ELECTRONIC LEAK DETECTION:

A QUALITY ASSURANCE TOOL

BY DAVE HONZA

Water penetration through roofing and waterproofing systems is a common problem to many buildings. In fact, industry studies show that over 50% of newly completed buildings are delivered with water intrusion problems of the building envelope. Low-slope roofs, commonly referred to as "flat roofs," have a disproportionate share of leaks, due mostly to the fact that they also act as a staging area for other trades during new construction. We also see them used as a traffic surface and work platform for performing maintenance on rooftop equipment and adjacent surfaces. These circumstances are further supported by a study completed by the National Roofing Contractors Association (NRCA) in which poor workmanship, bad design, and accidental damage during construction were blamed for over 60% of leaks and premature roofing failures.

Given these statistics and the fact that it is considerably less expensive to make a repair at an identified breach while on site than to come back to the site after the project is complete, it's no surprise that quality assurance testing is becoming more prevalent.

To address these problems, certain quality assurance methods have been in place for a number of years. To date, these standard testing methods have consisted of the following: construction observation, flood testing, and a number of nondestructive test methods, including electronic impedance testing, infrared thermal imaging, and nuclear testing. For comparison purposes, we will mention these methods briefly.

FLOOD TESTING

- This is used most often in waterproofing and roofing applications over concrete decks in protected membrane roof (PMR) assemblies.
- Loads exerted on decks are considerable and may exceed the structural capacity of the deck.
- This is not recommended for use on conventional roof assemblies due to the potential for water damage to the insulation or structure.
- This does not identify the leak source.

ELECTRONIC IMPEDANCE, INFRARED IMAGING, AND NUCLEAR TESTING

- All are nondestructive tests.
- These are used most often on conventional roof assemblies, as test methods are very effective in detecting moisture content in insulation.
- None identifies the leak source.

WHAT IS ELD?

Electronic leak detection (ELD) is also known as electronic field vector mapping. This introduction of ELD will cover

- The principles of ELD,
- A description of the process and the hardware,
- When ELD is to be used,
- Where ELD can be used,
- Limitations of this growing technology, and
- Comparisons to existing quality assurance test methods.

Fundamentally, ELD entails creating a conductive electronic field over the roofing and/or waterproofing membranes, grounding the test equipment to the structure, and having the nonconductive membrane act as an insulator. If there is a breach in the membrane, the electronic field grounds itself to the structure. Below is a more in-depth description of the methods.

There are two common methods of electronic leak detection: low voltage and high voltage. An in-depth description of the process and equipment follow.

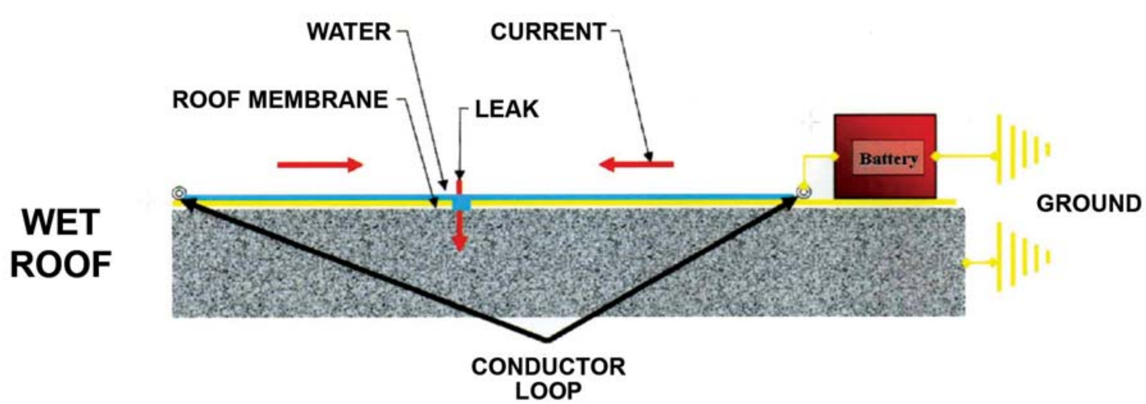


Figure 1 – The surface of the waterproofing must be wetted to provide an electrically conductive medium.

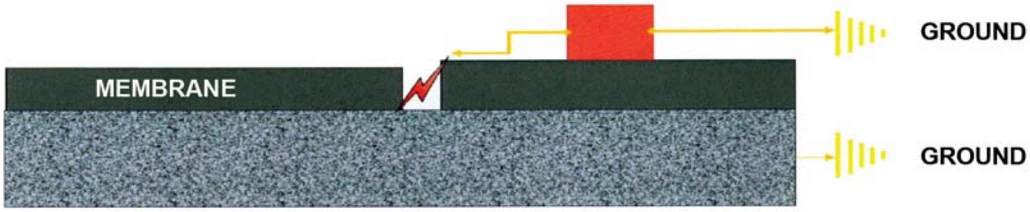


Figure 2 – The power source is grounded to the conductive deck, with the membrane acting as insulator.

LOW VOLTAGE – WET METHOD

A wire loop, to act as a conductor, is placed directly on the membrane or the membrane's protection course around the perimeter of the area to be tested. One of the two leads from a pulse generator is connected to this wire loop. A second lead from the pulse generator is grounded to the structural deck at a drain, vent pipe, flashing, or other grounded roof component. The surface of the waterproofing must be wetted (not flooded) to provide an electrically conductive medium (*Figure 1*).

Every few seconds, a low-volt charge is delivered from the pulse generator for one second. As a result, an electrical potential difference is set up between the roof surface, which is wet, and the roof deck, which is "earthed" or grounded – essentially producing two electric plates. If there are any "leaks" or breaches through the waterproofing membrane (which acts as an electrical insulator), the small electric current will flow across the membrane surface and down through the breach, completing the circuit between the two "electric plates."

A technician uses a receiver connected to two probes to identify the direction of the electric current. By moving the probes, he or she is able to systematically follow the flow to even the smallest breach or leak through the membrane. Once located, the leak can be marked for repair and plotted on a roof plan.

HIGH VOLTAGE – DRY METHOD

With high-voltage ELD, the power source is grounded to the conductive deck, with the membrane acting as an insulator (*Figure 2*). The other lead is attached to the testing equipment. The testing equipment looks much like a broom. The difference, for ELD purposes, is that the bristles are small conductors. When the broom is swept across the membrane and over a breach, the circuit is completed, allowing current to flow, resulting in the unit emitting an audible tone. When a breach has been initially located within the electronic field of the broom, the operator sweeps the area again with the contact area reduced to pinpoint the exact breach location.

Unlike the low-voltage method, the high-voltage method does not entail installing a wire perimeter to define the test area, and water is not used to enhance the conductivity over the surface of the membrane/insulator, due to the higher voltage.

WHERE IS IT USED?

The structural roof deck must be conductive. This includes metal, concrete, composite, and lightweight cementitious decks. It is important to know if the roof assembly has a vapor retarder, as it will also act as an insulator just as the membrane does and break the current flow, masking the breach.

Wood decks are not conductive, and vapor barriers break current flow on conductive decks. These assemblies can be tested if a conductive layer (such as aluminum screening) is included in the membrane assembly. The conductive layer will need to have a wire run to a location above the membrane so that the company performing the testing can use the lead to connect to the ground (*Figure 3*).

Drains provide good grounding components, as the drain lines are secured to the structure. Drains with PVC piping are ineffective. Metal vent pipes, metal flashings, and exposed rebar secured to the structure are additional grounds.

WHICH MEMBRANES?

ELD can be used on nonconductive membranes such as built-up roofs, modified bitumen, hot-fluid-applied rubberized asphalt, self-adhering polymer-modified roll goods, urethane, thermoplastic, and white EPDM (thermoset) membranes. ELD is not effective on black EPDM due to its conductive composition (carbon black).

ELD testing can be completed on conventional roof systems and on PMR membranes. Low-voltage testing can be complet-

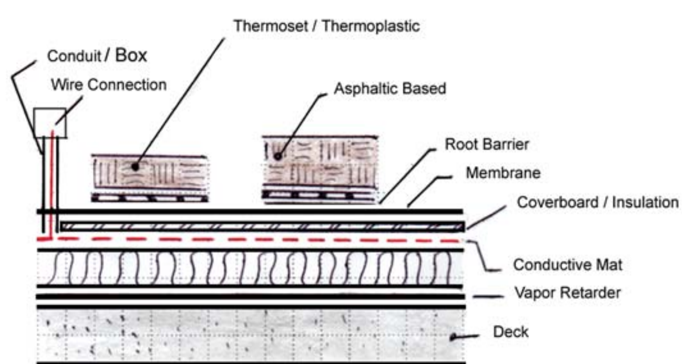


Figure 3 - Testing at nonconductive decks or conductive decks with vapor retarders.

ed with some overburden materials left in place, such as but not limited to paver blocks on sand setting beds, ballasted membranes, vegetated roofs, and nonreinforced topping slabs.

ADVANTAGES OF ELD OVER TRADITIONAL TESTING TECHNOLOGIES

The advantages of ELD testing compared with standard flood testing of membranes applied directly to the structure are:

- ELD pinpoints the location of breaches as compared to plotting and hunting for breaches in flood testing.
- This test method saves times compared with filling and waiting 24 to 48 hours, then draining and drying the test area to complete repairs.
- In many instances, the bond of adhered membranes will isolate the water intrusion to the breach itself, resulting in no leak during the flood test. However, over time, this minor breach can allow enough water to enter to undermine the membrane integrity, resulting in a leak.
- Sloped decks pose problems for flood testing due to water depths necessary to flood large areas. Even with one-quarter in/ft slope, it only takes 40 ft to require a minimum of 12 inches for a flood test resulting in a load of over 62 lb/sq ft at the deepest location.
- With roof renovations, ELD does not risk causing interior damage from two inches or more of water on the roof.
- ELD will locate breaches where flood tests will not reveal leaks. These are the type of breaches that present problems years later.
- ELD does not risk damage to drainage systems when the drains are unplugged.
- Much less water is needed for testing.
- With high-voltage tests, repairs can be completed immediately.

ADVANTAGES OF ELD OVER INFRARED, NUCLEAR, AND ELECTRONIC IMPEDANCE ON CONVENTIONAL ASSEMBLIES

- ELD identifies the exact breach location.
- With low-voltage testing, by leaving the wire in place, testing can be completed in the future, within limitations.
- The amount of moisture needed to enter the assembly is much less to obtain a reading than to identify a breach. Testing can be completed sooner, with less sustained damage.

Anomalies identified include but are not limited to:

- Punctures as a result of fasteners used by numerous other trades.
- Punctures or splits as a result of materials dropped on the membrane.
- Damage as a result of slits or tears from construction traffic.
- Membrane burns as a result of welding.
- Damages as a result of slits or tears caused by dragging equipment across the roof.
- Pinholes in the membrane as a result of moisture in the deck.
- Incomplete lap welds.

Implementing this state-of-the-art quality assurance testing after membrane installation and immediately before installa-

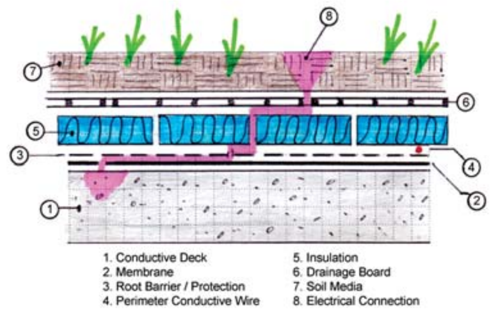


Figure 4 - ELD section with overburden in place.

tion of the overburden (be it insulation or soil media) is the single most cost-effective step in reducing immediate and latent leaks.

LIMITATIONS

It should be noted that if water gets behind flashings or under the membrane from adjacent surfaces such as windows, storefronts, porous masonry, or unsealed base flashings, and there are no breaches in the membrane or flashings, no reading will be obtained. This is because there is no breach in the membrane or flashing materials to create a grounding connection.

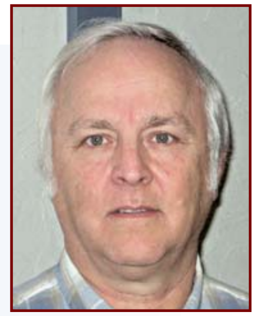
Many owners, designers, and contractors desire to keep the wiring in place so that the system may be used permanently. This can be done, but there are limitations (*Figure 4*). These include:

- Accuracy in leak location is diminished. On a vegetated roof, a three-dimensional electronic field is now being created due to the depth of the soil. The electrical flow is shaped like an inverted cone. The deeper the soil, the larger the cone.
- The soil media must be wet throughout, because an area of dry soil will produce no conductivity, which could result in a missed breach.
- As more layers of materials are added on a vegetated roof, one must be aware of the implications.
  — Extruded polystyrene is an insulator. In testing, thorough wetting is imperative so that the electrical flow registers moisture on the top horizontal surface of the insulation and down the joints at the perimeter of the 2-by-8-ft pieces of insulation.
  — Since 20- to 40-mil polyethylene is a widely used root barrier and a nonconductive material, testing must rely on water migrating across the surface to a lap in order to have the electrical flow follow the water to the membrane. Sheets may be 6-, 10-, or 20-ft wide, and in many applications, the laps are thermally fused or taped, resulting in potentially greater flow distances.
  — Dimple-type drain boards are high-density polypropylene or polyethylene (HDPE), and as such are nonconductive, once again requiring water migration and electrical flow to laps.
- With paver-on-pedestal applications, the pedestals are set for 3/16-in joints between the pavers, which does not allow sufficient room to position ELD probes between the pavers to take readings with a receiver.

In conclusion, ELD provides the ability to implement exacting quality assurance testing methods to provide owners with longer-lasting, leak-free roofing and waterproofing applications. ELD can also be used in locating existing leaks on conventional and protected membrane roof assemblies. Within limits, ELD can be used in leak detection with various overburden assemblies.

Another generation of leak detection equipment will be required to fully meet owners' expectations for permanent leak-detection systems.

Dave Honza



Dave Honza has over 35 years of experience in the roofing and waterproofing industry, 21 of which were spent with major manufacturers, promoting products to the architectural community and technical support and application training to contractors. For 14 years, Honza was a roofing and waterproofing consultant involved in identifying problems and implementing solutions. For the last decade, Honza has actively promoted green roofs, acting as a course trainer. He is accredited as a Green Roof Professional (GRP) through Green Roofs for Healthy Cities. His company, the Honza Group, has provided ELD services since 2006.