~~Designation:D6747–04~~ Designation: D6747 – 12

Standard Guide for Selection of Techniques for Electrical Detection of ~~Potential Leak Paths~~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 standard guide is intended to assist individuals or groups in assessing different options available for locating ~~potential leak paths~~ leaks in installed geomembranes ~~through the use of~~ using electrical methods. For clarity, this document uses the term ~~potential~~ leak ~~path~~ to mean holes, punctures, tears, knife cuts, seam defects, cracks and similar breaches ~~over the partial or entire area of~~through an installed geomembrane.

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.

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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 *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 practices and determine the applicability of regulatory requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

~~D4439Terminology for Geosynthetics~~

D4439 Terminology for Geosynthetics

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

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

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

3. Terminology

~~3.1*Definitions:*~~

~~3.1.1*electrical leak location*, *n*—any method which uses electrical current or electrical potential to detect and locate potential leak paths.~~

~~3.1.2*geomembrane*, *n*—an essentially impermeable membrane used with foundation, soil, rock, earth or any other geotechnical engineering related material as an integral part of a manmade project, structure, or system.~~

~~3.1.3*geosynthetic*, *n*—a planar product manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a manmade project, structure, or system.~~

~~3.1.4*potential leak paths*, *n*—for the purposes of this document, a potential leak path is any unintended opening, perforation, breach, slit, tear, puncture, crack, or seam breach. Scratches, gouges, dents, or other aberrations that do not completely penetrate the geomembrane are not considered. Leak paths detected during surveys have been grouped into five categories: (*1*) Holes—round~~

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

~~Current edition approved Nov. 1, 2004. Published November 2004. Originally approved in 2002. Last previous edition approved in 2002 as D6747–02[ε1] DOI: 10.1520/D6747-04.~~

Current edition approved Feb. 15, 2012. Published February 2012. Originally approved in 2002. Last previous edition approved in 2002 as D6747–04. DOI: 10.1520/D6747-12.

[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.

~~shaped voids with downward or upward protruding rims, (*2*) Tears—linear or areal voids with irregular edge borders, (*3*) Linear cuts—linear voids with neat close edges, (*4*) Seam defects—area of partial or total separation between sheets, and (*5*) Burned through zones—areas where the polymer has been melted during the welding process.~~

3.1 *For general definitions used in this document, refer to D4439.*

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *electrical leak location, n*—a method which uses electrical current or electrical potential to detect and locate leaks

3.2.2 *leak, n*—for the purposes of this document, 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. Leaks detected during surveys have been grouped into five categories:

3.2.2.1 *holes*—round shaped voids with downward or upward protruding rims.

3.2.2.2 *tears*—linear or areal voids with irregular edge borders.

3.2.2.3 *linear cuts*—linear voids with neat close edges.

3.2.2.4 *seam defects*—area of partial or total separation between sheets

3.2.2.5 *burned through zones*—voids created by melting polymer during welding.

4. Significance and Use

~~4.1Types of potential leak paths have been~~ 4.1 Leaks are typically related to the quality of the sub-grade material, quality of the cover material, care in the cover material installation and quality of geomembrane installation.

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

4.3 The damage to a geomembrane can be detected using electrical leak location systems. Such systems have been used successfully to locate ~~leak paths~~ 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.

4.4 The principle behind these techniques is to place a voltage across a synthetic geomembrane ~~liner~~ and then locate areas where electrical current flows through discontinuities in the ~~liner~~geomembrane (as shown schematically in Fig. 1~~). Insulation must be secured prior to a survey to prevent pipe penetrations, flange bolts, steel drains, and batten strips on concrete to conduct electricity through the liner and mask potential leak paths. The liner must act as an insulator across which an electrical potential is applied. This electric detection method of locating potential leak paths in a geomembrane can be performed on exposed liners, on liners covered with water, or on liners covered by a protective soil layer, or both.~~). Other electrical leak paths such as prevent pipe penetrations, flange bolts, steel drains, and batten strips on concrete and other extraneous electrical paths should be electrically isolated or insulated to prevent masking of leak signals caused by electrical current flowing through those electrical paths. The only electrical paths should be through leaks in the geomembrane. This electric detection method of locating leaks in geomembranes can be performed on exposed geomembranes, on geomembranes covered with water or on geomembranes covered with an earthen material layer, or both.

5. Developed Systems

5.1 Electrical leak detection systems were developed in the early 1980's and commercial surveys have been available since 1985. A short description of each of these systems is presented in this section.

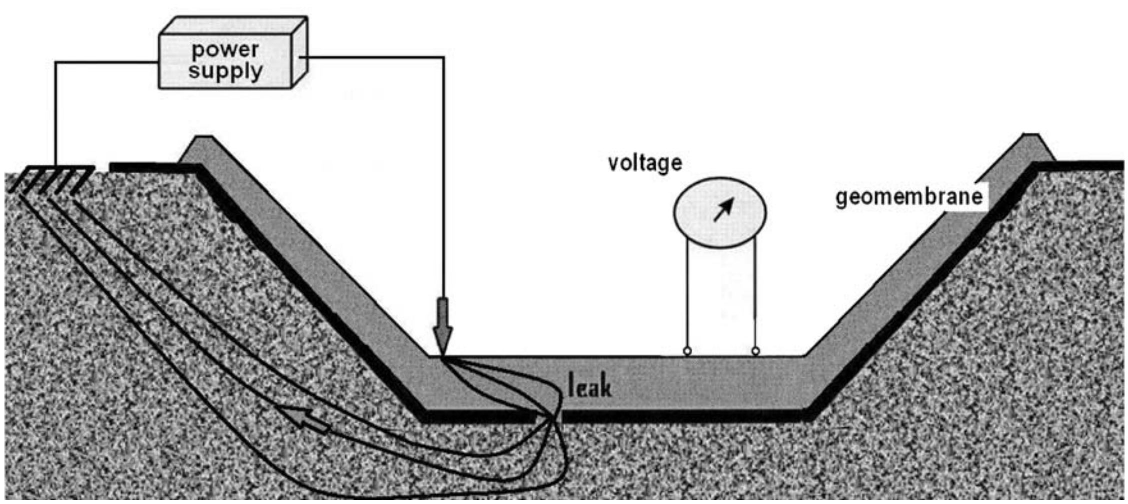

FIG. 1 Schematic of the Electrical Leak Location Method (Earthen material-Covered Geomembrane System is Shown)

5.2 *The Water Puddle and Water Lance System*~~—The technique is appropriate to survey a dry uncovered geomembrane during its installation when placed directly on a subgrade that is an electrically conductive layer below the geomembrane. The lower conductive layer is usually the soil and the upper conductive layer being water. A cathode ground is established and an anode is placed in a water puddle maintained by a squeegee or to the water stream of a lance (as shown schematically in~~ —The technique is appropriate to survey a dry uncovered geomembrane placed directly on a conductive layer below the electrically insulating geomembrane. Practice D7002 is a standard practice describing the water puddle method. The lower conductive material is usually the sub-grade soil and the upper conductive layer being the water in a puddle or a stream of water. One electrode of a low voltage power supply is placed in contact with the lower conductive material and another electrode is placed in a water puddle maintained by a squeegee or in the water stream of a lance (as shown schematically in Fig. 2 ~~). Water is usually supplied by gravity from a tank truck parked at a higher elevation than the lined area. For this technique to be effective, the leaking water must come into contact with the electrical conducting medium to which the ground electrode of the 12 or 24 volts dc supply can be connected. Since the geomembrane is not a perfect electrical insulator, a steady background signal can be audible. As the water flows through a leak path, there is an increase in the signal. Leak paths as small as 1 mm in size are then located by an audio signal or by measuring a current of magnitude related to the size of the leak. It can also be used to search for leak paths in geomembrane-lined concrete and steel tanks.~~ and Fig. 3, respectively). Water is usually supplied from a tank 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 usually convert a change in the current into a change in an audio tone. Leaks as small as 1 mm in size have been identified with this method; typically by listening to an audio signal or by measuring a current

5.2.1 *Features*~~—The main advantage of this system is the possibility to detect leak paths in geomembrane joints and sheets as work progresses during the construction phase. Larger leak paths do not mask smaller ones because this technique locates leak paths independently on uncovered liner. The electrical survey rate of approximately 500 m~~—The main advantage of this system is the detection of leaks in geomembrane seams and sheets while the geomembrane installation work progresses during construction. The system does not require covering the geomembrane with water other than the small puddle of water or stream. Procedures can be used to differentiate smaller leaks from larger leaks in their vicinity. The electrical survey rate of approximately 500 m^2/h per operator does not affect the installation work schedule and permits a rapid construction quality control ~~(CQC)~~ of the geomembrane installers' finished work. The approximate setup time varies from 1 to 3 h.

5.2.2 *Limitations*~~—This technique cannot be used with a protective layer covering the liner. The presence of wrinkles and waves, steep slopes and lack of contact between the liner and the conductive soil at bottom of slopes inhibits the survey speed. This technique cannot be used during stormy weather when the membrane is installed on a desiccated subgrade, or whenever conductive structures cannot be insulated or isolated. The procedure to detect potential leak paths in seams of repair patches is difficult and lengthy since it requires a certain infiltration time.~~ —This technique cannot be used when an earthen material layer is covering the geomembrane. The presence of wrinkles and waves, steep slopes and lack of contact between the geomembrane and the conductive material underneath inhibits the survey from being performed at those locations unless special measures are undertakingen. This technique cannot be used during rainy weather or when the membrane is installed on an electrically

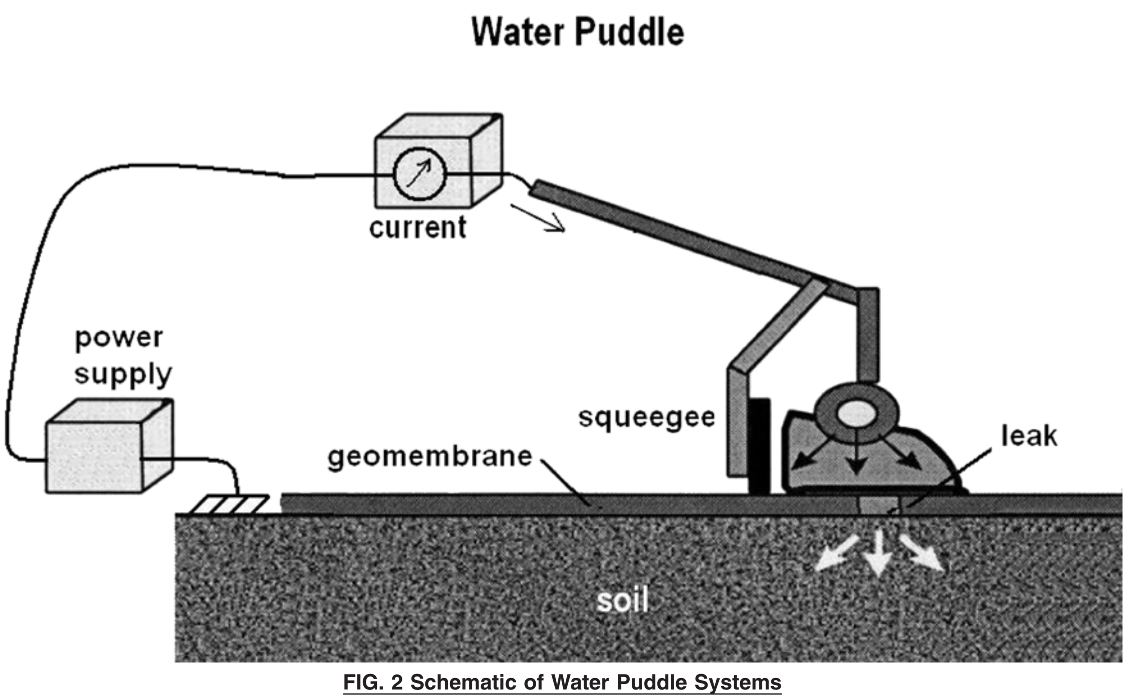

FIG. 2 Schematic of Water Puddle Systems

non-conductive material, typically a desiccated subgrade, 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.

5.3 *The Water-Covered Geomembrane System*—The principle behind this system is to test the geomembrane while it is covered with water, a technique similar to the previous system requiring an electrically conductive layer below (subgrade) and above the liner (water or saturated drainage layer). A cathode ground is established and an anode is placed in contained water. The voltage impressed across the liner (by a high voltage dc or ac power supply) produces a low current flow and a relative uniform voltage distribution in the material above the geomembrane. To maximize this current, a high voltage power supply with safety circuits is used that can provide up to 400 volts DC. A hand-held probe is then traversed through the water. An electrical current flows through the potential leak paths causing localized abnormalties in the electrical paths as shown schematically in Fig. 3. The typical procedure is to flood the test area, then locate the potential leak paths, drain the area and perform repairs. A hand-held probe or a probe on a long cable is scanned through the water to locate these places where current is flowing through a leak. A typical procedure is to flood the test area to a depth of approximately 0.15 to 0.75 m. This technique can locate very small leaks, smaller than 1 mm. The signal amplitude is proportional to the amount of electrical current flowing through the leak, so practical measures should be taken to maximize the current through the leaks. The signal amplitude is inversely related to the distance from the leak, so the scanning spatial frequency should be designed to provide the desired leak detection sensitivity. —This system is to test the geomembrane while it is covered with water , with an electrically conductive material below the geomembrane. Practice D7007 contains a standard practice for this system. An electrical power supply is connected to one electrode which is put in the water and another electrode is placed in contact with the electrically conductive material under the geomembrane. The voltage impressed across the geomembrane produces a low current flow and a relative uniform voltage distribution in the material above the geomembrane. An electrical current flowing through the leaks causes localized abnormalties in the electrical potential at the location of the leak as shown schematically in Fig. 4. To maximize the current flowing through the leaks, a high voltage power supply with safety circuits can be used. A hand-held probe or a probe on a long cable is scanned through the water to locate these places where current is flowing through a leak. This technique can locate very small leaks, smaller than 1 mm. The signal amplitude is inversely related to the distance from the leak, so the scanning spatial frequency should be designed to provide the desired leak detection sensitivity.

5.3.1 *Features*—This system has the advantage of being used to locate potential leak paths in in-service impoundments. Primary and secondary liners can be tested. The water head on the liner facilitates the survey speed by minimizing the presence of wrinkles and waves, and lack of contact between the liner and the conductive soil at the bottom of slopes. This technique can be used in wet conditions. The main advantage of this technique is the detection of leak paths with the protective granular layer covering the liner (after the installation of the drainage layer on the geomembrane) (refer to 5.5 for description of the method). The survey rate depends primarily on the spacing between sweeps and the depth of the water. A close spacing between sweeps is needed to detect the smallest leaks. The survey rate for a survey while wading, sweeping the probe so that it comes within 0.25 m of every point on the submerged geomembrane is 800 to 1200 m—This system has the advantage of being used to locate leaks in in-service impoundments (assuming the contained liquid is electrically conductive). Primary geomembranes can be tested when a conductive material is available underneath the geomembrane. Secondary geomembranes can be tested before the primary geomembranes is installed. The water head on the geomembrane ensures good electrical contact with the conductive material under the geomembrane through any leaks, resulting in optimum leak detection sensitivity. While this technique can be performed in rainy conditions, it is never recommended to do a survey during stormy conditions. The system can also be used for the detection of leaks with an earthen material layer covering the geomembrane (for example after the installation of the drainage layer on the geomembrane). The survey rate depends primarily on the spacing between sweeps and the depth of the water. A close spacing between sweeps is needed to detect the smallest leaks. The survey rate for a survey while wading, sweeping the probe so that it comes within 0.25 m of every point on the submerged geomembrane is 800 to 1200 m^2/h per person. For a survey with a towed probe with the probe scanned within 0.4 m of every point, the survey rate is 800 to 1000 m^2/h per two persons, including establishing the survey lines. The approximate setup time is 30 to 90 min. These times do not include the time to floodcover the liner. geomembrane with water.

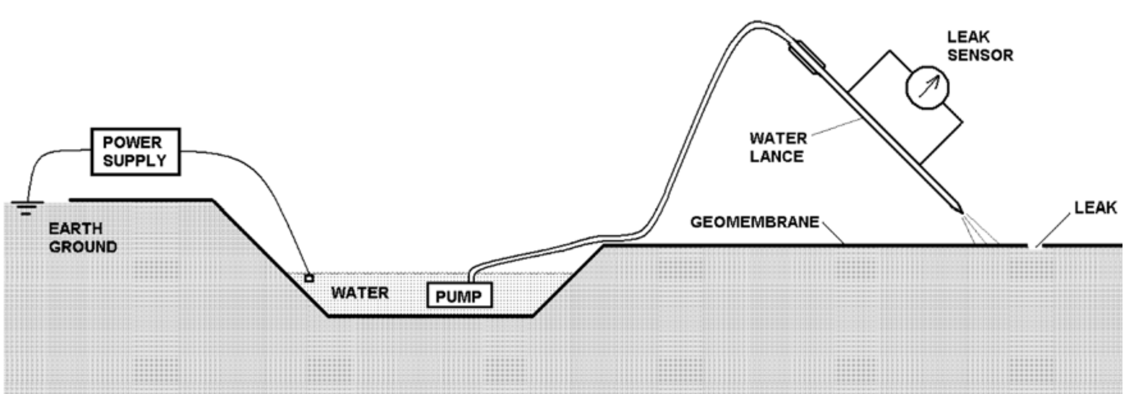

FIG. 3 Schematic of Water Lance System