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Sto Technical Report 01-07.1

Sto Guard®: Development of Durability Requirements for Canada and Compliance*

In 2000 Sto Corp. introduced Sto Guard®, an innovative moisture protection concept for exterior walls. A fluid-applied waterproof membrane and air barrier applied by standard paint roller or spray equipment, Sto Guard® provides protection from both water penetration and air leakage. It is installed as a seamless protective layer over water-sensitive substrates such as wood-based and gypsum-based sheathings. It can also be installed over concrete and concrete masonry units. Initially developed for use beneath Sto EIF systems, Sto Guard® can be utilized behind most types of claddings including brick veneer, horizontal lap siding and stucco.

Commercialization of innovative new products like Sto Guard® requires acceptance by agencies that evaluate compliance with model building codes. This service is provided in the United States by International Code Council - Evaluation Service (ICC-ES) and in Canada by the Canadian Construction Materials Centre (CCMC).

Evaluation of Sto Guard® installed over wood substrates introduced challenges for CCMC because the evaluation methods in the CCMC Technical Guide[1] were developed for non-wood based substrates. Evaluations in Canada had been conducted for adhesively attached EIF systems with fluid-applied water penetration barriers installed over gypsum-based sheathing. Questions remained about the performance over wood sheathing in frame construction.

In 2004, members of the EIFS industry and CCMC formed a consortium to develop evaluation methods for EIFS installed over wood substrates. The primary focus of the research centered on the characteristics of the fluid-applied water penetration barrier and its performance when bonded to a wood substrate.

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* Research was conducted as three separate studies integrated into a common research goal - to demonstrate the durability and effective functioning of Sto Guard®.
  - Part one, covered in this paper, describes the research conducted to determine the appropriate evaluation methods to add to the CCMC Technical Guide to include wood substrates.
  - Part 2 describes the research conducted for Sto Corp at Oak Ridge National Laboratories. Using advanced computer modeling techniques and detailed material characterization, the performance of four different wall assemblies using Sto Guard® as the water resistance and air barrier were studied. Eleven different cities were selected to represent different climate zones across North America.
  - Part 3 summarizes the testing conducted to meet ICC-ES Acceptance Criteria 212 and 235. The testing and evaluation resulted in Sto Corp. receiving the first ICC-ES Evaluation Reports (ESR-1233 and ESR-1748) covered by these criteria.

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[1] CCMC Technical Guide for Exterior Insulation and Finish Systems, Class PB, published by Canadian Construction Materials Centre, Institute for Research in Construction, National Research Council, Ottawa, Canada

Research Summary

A consortium of EIFS manufacturers, including Sto Corp., participated in several research projects to answer fundamental questions concerning fluid-applied membranes and EIFS. The ultimate goal was to verify durability, drainage capability and performance over wood substrates. The results of the research became the basis for the *CCMC Technical Guide for the Evaluation of Exterior Insulation and Finish Systems, Class PB, Addendum A4 for Wood Substrates*. The bulk of the testing and research was conducted at two labs in Canada, Forintek Canada Corp., and Canadian Building Envelope Science and Technology (CAN-BEST). Sto Corp. is grateful for the assistance provided by Dr. Donald Onysko, DMO Associates, for developing the research program and providing guidance to the consortium and CCMC.

Tests associated with traditional moisture protection for exterior walls, i.e., building felts, house wraps, and other sheet products, are inappropriate for coatings since EIFS cannot be adhered to a sheet material. Furthermore, liquid coatings adhered to the substrate become a structural component of the wall assembly subject to the stresses and movement of the substrate, joints and connections.

Durability is a fundamental requirement of any water or air penetration barrier. Secondary barriers that provide the innermost plane of protection from water penetration are always located behind the cladding. Air barriers may be anywhere within the wall assembly but are typically also located behind the cladding. This is true of Sto Guard®, which performs both air barrier and water barrier functions. These barriers are not accessible for maintenance or repair: hence the requirement for durability for the expected life of the cladding and the rigorous series of tests developed by CCMC to evaluate the durability of Sto Guard®.

Shear Resistance at Joints

Research into shear resistance was conducted at Forintek Canada, Inc., using two 2.4 x 2.4 m (8' x 8') panels with a vertical and horizontal joint. One panel was prepared with Sto Guard®; the other had no coating. Racking tests demonstrated that the coating improved the shear resistance of the wall. Given that walls will continue to be designed as if there were no coatings, the addition of a fluid-applied air and water barrier will result in a wall that is structurally over designed, i.e. the wall will rack less and the coatings will not be stressed to the degree anticipated in the original design. Based on this result, researchers determined that racking was not a useful method for evaluating the performance of coatings.

Smaller tests were developed to evaluate the performance of coatings at stress points such as joints. These tests, Resistance to Relaxation and Water Penetration Resistance (see below), were more severe.

Structural Deformation

Two 1.2 x 2.4 m (4' x 8') panels were constructed with a sheathing joint, one 2 mm (approx. 1/16") and the other 4 mm (approx. 1/8"). Loading to induce deflection in the joint was applied. Both panels were deflected to L/170 (13.5 mm [1/2"] on a 2,286 mm [90"] span) without failure of the joint. The peak loading to induce deflection was 6.10 kN (1,373 lbf). The panels were not tested to failure; e.g., cracking at the mid-span joint, so joint samples could be removed and parts re-tested under cyclic environmental conditions.

Resistance to Relaxation under Cycling Environmental Conditions

To evaluate the durability of Sto Guard® at sheathing joints, joint sections were removed from the panels described above and tested. The samples were installed in a frame and stretched 40% from their relaxed conditions. The samples were then heated to 65°C (149°F) at 90% RH for a period of 18 hours, after which the temperature was reduced to -10°C (14°F) for 5 hours. The samples were stored at room conditions for one hour between each cycle. The cycle was repeated 20 times with a total exposure of

480 hours. There were no failures based on visual observation. The pass criterion of the *CCMC Technical Guide* is to meet the requirements of the water transmission resistance test that followed.

Water Transmission Resistance

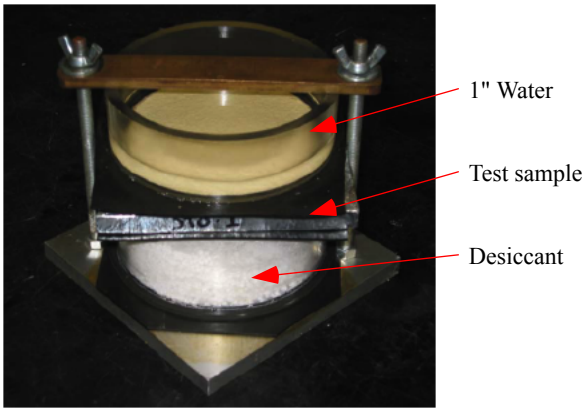


Figure 1: Water Transmission Test

The samples from the testing noted above were then subjected to water resistance tests to demonstrate Sto Guard's® ability to limit water transmission into a wall assembly. A scenario was envisioned where some penetrating water might be retained in an EIFS assembly. This raises the question that even if liquid water could not pass through the coating, would the vapor pressure from a localized pocket of liquid water increase the relative humidity in the adjacent wood substrate? Any potential for increase of the RH and collection of water in the wood substrate could result in wood degradation or mold growth.

A test method was established based on a modification of ASTM E 96, *Standard Test Methods for Water Vapor Transmission of Materials*. Typically, E 96 uses a "Wet Cup" or "Dry Cup" method for determining water vapor transmission rates. For the modified procedure the test agency combined these two methods with a desiccant below (Dry Cup) and 25 mm (1") of water in the Sto Guard® sample above (see fig. 1). The tests were conducted for 206 hours. Testing on one plywood and one OSB sample was extended to 1,968 hours (82 days). The samples were then retained in the test chamber at 50% RH. Both the plywood and OSB were examined a month after the test and no degradation or mould growth was found.

"Based on experience," the test report concluded, "had the specimens not been protected by the coating, mould growth on the wetted surfaces of the OSB would have been rampant."[2]

In the *CCMC Technical Guide*, the three sequential tests above were adopted for the evaluation of fluid-applied barriers over joints in wood-based sheathings.

Coating Bond to Wet Substrates

In real world job-site conditions, coatings will be applied to substrates of varying degrees of moisture content. Researchers studied the effect of sheathing wetness by coating wood sheathing samples that were dry and others that had been soaked in water for one hour or 24 hours. Adhesion tests were conducted on cured samples following ASTM D5651, *Standard Test Method for Surface Bond Strength of Wood-Base Fiber and Particle Panel Materials,* to determine the cause of failure and the effect, if any, of the wet substrates on the adhesion of Sto Guard®. Failure of the wood substrate occurred in all samples. This indicates that the degree of wetness of the substrate at the time of application will not affect the bond of Sto Guard® to the wood.

[2] Basic Physical and Mechanical Property Tests Related to Evaluation of Exterior Insulation and Finish Systems (EIFS), Report 550-4480 (report No. 2 rev.), Forintek Canada Corp. for Sto Corp., January 11, 2006

UV Resistance (time of exposure)
Generally, over the life of a structure, the water-resistive layer and air barrier remain behind the cladding protected from UV radiation. However, during construction, before the cladding is installed, the membrane is unprotected. To evaluate the effects of UV exposure, six panels were subjected to 334 hours of accelerated weathering in accordance with cycle 2 of ASTM G155-00, *Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*. The samples showed no signs of cracking or degradation.[2]

Nail 'Pop' Resistance
Wood frame construction moves naturally as it dries and as humidity levels in the air change. This can result in stresses on the fasteners, and occasionally nails will 'pop' or back out slightly from the surface of the sheathing. Initial attempts to induce nail popping by racking testing and impact on the back of the full-scale mock-up were unsuccessful. As an alternative, a test was devised where nails would be countersunk 1 mm (1/25") into the face of the sheathing (both OSB and plywood), which was then coated with Sto Guard®. Following a normal cure period the nails were backed out 1 mm (1/25") in a controlled manner. The results of 20 specimens subjected to the test showed no signs of cracking or degradation of the coating.[3]

Drainage
CCMC adopted an extremely demanding drainage test protocol to evaluate the drainage characteristics of Sto EIFS cladding with Sto Guard® behind it (Sto EIFS NExT®). The focus of the research and testing was water retention. No other cladding system is tested for drainage efficiency, so ASTM E2273-03 *Standard Test Method for Determining the Drainage Efficiency of Exterior Insulation and Finish System (EIFS) Clad Walls* was used as a starting point. The procedure was refined at Forintek Canada Corp., introducing "dribble" water entry and weighing the panel during the draining and drying phases of the test. Dribbling water is considered a similar method of delivering water into a wall assembly as an actual leak. The ASTM standard only requires the water injected and drained to be weighed to determine drainage efficiency. The CCMC test protocol required that the test wall assembly be suspended and counter-balanced, allowing panel weight differences less than a gram to be measured (see fig.2). The panels were protected from the drying effects of wind and solar radiation. Relative humidity of the air was recorded at the top and bottom of the test panel.

Eight liters (2.1 US gallons) of water were dribbled into the panel over a one-hour period. The panel weight was recorded over a two-hour

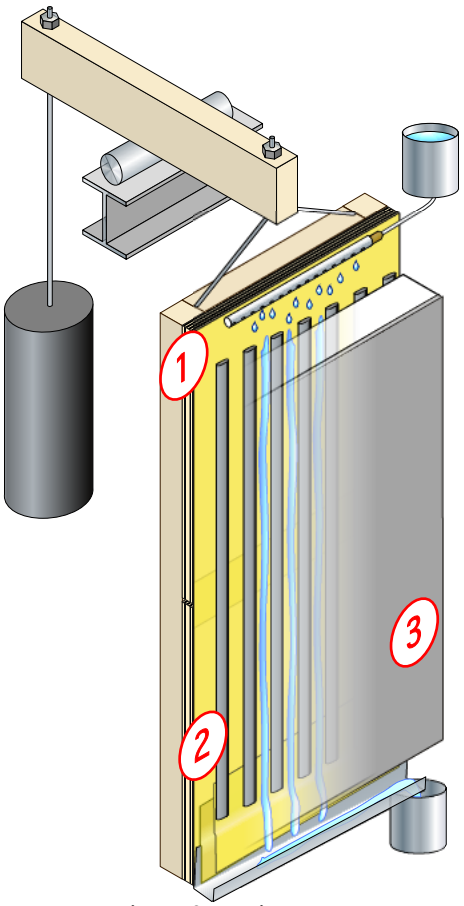
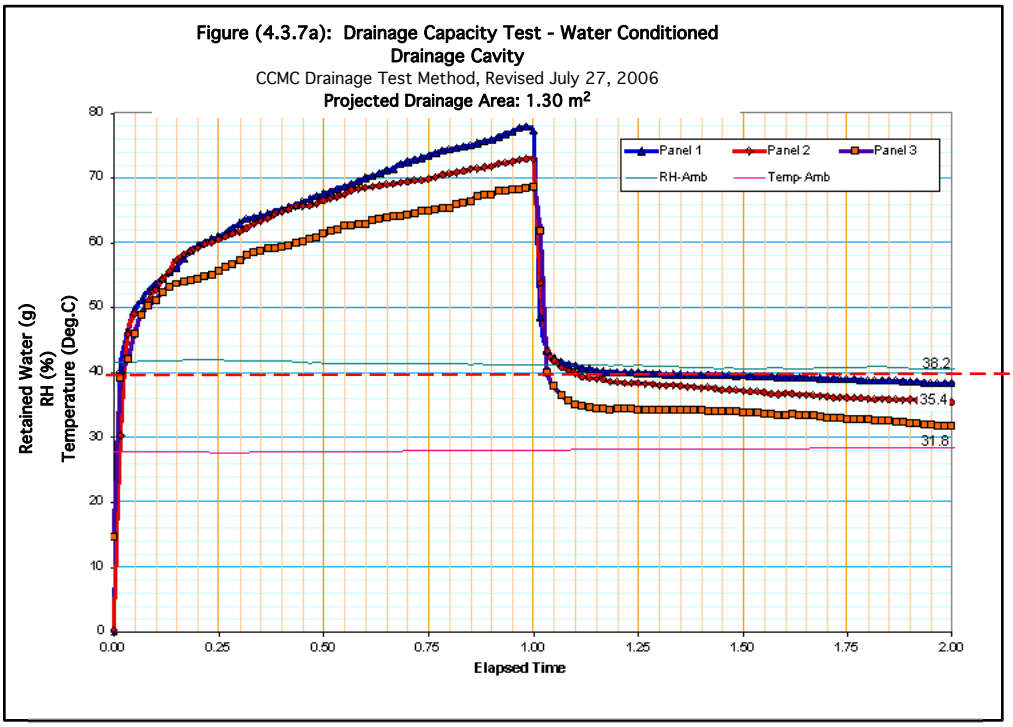


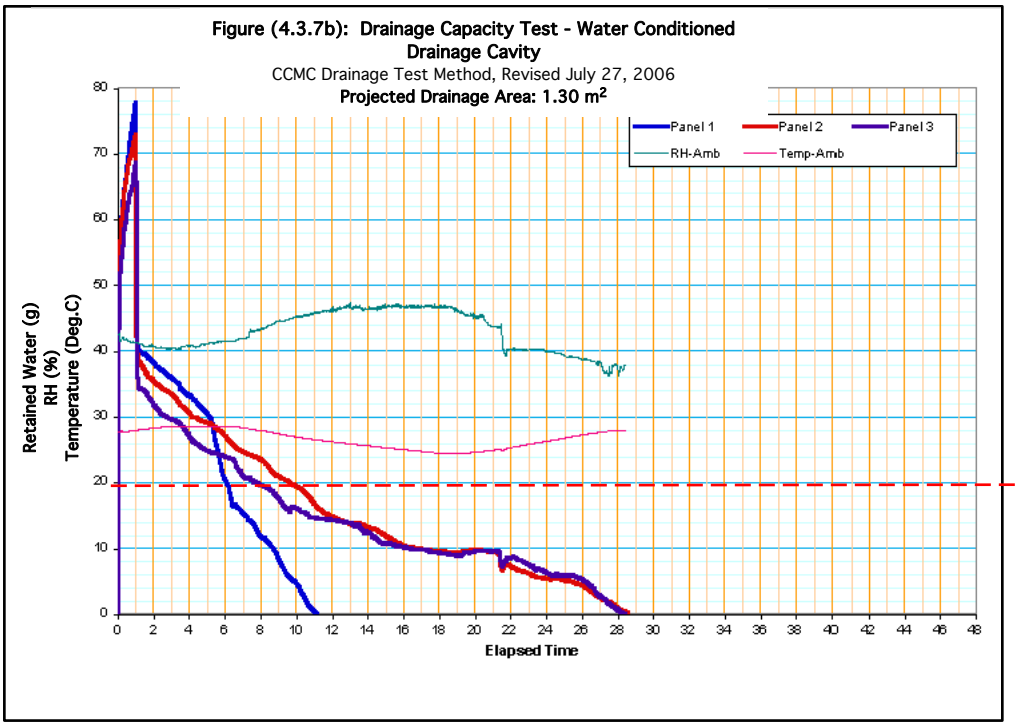
Figure 2: Drainage test apparatus
1. Sto Guard® on substrate
2. Vertical ribbons of adhesive
3. Sto EIFS cladding

[2] ibid
[3] ibid



CCMC criterion for drainage efficiency for 1.3 m^2 (14 s.f.) of wall area: below line at 2-hours is a pass

Figure 3: CAN-BEST 2-Hour Drainage Curve



CCMC criterion for drying efficiency for 1.3 m^2 (14 s.f.) of wall area: below line at 48-hours is a pass

Figure 4: CAN-BEST 48-Hour Drying Curve

and 48-hour period. The test panels drained efficiently and dried prior to the end of the 48-hour period. A sample result for drainage is shown (fig. 3) and for the 48 hour drying period (fig. 4). Drainage efficiency was reported to average 99.6%.[5]

The research also compared the drainage ability of Sto Guard® to sheet materials uses as water-resistive barriers. Using the same counter-balanced test apparatus noted above, building felt, a polymeric sheet material, a sample with a taped joint, and a sheet of EPS insulation were evaluated. Sto Guard® drained more efficiently than the other barriers and equally to the EPS insulation. The performance of the EPS is significant because it forms one side of the drainage cavity in an EIFS cladding.

University of Waterloo testing (reviewed in Part 2) showed that exposure to wind and solar radiation shortened the drying time[6]. It should be noted that the amount of water present in the panels is so small that minor changes in relative humidity in the surrounding atmosphere can have a significant effect on the drying curves. In one example, dry panels left hanging over a weekend actually gained 40 grams because the EIFS and wood frame absorbed water vapor from the air.

Summary

This comprehensive series of physical and mechanical tests evaluating the effects of substrate movement, exposure to excess water and water vapor pressure, UV exposure, and drainage performance, imposed extremely harsh conditions on Sto Guard® with tough pass/fail criteria.

It should be noted that no other exterior wall assembly nor any other water-resistant barrier or air barrier material is tested to the extremely tough standards listed in the *CCMC Technical Guide*. It is unlikely that asphalt saturated felt or mechanically fastened synthetic sheet material (house wrap), sealed with a tape, could undergo the 40% joint elongation test and rigorous environmental cycling without tearing at the fastener locations or separation of the tape connections. These materials are typically tested within the sheet and not at joints or overlaps.

The drainage testing was extremely comprehensive, perhaps the most sophisticated drainage testing ever conducted on a wall cladding assembly. Comparative testing conducted at Forintek Canada Corp. between EIFS and horizontal siding assemblies (vinyl and wood) for Canada Mortgage and Housing Corp. (CMHC) showed that EIFS with adhesive ribbons for drainage were the most efficient in draining water from the cladding assembly. Whether 19 mm (3/4") strapping or special drainage mats were used, more water was retained by the siding systems than by the EIF systems tested.

Based on these independent tests, Sto Guard® has been proven to be an extremely durable waterproofing and air barrier material with exceptional drainage performance when installed beneath Sto EIFS (Sto EIFS NExT®). CCMC has issued an evaluation report on Sto Guard as an Air Barrier Material (CCMC 13210-R) and a second evaluation report (CCMC 12416-R) covering its use beneath EIFS (including wood-based sheathing) is near completion.

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[5] Drainage Capacity Evaluation of Exterior Evaluation and Finish System, Sto EIFS NExT®, Canadian Building Envelope Science and Technology (CAN-BEST), Report No. L06-450-xxx, 27 November 2006.

[6] Sto EIFS NExT® System with Drainage, Drainage & Drying Study Final Report, University of Waterloo, Building Engineering Group, Civil Engineering Department, August 2005.