Feature

The Silent Killer of Roofs: Water Intrusion and the Case for Proactive Leak Detection

By Shaun Katz

TOO MANY ROOFS are closed wet.

Of all construction-defect disputes, some experts estimate that 75% to 80% are related to roof failures, and more than 70% of construction litigation involves water intrusion.[1,2] With the advent of electronic leak detection (ELD) testing and the availability of continuous moisture monitoring, the data assimilated indicate that water intrusion issues often begin during construction, long before the building is commissioned and passed to the ownership. Unfortunately, when not monitored during and after construction, water intrusion is often not detected until the leak is visible within the building, and by then, the damage is done.

This article highlights years of compiled information, demonstrating avoidable construction errors within the industry that can be easily mitigated utilizing ELD and proper moisture monitoring.

Architects can design a watertight assembly but cannot ensure it is installed as designed. Manufacturers make reliable products but cannot ensure good workmanship, including adequate drainage and proper flashing. Contractors can install a watertight membrane system only to have other trades damage it without informing others. Owners and facility management firms place their trust in all parties involved, but there is no guarantee the roof assembly is properly installed and will perform as designed for the expected service life or even for the length of the warranty.

While developing ASTM D7877, *Standard Guide for Electronic Methods for Detecting and Locating Leaks in Waterproof Membranes,*[3] and ASTM D8231, *Standard Practice for the Use of a Low Voltage Electronic Scanning System for Detecting and Locating Breaches in Roofing and Waterproofing Membranes,*[4] for ELD on roof systems, it became clear that there was a lack of understanding in the industry of how and why ELD was being utilized. Over the past decade, considerable practical experience has been invaluable to help demystify and illustrate the importance of ELD. As listed in ASTM D7877, there are four methods of ELD. Although the methods are different, physics remain the same for high- and low-voltage ELD.

ELD TESTING OF MEMBRANES

ELD is a point-in-time test that locates breaches (such as voids, holes, punctures, and the like) in roofing and waterproofing membranes and includes both low-voltage (up to 40 V) and high-voltage (up to 40,000 V) methods. The four ELD methods include the low-voltage scanning platform, low-voltage vector mapping, low-voltage vertical roller, and high-voltage (also known as spark testing or holiday testing) (**Fig. 1**).

ELD testing is preferred in lieu of flood testing on waterproofing applications and is an effective procedure for new roofing or reroofing. It can also be a useful forensic tool for existing roofs with active leaks.

ELD applies an electrical potential to the surface of an exposed membrane. At the location of a void, an electrical current passes through the membrane and travels to an electrically grounded substrate below the membrane, thus completing an electrical circuit. The capabilities and limitations of each method can be found in detail in ASTM D7877.[3]

Contrary to some claims in the ELD community, ELD testing cannot be performed with reliable or repeatable results once the membrane is covered with any overburden. This is particularly true when membranes are covered with intensive or extensive vegetative roofing, topping slabs, or pavers. ELD testing equipment, whether high or low voltage methods are used, must make direct contact with the membrane itself. Any layers above the membrane such as drain mat, insulation, or root barriers tend to block the electrical path.

Interface articles may cite trade, brand, or product names to specify or describe adequately materials, experimental procedures, and/or equipment. In no case does such identification imply recommendation or endorsement by the International Institute of Building Enclosure Consultants (IIBEC).

 ©2026 International Institute of Building Enclosure Consultants (IIBEC)

Figure 1. *The four electronic leak detection methods.*

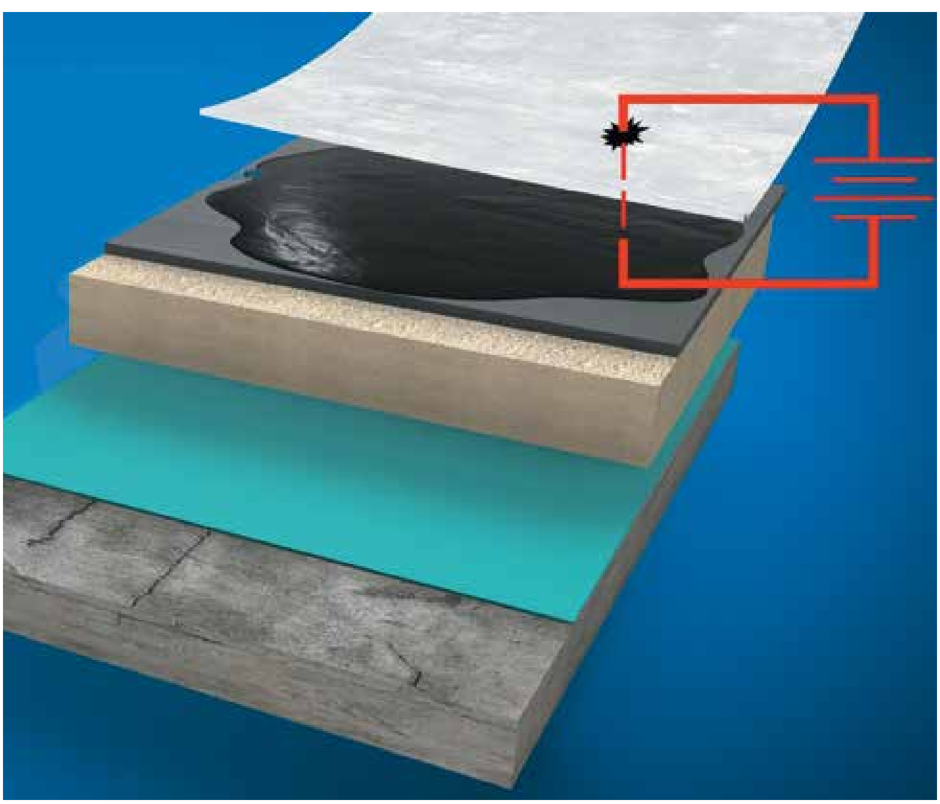

Figure 2. *Conductive medium enables electronic leak detection.*

CONDUCTIVE MEDIUM

ELD requires a conductive substrate directly below the membrane (**Fig. 2**). A conductive medium is an electrically conductive material that provides a current return path to enable low- and high-voltage electronic testing. Without the addition of a conductive medium in a conventional roof assembly, valid ELD testing is impossible, as electrically insulating materials below the membrane (cover board, insulation, vapor barrier) block the electrical path to the conductive deck (structural concrete or metal). Improper placement of a conductive medium below the cover board or insulation also prevents valid ELD testing due to a break in the electrical path. This is addressed in Sections 4.4 and 5.5 of ASTM D7877.[3] ELD testing agencies have a responsibility to inform all parties of the requirements and limitations, although this is not always the case. The sole purpose of performing ELD is to provide quality control testing. Excluding a conductive medium on new conventional roofs results in the inability to perform valid QC testing, and the consequence is undetected breaches in the membrane causing trapped hidden moisture.

FORENSIC ELD

In an existing roof with an active leak, ELD can be used as a forensic tool to assist with determining the origin of the moisture intrusion (**Fig. 3**). For roof assemblies where the intrusion problem is not obvious, ELD can often be used to determine whether the source of moisture intrusion is coming from the roof membrane. The electrical circuit would be completed through any wet roofing materials that complete a continuous path to the conductive deck. If no breaches in the membrane are located, then it is most likely that the moisture intrusion is coming from somewhere else.

Often, forensic ELD is used in conjunction with other forensic methods such as infrared thermography, impedance, or nuclear roof moisture surveys. This provides additional information on the area of trapped water under the assembly as well as an indication of where the leak is originating from.

CONTINUOUS MOISTURE MONITORING

Moisture monitoring is accomplished by installing sensors within the roof assembly to provide a continuous tracking of any moisture (**Fig. 4**). The monitoring system is most effective when activated during construction. Monitored systems identify any intrusion issues in real time so corrective actions can be made to remove trapped moisture prior to closing the assembly.

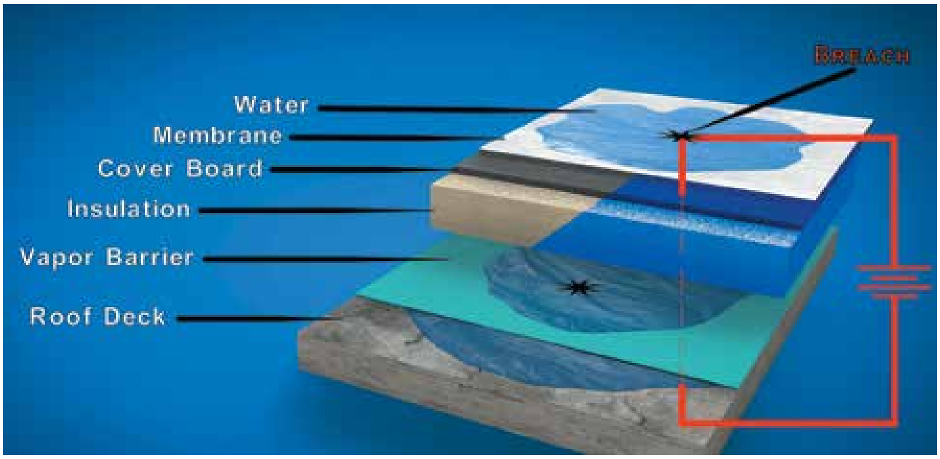

Figure 3. *Forensic electronic leak detection.*

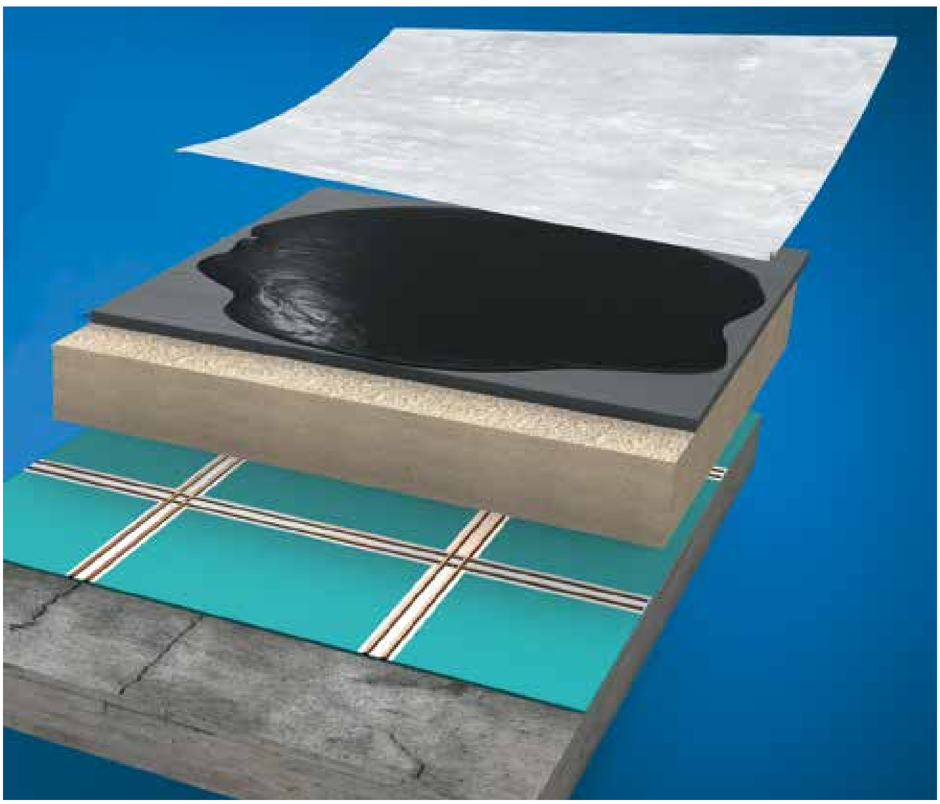

Figure 4. *Sensors installed for continuous moisture monitoring.*

After closing and in operation, the roof assembly is monitored 24 hours a day, 7 days a week for any moisture intrusion. If excessive moisture is detected, an alert is issued so that any needed repairs can be completed in a timely fashion, thereby avoiding a roof failure along with costly damage that would otherwise occur. Even if an excessive moisture load is in the assembly without serious leakage, the long-term deterioration of the roof material can result in mold growth along with associated health issues. Additionally, the thermal performance is often compromised, with the roof becoming a thermal bridge.

It is impossible to overstate the value of continuous monitoring during construction and for the service life of the roof. It provides ongoing performance data to provide risk mitigation and loss control.

ELD TESTING USED IN CONJUNCTION WITH MOISTURE MONITORING DURING CONSTRUCTION

ELD testing as part of quality control during new construction pinpoints any damage to the membrane, which can be repaired and retested before covering with overburden or prior to initiating the warranty. This prevents any hidden moisture damage from causing expensive future repairs. ELD testing also reduces warranty claims or future callbacks.

Continuous moisture monitoring notifies all relevant parties during construction. The notification allows an immediate response to determine the cause of water ingress. The damaged area can be repaired immediately so standing water and wet material such as insulation can be removed from the roof assembly. This ensures the roof is built without trapped water, which would otherwise impact the performance and service life of the roof. A 1985 extensive field survey of low-slope roofs by R. G. Anderson found a significant percentage had high levels of liquid water entrained in the insulation, according to the National Institute of Standards and Technology.[5]

The experience, challenges, and input from industry professionals dealing with leak investigations have also provided critical information on the benefits of ELD testing and continuous monitoring.

CASE STUDIES

Due to the sensitivity of the data, project names, products used, and parties involved are not included to keep anonymity.

Case Study #1—Light Rail Station, Washington

A rapid-curing, cold fluid-applied coating was utilized on this project. ELD testing found 59 breaches in just under 14,500 ft^2 (1,350 m^2). While flood testing historically was the selected test method for waterproofing, it is not considered conclusive for testing the integrity of the field of the membrane. Additionally, flood testing cannot pinpoint breaches in the membrane or determine how many breaches are present, and it cannot test a vertical surface. These are critical areas that can only be reliably tested utilizing ELD.

The average breach per square foot count on this project was one breach located per 245 ft^2 (23 m^2) tested, most of which were pinholes (**Fig. 5**).

Pinholes are commonly found with cold fluids, including traffic coatings. These pinholes are often formed by off-gassing from the concrete below or exposure to rain prior to curing. Without performing ELD, it is highly unlikely that flood testing or a visual inspection would provide the same type of results.

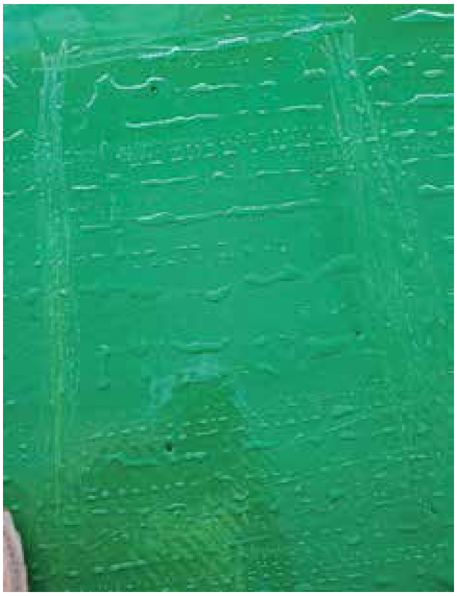

Figure 5. *Examples of pinholes located at light rail station.*

Case Study #2— Lab Space, California

On this project, a polyvinyl chloride (PVC) roof was installed, but ELD testing was removed from the scope to save costs during construction. Eventually, the roof began to leak, and the client chased the leaks for approximately a year, unable to lease the facility during that time.

Upon performing a forensic test, nine breaches were located in approximately 22,000 ft^2 (2,040 m^2). Breaches found included seam voids as well as trade damage (**Fig. 6**).

If the client had included ELD testing during construction, the cost would have been far less than just a month's lost revenue due to moisture intrusion, not to mention the costs to repair the water damage.

Case Study #3—Food Manufacturing Plants, Multiple Locations Throughout the US

The facilities manager for one of the food manufacturing plant locations inquired about forensic ELD testing. Forensic ELD testing is possible in existing roofs with active leaks, even if a conductive medium is not included. This is due to the active moisture intrusion within the roof assembly that carries the electrical current down to the conductive deck. After successfully testing one plant, six others reached out for assistance locating the leaks in their roofs. In total, over 1,000,000 ft^2 (93,000 m^2) of actively leaking single-ply roofing was tested. The average breach per square foot count for all seven plants in total was approximately one breach per 5,000 ft^2 (465 m^2) tested. The majority of breaches were seam voids and punctures from trade damage (**Fig. 7** and **8**). Many of these roofs were covered in debris, staged materials, and screws (**Fig. 9**).

If the customers had included a conductive medium in the assembly and performed ELD during construction, these breaches would have been found and repaired prior to starting

Figure 6. *Examples of breaches found during forensic electronic leak detection testing at lab space in California.*

Figure 7. *Examples of breaches found on one of the seven food manufacturing plants.*

Figure 8. *Examples of breaches found on one of the seven food manufacturing plants.*

Figure 9. *Site conditions on one of the seven food manufacturing plants.*

the warranty. It also highlights that planned maintenance is very important in the effort to realize the expected service life of the roof.

Case Study #4—Office Building, California

During construction, a conductive metal mesh was installed within the roof assembly; however, it was placed incorrectly under the cover board. A low-voltage vector mapping test was performed, which did not detect any breaches during the quality control test. Breaches were not found due to the incorrect placement of the conductive medium. The area was then covered with intensive overburden, which consisted of pavers, small plants, fully grown palm trees, and an irrigation system. The roof system failed, and a complete removal of the overburden was required to conduct a comprehensive leak investigation, which included a visual inspection, impedance scans, and forensic ELD.

The impedance testing located numerous areas of trapped moisture, and construction defects were visible throughout the area. Upon further inspection, it was found that the improperly placed conductive mesh had punctured the membrane. After performing forensic ELD, breaches and seam voids were pinpointed (**Fig. 10**).

If a noninvasive conductive medium, such as a conductive primer, had been installed correctly, directly below the membrane where it is required to be, then these breaches would have been found in the initial quality control test. Unfortunately, this specific conductive medium was improperly installed below the cover board, which invalidated the ELD test and damaged the membrane. This resulted in complete removal and replacement of the entire roof assembly.

When ELD testing is to be included on a conventional roof, a conductive medium must be installed *directly below* the membrane.

Figure 10. *Examples of seam voids and punctures found at office building in California.*

Case Study #5—Office Towers, Washington

On this project, a new thermoplastic polyolefin (TPO) roof membrane was installed with a conductive medium correctly placed directly below the membrane. ELD testing found 106 breaches in approximately 57,000 ft^2 (5,300 m^2).

During the test, the ELD technician noticed that nearly all seams were alarming, indicating an electrical path to ground was present (also known as the breach). It was determined that all the cut edges were missing the cut-edge sealant, which allowed water to seep down to the conductive primer under the membrane (**Fig. 11**). After ELD testing, the roofing contractor added cut-edge sealant to these seams, and the areas were retested, all passing secondary inspection.

Case Study #6—Department of Transportation, Texas

Just over 121,000 ft^2 (11,200 m^2) of new PVC roofing was installed directly on top of a conductive medium. ELD testing found 133 breaches, which is an average of approximately 1 breach per 900 ft^2 (84 m^2) tested. Seam voids and trade damage were found throughout the area (**Fig. 12**).

With a properly installed conductive medium in a conventional roof assembly and performing ELD testing, breaches can be found, repaired, and retested prior to starting the warranty. Often, seam probing and a visual inspection are performed, which are not sufficient when it comes to determining the integrity of roof membranes. Another item to note is that damage caused by construction is commonly found, especially if these roof areas are used for staging materials or allow heavy foot traffic. Protecting the membrane from other trades is highly recommended; otherwise it is likely the area will be damaged.

MOISTURE MONITORING DURING CONSTRUCTION

The following case studies include the installation of a permanent moisture monitoring system during construction. The system was activated during the construction process, thereby continuously monitoring every section of the roof as it was built. The system reports data at specific intervals during construction with a time stamp. This makes it easy to see the location and time that an initial moisture event occurs, as well as when and where the water spreads.

Case Study #7— Apartment Building, Oregon

During a break in the construction schedule over Thanksgiving weekend, a zone went into alert. Within 45 minutes, water traveled to three additional zones. Each zone was approximately 15 ft × 15 ft (5 m × 5 m). The moisture monitoring system determined where the moisture presented itself at the vapor barrier, tracked where the moisture moved, and provided a time stamp. After the weekend, the roofer cut into the roof and found standing water at the vapor barrier. When the building sign-in log was checked, it was confirmed that someone had shown up on-site and cut a curb around a heating, ventilating, and air conditioning unit without informing anyone. It then rained over that long holiday weekend. Water flowed through the roof assembly and pooled on the moisture monitoring sensors, alerting the roofer in real time (**Fig. 13**).

Without a monitored system, no one would have known about the incident, and the building would have been built with trapped standing water. This also verified that the roofer was not to blame for the damage done by other trades.

Case Study #8— Health Care Complex, Iowa

The moisture detection system was installed on the vapor barrier in late August. The contractor created a night seal in preparation for rain in the forecast. After the first significant rainfall, the sensors went into alarm, indicating the night seal had failed. The source was from several gaps present in an unfinished wall, which allowed water to flow under the membrane. All materials under the membrane were saturated, and staged materials on the roof were exposed to rain. All wet areas were dried out, and wet materials were replaced, ensuring that the roof assembly was dry.

A few weeks later, 60 moisture detection zones (each approximately 225 ft^2 [21 m^2]) went into alarm as they were flooded due to a failed drain pressure test (**Fig. 14**). All wet areas were removed and replaced.

Later that same week, rain penetrated the night seal again, causing four zones to go into alarm. Once again, the standing water and existing wet roofing material had to be removed. Once replaced, a night seal was created for that weekend.

Figure 11. *Examples of numerous seam voids at office towers in Washington.*

Figure 12. *Examples of breaches and seam voids located at Department of Transportation in Texas.*

Figure 13. *Standing water on moisture detection sensors at apartment building in Oregon.*

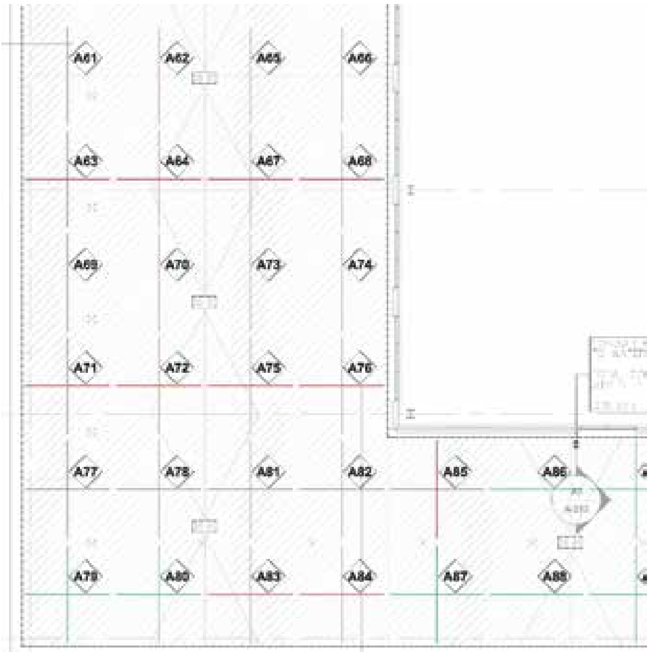

Figure 14. *Flooded zones at health care complex in Iowa.*

Figure 15. *Two inches (50 mm) of standing water on the exposed roof.*

On the following Monday, it was apparent that the night seal failed once again (**Fig. 15**). All areas were removed, dried, and replaced. The rest of the installation went smoothly, with occasional zones going into alert, but the moisture intrusion was caught right away and repaired quickly before it became a larger issue.

Without monitoring during construction, there is no doubt this roof would have been built with trapped standing water. The insulation and cover boards would have been wet, affecting *R*-values and creating energy loss. Hidden moisture would have remained undetected, and costly repairs would be required, possibly after the warranty period.

Towards the end of construction, ELD testing was performed on the single-ply roof which included a conductive medium directly below the membrane. Five breaches were found, repaired, and retested, preventing any future moisture intrusion (**Fig. 16**).

Figure 16. *Breaches located, repaired, and retested at health care complex in Iowa.*

This was one out of nine roofs on this project, and it was the only roof to receive any form of moisture monitoring or ELD testing. Based on all the data, it is highly likely that the other eight roofs were built with trapped moisture and have breaches in the membrane.

AVERAGE ELD TESTING RESULTS FROM 2021 TO 2023

The following ELD testing data include testing results performed by 20 certified testing agencies in over 400 separate projects throughout the US and Canada. There are some things to note:

- Some square footage logged is an approximate (that is, based on physical measurements in the field, per drawings, or per information provided by the customer).
- Some square footage includes retesting of areas after repairs or after the area was exposed to additional trade traffic and/or damage.
- Clusters of breaches are often marked as one breach instead of individually (**Fig. 17**).

For ELD testing on cold fluid-applied inverted waterproofing, including traffic coatings, the average for the 3-year period was approximately one breach located per 300 ft^2 (28 m^2) tested. Pinholes were commonly found.

For ELD testing on hot fluid-applied inverted waterproofing, the average for the 3-year period was approximately one breach located per 287 ft^2 (27 m^2) tested. Hot fluid-applied waterproofing is the most commonly ELD-tested membrane in the US. The data for this membrane includes five times the square footage tested on cold fluid-applied membranes. The data also includes five times the number of breaches located. Most commonly, breaches were caused by trade damage.

In Canada, styrene-butadiene-styrene modified bitumen (SBS Mod Bit) inverted waterproofing is the most commonly tested

Figure 17. *Example of clusters of breaches.*

membrane. The average for the 3-year period for modified bitumen inverted waterproofing in Canada alone was approximately one breach located per 170 ft^2 (16 m^2) tested. Most commonly, breaches were caused by trade damage and form holes.

For forensic ELD testing (existing building with an active leak), the average for the 3-year period was approximately one breach per 3,284 ft^2 (305 m^2) tested. Typically, trade damage and seam voids were the cause.

For ELD testing conventional roofing including a conductive medium directly below the membrane, the average for the 3-year period was approximately one breach per 2,164 ft^2 (201 m^2). Typically, trade damage and seam voids were found.

SUMMARY

Based on individual case studies and years of compiled data, it is apparent there is a pattern. Without the use of ELD testing and moisture monitoring to alert the roofer and/or the general contractor so they can repair the leak and remove the water and wet materials, many conventional roofs are closed wet.

Almost always, moisture detection systems, used to monitor the roof assembly during construction, have gone into alert due to active moisture intrusion. Night seal failures are very common, and it is safe to assume that without moisture monitoring, wet roof materials are being left in place. Roofing in the wintertime or during wet times of the year has proven time and time again that moisture intrusion is commonplace during construction.

Every year building owners, development teams, and their insurers spend millions of dollars to repair problems that could have been corrected during construction. This enormous waste happens primarily because of value engineering, or a lack of awareness and understanding of concealed moisture accumulations during construction. Unchecked, concealed moisture penetrations that accumulate for extended periods, rot wood components, create mold problems, corrode steel components, affect *R*-values, and increase energy loss due to wet materials such as insulation.

The collateral damage includes thousands of construction-defect claims, wasted materials, legal and consulting fees, increased insurance rates, lost productivity, and injured reputations.

The solution includes a comprehensive ELD test enhanced with continuous moisture monitoring of the roof assembly during construction. Regular roof maintenance is essential and must be supported by continuous moisture monitoring for the service life of the roof.

REFERENCES

1. Seward, A. 2011. "When It Leaks It Pours." *Architect.* https://www.architectmagazine.com/technology/when-it-leaks-it-pours_o.
2. Hoch, J. 2016. "Water Intrusion Is the Largest Generator of CDL Claims and Insurance Losses" (Tech Alert blog post). Quality Built. https://www.qualitybuilt.com/resources/tech-alert-water-intrusion-is-the-largest-generator-of-cdl-claims-and-insurance-losses/.
3. ASTM International. 2014. *Standard Guide for Electronic Methods for Detecting and Locating Leaks in Waterproof Membranes.* ASTM D7877-14. West Conshohocken, PA: ASTM International.
4. ASTM International. 2019. *Standard Practice for the Use of a Low Voltage Electronic Scanning System for Detecting and Locating Breaches in Roofing and Waterproofing Membranes.* ASTM D8231-19. West Conshohocken, PA: ASTM International.
5. Anderson, R. G. 1985. "Dry Range and Wet Range Moisture Content of Roofing Materials as Found in Existing Roofs." In *Proceedings of the Second International Symposium on Roofing Technology,* 409–415. Rosemont, IL: NRCA.

ABOUT THE AUTHOR

SHAUN KATZ

Shaun Katz *has over 25 years of experience in customer service and business administration, and he has been involved in electronic leak detection for the past 10 years. He is an active member of the Construction Specifications Institute, ASTM, and IIBEC. He has assisted property managers, building owners, contractors, architects, engineers, consultants, manufacturers, and testing agencies with forensic leak investigations and leak detection in new construction projects. He has delivered hundreds of presentations and conducted demonstrations on electronic leak detection throughout the world. His goal is to provide a fundamental understanding of electronic leak detection and to assist all parties in ensuring valid and conclusive results.*

Please address reader comments to chamaker@iibec.org, including "Letter to Editor" in the subject line, or IIBEC, *IIBEC Interface* Journal, 434 Fayetteville St., Suite 2400, Raleigh, NC 27601