1. Introduction

Over the past 30 years or so, Electronic Integrity Testing (EIT) has become the recognised standard for the purpose of on-site testing and certification of the waterproofing integrity of many flat roof and structural waterproofing systems, including Liquid Applied Membranes (Hot-Melt and cold applied), Reinforced Bitumen Membranes (RBM) and most Single Ply Membranes (SPM).

There are many organisations that carry out these tests and they should be approved by the manufacturer of the waterproofing system. Roofing and Waterproofing Test Association (RAWTA) members are all independent third party On-Site Test House (OSTH) companies with no ownership or allegiance with waterproofing system manufacturers, suppliers or waterproofing contracting businesses. As such they provide independent testing and certification.

2. Principles of test

Electronic Integrity Testing offers superior accuracy, efficiency, and safety over flood testing. Flood testing can be inaccurate, time consuming and can potentially be harmful to the structure or underlying materials. For the On-Site Test House (OSTH) to certify the integrity of the waterproofing, it is essential that any readings indicating breaches (i.e. water pathways to electric earth) are identified prior to the application of any surface finishes, such as green roofs, paving, decking or inverted roof components.

With Electronic Integrity Testing (EIT) the time to carry out the test varies depending on whether the waterproofing system is an inverted, warm, or cold roof application, as well as the type of structural deck.

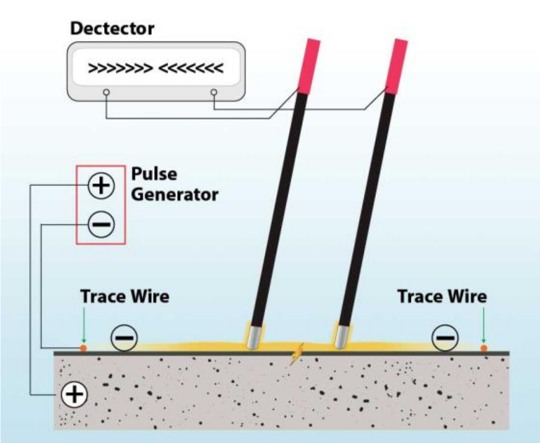
For inverted roof applications, testing is carried out **before** the insulation and/or finishes are installed. In contrast, a warm roof system is tested **after** the waterproofing membrane has been applied over the insulation but **before** any finishes are added. Warm roof assemblies require special consideration, as the insulation can act as an electrical insulator—this may impact test accuracy and should be discussed with the testing provider. Whether a cold roof can be tested depends on the type of structural deck; for example, timber or composite boards are not usually conductive and may affect test validity.

EIT utilises the electrical insulation properties of the waterproofing membrane and partial conductivity of both water and the substrate to which the membrane is applied. As decks such as metal and concrete are electrically earthed, it is possible to create a circuit to and from an electric generator via any breaks in the membrane surface. Electrically conductive membranes (such as EPDM or liquids with a high carbon black content) are not suitable for EIT testing.

RAWTA members adopt one of two test types, depending on membrane type and surface conditions at the time: low voltage wet and high voltage dry.

Note: variations in deck type, insulation, and waterproofing result in many combinations of warm roof constructions. For the purposes of this document, therefore, the principles discussed relate to cold roofs and structural concrete only.

3. Low Voltage Wet Test Method

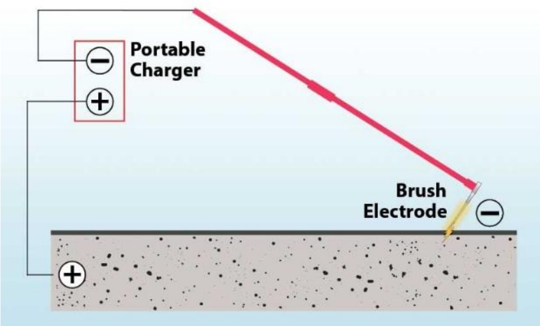


For this, a test area is set up by means of a loop of conductor wire. The enclosed section is thoroughly wetted, creating an electric “plate”, which is insulated from the deck by the membrane system. The conductor loop masks extraneous signals from outside the area and can be wound around any earthed items within it (such as outlets, plinths, etc.).

A purpose-made generator delivers electric pulses to the circuit formed by the electric “plate”. Current from any break in the waterproofing creates a directional electric field on the surface, from which it is possible to locate the source of any damage, penetration, puncture, or defect by reading a meter connected to the surface via hand-held probes. Where more than one breach is detected in a section, each can be isolated by means of the same looping system or dried out so that no conductivity remains. Voltages applied are low – of the order of 40 volts – so the test method is completely safe.

Because readings to one breach could mask others close by, it is necessary to repair a reasonably large section around each. A larger section around each repair should then be re-tested until no signals remain.

4. High Voltage Dry Test Method



This test, also known as a brush test or Holiday test, utilises a circuit of constant high voltage electricity, nominally in the thousands of volts, delivered from a battery-powered source via a copper brush (or wand for upstands or constricted areas). Where a break in the waterproofing system is encountered, electricity is discharged to earth (via the deck) and an audible alarm is sounded. At the same time, the voltage can be seen to drop considerably on the meter, all factors combining to confirm the breach.

Despite the high voltages, the current generated is extremely low, so it is considered safe. The method can only be used on membrane systems with a reasonably high dielectric strength*, the waterproofing manufacturer and/or OSTH can advise.

*Dielectric strength refers to the electrical strength of a material as an insulator. It is defined as the voltage per unit thickness that induces the material to conduct electricity. Dielectric strength is measured in volts per unit thickness (V/m).

5. Repairs

All breaches of the waterproofing indicated by the test should be repaired on the same day and be re-tested by the OSTH operative as appropriate.

If such repairs are not undertaken on the same day, the waterproofing contractor should ensure that such action is taken at a later date. Under such circumstances, the OSTH operative should clearly identify the location of the breach(es) both on the waterproofing layer surface and on their site plan. The OSTH should return to re-test when requested. Where such action is not possible, the waterproofing contractor and OSTH management should agree to the production of clear and concise photographic evidence of the repairs. Such evidence will be included in the final report and certification.

6. Reporting

Once testing on any one day is complete, the OSTH operative and the waterproofing contractor should agree the section tested. For this the operative should:

- Identify the test methodology used and include the test equipment calibration certificate.
- Clearly identify the boundaries of the test area by physical marking on the waterproofing layer.
- Photograph the section boundaries for reference purposes.
- Mark and photograph breaches detected but not repaired within the test area (s), with long and short views, for reference.
- Draw up the test area on an accurate site plan or, where none is available, prepare a sketch plan of the total roof area. This should also clearly identify the location of any breaches detected but not repaired.

A copy of the plan is to be included within the site report.

An up-to-date master copy of the site plan should be retained by both the waterproofing contractor and the OSTH. Ideally, the waterproofing contractor should hold an up-to-date plan on site, to be updated after each test. Therefore, there will be no dispute regarding the untested sections upon completion.

7. Multiple sections

Where multiple adjacent sections are to be tested over a period of time, the waterproofing contractor should restrict:

1. access by other trades to the tested roof area to reduce the risk of post-test damage.
2. application of finishes to a margin of a minimum 1 metre from the marked-up boundary line to any untested sections. By identifying the boundary lines, the OSTH operative on subsequent tests should include a minimum margin of 0.5 metres onto the previously tested section, thereby ensuring continuity of test.

The waterproofing contractor and the OSTH should agree on the certification of areas, so that that multiple tests can be incorporated into a single document.

8. Handover

Where the roof is being handed over to a third party contractor, such as a green roof, blue roof, solar, or landscape contractor, a suitable handover document and handover timescale should be agreed between all parties.

9. Specific Waterproofing Guidance for Waterproofing Membrane Type

The OSTH should recommend an appropriate test method based on the roof area, waterproofing membrane, and weather conditions. They should consult the membrane manufacturer to confirm the chosen test is suitable, especially considering factors like carbon content or other compounds that may affect the waterproofing membrane’s electrical properties.

Hot Melt Waterproofing

Either test method is suitable, depending on the particular circumstances at the time of the test. If high voltage testing is not practical, such as during wet weather, perform a low voltage test using detergent in the surface water to ensure a continuous film throughout the test.

Testing is conducted on the Access/Protection Sheet installed over the Hot Melt material due to the adhesive nature of the raw Hot Melt which cannot be accessed by foot.

Where the Access/Protection Sheet is adhered directly onto the Hot Melt surface whilst it is still hot, air pockets can be formed between the two layers. Whilst this does not affect the waterproofing capability of the system, it could potentially mask punctures in the Hot Melt unless the air pockets in the Access/Protection Sheet are punctured and resealed. The OSTH operative should identify these locations if found.

Liquid Applied Membranes (LAM)

These are tested once the membrane has cured sufficiently to allow access to the surface without damage. Application to concrete can result in outgassing, due to evaporating moisture under pressure, which can lead to pinholes developing prior to full cure. Where there are multiple pinholes, each would generate its own electric field on a wet surface. They would then be difficult to isolate for each subsequent pinhole. High voltage testing is thus the preferred method in this case. The voltage should be carefully set allowing for the thickness of the liquid applied membrane.

Where high voltage testing is not practical – e.g. in wet weather – a low voltage test with the addition of detergent to the surface water is required to produce a continuous film across the surface and maintain that condition throughout the test.

LAM applied to aluminium faced carrier membranes provide a suitable substrate for either test method.

Note: carbon black is sometimes used as a filler or colourant in membrane formulations but, as this is also electrically conductive, it can reduce the dielectric strength to a point where it renders the membrane unresponsive to test.

For Liquid Overlay to Existing Waterproofing Systems

For overlay situations of other existing substrates before the application of liquid systems, the substrate can be tested with the following:

- **Reinforced Bitumen Membranes (RBM)**
  Due to the wide laps in RBM they should be subjected to exposure to water prior to test. This could be from a period of rainfall but, failing that, hosing the area with water containing sufficient detergent to produce a continuous film across the surface and maintain that condition throughout the test will be necessary for the low voltage test. For a Dry test, allow the surface to dry out thoroughly before testing.
  Where deemed necessary, laps can also be probed with a specialist blunt-end tool to ensure full adhesion and watertightness throughout.

- **Single Ply Membrane (SPM)**
  Most single ply membranes lend themselves very well to high voltage testing but the laps should be subjected to exposure to water prior to test, either by rainfall or hosing. The membrane should be allowed to dry out thoroughly prior to test. Membranes with high carbon content, such as EPDM are not suitable.
  Alternatively, they may be wet-tested by the low-voltage method. For this, the surface should be thoroughly wetted out with detergent-based water (sufficient to produce a continuous film across the surface) and maintained in that condition throughout test.

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