Electronic leak detection can be an important tool, but its use must be carefully considered

by Jason P. Wilen, AIA, CDT, RRO

Many consider flood testing to be the traditional method of testing the integrity of a roof or waterproofing membrane. But since the late 1980s, electronic leak detection (ELD) methods have been offered as an alternative to flood testing, and recently some building enclosure standards have begun to reference ELD as an option.

ELD methods are useful for finding breaches in a roof or waterproofing membrane. However, when deciding whether to use ELD in lieu of other post-installation membrane test methods such as flood testing, there are a number of factors to consider.
ELD methods

There are several variations of ELD, but all fall into two main types: low voltage and high voltage.

The most common ELD involves a low-voltage procedure where a wire conductive to electricity is placed in direct contact with an exposed nonconductive roof or waterproofing membrane. The wire is placed on the perimeter of a test area, and a lead from a power source is connected to the perimeter wire. A second lead from the power source then is grounded to a structural deck conductive to electricity, such as a metal deck or reinforced concrete. Instead of a conductive structural deck, the second lead can be grounded to a dedicated conductive medium (sometimes called a grounding grid or a grounding screen) that can be installed in the roof or waterproofing system beneath the membrane.

Water then is sprayed over the membrane’s surface within the testing area. If there is a breach in the testing area, current will flow from the power source through the surface water, into the breach, through the dedicated conductive medium or structural deck (ground) and back to the power source, completing a simple electrical circuit. An ELD technician uses equipment that can trace the current flow direction and pinpoint the breach location. When found, each breach is isolated using a loop of wire effectively removing the breach from the testing area and allowing other breaches to be found.

When several breaches are located within the test area, a skilled technician’s expertise especially is important to properly interpret the readings because current will flow in multiple directions. Large areas are tested in sections with a maximum area of about 5,000 to 6,000 square feet per section. Tape or weights often are used to hold down the perimeter wire to ensure complete contact with the membrane; areas where the wire does not contact the membrane can create inconclusive readings or result in undetected breaches.

Also, any electrically conductive penetrations within the test area, such as metal stacks or drains, should be isolated with a loop of wire to remove them from the area. This method also can function through overburden, such as vegetative components, pavers, etc., and is installed as an assembly component.

Another low-voltage ELD method involves the use of a small scanning platform. Breaches in the membrane beneath the platform trigger an indicator for the technician. The system essentially is a miniature version of the procedure described earlier, but the edges of the scanning platform act as the perimeter conductive wire. A metallic sweep beneath the platform can detect the current flow when a breach is within the platform’s perimeter while the technician walks the entire surface area being tested (similar to mowing a lawn). The membrane surface must be wet, and the scanning platform must be connected to a conductive deck or dedicated conductive medium (ground). Areas inaccessible to the scanning platform cannot be tested, and this method does not function through overburden.

High-voltage ELD methods employ a broom-like sensor with metallic tines swept over a membrane. Breaches are detected when current flows from the tines, through a breach in the membrane and to a conductive deck or dedicated conductive medium (ground) connected to the sensing equipment. Where no breach exists, the roof membrane acts as an isolator, preventing a circuit from being formed. Unlike low-voltage ELD, the procedure must occur when the membrane’s top surface is dry. Also, this method does not function through overburden.

ELD for integrity testing

Using ELD to test for membrane breaches following installation of roofing or waterproofing components is
becoming more common. Some membrane manufacturers require ELD to be performed as a condition for providing a roof system warranty. This especially is true for roof systems that include overburden, such as pavers and vegetative components, or for protected membrane assemblies where the membrane is installed directly on the deck with other roof system components, such as insulation and pavers. Because ELD is conducted before overburden is installed in these cases, low- and high-voltage methods potentially can be used.

Membrane materials determine the type and whether ELD can be used. The membrane must be nonconductive to electricity. Traditional black EPDM membranes generally are conductive though gray or white EPDM membranes often have a low enough conductance to use ELD. Membranes with a metallic or foil-type surface generally are not compatible with ELD. In systems where an aluminum coating will be used, ELD should be conducted before coating installation.

Some ELD vendors offer material testing to determine whether ELD can be used for a particular roof or waterproofing system. Gravel-surfaced built-up roof systems may be difficult to keep continuously wet during low-voltage testing, and high-voltage testing generally is not possible through aggregate or ballast.

Components within a roof or waterproofing system also may affect ELD effectiveness. A vapor retarder or other material between the membrane and conductive deck can prevent an electrical circuit from being completed, causing breaches to be missed. Also, ELD requires moisture be in the system for the breach to be detected. Testing performed immediately after membrane installation generally requires robust wetting to ensure enough water has entered the breach to allow for the electrical circuit completion. This especially is important in systems where there is a large dimension or several layers of material between the membrane surface and conductive deck.

When there is concern a vapor retarder or insulation layers may prevent ELD from being effective, a dedicated conductive medium such as a stainless-steel mesh can be used beneath the membrane to create a grounding plane. The closer the grounding plane is to the membrane, the more effective ELD will be. Often, the dedicated conductive medium is attached to metallic plumbing components or other grounded items to facilitate ELD equipment grounding. Sometimes, a dedicated attachment port also is installed so there is a reliable location to attach the power source to the grounding plane.

Weather also can be a factor. Using low-voltage ELD methods during freezing conditions is difficult because ice formation from the water-spray equipment and resulting slick surfaces can be hazardous for a technician. During hot weather, it may become more difficult to maintain the uniform wet surface required in the testing area because of rapid evaporation. During rainy, dewy or snow-covered conditions, high-voltage ELD cannot be used because an exposed, dry membrane surface is required.

The roof or waterproofing area configuration may affect testing effectiveness and dictate the ELD type used. Vertical membrane surfaces, such as parapet flashings, cannot be tested with low-voltage methods. Electrically conductive penetrations such as roof drains or metal plumbing stacks cannot be tested with ELD methods, and ELD equipment such as scanning platforms may not be maneuverable in tight areas. Also, ELD will not detect
a leak that is not caused by a membrane breach, such as a leak from a defective wall component above a flashing termination.

If ELD is used to evaluate post-installation membrane integrity as a condition for warranty or before overburden installation, it is best the roof or waterproofing system designer consider ELD limitations to ensure ELD procedures will produce reliable results. Part of the design process should include working with the membrane manufacturer and ELD vendors to ensure the proper placement of a dedicated conductive medium if it is needed in a particular assembly.

It also should be noted that low- and high-voltage ELD may be used together—for example, the low-voltage procedure can be used on a roof system's field and the high-voltage procedure can be used on flashings. Also, not all areas subject to leaks, such as metal roof drains or metal pipe penetrations, can be evaluated with ELD. Construction sequencing may affect ELD testing, as well, because some procedures are affected by particular weather conditions.

Building enclosure commissioning

The commissioning of newly constructed building elements is commonplace in the roofing and construction industries. Commissioning is defined in the International Green Construction Code, 2012 Edition as "a process that verifies and documents that the selected building and site systems have been designed, installed, and function in accordance with the owner's project requirements and construction documents, and minimum code requirements."

More recently, the commissioning concept has been applied specifically to the building enclosure. ASTM International has approved a commissioning standard, ASTM E2813–12, “Standard Practice for Building Enclosure Commissioning.” In the standard's Table A2.1, “BECx Performance Testing Requirements,” flood testing of horizontal waterproofing installations per ASTM D5957, “Standard Guide for Flood Testing Horizontal Waterproofing Installations,” is listed as a mandatory field test for fundamental and enhanced commissioning.

ELD is mentioned in a footnote associated with the flood test requirement. Footnote F states: “Depending upon roofing type and installation, Electronic Leak Detection (ELD) or Nuclear Radioisotopic Thermalization may also be considered to supplement or replace this evaluation.”

Although ASTM E2813-12 mentions ELD in a footnote, the National Institute of Building Sciences (NIBS) Guideline 3-2012, “Building Enclosure Commissioning Process BECx,” references electronic field vector mapping (EFVM®), a specific type of low-voltage ELD.

NIBS Guideline 3-2012 recommends roof and waterproofing membranes undergo flood or EFVM testing of completed systems. Although NIBS recommends flood testing as an option for roof and waterproofing membranes, NRCA considers flood testing a viable option only for waterproofing membranes (see “Water, water everywhere,” February 2006 issue, page 38).

It also is important to note that unlike many products and procedures common in the roofing and construction industries, ELD equipment, components and procedures are not yet part of a consensus standard similar to those developed by ASTM International or the American National Standards Institute. Therefore, specific ELD equipment and procedures can be difficult to evaluate or compare.

ELD during service life

One of the attributes often touted by ELD vendors is the ability of the procedures to be used during a membrane's service life to identify leaks that might develop after initial installation. Although it is true ELD components can
be incorporated into a roof or waterproofing system to facilitate repeated testing during the roof system’s service life, there are important factors to consider when evaluating ELD’s value.

For systems with overburden, it is important to realize some methods used to test the membrane’s immediate post-construction integrity cannot be used after the overburden is in place. High-voltage ELD and low-voltage methods that use a scanning platform rely on the testing equipment’s intimate contact with the membrane and, therefore, cannot be used through pavers, vegetative roof components and other types of overburden.

Low-voltage procedures that use a conductive wire installed on each testing area’s perimeter often can be used after overburden placement because the wire loop can be left in place beneath the overburden and on the membrane’s top surface. However, it will be challenging to find the wire years later. A portion of the wire often is left exposed but must be protected until needed.

Sometimes, the wire is run to a mounted connection box for later use, but this option is costly. If the wire is damaged or an exposed section cannot be located, the overburden will need to be removed to find the wire or a new wire will need to be installed before the ELD procedure can be conducted. Sometimes, a dedicated connection box is used; if a dedicated conductive medium is used as a grounding plane, a future ELD technician will need to be informed of its existence to be able to connect to it.

Vegetative and protected membrane assemblies also can present issues. Components of these systems, such as insulation, root barriers and drainage mats, are not in place during the initial ELD evaluation and can interfere with moisture reaching the membrane’s surface, preventing ELD procedures from yielding reliable results. It is important for the system to be designed with later ELD use in mind.

Coordination with the membrane manufacturer, careful material selection and consideration of system configuration can result in reliable ELD during a roof system’s service life. The building owner should maintain documentation so ELD components left in place can be found when needed.

Also, when dedicated connection boxes are used, vendor-specific components sometimes are needed to interface with the connection points. This type of situation may require a request to the same vendor that performed the initial testing to do in-service ELD.

Final thoughts

ELD should not be considered a replacement for quality control performed by a roofing contractor or quality assurance performed by an owner’s representative, such as an architect, engineer, roof consultant or manufacturer representative. At the time of application, a quality regime is essential for all roofing and waterproofing projects and should be viewed independently from integrity testing such as ELD or flood testing.

Often, building owner requirements will be the most important factor when determining whether ELD is appropriate for a particular project. ELD often is as costly to perform as other integrity testing or building enclosure commission activities, especially if additional components are needed within the roof or waterproofing assembly to facilitate its use. ELD may be best-suited for projects with larger budgets where internal components are susceptible to potential damage from flood testing or for building areas employing redundant water infiltration prevention measures such as data centers, record storage and some government uses.

In some cases, specialized ELD applications have been developed to create dedicated scanning regions that are permanently left in place and can be manipulated by a vendor to provide detailed water infiltration data over time. Although costly, this kind of specialized ELD use can be effective and valuable to an owner. It seems likely ELD technology will continue to develop and new forms will begin to be used more widely. The use of active moisture sensors placed within a roof or waterproofing system already is being used on a limited basis.

For projects where ELD is being considered strictly to meet warranty requirements or satisfy a general institutional guideline, careful consideration should be given to determine whether its cost and value are warranted. Also, if a roof or waterproofing system has to be modified strictly to accommodate ELD use and the resulting configuration is less robust than it would be otherwise, the pros and cons should be weighed to be sure the potential performance sacrifice is worth the value ELD brings to the project.

When appropriate, discussions with an owner or manufacturer should be requested to see whether other forms of integrity or building enclosure commissioning may be appropriate for a particular project. ☑️

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