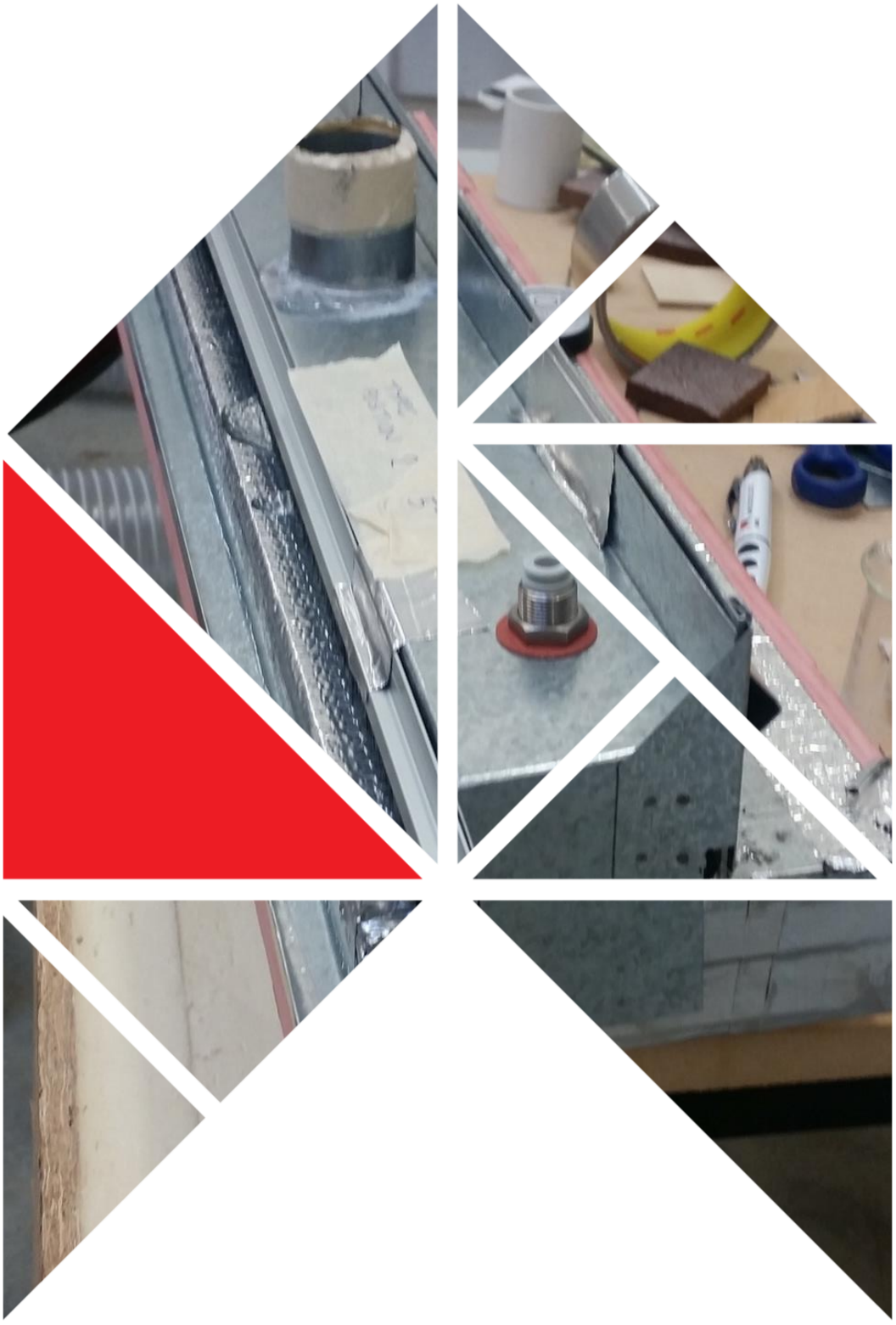
Evaluation Method

BRANZ EM9 [version 1, May 2021]

Window installation – an evaluation method for weathertightness assessment of the window to wall junction

John Burgess and Roman Jaques



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Preface

This evaluation method (EM9) provides a test for the management of inadvertent water ingress around the perimeter of an external window (or glazed door) installed into the structure of a wall, using typical residential techniques. It provides a specific weathertightness performance test for window installations to add robustness to the existing E2/VM1 test. The method is applicable to windows that may be recessed into direct-fixed or cavity cladding systems since the focus is on the location of the air-seal around the window, not just the cladding to window joint. This evaluation method can be applied to aluminium, uPVC, timber or steel-framed, extruded, profiled or pultruded window and door framing systems in exterior claddings of domestic-oriented buildings.

An associated evaluation method (EM8), which assesses the thermal performance of a window installation using a standardised method for the window sill, should be read in conjunction with this document. The two evaluation methods were produced to provide more certainty around two critical aspects of higher-performing windows.

Acknowledgements

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BRANZ Evaluation Method EM9 (version 1)

Authors

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Reference

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Abstract

Recognising that recessing windows into the structure of low-rise and mid-rise buildings is risky, this document describes a test method (EM9) to provide greater security around the weathertightness of alternative window installation systems.

Whereas E2/VM1 and E2/VM2 are methods for verifying the water management performance of cladding systems, which may include windows, this method focuses on the water management within the window installation to add robustness to the Verification Methods. EM9 introduces defects into the window frame and quantifies how water drains from these defects. It recognises the increasing use of window installation methods and defines a simple means to add robustness into the weathertight design of the junction between the window and the structure.

Together with NZS 4211:2008 *Specification for performance of windows* and the thermal evaluation method provided in EM8 this provides a method to ensure a window installation is both weathertight and thermally efficient.

Keywords

Water leakage, EM9, evaluation method, windows, E2/VM1, E2/VM2, window to wall junction, window installation, E2, weatherproof, EM8.

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1. Background

The assessment of weathertightness of claddings on domestic-oriented buildings in New Zealand has been developing over many years, driven by responses to weathertightness concerns or advances in construction, cladding or window technologies. This led to methods for testing the performance of claddings, including tests such as AS/NZS 4284:2008 *Testing of building facades*, which focused on commercial cladding systems, and NZS 4211:2008 *Specification for performance of windows*, which focused on the performance of domestic-oriented windows.

With the development in 1992 of a performance-based New Zealand Building Code (NZBC), new methods seeking to integrate windows and claddings were developed including E2/VM1[1] (for low-rise construction) and E2/VM2[2] (for mid-rise construction). These approaches addressed weathertightness and some aspects of the integration of cladding with windows but were not concerned with thermal performance.

Within Europe, windows (and their installation) are expected to have high levels of thermal performance, with weathertightness being of less concern. Windows are often fully recessed into claddings and structure of masonry or stone, and the junction around their outer frame (the trim cavity) is often filled with insulating materials. Construction methods, industry practice and environmental factors in New Zealand are different, so we cannot necessarily simply apply installation methods from other jurisdictions. In fact, due to high levels of concern around weathertightness in our different construction environment, recessing windows to be more in-line with the thermal envelope in low- and mid-rise construction in New Zealand has been discouraged as it is perceived as risky. This has resulted in the installed thermal performance of windows often being less than ideal.

However, there are ways that weathertightness and thermal performance can both be achieved within a window installation. EM8 and EM9 were developed at BRANZ to provide a more robust assessment of the weathertightness of window to wall joints and also to ensure that thermal performance (NZBC clause H1 *Energy efficiency*) could be addressed in a coherent manner. EM8 is described in a separate document.

1.1 NZS 4211:2008, E2/VM1 and E2/VM2

NZS 4211:2008 is concerned only with some performance aspects of window systems, (not their junctions to the cladding) and includes an assessment of weathertightness of the window portions inside the outer window frame. Drainage paths to remove water from within the window system are assessed, but the exit points of these drainage paths are not necessarily relevant to compliance with the standard.

The E2/VM1 and E2/VM2 tests were developed from experience with AS/NZS 4284:2008 in New Zealand. They both assess the management of drainage water and include the introduction of defects within the cladding system intended to assess the

[1] https://www.building.govt.nz/assets/Uploads/building-code-compliance/e-moisture/e2-external-moisture/asvm/e2-external-moisture-3rd-edition-amendment-10.pdf
[2] https://www.building.govt.nz/assets/Uploads/building-code-compliance/e-moisture/e2-external-moisture/asvm/e2-external-moisture-vm2-1st-edition.pdf

ability of the cladding cavity to manage inadvertent water ingress.[3] E2/VM1 requires defects above the head and within the jamb and expects this water to be managed within the cladding and window system. However, experience with this test has shown that these defects do not always stress the window to wall junction as intended and may encourage designs incorporating poor thermal performance.

This evaluation method extends the test for the management of water available in E2/VM1 and E2/VM2 to focus on the management of inadvertent water ingress that leaks into and around a window installation system and hence has different pass/fail requirements.

1.2 EM9

EM9 is intended to follow on from the end of an E2/VM1 or E2/VM2 test on a cavity-based system and has a different compliance assessment since it is concerned with the management of inadvertent water ingress, not designed drainage water paths.

Whereas E2/VM1 does not allow water to be found at the line of the housewrap/rigid sheathing/air barrier, EM9 accepts some inadvertent water ingress may result in water at this point. As with the existing philosophy of NZBC clause E2 *External moisture*, no water is expected in this test to drain behind the cladding when the cladding is direct fixed. (There remains no weathertightness test for direct-fixed cladding systems, partly since they rely upon workmanship and may have no tolerance for defects.)

In E2/VM1, where there is a drainage cavity behind the cladding, drainage water during the test must be directed to the line of the cladding and is not allowed to drip in the cavity. Within EM9, the purposely introduced water may be on either side of the cavity or potentially drip within the cavity. In EM9, inadvertent water ingress in both cavity and non-cavity is only expected to contact durable non-absorbent materials of low permeability, such as those that are compliant with ICBO AC148 *Acceptance criteria for flexible flashing materials*.

EM9 is applicable to the following:

- Windows and glazing with any type of profiled frame,[4] expecting the window has a system to restrict inadvertent water ingress from contacting moisture-sensitive materials within any of its cavities, paths, pockets or spaces.
- Windows in many types of cladding and structure, provided there is a designed interface with the structure. It is based on the premise that any inadvertent water ingress entering into either the window system or the joint between the window and the structure is able to drain to the sill where it can drain to the outside or be safely evaporated away. It is assumed that the structure will be adversely affected by water such that water that can access the structure is minimised or eliminated.
- Windows that are projected out from the face of the cladding or structure, aligned with the face of the cladding or structure or recessed into the structure, expecting there is provision to direct any drainage water to the plane of the wet-wall.

[3] Water that inadvertently passes through a window system or installation through an unintended entry point. Examples include leaking corner mitre joints, poorly installed head flashings and partially open jamb or sill-window joints. Draining this water may include water moving in the cladding cavity.

[4] The use of this test for timber-framed window systems (or windows with solid or absorbent framing) has not yet been examined.

EM9 allows users to isolate the window installation method and develop solutions that assist with the management of inadvertent water ingress in the window trim cavity and cladding junction at the sill. EM8 is then able to assess the thermal performance of this window-wall junction in detail.

1.2.1 Intent of the EM9 test

The intent of this test is that water is purposefully introduced through a defect in the sill of an outer window frame and that this inadvertent water ingress is acceptably managed. The outer frame could be glazed or could hold a fixed or moving sash. The idea is to simulate inadvertent water ingress in the sill trim cavity and assess its management. This inadvertent water may originate from any or all the following places:

- Window outer frame corner joints, which are often mitred, or may be welded, sealed, use moulded external (or internal) corner soakers or otherwise treated to reduce leakage of inadvertent water ingress onto the sill trimmer, floor slab or structural materials below the sill (sill trimmer area).
- Defects in the connection between any thermal break and the metal of aluminium-based window framing where inadvertent water ingress may inadvertently drop onto the sill trimmer area.
- Defects in the connection between any composite window frame profiles or inappropriate filling of window frame cavities.
- Inadequately sealed mullion screws or other connections that penetrate the outer window frame sill profile and allow inadvertent water ingress to leak from the outer frame down to the sill trimmer area.
- Water draining from a window system behind the cladding line (but not necessarily water than has already penetrated to inside the glazing line).
- Water penetrating into the window trim cavity from joints at the window head to cladding joint, the window jamb to cladding joint or the window sill to sill tray or cladding joints.

This inadvertent water could subsequently track down the window framing, drip within the trim cavity, track down the materials used to create the rough opening or track down the back of the cladding, hardware, through the cladding cavity or battens to the sill trimmer area.

This method allows users to isolate the window installation method and develop solutions that assist with the management of inadvertent water ingress within the trim cavity at the sill trimmer area. This adds considerable confidence to the design of window installations (particularly for recessed windows in cavity-based cladding) going beyond the requirements of E2/VM1, which may not adequately assess weathertightness of the window installation.

2. Aim of the evaluation method

The aim of this evaluation method is to determine whether a window installation method adequately drains water from around the windows away from the structure. The window may or may not include corner soakers or other elements expected within E2/AS1 and allows the removal of water that has inadvertently leaked into the window frame.

The wider aim of this test is to:

- provide more certainty for the building and related industries on window installation weathertightness performance
- allow the direct comparison of window installation practices for the purposes of installation method development
- provide an alternative to the prescriptive window installation requirements of E2/AS1
- be added to the end of E2/VM1 and E2/VM2 so that specific performance is demanded of the window installation method, rather than the more generic assessment currently provided in E2/VM1 and E2/VM2
- encourage the development of more thermally efficient window installation systems.

This evaluation method assumes that water entering the head, jamb or sill of the window (within the window framing or in the trim cavity) drains by gravity to the sill, where it is managed.

3. Test requirements and preparation

3.1 Requirements

Equipment required for the test comprises:

- calibrated scale with 0.1 g accuracy
- funnel and/or tubing to allow accurate introduction of the water
- paper towels to be weighed before and after mopping up water
- catch channel and fixings
- beaker or vessel for weighing water
- bucket for catching drained water.

This test does not require the use of a test rig capable of performing E2/AS1 or E2/AS2 tests, since it does not require air pressure differences or water sprays, but is expected to follow on from E2/VM1 or E2/VM2 tests. It is also expected that this test will be undertaken by personnel who are familiar with E2/AS1 or E2/AS2 testing and are IANZ accredited to undertake these tests, since it requires calibrated equipment and to be undertaken under a procedures manual and quality system.

3.2 Preparation for test

1. Follow any sample preparation guidelines of E2/VM1 or E2/VM2 regarding the window and installation (Figure 1).

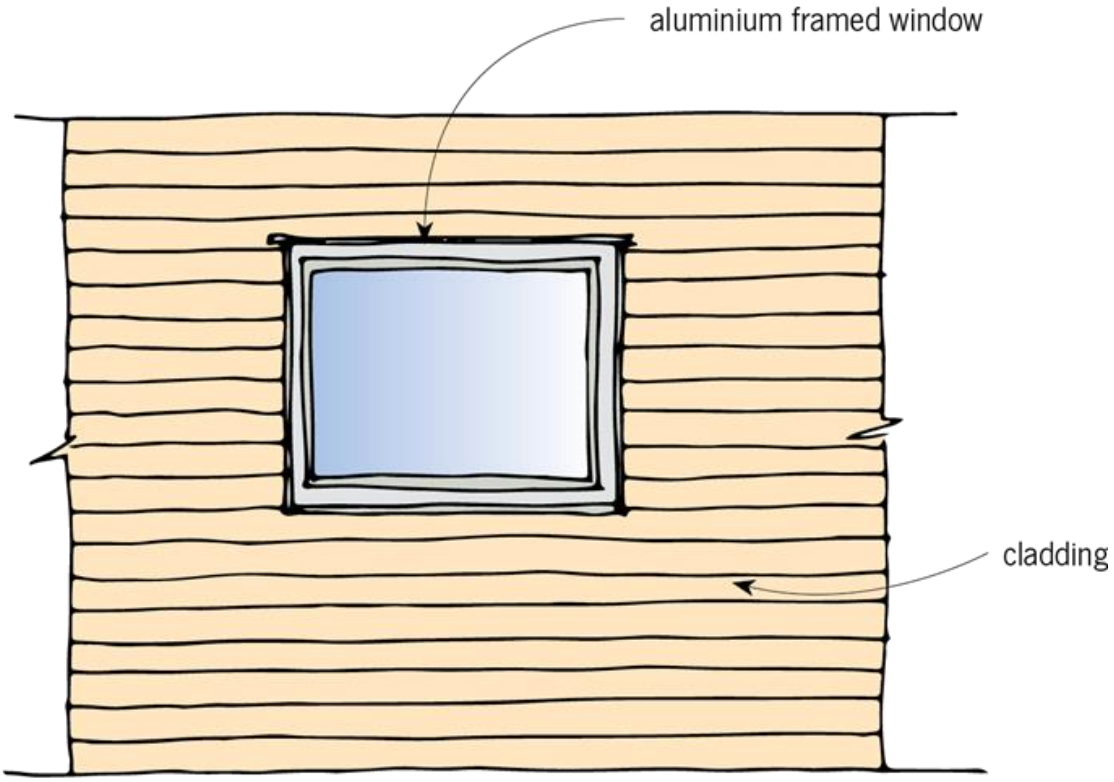


Figure 1. Window installed in a test panel for E2/VM1.

2. At the completion of testing to E2/VM1 or E2/VM2 tests (or prior to testing a new sample or non-cavity-based sample), undertake the following steps. (Note that steps 3–23 need not all be undertaken in numerical order.)

Preparation of opening

3. Cavity and non-cavity based windows:
   a. For a cavity-based system, remove window, cladding and battens around the window(s) to be assessed but retain the housewrap or rigid wall underlay if present (Figure 2).

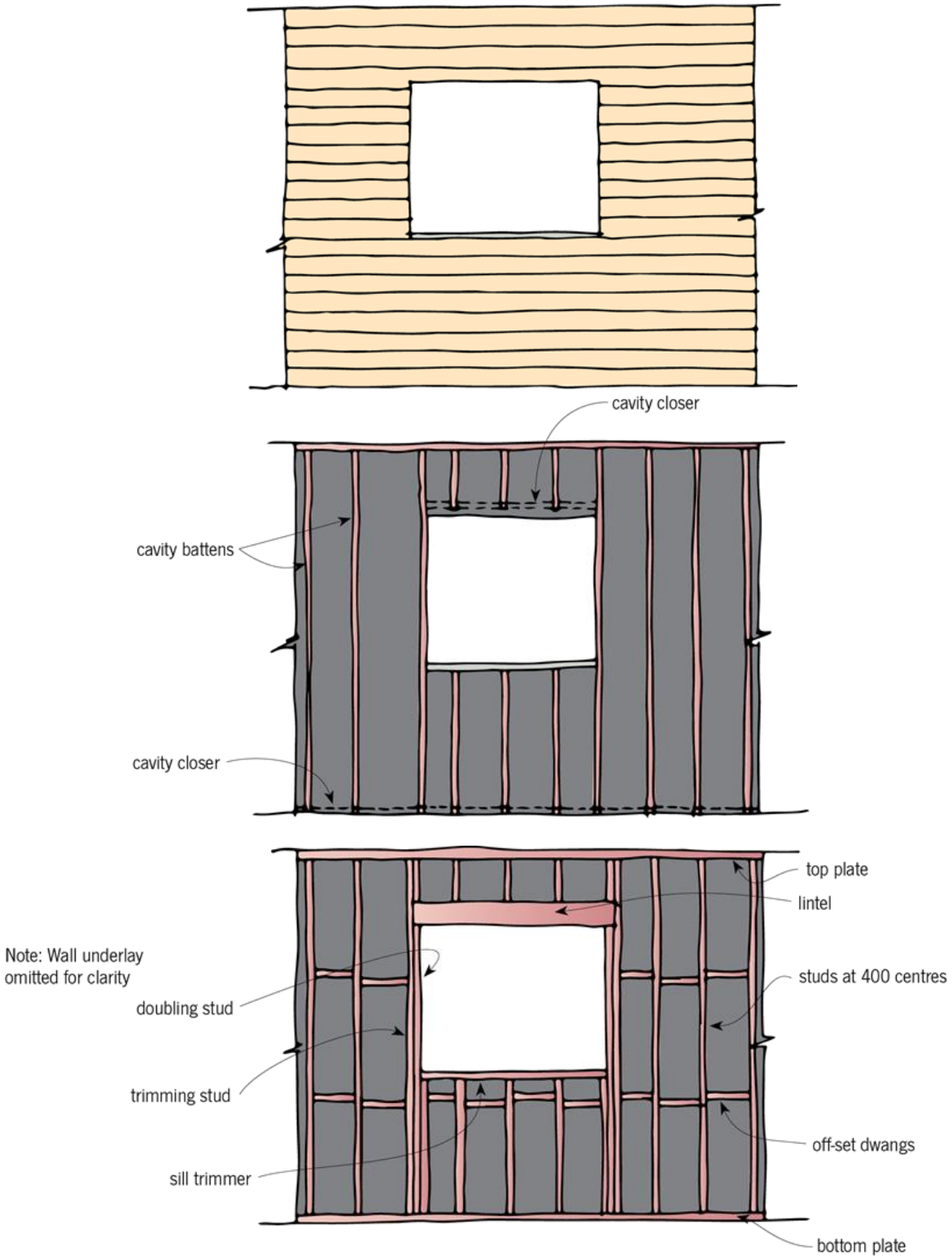


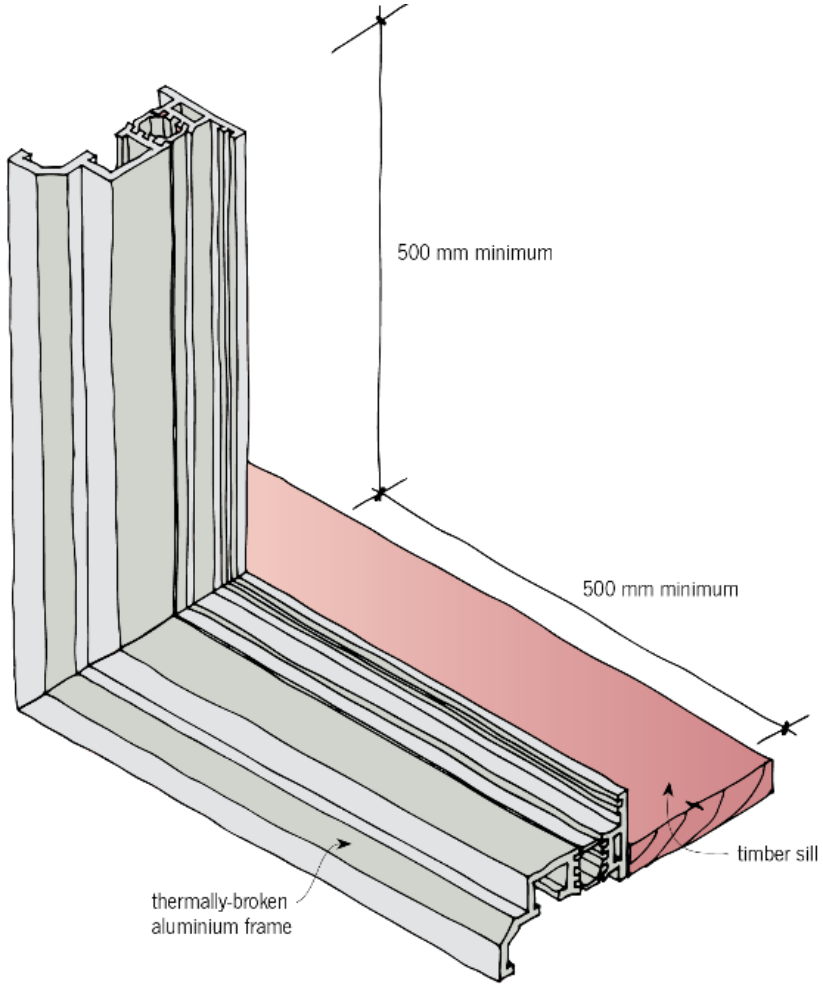
Figure 2. Window, cladding and battens removed, leaving bare framing

b. For a direct-fixed cladding system, remove the window and cladding, retaining the housewrap or rigid wall underlay.

4. Remove any glazing, sashes or panels from within the outer window frame of any window(s) being assessed (i.e. deglaze the frames).
5. Remove the window(s) from the opening.
6. Remove any seismic or subframing that sits below or around the window.
7. Ensure that the window and surrounding materials are dry.
8. Remove any installation materials (sealants, foams, packers, spacers, flashings, soakers) and water management systems from the rough opening and window frame, leaving only housewrap and adhered flashing tapes if they are present. If waterproofing materials are damaged, they shall be replaced or made good.

Preparation of window section

9. Prepare the window outer frame sufficiently such that it can be cut safely without endangering health and safety.
10. Cut the outer frame to obtain a section of sill that is at least 500 mm long and connected to a section of jamb that is at least 500 mm long (Figure 3). If a mullion to sill joint is to be tested, the sill must include a section 250 mm long on each side of the mullion connection with at least 100 mm of mullion height. Where there are multiple locations for testing, multiple sections of frame may be required, particularly if there are different provisions made to capture inadvertent water ingress from different locations (such as tracks) within the window and tests are performed independently.



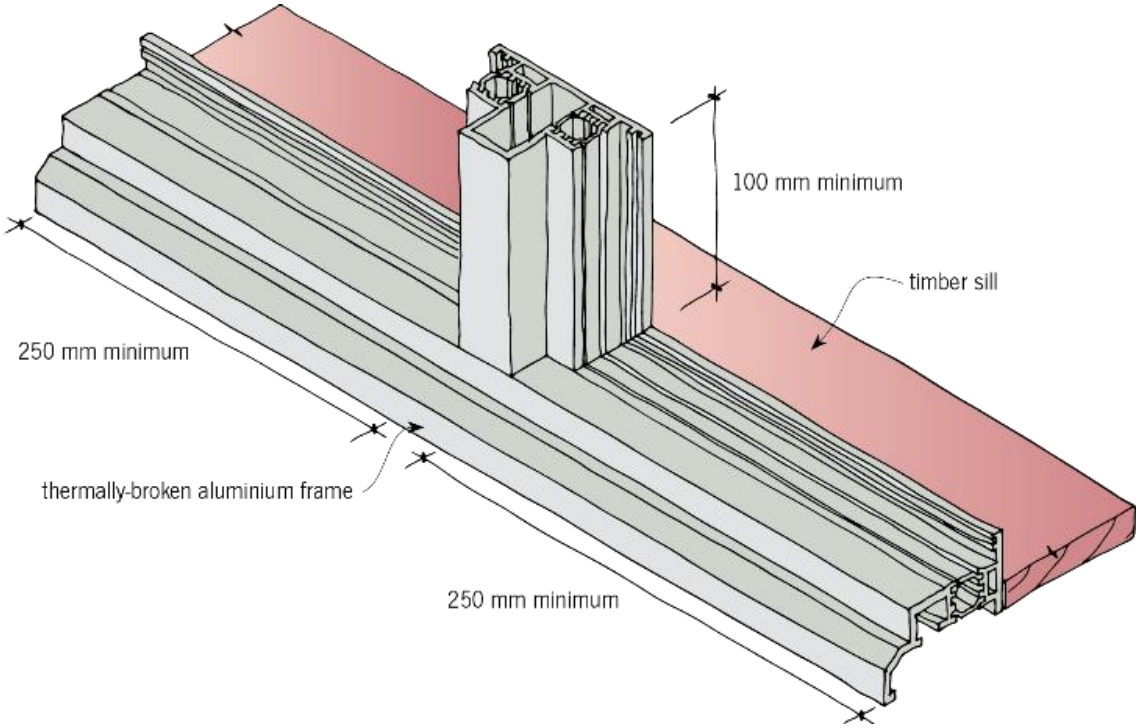


Figure 3. Window deglazed and 500 x 500 mm corner cut out.

11. Identify the location (transition point) that is closest to the inside where water may feasibly be within the window sill extrusion. This will often be the furthest inside point of the glazing pocket. All locations outside (and below) of this transition point could conceivably be wetted by a failure in the weatherproofing of the extrusion, and all locations inside the transition point/line are expected to be kept dry.

Reformation of window opening

12. Reinstall any necessary water management materials and systems on the wet side of the transition line. It is normally not necessary to reinstall any materials on the dry side of the transition line unless they are necessary for structural support.[5]
13. Where a window installation system (not the window itself) uses wet-applied sealants to fill gaps (other than sealant specified within designed joints) these **shall not be installed**.[6] Omitting these means that the worst case of installation is tested.

Formation of wetting point(s)

14. Drill a hole at the transition point (as close to perpendicular as possible) through any layers of the outer frame sill section as close as possible to the jamb of the window outer frame.[7] The hole diameter shall be large enough (for example, 10 mm) to allow the funnel to penetrate through all layers/cavities of the profiled frame section to introduce water as if it was dripping from the bottom of the frame. This may require the removal of part of the backing rubber. The hole (and funnel)

[5] Since there is no air pressure to be held, air sealing materials do not need to be restored, provided they do not impact upon the movement of water under gravity and surface tension.
[6] The test must assume wet-applied sealants intended to be a critical part of weathertightness that are used as gap fillers or glues are compromised due to poor workmanship.
[7] It is expected that the diameter of the chuck of a drill may mean this distance is 50 mm.

shall allow water from the outer frame to drop through the sill system towards the sill trimmer area and is intended to simulate inadvertent water ingress from both the outer frame and from within the jamb trim cavity. The location of the hole is intended to be in the most likely location for a defect in the frame (corner mitres) to exist and also be close to the jamb where water may be draining (see Figure 4). If there are multiple potential failure locations, form other holes similarly. The holes shall not penetrate the sill trimmer nor any material layers or installation elements in the sill trimmer area that are intended to deal with inadvertent water ingress such as sill trays or soakers.

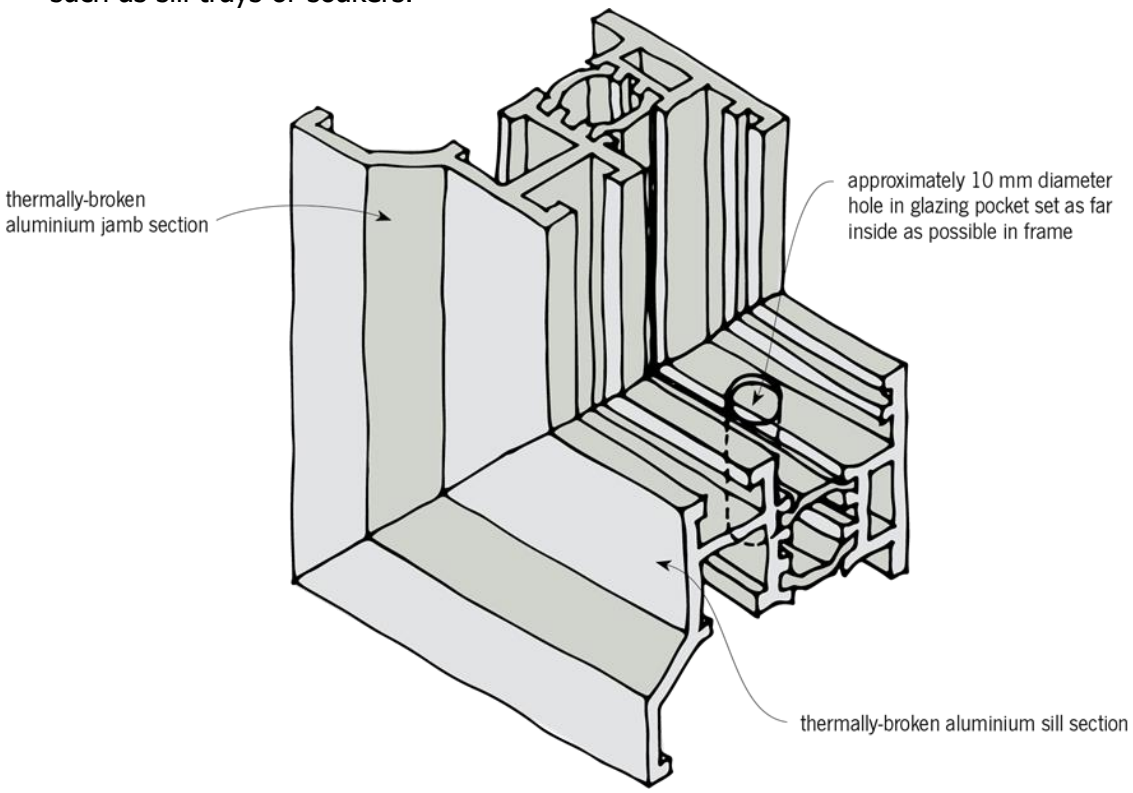


Figure 4. Indicative location of 10 mm hole through furthest inside point of outer frame.

Reinstallation of window section

15. Reinstall the section of outer window frame as it would normally be installed, ideally with the same structural fixings, sufficient to prevent the window section being dislodged during the following activities (Figure 5).
16. Prepare a catch channel to intercept inadvertent water ingress that is drained from the window. A suitable catch channel may be formed from an aluminium channel 50 mm wide x 20 mm deep with a 1.0 mm wall thickness longer than the length of the sill section. Its ends shall be stopped or taped to allow the capture of the water from the system under test.
17. Mount the catch channel across the full width of the sill section below the bottom of the window and any installation components or drainage mechanisms but otherwise as close (vertically) to the window as possible (Figure 6). The channel must not interfere with any drainage mechanisms of the window installation method and can be used for direct-fixed and cavity-clad walls.[8]

[8] It can be useful to mount the channel on an angle, running into a watertight container that can be weighed before and after to determine the weight of captured water.

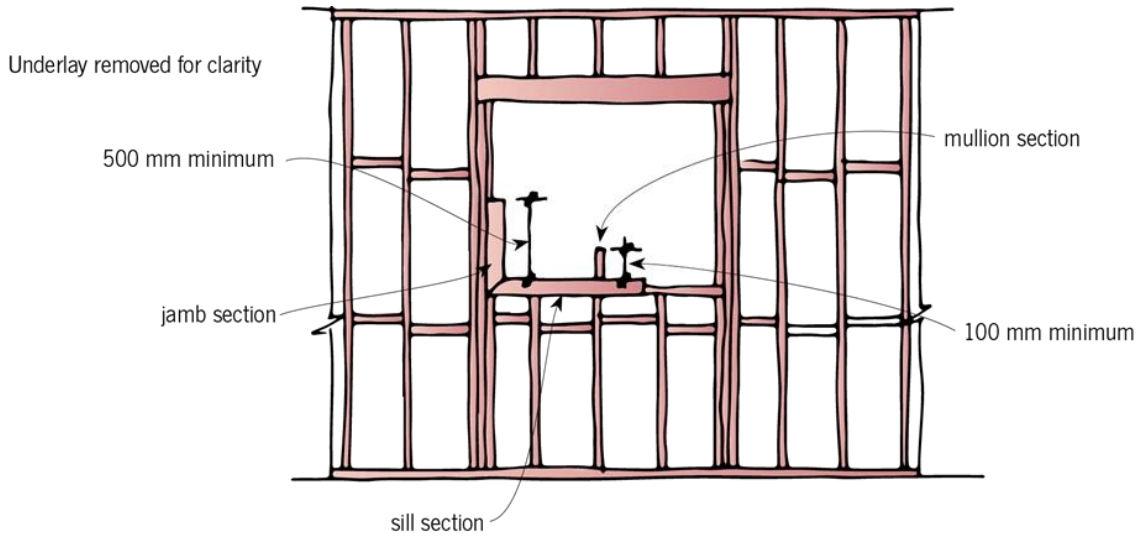


Figure 5. Corner section of window frame reinstalled into rough opening.

18. Tape across the top of the catch channel or slice the tape/wrap to insert the channel under the wrap and ensure that all water enters the channel.

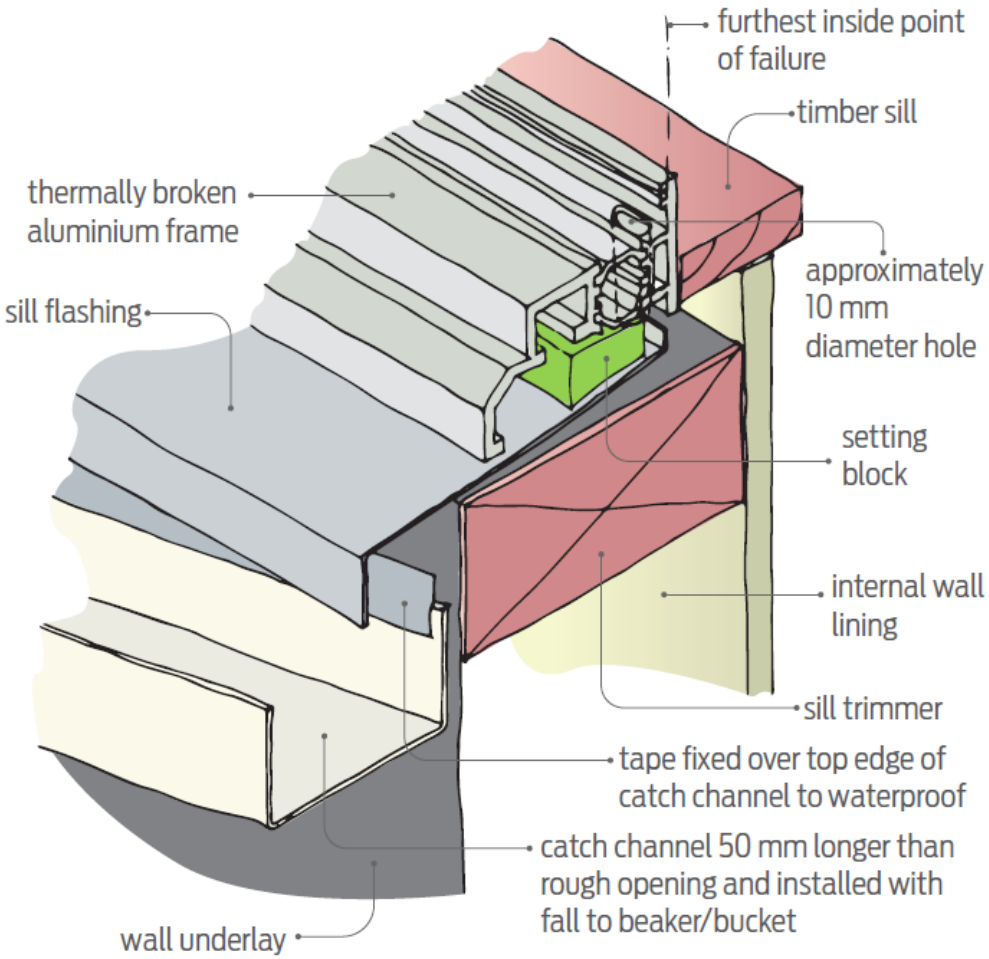


Figure 6. Generic layout of test with channel either over direct-fixed cladding or at the line of the house wrap for cavity-based cladding.

19. Prepare a funnel (or other device) with an outlet hole of 5 ± 1 mm internal diameter to deliver 100 g of water through the wetting point(s) (Figure 4). This funnel may be used multiple times but should never be filled with more than 100 g of water to prevent flow under pressure.
20. As for the water management tests in E2/VM1 and E2/VM2, the intent is to force leakage to occur through an area that may leak since it has a joint. The window installation system is then expected to manage this inadvertent water ingress by one of the following mechanisms:
    a. Drainage into the cavity. Note that, since this is inadvertent water ingress, it can drain down the wet or dry side of the cavity. It is not a designed drainage path but is a path allowed for removal of inadvertent water ingress. If this water drains across materials that are sensitive to moisture, they must be non-absorptive, impermeable and durable to the extent required by NZBC clause B2 *Durability*. (This may be 5, 15 or 50 years, and the ICBO AC148 test may be used to confirm this.) Drainage of water from inadvertent ingress may be temporarily delayed within the system. This is acceptable provided there is a path for this water to escape under gravity and the water cannot permeate or absorb into non-durable materials. It is expected that this water will drain and evaporate away over time.
    b. Drainage to the outside of the cladding – see Figure 7 for a typical implementation.

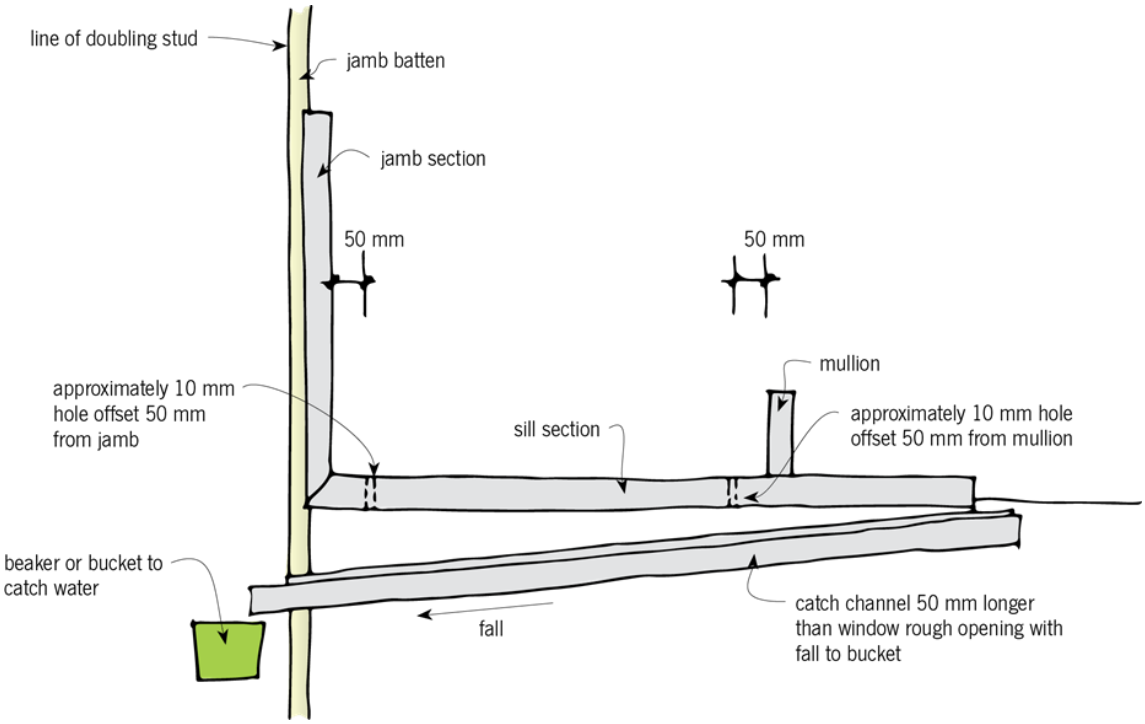


Figure 7. Elevation of window test set-up.

21. Confirm that the outer frame of the window sill remains flat and level within ±3°.
22. Prepare the water measurement equipment, which may include the following:
    a. Paper towels within a watertight sealable plastic bag that is weighed before and after testing to determine the amount of water caught. It is appropriate to assume that 1 ml of water weighs 1 gram.
    b. Latex gloves to prevent water being absorbed into operator's hands as water is collected with the paper towels.

c. Containers used to capture water, which may be weighed before and after capturing the water to determine the amount of water caught.
d. Burettes, funnels, tubes as necessary to allow the introduction and collection of measured amounts of water, which may also be weighed.

23. Prepare the test result recording system, which needs to separately record water found in the four different areas and the identity of materials that are involved. Remove any water, dust, swarf or loose debris from the sill trimmer area and window installation elements and ensure that any necessary sealants or other wet-applied materials are sufficiently cured by wiping with a paper towel or soft cloth.

4. Testing of the sample

1. Using the funnel (or similar device) and within 1 minute, slowly introduce 100 g of clean water through the hole in the sill. This is W_{i1}, the introduced water at point 1. If necessary, repeat the process at other locations, numbering as applicable.
2. Observe the test for 10 minutes and identify where any water moves in this time and any materials it contacts. Do not disturb the sample during this time.
3. Measure and remove any of the water that has drained into the catch channel. This is W_d, the drained water. Record the materials that W_d has been in contact with.
4. Remove the window section and identify the location of water as either W_s, W_d, W_f or W_c as appropriate (Figure 8).

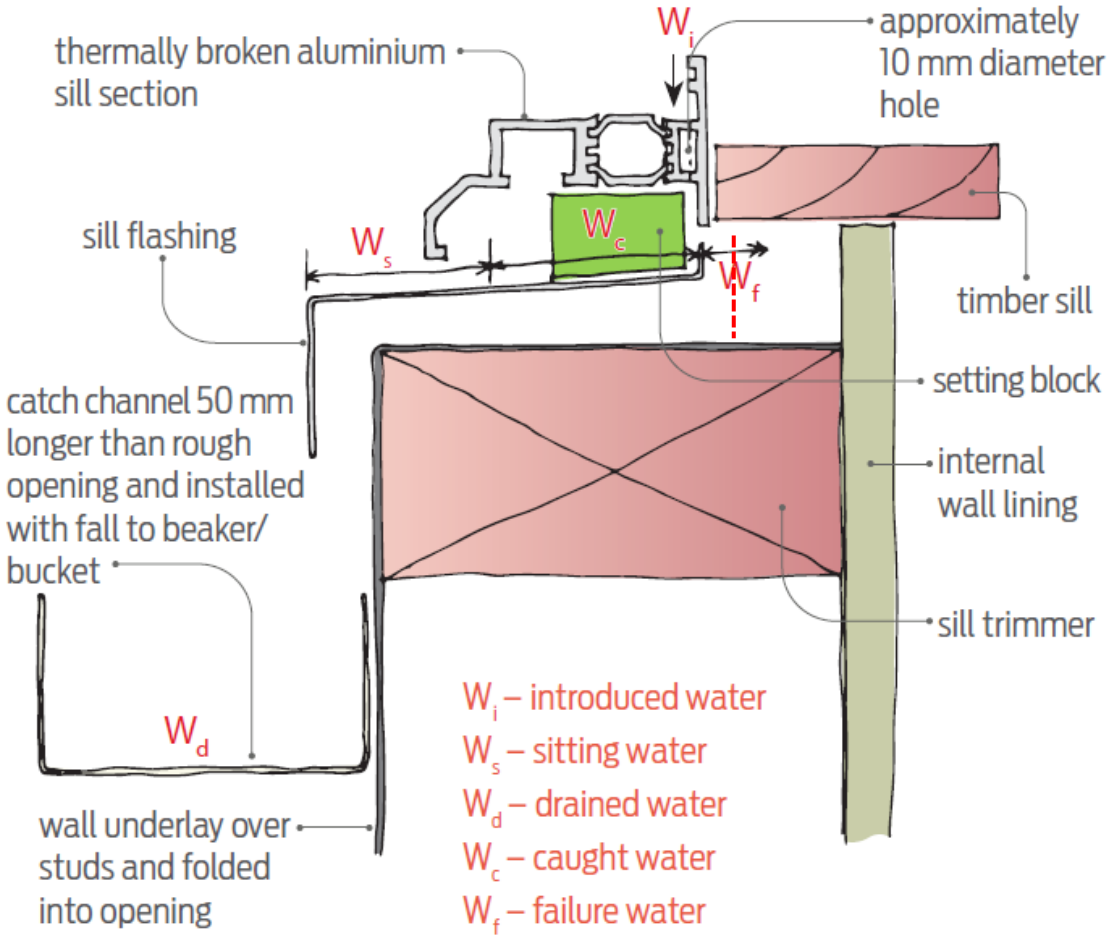


Figure 8. Location of water measurement points W_i, W_d, W_f, W_c and W_s.

5. Identify any water that has passed inwards, beyond or through any water management systems over the wet/dry transition line/plane. This is W_f, the failure water, which causes an immediate fail of the test. (It is shown with the red dotted line in Figure 8.)
6. Remove and measure any water that remains sitting on the sill trimmer, within the installation area and in any other areas where water could drain into the catch channel. This is W_s, the sitting water. Record the materials that W_s is in contact with.

7. Remove and measure any water from other areas of the sill and associated installation elements where water is trapped and cannot drain into the channel and would need to be evaporated away. This is W_c, the caught water, which may be held in screw ports, T-slots or other cavities. Record the materials that W_c is in contact with or could be in contact with.

It is expected that water relevant to steps 3–7 is captured within about 5 minutes and measured promptly, the room air temperature is between 5°C and 25°C and the room relative humidity is between 50% and 95%.

Note: While measurement of any failure water W_f, and drained water W_d, is important, it may not be necessary to separate W_c and W_s except in development testing.

5. Compliance

5.1 Compliance checks

Undertake the following checks.

Check 1: Durability

Confirm whether any materials that have been in contact with water (W_d, W_s or W_c)[9] are durable in this situation to the extent required within NZBC clause B2. This is normally provided by a statement from the supplier of the window installation system.

Check 2: Absorptance and moisture transfer

Confirm whether any materials that have been in contact with water (W_d, W_s or W_c)[10] are able to absorb and transfer water to other materials whose durability may be compromised if wetted. This is normally provided by a statement from the supplier of the window installation system.

Check 3: Water locations

Calculate W_i – the total amount of introduced water – expected to be multiples of 100 grams (or 100 ml).

5.2 Compliance criteria

The installation method is compliant with the test requirements if:

- $W_d + W_s + W_c \geq 0.95\ W_i$[11]
- $W_d \geq 0.05\ W_i$[12]
- materials in contact with W_d, W_s or W_c are sufficiently durable (i.e. they comply with B2 or ICBO AC148) and are unable to transfer water to non-durable materials[13]
- water does not enter behind any direct-fixed cladding[14]
- $W_f = 0$.[15]

If the above points are not met, the installation method is non-compliant with the test requirements.

[9] Or would have been in contact with water if they were unnecessary and have not been reinstated after step 11.
[10] Or would have been in contact with water if they were unnecessary and have not been reinstated after step 11.
[11] The drained water plus the sitting water plus the caught water is more than 95% of the introduced water – i.e. less than 5% of the water introduced has been absorbed into other materials, evaporated or lost.
[12] More than 5% of the water has drained into the catch tray – indicating that drainage is possible.
[13] Material durability and/or absorptance and vapour resistance assessments are necessary. Typically the supplier of the window installation system will supply statements confirming this information.
[14] Undertaken by observation and accounting for water.
[15] No water has been observed to escape past the transition point towards the inside or other locations that are expected to remain dry.

To complete this evaluation method test, it is suggested that detailed installation instructions should accompany the window systems. This provides an easy way for educating installers and ensures the necessary process is being followed consistently. Where the in situ installation is not being carried out by the window manufacturing company, a clear and comprehensive set of instructions should be provided to the installer to follow.

5.3 Retesting

In the event that:

- the results of the test are inconclusive
- it is unclear whether water could contact other materials (see 5.1)
- more than 5% of the introduced water has been lost
- there are other reasons for uncertainty about results

the test shall be repeated twice to obtain three independent sets of results. The system shall be thoroughly dried[16] between tests to prevent the establishment of preferential water paths.

The quantities of water from each source shall be averaged across the three tests and an assessment of compliant, non-compliant or inconclusive made. Any water in any of the tests that is identified as W_f causes an immediate fail.

[16] It is expected that drying of non-absorbent surfaces can be performed with compressed air and paper towels. However, drying absorbent materials or cavities in non-absorbent materials may require their replacement, or, alternative drying processes.

6. Reporting

The test report recording the results of this EM9 assessment may be appended to the report from any preceding E2/VM1 or E2/VM2 tests. In addition to the requirements for the relevant tests above, the test report shall include the following:

- Summary of test result being "compliant", "non-compliant" or "inconclusive – pending material property results".
- Drawings of the as-built window installation method.
- Location of the catch channel.
- Number of simulated water entry locations.
- Number of test iterations.
- Temperature and humidity of air in the vicinity of the test rig.
- The information in the following table.

Weight of water introduced at location/iteration	**Weight of water captured**				**Materials in contact with water at W_d, W_s or W_c**	**Acceptability of material in this location**
	W_d	W_s	W_c	W_f		