TITLE: Electronic Leak Detection (ELD)

DESIGNATION: RCI-TA-018-2019

OBJECTIVE: To provide information on the methods and qualifications for electronic leak detection testing used for installed roofing and waterproofing systems.

BACKGROUND

With the desire to improve the service life of roofing and waterproofing systems, a need has arisen to improve quality control and troubleshooting techniques. The introduction of nondestructive electronic leak detection (ELD) testing has provided additional options to meet this demand. Since quality control is an important aspect in today's construction projects, electronic leak detection is becoming a commonly specified and utilized procedure to determine watertightness in roofing and waterproofing assemblies. The introduction of this technology occurred around 20 years ago in the North American market and has led to an increased confidence in roofing and waterproofing systems installed on more complicated design and construction projects. In recent years, many questions have arisen regarding differences in technology and training required to provide accurate results using ELD. This advisory provides information on the following:

- History and development of equipment currently utilized
- Current ASTM guide and how it relates
- Basic principles needed to achieve testing
- Characteristics and limitations of the different technologies
- Training and proper implementation
- Recommendations

DIFFERENT TECHNOLOGIES

The origins of electronic leak detection began with high-voltage (holiday) testing equipment. This equipment was originally designed to test corrosion-resistant coatings applied on metallic pipes and was later modified to test geomembranes, waterproofing membranes, and low-slope roofing assemblies. Moving into the mid-1990s, a new testing method was developed due to the inherent shortcomings with high-voltage testing. Low-voltage testing made its way slowly into the German market as a means of troubleshooting existing roofing assemblies. Although often considered to be more accurate, it became clear that much more experience and training was necessary for this testing method. It quickly became evident that low-voltage equipment was more suitable for identifying leaks in exposed roofing membranes, as well as having the ability to assist with the troubleshooting of roofing and waterproofing through different types of overburden covering the membrane.

In the late '90s, the first electronic leak detection introduced in North America was low-voltage ELD. First promoted as a troubleshooting tool, as it was in Europe, it quickly became apparent that many individuals in the industry became interested in using the technology as a quality control (QC) tool during installation of roofing and waterproofing systems.[1] Several developments have been made in the equipment over the years to allow for QC on several different types of roofing and waterproofing systems. Within the last ten years, conductive grids and other materials have also been introduced into the market that are incorporated into systems to allow for testing on insulated roofing systems.

While there are several forms of equipment utilized for electronic leak detection, (i.e., high-voltage broom, scanning platforms, EFVM,® etc., the basic electrical theory of either high or low voltage is similar.

ASTM GUIDE D7877

ASTM Guide D7877[2] was introduced in 2014 and specifically explains the various pieces of equipment in use, as well as the conditions required to perform a test. While this standard outlines the terminology and methodology associated with current electronic test methods and equipment variations, it does not address training and experience of the individual performing the tests.

Equipment Addressed in the Standard*

ASTM Guide D7877 currently outlines two methods of low-voltage ELD for horizontal surfaces, one method of low-voltage ELD for vertical surfaces, and one method of high-voltage ELD, further described as follows:

Low-Voltage Methods of ELD

- Low-Voltage Membrane Horizontal Scanning Platform (method performed with wetted membrane)
    - This equipment utilizes direct current contained within a wheeled scanning platform that reads a field between two different "sweeps" making contact to the membrane. This is utilized for testing membranes on horizontal substrates only.

* Refer to ASTM D7877 for photographs of equipment.

- Electric Field Vector Mapping (EFVM®) (method performed with wetted membrane)
    - This equipment utilizes two poles which read a direct current field being placed across the membrane via a looped conductor wire at the membrane perimeter. This is utilized for testing membranes installed on horizontal and vertical substrates.

- Low-Voltage Vertical Membrane Surface Scanning (method performed with wetted membrane)
    - Similar to the platform utilized for horizontal applications, but the equipment is designed to be handheld and utilized for testing membranes installed on vertical substrates.

High-Voltage Method of ELD

- High-Voltage Membrane Testing (method performed with dry membrane)
    - This is a broom-like device with electrodes at the head and is "swept" across a dry membrane, locating punctures in the membrane. This is utilized in testing membranes on horizontal and vertical substrates.

BASICS REQUIRED FOR ELD

The basics required for either high- or low-voltage ELD are very similar, even though the results are achieved through different methods. In either method of testing, the basics of electrical principles apply and cannot work without meeting specific items.
The first thing that needs to be verified is that the membrane being tested will not allow electrical flow to pass through. Most fluid-applied and sheet membranes in the roofing and waterproofing market are suitable candidates for performing ELD, except black EPDM, as it contains electrically conductive carbon black. If the membrane is suitable, then the substrate immediately below the membrane must have the ability to carry an electrical charge. Acceptable substrates are cast-in-place concrete (CIP), steel-reinforced concrete (double "T" concrete), metal decks, and conductive materials specifically manufactured to be incorporated into the system by the testing firm.

If any of these conditions indicated herein are present, then either a low- or high-voltage ELD method can be successfully performed. If these conditions are not present, then it is up to the testing firm to present options to the project personnel that will create a method suitable once final membrane installation is complete. In all cases, it is prudent to review the entire assembly design prior to installation for other potentially limiting factors such as adhesives, vapor barriers, overburden components, etc.

ADVANTAGES AND LIMITATIONS OF EACH TECHNOLOGY

Low Voltage

The most notable shortcoming of low-voltage ELD is the inability to perform the test on black EPDM single-ply membrane. Due to the carbon-black content in this material, the proper electrical isolation needed for testing cannot be created with black EPDM single-ply membranes. Secondly, scanning platforms must make direct contact with the membrane; therefore, they cannot be used on assemblies with overburden such as pavers, garden/vegetation, ballast, etc.

that cannot be readily removed. Thus, another method of low-voltage testing would be more appropriate.

High Voltage

Like low-voltage, high-voltage ELD cannot be used to test black EPDM single-ply membranes for the same reasons indicated previously. Another issue that can affect the test results is varying membrane thickness common in fluid-applied membranes. The equipment should be calibrated on each project to perform the test based on a consistent fluid-applied membrane thickness. Consequently, false "positive readings" of a breach can occur in areas where the membrane thickness is less than the test standard. Seams in the membrane and flashings in both fluid and sheet-applied products can create the same problem, as material thickness is greater at these locations. Seams in the membrane can also pose challenges as voltage will not travel laterally through a void within a seam to the underlying conductive substrate. This has been addressed in ASTM D7240 section 2.3.* "Unless the conductive geomembrane has been installed with the conductive layer sufficiently broken in the fusion weld, this method cannot be used to test fusion-welded seams."[3] Although this applies to geomembranes, the same basic science is applied to roofing or waterproofing membranes.

TRAINING AND PROPER TEST IMPLEMENTATION

As with any other specialized trade in the construction industry, both low-voltage and high-voltage ELD require a significant amount of training for technicians to have the appropriate knowledge to properly implement the test. In the last few years there have been several companies beginning to offer ELD services using technicians with little to no training. A concern the industry faces is the qualifications of companies and personnel offering ELD services and the ability to provide accurate and repeatable test results. Currently there are no independent educational or training opportunities being offered for either low- or high-voltage ELD testing. Nor are there industry recommendations for minimum training requirements for ELD technicians.

The following items are important questions when establishing basic technician qualifications:

- Length of time providing this service
- Equipment and testing method utilized
- Type and duration of training
- Approvals from roofing/waterproofing manufacturer for testing firm and method being used
- A list of references of the technician providing testing on similar projects

RECOMMENDATIONS

It is important when specifying ELD testing to ensure membrane compatibility as well as manufacturer acceptance. Consulting with a firm knowledgeable in this technology during the design phase is also critical to achieving a successful roofing/waterproofing project. In several assembly designs, ELD testing, if desired, cannot be considered as an afterthought if the conductive medium is to be incorporated within the assembly. It is important to remember that test results are only accurate when proper procedures are followed by trained and experienced technicians.

* Section number may change. When this Technical Advisory was published, section 2.3 was current.

[1] Keith Roberts. "The Electrical Earth Leakage Technique for Locating Holes in Roof Membranes." *Proceedings of the Fourth RCI International Symposium on Roofing Technology*. September 1997.
[2] ASTM International. ASTM D7877-14, *Standard Guide for Electronic Methods for Detecting and Locating Leaks in Waterproof Membranes*. 2014.
[3] ASTM International. ASTM D7240-18, *Standard 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). 2018.