Field Determination of Water Penetration of Windows using Blowerdoor and Infrared Camera

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ABSTRACT

The manufactures tests of windows in Europe are executed in accordance with the CE-directive. Air- and water tightness testing are performed in accordance with EN 1026 and classified in accordance with EN12207. Air- and water leakage measurements are performed under laboratory conditions using a test chamber and accurately air- and water flow and pressure difference. This type of test has the advantage that large numbers of samples can be examined under similar conditions eliminating effects of climatic factors.

On site many cases of water leakage in newly installed and sealed windows are observed. Investigations are therefore set out by contractors to detect where the leakages are and why they occur. The crofters test method often consists of a garden hose or garden fan for spraying water to smaller parts of the surface of the window in question and to adjacent joints primarily for a visual evaluation of where the water penetrates the construction. As this test often is used with none or very little pressure difference the method is not sufficient to detect all leakages under different conditions. Specialized consultants and further testing are therefore called for.

The testing of air leakage of windows on site can be evaluated by fan technique, infrared camera or using ultra sound. The testing of water leakages of windows on site is however more difficult and standards for this type of testing is lacking.

Due to the quality of workmanship, installation technique and the transportation of components, the situation on site differ significantly from the laboratory based situation at the manufacturer and comparison of test results are therefore often out of proportion.

This paper presents three cases of water- and air leakage in windows. In all cases a simple test method using a blowerdoor, an in situ placed pipe providing a water film, some cardboard, a digital camera and an infrared camera has proven successful.

INTRODUCTION

The exterior enclosure of buildings, especially windows must resist weather conditions, withstand wind, rain, snow, ice, hail, surface water, damp subsoil, humidity and exterior temperature extremes. Water penetration can be problematic if moisture levels exceed the planned resistance. Problems associated with leakages (air or water) are therefore likely to compromise overall building performance and adversely affect the performance of other components.

Newly installed facades, windows and doors do not only depend of the quality of the window, but also the quality af workmanship, installation technique, the quality of the adjacent joints and the transportation of components.

As with most materials, windows and doors deteriorate with age, and some repair and maintenance may be necessary. The original performance of the components and materials used are often reduced over time, which can adversely affect interior conditions and surrounding building construction.

Repairs may extend service life, enabling the components and materials to meet their original function or at least an acceptable level of performance. The selected repair strategy may also affect operational and maintenance costs. Remedy of water leakages in buildings is however not based on sound judgment and full knowledge of the extent of the existing conditions.

Exterior perimeter sealants and flashings are typically installed to seal and integrate with the system of the adjacent wall cladding. Joint sealants, gaskets and flashings need to be designed carefully to accommodate anticipated movements and to withstand air- and water pressure.

Windows are constructed by combining different components and materials into a single composite unit or system. The basic components of a typical window include glazing, framing system (usually aluminum, vinyl or wood), gaskets, a thermal separator system (in aluminum systems), and internal seals.

Selecting window frames and glazing system typically depends on project conditions such as type of project, budget, thermal and structural requirements and the desired aesthetic expression. Wood and aluminum framing are often used for windows in low-rise commercial buildings, aluminum framing or curtain walling is more typically used for windows or facades in taller buildings where wind loads often are significantly greater.

There are two primary approaches to water penetration resistance in window systems: A barrier system or a drainage system. A barrier system is often constructed with a exterior surfaces and joints of the window or curtain wall designed to be permanently sealed to prevent any water penetration into the system. This type of system usually incorporates exterior gaskets and sealants. Water penetration beyond the barrier seals typically results in water accumulation within the framing or penetration into the interior of the building. The drainage system approach assumes that some water may penetrate the primary exterior glazing seals and joints in the window assembly. Water is collected in the frame and lead to the exterior of the construction. Drainage systems are typically preferred as they tend to equalize the pressure of the outside and inside of the system.

The manufactures tests of windows in Europe are executed in accordance with the CE-directive. Air- and water tightness testing are performed in accordance with EN 1026 and classified in accordance with EN12207. Air- and water leakage measurements are performed under laboratory conditions using a test chamber and accurately air- and water flow and pressure difference. The spray system use pulsating water and/or air. This type of test has the advantage that large numbers of samples can be examined under similar conditions eliminating effects of climatic factors.

On the building site water leakages may be difficult for the contractor to detect, difficult to explain and difficult to solve. The crofters test method often consists of a non destructive investigative method using a garden hose or garden fan for spraying water to smaller parts of the surface of the facade or window in question and to adjacent joints primarily. This method is often used for a visual firsts hand evaluation of where the water penetrates the construction. As this test often is used with none or very little pressure difference the method is not sufficient to detect all leakages under different conditions. Specialized consultants and further testing are therefore called for to determine and evaluate causes of water leakage in the building envelope.

The testing of air leakage of windows on site can be evaluated by using fan technique, infrared camera or using ultra sound. The testing of water leakages of windows on site is however more difficult and standards for this type of testing is lacking, especially if you want to combine methods and use methods similar to those of the window and door manufacturers.

Due to the quality of workmanship, installation technique and the transportation of components, the situation on site however differ significantly from the laboratory based situation at the manufacturer and comparison of test results are therefore often out of proportion.

METHOD

The test method used is intended to determinate water penetration of installed exterior facade windows, doors, wall, cladding, flashings, joints, mass wall assemblies and mock-ups on site. With the exemption of a laboratory stand the method is in general accordance with NT BUILD 116 and DS/EN13187.

The test includes water leakage testing along with reviewing drawings and specifications, surveying the building components, and performing exploratory openings. This test method utilizes a 4 m pipe with 3 mm holes with a distance of 30 mm connected to a water tap providing 3 bar water pressure to apply a 3 mm thick film of water to the exterior surface of the wall, window, or other test area. If needed a device for creating pulsating water application can be added. The pipe is fixed to the façadecladding, window or door with the aid of 2 sucking discs and tape or wire. The test uses one or more Blowerdoors to create depressure of 10 to 50 Pa. Strips of cardboard, a digital camera and a high sensitive infrared camera is used to register water penetration from the inside.

The test method is also applicable to curtain-wall area or to individual windows, skylights, or doors alone and may also be used to determine the resistance to penetration through joints between the assemblies and the adjacent construction or copings and joints in metal plate co.

The test may incorporate air infiltration testing and determination of air leakage through installed exterior facades, windows and Doors.

DESCRIPTION OF CASES

This paper presents three cases of water- and air leakage in windows.

Case no. 1

This case concerns leaky windows in lowrice townhouses of brick, zinc plated roofing and zinc plated and wooden cladding with windows and garden entrance doors of frames of aluminium and wood. Elastic sealant on soft backing rod was used in 2-stage perimeter joints.

A blowerdoor was placed in a door in the envelope and a pressurization and depressurization test was done at 50 Pa. After the preliminary test a pipe and water hose was put up on the outside window. The blowerdoor was then set up for depressurization at constant of 50 Pa. Investigations with infrared cameras was then carried out and water leakage in the construction detected.

In this case the drainage system of the windows and placing of the perimeter sealant joints at the lower part of the window was at fault.

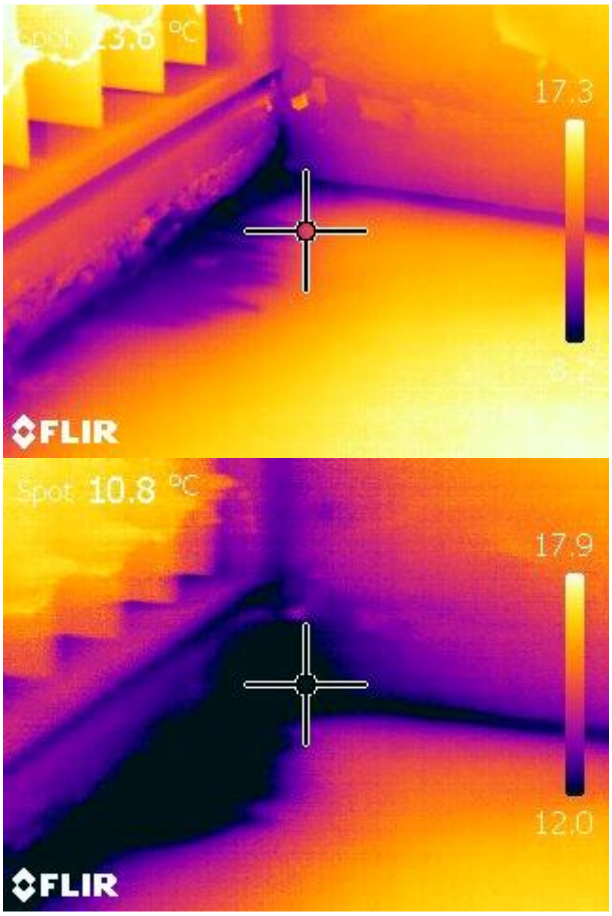

Fig. 1 Example from case 1 of water penetration at 50 Pa at the beginning of the test and after (right)


Fig. 2 Trial set up case no. 1

Case no.2
This case concerns leaky aluminium framed windows, leaky joints of plaster in 1-stage perimeter joints and loose slate sills in a 2 storage industrial building from 1950 with facades of hard burnt brick.

A blowerdoor was placed in a entrance door near the window and a pressurization and depressurization test was done at 50 Pa. After the preliminary test a pipe and water hose was put up on the outside window. The blowerdoor was then set up for depressurization providing constant 50 Pa. Investigations with infrared cameras was carried out.

In this case mainly air leakages and some water leakage were found. The perimeter plaster joints had no adhesion to the aluminium frame and as the joints were mainly 1-stage, water penetrated the perimeter joint several places at the indoor panels surrounding the window.

Case no. 3
This case concerns a several storage town hall with sloping or tilted facades. The facade consists of aluminium-wooden and wooden framed windows and slate cladding. The facade includes a special ventilation system opening windows at room temperatures over 26 °C.

As an overall several liter of water leaked in shortly after rainy weather or storms. The contractor requested a preliminary investigation with ultrasound to detect air leakage in known leaky windows. As this only addressed air leakages further investigation were carried out. A blowerdoor was placed in an entrance door to a selected meeting room with known leaky windows. A pressurization and depressurization test was done at 50 Pa. After the preliminary test a pipe and water hose was put up on the outside of the facade. The blowerdoor was then set up for depressurization providing constant 50 Pa. Investigations with infrared cameras was carried out.

In this case the automatic system was at fault as the windows opened during rain. Several gaskets and the drainage system of the windows and the fact that the windows were tilted were found to lead water into the windows.

Fig. 3 Window in case 3 undergoing investigating of water penetration with infrared camera

CONCLUSIONS

The use of a water film in combination with pressure from the blowerdoor is highly efficient and helps to detect water leakages quite fast if the investigating is done from the inside and done with a high sensitive infrared camera.

Water penetration on white surfaces is difficult to detect at the beginning of the test. The use of infrared camera has proven useful as water penetration on the inside can be detected straight away.

Nevertheless the proper use of this test method requires a thorough knowledge of the principles of water resistance and air infiltration in building facades and pressure measurement.

The pipe water system used can be difficult to install and to be kept completely watertight. Its performance is highly dependent on workmanship of the pipe prepared for the test, during installation and maintenance throughout the life of the system. With a uniform pipe with fixed holes, you cannot fully adjust to all field conditions. The system is not similar to laboratory conditions but allows you to have a more defined water film than using garden equipment. The water film is quite similar to that of a fully water saturated facade and very near laboratory conditions.

REFERENCES

The following is a list of selected reference standards for field determination of water penetration of installed windows:

ASTM E2268 This standard test method is applicable to exterior windows, skylights and doors. The method described can be used for the determination of the resistance of windows, skylights, and doors to water penetration when water is applied to the outdoor face and exposed edges simultaneously with a rapid pulsed air pressure at the outdoor face higher than the pressure at the indoor face. Testing of curtain walls to rapid pulsed air pressure differences should however use AAMA 501.1-94.

ASTM E 1105 Test method for field determination of water penetration of installed exterior windows, curtain walls and doors by uniform or cyclic static air pressure Difference

ASTM E 2128 Standard guide for evaluating water leakage of building walls

ASTM E 331 Test method for water penetration of exterior windows, curtain walls and doors by uniform static air pressure difference

ASTM E 547 Test method for water penetration of exterior windows, curtain walls and doors by cyclic static air pressure differential

AAMA 501 Field check of metal storefronts, curtain walls and sloped glazing systems for water leakage

AAMA 502 Voluntary specification for field testing of newly installed fenestration products

AAMA 503 Voluntary specification for field testing of storefronts, curtain walls, and sloped glazing systems

AAMA 511 Voluntary guideline for forensic water penetration testing of fenestration products

ASTM E 783 Standard test method for field measurement of air leakage through installed exterior windows and doors

DS/EN 13187 Thermal performance of buildings – Qualitative detection of thermal irregularities in building envelopes – Infrared method

NT BUILD 116 Windows, window-door, external doors, facades: Pulsating air pressure test