For survey areas with leaks found during the first survey, a second survey may not be necessary, especially if documentation of a zero-leak condition is not required. Current will flow preferentially through the largest leaks in an impoundment and sometimes the smallest leaks will not draw current until the larger damage locations have been repaired. The results of the initial survey should inform whether a second survey would be beneficial. It is possible that multiple surveys will be required if the damage to the geomembrane is extensive.

5.12 In some impoundments, damage can be so extensive that the geomembrane fails to restrict current flow to discrete and detectable leak locations. This can also be the case for sites that are not properly prepared for a survey. In these cases, electrical methods may not be effective in locating the leaks.

5.13 Installed geomembranes vary in their ability to restrict current flow as a function of their bulk electrical resistivity, thickness, contact with cover and subgrade materials, the surface area subjected to the applied voltage differential, and the impoundment facility liner cross section. Quantification of current flow is used in these practices as a site-specific index.

6. Leak Location Survey Area Requirements

6.1 Sufficiently electrically conductive material must be present over the geomembrane, for example, earthen material or liquid. Frozen earthen materials are not sufficiently electrically conductive. In the case of bare geomembrane, the survey area can be flooded with water in order to perform this test method. The material covering the geomembrane should be as homogenous as possible. Anomalous features such as trenches or pipes are allowed, but may produce anomalous electrical readings.

6.2 The material covering the geomembrane must be completely isolated from the material underneath the geomembrane. This is typically achieved through an isolation trench around the entire perimeter of the survey area. It can also be achieved by a welded flap of geomembrane that separates the cover material inside the survey area from the material outside, or the geomembrane extending through the anchor trench to protrude above the earthen materials. Any conductive paths such as metal pipe penetrations, pump grounds, and batten strips on concrete must be isolated or insulated from the water or earthen material over the geomembrane. The only path for electrical current flow must be through leaks in the geomembrane under the level of water or earthen materials covering the geomembrane in the survey area.

6.3 There must be a sufficiently conductive material directly below the electrically insulative geomembrane being tested. Typically, leak location surveys on a 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 beneath the geomembrane to facilitate electrical leak location surveys on geomembranes without an underlying conductive layer.

6.4 For lining systems comprised of two geomembranes with only an electrically insulative geonet or a geocomposite between them, the volume between the geomembranes can be filled with water to create an electrically conductive layer. The water level in the area between the geomembranes should be limited so that it exerts a pressure less than the pressure exerted by the water and any earthen materials on the primary geomembrane. When the head pressure of the water under the geomembrane exceeds the downward pressure exerted by the weight of the water and any earthen materials on the geomembrane, the primary geomembrane will begin to float. For surveys with only water on the geomembrane, the survey area is limited to the area of the geomembrane that is covered with water. For this type of lining system, a conductive-backed geomembrane can be used as the primary geomembrane in lieu of flooding the interstitial layer if it is an electrically isolated conductive-backed geomembrane installation. Conductive geotextile may also be used under the primary geomembrane.

6.5 For surveys with earthen materials covering the geomembrane, the earthen materials shall have adequate moisture at the surface to provide good electrical contact with the electrodes used to take electrical measurements. Sometimes the surface of the cover material must be watered directly in front of the progressing survey, especially with drainage gravel or desiccated clayey soils. The earthen material, along with any other geosynthetic layer directly above the geomembrane, should be saturated in order to ensure active leakage at the time of the survey.

7. Electrical Leak Location Survey Procedures

7.1 *Survey Equipment:*

7.1.1 Electrical measurements should be taken with measurement electrodes, which are not electrically or chemically reactive with the cover material in the survey area.

7.1.2 If voltage measurements are taken, the voltmeter should have an internal resistance of at least approximately 1 GOhm.

7.1.3 The electrical measurement apparatus must feature electrically insulative connection points for the electrodes so that current cannot short-circuit the measurement apparatus.

7.1.4 Current source and return electrodes shall have intimate contact with the layers above and below the geomembrane. For gravel or sandy materials, this could entail encasing the electrodes with saturated fine-grained soil. For geosynthetic layers such as the back side of a conductive-backed geomembrane, contact including pressure over an area of the layer may be required.

7.1.5 An artificial leak conforming to the general requirements of Fig. 1 shall be used. The electrode should not be electrically or chemically reactive with the cover material. If it is, then it may still be used if measures are made to counteract the effect of the reactivity. A typical artificial leak contains two separate electrodes with diameters of 3.2 mm and 6.4 mm. A smaller or larger electrode size may be used.

7.2 *Survey Set-Up:*

7.2.1 For earthen material-covered geomembrane that does not have apparent standing liquid, dig a test pit at the high end of the survey area and document the apparent moisture content of the material directly above the geomembrane.

7.2.2 Apply a voltage differential across the installed geomembrane in the survey area and record the voltage and site response current.

7.2.3 Choose a location for the artificial leak. This can be the same location as the test pit described in 7.2.1. It is a good idea to place it as far away from the current source electrode as possible, while maintaining approximately 10 m distance from any survey area edges, if possible.

7.2.4 Install the artificial leak as close to the geomembrane as possible. Ensure good contact between the circular electrode(s) and the cover material. Connect a current return electrode for the artificial leak to the conductive layer underneath the geomembrane in the same manner as the current return electrode of the survey area as detailed in 7.1.4. The current return electrode for the disk shall be separated from the current return electrode for the survey area by a distance of at least 3 m, if physically possible. In no case shall the artificial leak share the same electrode as the current return electrode of the excitation power source.

7.2.5 Apply the same level of voltage as in 7.2.2. Record the site response current with an artificial leak electrode connected to the current return electrode described in 7.2.3. With the artificial leak connected, perform the following:

7.2.5.1 Record the electrical measurement produced by the disk in the cover material when the electrical measurement apparatus is directly over the location of the disk, and also when it is offset by a distance of half the proposed measurement grid spacing of the survey as shown in Fig. 2 (either Measurement Point 1 or 2). This will result in a range of values to be expected for a leak in the liner with similar contact conditions of the artificial leak. The high end of the signal strength range will be the value directly over the artificial leak, and the low range will be one of the two measurement points shown in Fig. 2, which represent the furthest distance from an actual leak during the performance of the survey. If a dipole measurement is used, then readings should be taken for the four positions:

(1) Front foot directly over artificial leak,
(2) Back foot directly over artificial leak,
(3) Front foot directly over Measurement Point 1, and
(4) Back foot directly over Measurement Point 2.

7.3 *Survey Performance:*

7.3.1 The functionality of the electrical survey shall be evaluated through the steps outlined in 7.2.5.

7.3.2 A coordinate system shall be established for the survey area for mapping purposes (local coordinate system, GPS, or both).

7.3.3 The electrical measurements shall be acquired, at a minimum, in a grid pattern fully encompassing the survey area. Additional data points not conforming to a grid pattern may be acquired, especially for non-rectangular survey areas.

7.3.4 If the survey is conducted using dipole measurements, all edges of the survey area must be surveyed parallel to the edge in addition to the typical grid pattern. Any corners in the survey area must be scrutinized appropriately, since leaks can be missed if the dipole does not travel across a leak location.

7.3.5 The electrical measurements shall be organized according to their position in the coordinate system so that a complete and continuous electrical map of the survey area can be generated.

7.3.6 If the increase in site response current from the connection of a given artificial leak from 7.2.5 comprises

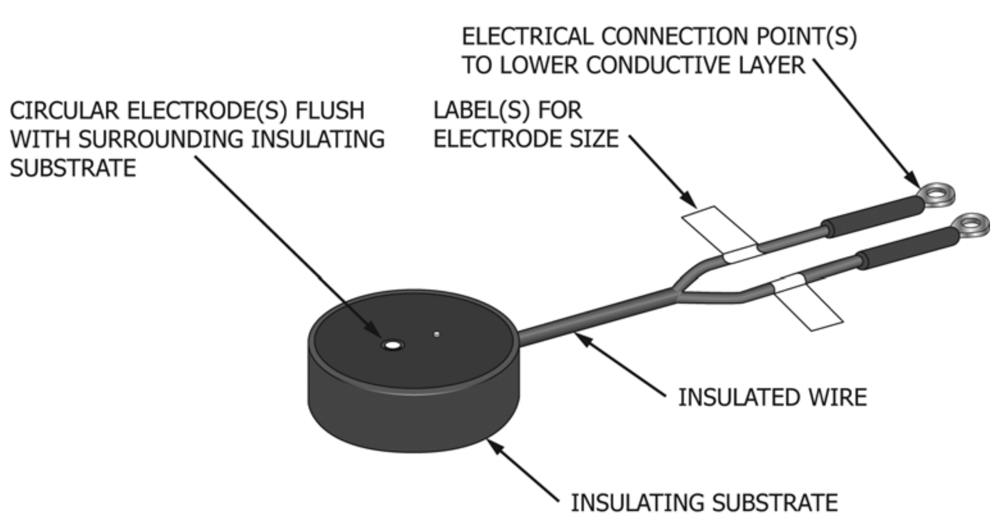

FIG. 1 Artificial Leak Example