Building Consulting Services

2025-02-21

Fortress Installation Systems
2230593 Alberta Inc.
Calgary, Alberta

Attn: Michael Gendrone

Re: Fortress Installation Systems – Products Testing Review and Comments

Dear Michael,

Building Consulting Services (BCS) has reviewed the testing results provided by Fortress Installation Systems, ‘Fortress Product Testing’ completed by Optimize Envelope Engineering Ltd, dated October 28th, 2019, as attached. The testing portion of the ‘Fortress Product Testing’ document that BCS will be referring to is related to the water penetration and further refer to within this letter as Resistance to Moisture Infiltration (RMI).

BCS has not completed any further testing of the Fortress Installation System products. This letter simply provides our clarification comments and interpretation of the provided testing results with respect to the Alberta Building Code (ABC) and the British Columbia Building Code (BCBC) and other fenestration standards.

BCS assumes no liability for the testing results within the provided and attached testing documentation complete by others.

Discussion

There are several industry standards for rating fenestration (windows, doors, skylights) and other fenestration types for performance.

Both the Alberta Building Code (ABC) and the British Columbia Building Code (BCBC), Sections 5.9.2. and 9.7.4. for windows and doors refers to the following industry standards regarding fenestration.

AAMA/WDMA/CSA 101/I.S.2/A440
North American Fenestration Standard (NAFS) Specification for Windows, Doors, and Skylights, Harmonized Standard.

and

CSA A440S1, Canadian Supplement to AAMA/WDMA/CSA 101/I.S.2/A440-17
North American Fenestration Standard (NAFS) Specification for Windows, Doors, and Skylights

Fenestration and NAFS's Performance Grade (PG) Rating

Within the AAMA/WDMA/CSA 101/I.S.2/A440 document, the NAFS defines methods of grading the performance of fenestration. The performance of the fenestration is generally identified by a Performance Grade (PG) rating. Within the NAFS Performance Grades (PG) there are several properties for rating fenestration performance.

For this discussion, we will only be focusing on the

Design Pressure Rating (DP)
and the
Resistance to Moisture Infiltration (RMI)

The **Design Pressure (DP)** rating of a fenestration unit is generally only concerned with the fenestration's ability to withstand uniform loads on the fenestration unit. The **DP** rating specifies the maximum wind pressure loading that the fenestration unit can withstand in pounds per sq.ft. (psf) of pressure.

If a fenestration unit has a **DP-60** rating, it means the window will withstand a wind pressure of 60 psf.

The **Resistance to Moisture Infiltration (RMI)** is generally only concerned with the fenestration unit's ability to resist moisture infiltration, but standard tests like ASTM E1105 and a modified ASTM E331 can also be used to test the performance of the Rough Opening Accessories (**ROA**s) as an assembly of parts, consisting of the Fortress Installation System, waterproof flashing membrane tape, and spray foam insulation sealant, all installed as an assembly within the rough opening of the fenestration unit.

For a passing **RMI** rating, a fenestration unit is required to resist moisture infiltration up to 20% of the fenestration's **DP** rating depending on the classification of the fenestration unit.

Fenestration units are classified into different Classes based on building type and height as follows.

- R - One and two storey family dwellings.
- LC - Low-rise buildings, multi-family dwellings, office, hotels
- CW - Low to mid-rise buildings, including hospitals, retail and institutional
- AW - High-rise buildings, larger institutional buildings

The following Table No. 1 shows minimal required ratings for Performance Grade (**PG**), Design Pressure (**DP**), and Resistance to Moisture Infiltration (**RMI**) with respect to the various fenestration classifications.

Minimum Window Requirements for Classifications				
Class	Min PG	Min Design Pressure - DP (psf)	Required % for Moisture Resistance Testing (RMI)	Water Infiltration Resistance Test Pressure (RMI) - (psf)
R	15	15	15% in areas	2.25
LC	25	25	15%	3.75
CW	30	30	15%	4.5
AW	40	40	20%	8

Table No. 1

Therefore, if a Class CW fenestration unit has a **PG** rating of **PG-30** it must meet a **DP-30** rating, meaning it can withstand up to 30 psf of wind load pressure and must resist moisture infiltration up to 15% of that force being 4.5 psf.

What this means is that the fenestration unit must resist structural failure up to 30 psf (**DP**), and must resist moisture infiltration up the 4.5 psf pressure (**RMI**), however the fenestration unit may start leaking moisture above the 4.5 psf loading point but the fenestration must remain structurally intact up to 30 psf.

The following chart reviews Class AW type fenestration with respect to **DP** and **RMI** required ratings in higher wind speed and wind loading conditions. The Class AW fenestration was chosen for this review chart as it is the most restrictive **RMI** at 20% of the **DP** rating.

Class AW - Moisture Infiltration Resistance Rating - Calulations Chart												
Huricane Catergory	Wind Miles/Hours (mph)			DP - Pounds/Sq.ft. (ps			DP - Pascals (pa)			20% Moisture Infiltration Resistance (RFI) (psf / Pa)		
Tropical Depression	0	to	38	0.0	to	3.7	0	to	177	0.7	/	35.4
Tropical Storm	39	to	73	3.9	to	13.6	186	to	653	2.7	/	130.6
1	74	to	95	14.0	to	23.1	671	to	1106	4.6	/	221.2
2	96	to	110	23.6	to	31.0	1130	to	1483	6.2	/	296.6
3	111	to	129	31.5	to	42.6	1510	to	2040	8.5	/	407.9
4	130	to	156	43.3	to	62.3	2071	to	2983	12.5	/	596.6
5	156	to	181	62.3	to	83.9	2983	to	4016	16.8	/	803.1
6	182	to	207	84.8	to	109.7	4060	to	5252	21.9	/	1050.4
7	208	+		110.8	+		5303	+		+	/	+
Wind preasure in pounds per sf.ft = 0.00256 x V^2				Pa = DP x 47.880208								

Table No. 2

The following chart reviews Class R, LC and CW type fenestrations with respect to **DP** and **RMI** required ratings in higher wind speed and wind loading conditions where the required **RMI** is 15% of the **DP** rating.

Class R, LC and CW Fenestration - Moisture Infiltration Resistance Rating - Calulations Chart												
Huricane Catergory	Wind Miles/Hours (mph)			DP - Pounds/Sq.ft. (psf)			DP - Pascals (pa)			15% Moisture Infiltration Resistance (RFI) (psf / Pa)		
Tropical Depression	0	to	38	0.0	to	3.7	0	to	177	0.6	/	26.5
Tropical Storm	39	to	73	3.9	to	13.6	186	to	653	2.0	/	98.0
1	74	to	95	14.0	to	23.1	671	to	1106	3.5	/	165.9
2	96	to	110	23.6	to	31.0	1130	to	1483	4.6	/	222.5
3	111	to	129	31.5	to	42.6	1510	to	2040	6.4	/	306.0
4	130	to	156	43.3	to	62.3	2071	to	2983	9.3	/	447.4
5	156	to	181	62.3	to	83.9	2983	to	4016	12.6	/	602.3
6	182	to	207	84.8	to	109.7	4060	to	5252	16.5	/	787.8
7	208	+		110.8	+	0.0	5303	+		+	/	+
Wind preasure in pounds per sf.ft = 0.00256 x mph^2				Pa = DP x 47.880208								

Table No. 3

<u>Fortress Installation Systems 'Fortress Product Testing' Report and Results</u>

Within the report, Section 2.2 Water Penetration Resistance Test, in paragraph 3, it states, *"… each window has been tested at a minimum pressure difference of 140 Pa, gradually increasing the differential by 10 Pa until reaching failure."*

140 Pa = 2.923964 psf
10 Pa = 0.208854 psf

The ASTM E331, Article 11.5 states that the test must be run for 15 min. Therefore, BCS assumes that each differential increase of 0.208 psf (10 Pa) was run for 15 minutes before increasing testing pressure another 0.208 psf (10 Pa).

Within the report, Section 3.1 Water Penetration Resistance, the report indicated test results for both Specimens A and B 'with' and 'without' spray foam insulation sealant. For clarity purposes within our report we are going to re-label these tests, and refer to the 'Fortress Product Testing' report's results as follows.

No-Foam-A = Specimen A without spray foam insulation sealant
No-Foam-B = Specimen B without spray foam insulation sealant
Foamed-A = Specimen A with spray foam insulation sealant
Foamed-B = Specimen B with spray foam insulation sealant

Within the report, Section 4.0 Limitations, the third bullet under 'Installation flaws' states, "*Sill plate of 'Specimen A' has not been installed square and true. Installation as is creates a bigger gap between the window frame and the Fortress at one of the corners. This detail, in addition to nailing fin discontinuities, might generate distorted results."*

Based on further discussion between Fortress and BCS, the 'Specimen A' was noted to be intentionally constructed with an out of square sill plate to emulate very poor framing construction that may be encountered on a job site.

Within the report, Section 3.1 Water Penetration Resistance, the first table indicates the testing results for Specimens A and B 'without' spray foam insulation sealer. Re-labeled as follows.

No-Foam-A = Specimen A without spray foam insulation sealant
No-Foam-B = Specimen B without spray foam insulation sealant

Test **No-Foam-A** being out of square with a larger unsealed rough opening cavity immediately **Failed** the **RMI** test as it encountered water mist through the rough opening at 2.9239 psf (140 Pa) and encountered water droplets at 6.2656 psf (300 Pa).

This test failed from the start as the starting pressure of the test was 2.9239 psf (140 Pa). And the fact that water droplets did not occur until 6.2656 psf (300 Pa) is also irrelevant (a **Fail**) as with enough water misting over time, water droplets will occur due to the collection of mist.

Test **No-Foam-B** with a more acceptably framed square rough opening did not experience water mist and then encountered water droplets at 6.8922 psf (330 Pa). Therefore, the **RMI** for this test was 6.6833 psf (320 Pa).

BCS views this is a significant achievement for **No-Foam-B** when considering that the rough opening is not air sealed, as a 6.6833 psf (320 Pa) **RMI** equates to the following.

For Class AW fenestration a 6.6833 psf (320 Pa) **RMI** @ 20%
= DP poundage rating of 33.416 psf
= √(**DP** / 0.00265) = 112 mph wind speed = Category 3 Hurricane

For Class R, LC and CW fenestration a 6.6833 psf (320 Pa) **RMI** @ 15%
= DP poundage rating of 44.555 psf
= √(**DP** / 0.00265) = 129.66 mph wind speed = Category 4 Hurricane
(Category 4 as it is 0.66 mph over 129 mph wind speed)

While this achievement may be of significant interest, the **No-Foam-A** and **No-Foam-B** test results cannot be relied upon, as the failure rate increases as the rough opening becomes more out of square. Therefore, these **No-Foam-A** and **No-Foam-B** tests should only be considered as a curiosity test.

Within the report, Section 3.1 Water Penetration resistance, the second table indicates the testing results for Specimens A and B ‘with’ spray foam insulation sealant installed.

Foamed-A = Specimen A with spray foam insulation sealant installed.
Foamed-B = Specimen B with spray foam insulation sealant installed.

Test **Foamed-A** being out of square with a larger sealed rough opening cavity was run up to 9.189 psf (440 Pa) with no water observed into the test chamber. Therefore, the spray foam insulation sealant successfully accommodated the out of square framing.

Test **Foamed-B** with a square and true sealed rough opening cavity was run up to 9.189 psf (440 Pa) with no water observed into the test chamber.

Within the report Section 3.1 Water Penetration Resistance, the last paragraph states, *“… pressure was increased until reaching 1000 Pa with no water penetration observed. The pressure incremental was applied for a short period time (i.e. less than 5 minutes).”*

BCS is uncertain as to why the test was not allowed to run for 15 minutes at 20.885 psf (1000 Pa) pressure, as per ASTM E331, but the fact that it would have taken time to increase the pressure differential to 20.885 psf (1000 Pa) and it was left to run 5 minutes at that 20.885 psf (1000 Pa) pressure without water penetration observed, would tend to suggest that the **Foamed-A** and **Foamed-B** tests were capable of resisting moisture infiltration (**RMI**) to a higher resistance than the recorded 9.189 psf (440 Pa).

In review of the **Foamed-A** and **Foamed-B** test results with an air sealed rough opening, a 9.189 psf (440 Pa) **RMI** equates to the following.

For Class AW fenestration a 9.189 psf (440 Pa) **RMI** @ 20%
= DP poundage rating of 45.94 psf
= √(**DP** / 0.00265) = 131 mph wind speed = Category 4 Hurricane

For Class R, LC and CW fenestration a 9.189 psf (440 Pa) **RMI** @ 15%
= DP poundage rating of 61.26 psf
= √(**DP** / 0.00265) = 152 mph wind speed = Category 4 Hurricane
(4 mph short of a Category 5 rating)

Product Revisions and Testing Review Summary

The ‘Fortress Product Testing’ results, tested Fortress’ previous generation of rough open accessories, not the current updated product line.

It is BCS’ opinion that the newly updated and enhanced Fortress Installation System’s ‘Corner Glove’ product with the full wrapping sill corner detailing will not deter from the test results and would further serve to eliminate potential membrane installation failure issues at the sill corners of the fenestration’s rough opening.

The ‘Fortress Product Testing’ indicates a Resistance to Moisture Infiltration (**RMI**) as defined by the NAFS Performance Rating for the various Classes of windows as follows.

For Class AW @ 20% of DP
= **RMI** of 9.189 psf (440 Pa)
= **DP** poundage rating of 45.94 psf, Category 4 Hurricane, 131 mph winds

For Class R, LC and CW @ 15% of DP
= **RMI** of 9.189 psf (440 Pa)
= **DP** poundage rating of 61.26 psf, Category 4 Hurricane, 152 mph winds

<u>Recommendations</u>

As a speculative note only, if the **Foamed-A** and **Foamed-B** test were allowed to run for the standard 15 min test at 20.88 psf (1000 Pa) or possibly even higher, with no water penetration observed, the **DP**, wind speed, and hurricane resistance results could have been as follows.

For Class AW fenestration a 20.885 psf (1000 Pa) **RMI** @ 20%
= DP poundage rating of 104 psf
= √(**DP** / 0.00265) = 198 mph wind speed = Category 6 Hurricane

For Class R, LC and CW fenestration a 9.189 psf (440 Pa) **RMI** @ 15%
= DP poundage rating of 139 psf
= √(**DP** / 0.00265) = 229 mph wind speed = Category 7 Hurricane

BCS recommends re-running the test to the point of failure to determine the highest possible **RMI**, either under the modified requirements of the ASTM E331 as completed within the provided 'Fortress Product Testing' report, or under ASTM E1105 which has an allowance in Article 1.2 for including and testing the rough opening accessories stating, *"… it may also be used to determine the resistance to penetrating moisture through the joints between the assemblies and the adjacent construction*." Then, blank off the front of the window with plywood sheathing and a waterproofing membrane to seal up and remove the window's performance from the test results.

I trust this explains the related NAFS's Performance Grade (**PG**), **DP** and **RMI** performance requirements related to your provided Fortress Installation System's test results.

If you have any further questions, please call.

Thank You Sincerely

Building Consulting Services
(Div. of Sigurd Group Incorporated)

Kevin S. Wilkins,
Registered P.L.Eng. in AB and BC.

Ph. 587-360-3885
Toll Free 1.866.668.3395
Email: kevin@buildingconsulting.ca
Website: www.buildingconsulting.ca

PROFESSIONAL LICENSEE (ENGINEERING) ALBERTA
KEVIN SIGURD WILKINS
ID 259947

2025-02-21
APEGA Permit to Practice: 15662

Association of Professional Engineers and Geoscientists of the Province of British Columbia
K. S. WILKINS
PROFESSIONAL LICENSEE ENGINEERING
Licence 59946

2025-02-21

Association of Professional Engineers and Geoscientists of the Province of British Columbia
PERTMIT TO PRACTICE
PERMIT NUMBER: 1005248

Attachments:

'Fortress Product Testing' completed by Optimize Envelope Engineering Ltd, dated October 28th, 2019.

ASTM E1105-15 (reapproved 2023) Standard test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference.

OPTIMIZE
Envelope Engineering Ltd.

Fortress Product Testing

Research Report

October 28, 2019

Submitted to:
Fortress Installation
Systems.
c/o Michael Gendrone
Suite 353, 1350 E. Flamingo Road
Las Vegas, NV 89119

Prepared by:

Dayana Barberi, P.Eng.
Project Manager, Optimize Envelope Engineering Ltd.
p: 403.990.9148 e: dayana@optimizeengineering.com

Steve Wolfe
Project Manager, Optimize Envelope Engineering Ltd.
p: 403.990.8517 e: steve@optimizeengineering.com

Dana Bjornson, P.Eng., M.Arch., LEED®AP
President, Optimize Envelope Engineering Ltd.
p: 403.990.3369 e: dana@optimizeengineering.com

APEGA Permit to Practice No. 108690

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1.0 INTRODUCTION

Optimize Envelope Engineering Ltd. (OEE) was engaged by Mr. Michael Gendrone, General Manager and Founder of Fortress Installation Systems, to test the water penetration resistance and thermal resistance of Fortress, a new product in the construction industry designed to deflect water from the window sill plate toward the exterior of the wall assembly.

Fortress is a window pan drainage system designed to provide protection from incidental water that might penetrate the window to wall interface. The Fortress product has a hollow wedge shape made from Polyvinyl Chloride (PVC) with a 15% slope at the top surface. It is intended to be installed on a level sill plate and the corners of the rough opening in wood frame constructions. Its hollow extruded construction is purposely designed to limit thermal transfer at the sill plate.

OEE performed a modified ASTM E331 test to determine the differential pressure at which water is able to enter the wall cavity when Fortress is installed on the window sill plate. Additionally, calculations have been performed to determine the effective thermal resistance provided by two (2) different generations of Fortress.

Observations, results, discussion and conclusions are outlined below.

2.0 METHOD

A mock-up wood frame wall, provided by Fortress Installation Systems, was built to be tested under laboratory conditions. Two (2) rough openings have been prepared to receive 610 mm x 1300 mm (24”x33”) casement windows manufactured by Pella Corporation. Rough openings preparation and window installation was executed by Fortress Installation System representatives using products supplied by Fortress Installation System. and following the Fortress Installation System installation procedure as per Fortress web site. Installations have been identified as “Specimen A” and “Specimen B”.

Procedure for rough opening preparation and window installation was as follows:

- Installed left and right corner Fortress over sill plate.
- Installed sloped Fortress center strip.
- Installed water-impermeable membrane over window pan and above Fortress, extending membrane 150 mm (6)” up to jambs.
- Installed shims.

  - "Specimen A" has been shimmed using pieces of Fortress strip. Shims are 38 mm (1.5") long with the sloped surface facing the center of the rough opening.
  - "Specimen B" has been shimmed using square and adjustable PVC shims manufactured by Fortress (Patented & Patent pending).
- Installed windows into rough opening and fastening nailing fins against wall sheathing. Sealant has been applied to the back of head and side nailing fins. No sealant has been applied at the bottom of the window.
- Installed self-adhering membrane (Tamlyn Xtreme flashing) over nailing fins at sides and head of window.

2.1 Assumptions

- No recognized test method exists in the building envelope industry to test thermal resistance of non-planar geometries such as Fortress. To determine the thermal resistance provided by the Fortress, OEE has resolved that the thermal characteristic of the sub-assembly can be determined by calculation.
- Thermal characteristics of the Fortress sub-assembly is determined by calculation following the Isothermal-Planes Method as specified in Note A-9.36.2.4(1) of the National Building Code – 2019 Alberta Edition (NBC-2019 (AE))
- Air thermal resistance value has been taken from Table A-9.36.2.4.(1) D of the NBC-2019 (AE). A continuous air cavity with an average depth of 27 mm (1-1/16") has been considered for the "1st Generation" Fortress calculations described herein.
- Thermal resistance value of the polyurethane foam used to infill the Fortress cavity has been taken from technical documentation publicly available in Tytan Professional website. An average R value of 4.5 per inch (RSI 0.79) has been used for calculations specified herein.
- Fortress "1st Generation" sub-assembly consists of PVC material and air cavity.
- Fortress "2nd Generation" sub-assembly consists of PVC material and foam infilled cavity.

2.2 Water Penetration Resistance Test

No industry-recognized test exists to specifically test water penetration resistance at the window sub-sill. OEE tested to a modified ASTM E331, an industry-recognized method to water test window assemblies to test the window pan drainage dam Fortress. The purpose of the test is to determine the differential pressure at which water is able to pass over the drainage dam and enter the wall cavity. OEE believes that this test, as modified, illustrates the likelihood of water penetration under in-use conditions.

The water penetration resistance test method consists of sealing the indoor face of the test specimen against a test chamber, exhausting air from the chamber at the rate required to maintain a specific test pressure difference across the specimen, while spraying water onto the outdoor face of the specimen at an approximate rate of 3.4 L/m^2-min.

Water penetration tests were executed using a spray rack apparatus as per the requirements of ASTM E331 window test standard which establishes a minimum test pressure difference as 137 Pa. Due to precision of the monometer used for testing, each window has been tested at a minimum pressure difference of 140 Pa, gradually increasing the differential by 10 Pa until reaching failure. The failure criteria of this test are defined as water penetration into the test chamber and over the upper edge of the Fortress. Water seeping through areas of the rough opening not containing Fortress, is not considered failure.

The water penetration test has been divided into two (2) phases. During the first phase, the specimens have been tested without the installation of spray foam interior seal around window. The second testing phase has been performed following the installation of the interior window seal as specified by Fortress Installation Systems.

2.3 Thermal Resistance Calculations

The effective thermal characteristics of the assembly under study has been determined following Isothermal-Planes Method as described in Section 9.36 of the NBC-2019 (AE). This model assumes that heat flow is perpendicular to the surface of the building envelope component within a given subsection.

To calculate effective thermal resistance, the NBC-2019 (AE) requires that contribution from all portions of an assembly be taken into account. The resultant thermal resistance depends on the thermal properties and thickness of the assembly materials. Materials considered to calculate the RSI value of the Fortress assembly are: 'Extreme Climate' spray foam by Titan Professional, Fortress air cavity and Fortress PVC material.

Fortress Installation Systems. has provided two (2) different versions of Fortress to be tested. They are identified as "1st Generation" and "2nd Generation", being the main difference that the 1st generation is a hollow shape, closed in all its three sides. Whereas the 2nd generation is an open shape that allows to be infilled with spray foam after the window is installed. Due to the variability in height of the spray foam applied into the cavity of the 2nd generation test specimen, the thermal resistance calculations consider only the depth of the material through the geometric center of the triangular shape. Therefore, thermal resistance values expressed herein are an average value of the assembly.

The nominal thermal resistance of materials that make up the Fortress assembly has been taken from the manufacturer's technical documentation and the NBC-2019 (AE). These values are as follow:

Material	R-value (h.ft^2.°F/BTU)	RSI (m^2.K/W)
PVC	negligible	negligible
Air cavity depth: 27 mm (Ezee Dam 1st generation)	1.0	0.18
'Extreme Climate' spray foam by Titan Professional	4.5 per inch	0.79 per inch

3.0 RESULTS

3.1 Water Penetration Resistance

Results of the water penetration resistance test of the Fortress *without* insulating foam interior sealant installed are as follow:

	Differential pressure	Test duration	Failure description
Specimen A	140 Pa	15 sec.	Water mist into the test chamber
	300 Pa	2 sec.	Water droplets into the test chamber observed immediately
Specimen B	140 Pa	15 min.	No water observed into the test chamber
	330 Pa	2 sec.	Water droplets into the test chamber observed immediately

Results of the water penetration resistance test of the Fortress *with* insulating foam interior sealant installed are as follow:

	Differential pressure	Test duration	Failure description
Specimen A	140 Pa	15 min.	No water observed into the test chamber
	440 Pa	15 min.	No water observed into the test chamber
Specimen B	140 Pa	15 min.	No water observed into the test chamber
	440 Pa	15 min.	No water observed into the test chamber

After completing testing as describe in above table, pressure was gradually increased until reaching 1000 Pa with no water penetration observed. The pressure incremental was applied for a short period of time (i.e. less than 5 minutes).

3.2 Thermal Resistance

- 1st Generation Fortress sub-assembly

Material	R-value ($h.ft^2.°F/BTU$)	RSI ($m^2.K/W$)
PVC	negligible	negligible
Air cavity (Fortress 1st generation)	1.0	0.18
'Extreme Climate' spray foam by Titan Professional	N/A	N/A
Total Effective Thermal Resistance	***1.0***	***0.18***

- 2nd Generation Fortress assembly

When spray foam is applied to infill the cavity underneath the slope surface of the Fortress, an average depth of 1-1/8" of spray foam is installed, resulting in the following insulation values:

Material	R-value ($h.ft^2.°F/BTU$)	RSI ($m^2.K/W$)
PVC	negligible	negligible
Air cavity (Fortress 1st generation)	N/A	N/A
'Extreme Climate' insulating foam by Titan Professional	5.1	0.89
Total Effective Thermal Resistance	***5.1***	***0.89***

4.0 LIMITATONS

- Lack of recognized standards to test water penetration resistance of back dam installed on window sill.
- Lack of recognized standards in the building envelope industry to test thermal resistance of asymmetrical and small size geometries.
- Installation flaws.
  - Nailing fin is not continuous around window perimeter creating voids that interconnect the outdoor and indoor conditions. In order to resemble on site installation, OEE has taped corners to provide continuity of nailing flanges.
  - Nailing fin has been snapped into the window frame in laboratory at the time of installation. Installation as is requires a flashing membrane to be installed against the window frame to seal discontinuity between window frame and nailing fin. OEE has modified installation by taping the sides window frame/nailing fin joints in order to reduce the likelihood of water intrusion at these locations. Modification is based on the assumption that onsite installations do not allow discontinuities at the window jambs.
  - Sill plate of 'Specimen A' has not been installed square and true. Installation as is creates a bigger gap between the window frame and the Fortress at one of the corners. This detail, in addition to nailing fin discontinuities, might generate distorted results.

5.0 CONCLUSIONS

5.1 Water Penetration Resistance

Results of water penetration test performed on Specimen A, where rough opening was not square and true, show that at a differential pressure of 140 Pa there is water ingress into the wall cavity when tested without the spray foam interior seal. When Fortress is installed tight to the window frame (i.e. Specimen B) and without spray foam interior seal, the system is able to resist up to 330Pa. At this point the system fails allowing water ingress into the wall cavity.

The research has shown that Fortress drainage pan system installed in conjunction with spray foam interior seal as per manufacturer's installation instructions provides greater water penetration resistance. The system is able to resist a differential pressure of 440Pa applied for 15 minutes without evidence of water penetration into the wall cavity. The system has been tested for a shorter period of time up to 1000Pa differential pressure without evidence of failure.

Limitations on the research may have introduced deviations of the results. OEE recommends increasing the size of the sample (i.e. more units to be tested) and repeat testing eliminating as many limitations as practical before using results for marketing or external use.

5.2 Thermal Resistance

Polyvinyl Chloride (PVC) material does not have appreciable R-value, therefore it is not deemed to be an insulation material. Thermal resistance characteristics of the Fortress product is provided by the spray foam applied into the hollow cavity or the air cavity depending on the generation installed. Air cavity of the Fortress '1st Generation' provides an average R value of 1.0. Infilling the hollow cavity of the Fortress '2nd Generation' allows to install an average spray foam depth of 28.5 mm (1-1/8") resulting in an average R value 5.1, significantly greater than Fortress '1st Generation'.

6.0 DISCLAIMERS

OEE notes that information, photographs and videos provided as part of this report are intended solely for internal use of Fortress Installation Systems, its Partners or Affiliates. OEE is not an accredited testing laboratory. Therefore, the purpose of the water penetration test is only for Research and Development (R&D) and results expressed herein should not be used for marketing, patents or permit purposes.

OEE is an independent third party and has no ties to ownership or financial gain of Fortress Installation System's., its Partners or Affiliates.

7.0 REFERENCES

AMERICAN SOCIETY FOR TESTING. (Reapproved 2009). *ASTM E331-00 - Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors and Curtain Walls by uniform Static Pressure Difference.* ASTM International.

EZEEDAM. (2019, September 23). *Fortress Installation Procedure*. Retrieved from Ezee Dam America, Inc.: https://www.ezeedam.com/installation

NATIONAL RESEARCH COUNCIL OF CANADA. (2019). *NATIONAL BUILDING CODE - 2019 ALBERTA EDITION.* Ottawa: National Research Council of Canada.

SELENA GROUP. (2019, October 10). *Pro Extreme Climate Insulating Foam Sealant - Technical data sheet.* Retrieved from Tytan Professional web site: http://www.tytanpro.ca/products/pro-extreme-climate-insulating-foam-sealant-24oz

APPENDIX A: ASTM E331-00 (REAPPROVED 2009)

Designation: E331 – 00 (Reapproved 2009)

Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference[1]

This standard is issued under the fixed designation E331; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the determination of the resistance of exterior windows, curtain walls, skylights, and doors to water penetration when water is applied to the outdoor face and exposed edges simultaneously with a uniform static air pressure at the outdoor face higher than the pressure at the indoor face.

1.2 This test method is applicable to any curtain-wall area or to windows, skylights, or doors alone.

1.3 This test method addresses water penetration through a manufactured assembly. Water that penetrates the assembly, but does not result in a failure as defined herein, may have adverse effects on the performance of contained materials such as sealants and insulating or laminated glass. This test method does not address these issues.

1.4 The proper use of this test method requires a knowledge of the principles of pressure measurement.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements, see 7.1.

2. Referenced Documents

2.1 *ASTM Standards:*[2]
E631 Terminology of Building Constructions

3. Terminology

3.1 *Definitions*—For definitions of general terms relating to building construction used in this test method, see Terminology E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *specimen, n*—the entire assembled unit submitted for test as described in Section 8.

3.2.2 *test pressure difference, n*—the specified difference in static air pressure across the closed and locked or fixed specimen expressed as pascals (lbf/ft^2).

3.2.3 *water penetration, n*—penetration of water beyond a plane parallel to the glazing (the vertical plane) intersecting the innermost projection of the test specimen, not including interior trim and hardware, under the specified conditions of air pressure difference across the specimen. For products with non-planer glazing surfaces (domes, vaults, pyramids, etc.), the plane defining water penetration is the plane defined by the innermost edges of the unit frame.

4. Summary of Test Method

4.1 This test method consists of sealing the test specimen into or against one face of a test chamber, supplying air to or exhausting air from the chamber at the rate required to maintain the test pressure difference across the specimen, while spraying water onto the outdoor face of the specimen at the required rate and observing any water penetration.

[1] This test method is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.51 on Performance of Windows, Doors, Skylights, and Curtain Walls.

Current edition approved Feb. 1, 2009. Published March 2009. Originally approved in 1967. Last previous edition approved in 2000 as E331 – 00. DOI: 10.1520/E0331-00R09.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

5. Significance and Use

5.1 This test method is a standard procedure for determining the resistance to water penetration under uniform static air pressure differences. The air-pressure differences acting across a building envelope vary greatly. These factors should be fully considered prior to specifying the test pressure difference to be used.

NOTE 1—In applying the results of tests by this test method, note that the performance of a wall or its components, or both, may be a function of proper installation and adjustment. In service, the performance will also depend on the rigidity of supporting construction and on the resistance of components to deterioration by various causes, vibration, thermal expansion and contraction, etc. It is difficult to simulate the identical complex wetting conditions that can be encountered in service, with large wind-blown water drops, increasing water drop impact pressures with increasing wind velocity, and lateral or upward moving air and water. Some designs are more sensitive than others to this upward moving water.

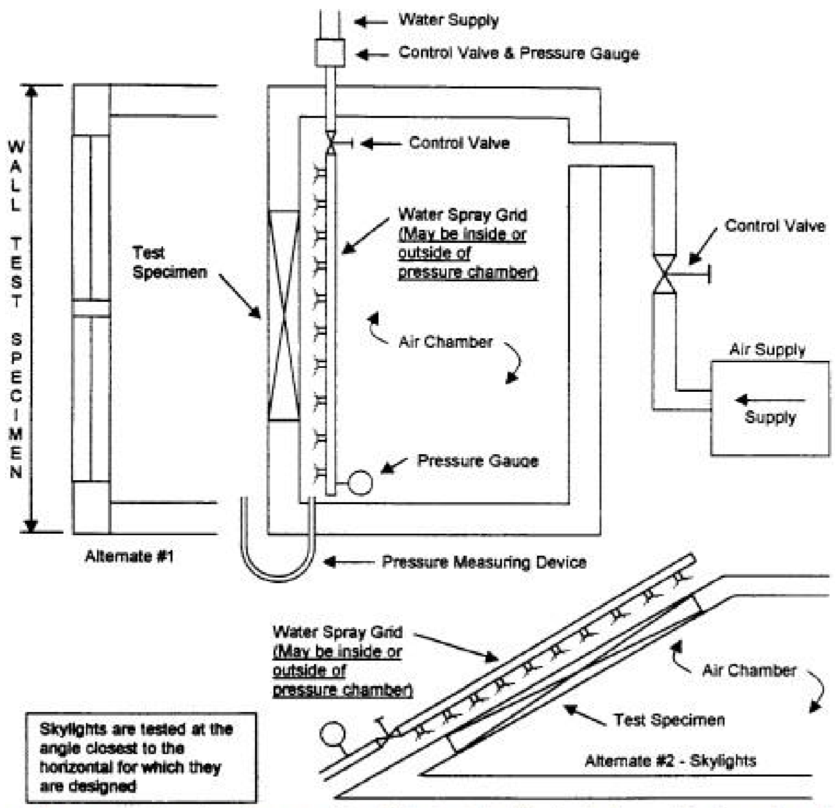
NOTE 2—This test method does not identify unobservable liquid water which may penetrate into the test specimen.

6. Apparatus

6.1 The description of apparatus in this section is general in nature and any arrangement of equipment capable of performing the test procedure within the allowable tolerances is permitted.

6.2 *Major Components* (Fig. 1):

6.2.1 *Test Chamber*—A test chamber or box with an opening, a removable mounting panel, or one open side in which or against which the specimen is installed and sealed. At least one static pressure tap shall be provided to measure the chamber pressure, and shall be so located that the reading is unaffected by the velocity of the air supply to or from the chamber. The air supply opening into the chamber shall be arranged so that the air does not impinge directly on the test specimen with any significant velocity. A means of access into the chamber may be provided to facilitate adjustments and observations after the specimen has been installed.



NOTE 1—For a negative pressure system, the water-spray grid would be located outside the chamber and the air supply would be replaced by an air-exhaust system.

FIG. 1 General Arrangement of the Water Leakage Apparatus Positive Chamber System

6.2.2 *Air System*—A controllable blower, compressed air supply, exhaust system, or reversible blower designed to provide the required maximum air-pressure difference across the specimen. The system must provide essentially constant airflow at a fixed pressure for the required test period.

6.2.3 *Pressure-Measuring Apparatus*—A device to measure the test pressure difference within a tolerance of $\pm 2\%$ or ± 2.5 Pa (± 0.01 in. of water column), whichever is greater.

6.2.4 *Water-Spray System*—The water-spray system shall deliver water uniformly against the exterior surface of the test specimen at a minimum rate of 3.4 L/m^2 · min (5.0 U.S. gal/ft^2 · h).

6.2.4.1 The water-spray system shall have nozzles spaced on a uniform grid, located at a uniform distance from the test specimen, and shall be adjustable to provide the specified quantity of water in such a manner as to wet all of the test specimen uniformly and to wet those areas vulnerable to water penetration. If additional nozzles are required to provide uniformity of water spray at the edge of the test specimen, they shall be equally spaced around the entire spray grid.

7. Hazards

7.1 **Warning**—Glass breakage will not normally occur at the small pressure differences applied in this test. Excessive pressure differences may occur, however, due to error in operation or when the apparatus is used for other purposes such as structural testing; therefore, exercise adequate precautions to protect personnel.

8. Test Specimen

8.1 Test specimens shall be of sufficient size to determine the performance of all typical parts of the fenestration system. For curtain walls or walls constructed with prefabricated units, the specimen width shall be not less than two typical units plus the connections and supporting elements at both sides, and sufficient to provide full loading on at least one typical vertical joint or framing member or both. The height shall be not less than the full building-story height or the height of the unit, whichever is greater, and shall include at least one full horizontal joint accommodating vertical expansion, such joint being at or near the bottom of the specimen, and all connections at the top and bottom of the units.

8.1.1 All parts of the test specimen shall be full size, using the same materials, details, and methods of construction and anchorage as used on the actual building.

8.1.2 Conditions of structural support shall be simulated as accurately as possible.

8.2 Window, skylight, door, or other component test specimens shall consist of the entire assembled unit, including frame and anchorage as supplied by the manufacturer for installation in the building.

8.2.1 If only one specimen is to be tested, the selection shall be determined by the specifying authority.

NOTE 3—It should be recognized, especially with windows, that performance is likely to be a function of size and geometry. Therefore, select specimens covering the range of sizes to be used in a building. In general, the largest size of a particular design, type, construction, and configuration to be used should be tested.

9. Calibration

9.1 The ability of the test apparatus to meet the requirements of 6.2.4 shall be checked by using a catch box, the open face of which shall be located at the position of the face of the test specimen. The calibration device is illustrated in Fig. 2. The catch box shall be designed to receive only water impinging on the plane of the test specimen face and to exclude all run-off water from above. The box shall be 610 mm (24 in.) square, divided into four areas each 305 mm (12 in.) square. Use a cover approximately 760 mm (30 in.) square to prevent water from entering the calibration box before and after the timed observation interval. The water impinging on each area shall be captured separately. A spray that provides at least 1.26 L/min (20 gal/h) total for the four areas and not less than 0.25 L/min (4 gal/h) nor more than 0.63 L/min (10 gal/h) in any one square shall be acceptable.

9.1.1 The water-spray system shall be calibrated at both upper corners and at the quarter point of the horizontal center line (of the spray system). If a number of identical, contiguous,

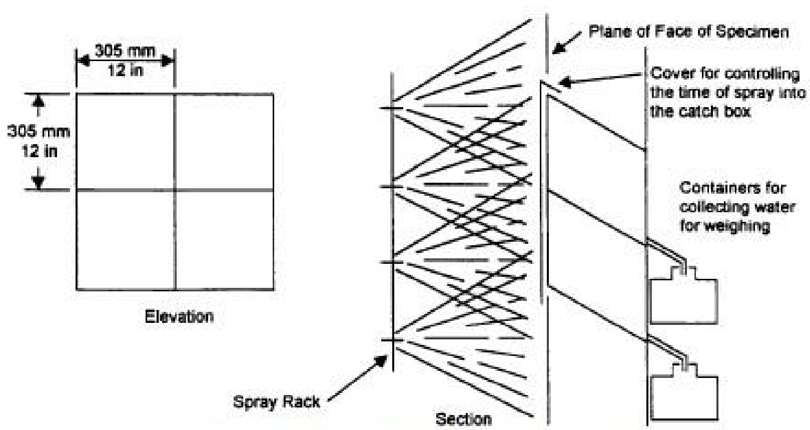


FIG. 2 Catch Box for Calibrating Water-Spray System

modular spray systems are used, only one module need be calibrated. The system shall be calibrated with the catch boxes at a distance within ±50 mm (2 in.) of the test specimen location from the nozzle. The reference point for location of the spray system from the specimen shall be measured from the exterior glazing surface of the specimen farthest from the spray system nozzles. The water spray shall be installed parallel to the plane of the specimen. Recalibrate at intervals of not more than six months.

10. Information Required

10.1 The test-pressure difference or differences at which water penetration is to be determined, unless otherwise specified, shall be 137 Pa (2.86 lbf/ft^2).

10.2 Unless otherwise specified, failure criteria of this test method shall be defined as water penetration in accordance with 3.2.3. Failure also occurs whenever water penetrates through the perimeter frame of the test specimen. Water contained within drained flashing, gutters, and sills is not considered failure.

11. Procedure

11.1 Remove any sealing material or construction that is not normally a part of the assembly as installed in or on a building. Fit the specimen into or against the chamber opening with the outdoor side of the specimen facing both the high pressure side of the chamber and the water spray, and in such a manner, that no joints or openings are obstructed. Skylight specimens shall be tested at the minimum angle from the horizontal for which they are designed to be installed. Seal the outer perimeter of the specimen to the chamber wall and seal at no other points.

NOTE 4—Nonhardening mastic compounds or pressure-sensitive tape can be used effectively to seal the test specimen to the chamber opening, to seal the access door to the chamber, and to achieve airtightness in the construction of the chamber. These materials can be used to seal a separate mounting panel to the chamber. Rubber gaskets with clamping devices may also be used for this purpose provided that the gasket is highly flexible and has a small contact edge.

11.2 Without disturbing the seal between the specimen and the test chamber, adjust all operable units included in the test specimen so that their operation conforms to the specification requirements. Adjust all hardware for maximum tightness without interfering with their operation.

11.3 Submit each operable unit to five cycles of opening, closing, and locking prior to testing.

11.4 Adjust the water spray to the specified rate.

11.5 Apply the air-pressure difference within 15 s and maintain this pressure, along with the specified rate of water spray, for 15 min.

11.6 Remove the air-pressure difference and stop the water spray.

11.7 Observe and record the points of water penetration, if any.

12. Report

12.1 Report the following information:

12.1.1 Date of test and date of report.

12.1.2 Identification of the specimen (manufacturer, source of supply, dimensions, model, type, materials, and other pertinent information).

12.1.3 Detailed drawings of the specimen that provide a description of the physical characteristics including dimensioned section profiles, sash or door dimensions and arrangement, framing location, panel arrangement, installation and spacing of anchorage, weatherstripping, locking arrangement, hardware, sealants, glazing details, angle from the horizontal for skylights, and any other pertinent construction details. Any modifications made on the specimen to obtain the reported values shall be noted on the drawings.

12.1.4 For window, skylight, and door components, a description of the locking and operating mechanism.

12.1.5 Identification of glass thickness and type and method of glazing.

12.1.6 Type or types of weatherstrip.

12.1.7 A statement or tabulation of pressure difference or differences exerted across the specimen and temperature during the tests and water application rates during the test.

12.1.8 A record of all points of water penetration on the indoor face of the test specimen, and of water penetration as defined in 3.2.3.

12.1.9 When the tests are made to check the conformity of the specimen to a particular specification, an identification or description of that specification shall be included.

12.1.10 A statement that the test or tests were conducted in accordance with this test method, or a complete description of any deviations from this test method.

12.2 If several identical specimens of a component are tested, the results for all specimens shall be reported, each specimen being properly identified, particularly with respect to distinguishing features or differing adjustments. A separate drawing for each specimen shall not be required if all differences between them are noted on the drawings provided.

13. Precision and Bias

13.1 No statement is made either on the precision or bias of this test method for measuring water penetration since the result merely states whether there is conformance to the criteria specified for success.

14. Keywords

14.1 curtain walls; doors; skylights; water penetration; windows

APPENDIX B: 2019 NATIONAL BUILDING CODE – ALBERTA EDITION EXCERPTS

A-9.36.2.4.(1) Calculating the Effective Thermal Resistance of Building Envelope Assemblies. The general theory of heat transfer is based on the concept of the thermal transmittance through an element over a given surface area under the temperature difference across the element (see Sentence 9.36.1.2.(2)). As such, the NECB requires all building envelope assemblies and components to comply with the maximum U-values (overall thermal transmittance) stated therein. However, the requirements in Subsection 9.36.2. are stated in RSI values (effective thermal resistance values), which are the reciprocal of U-values.

To calculate effective thermal resistance, Section 9.36. requires that contributions from all portions of an assembly—including heat flow through studs and insulation—be taken into account because the same insulation product (nominal insulation value) can produce different effective thermal resistance values in different framing configurations. The resulting effective thermal resistance of an assembly also depends on the thermal properties and thickness of the building materials used and their respective location.

The following paragraphs provide the calculations to determine the effective thermal resistance values for certain assemblies and the thermal characteristics of common building materials. The Tables in Notes A-9.36.2.6.(1) and A-9.36.2.8.(1) confirm the compliance of common building assemblies.

Calculating the Effective Thermal Resistance of an Assembly with Continuous Insulation: Isothermal-Planes Method

To calculate the effective thermal resistance of a building envelope assembly containing only continuous materials—for example, a fully insulated floor slab—simply add up the RSI values for each material. This procedure is described as the "isothermal-planes method" in the "ASHRAE Handbook – Fundamentals."

Table A-9.36.2.4.(1)-D
Thermal Resistance Values of Common Building Materials(1)

Air Films	Thickness of Material	Thermal Resistance (RSI), ($m^2 \cdot K$)/W per mm	Thermal Resistance (RSI), ($m^2 \cdot K$)/W for thickness listed
Exterior:			
ceiling, floors and walls wind 6.7 m/s (winter)	—	—	0.03
Interior:			
ceiling (heat flow up)	—	—	0.11
floor (heat flow down)	—	—	0.16
walls (heat flow horizontal)	—	—	0.12
Air Cavities(2)(3)	Thickness of Air Space	Thermal Resistance (RSI), ($m^2 \cdot K$)/W per mm	Thermal Resistance (RSI), ($m^2 \cdot K$)/W for thickness listed
Ceiling (heat flow up) faced with non-reflective material(4)	13 mm	—	0.15
	20 mm	—	0.15
	40 mm	—	0.16
	90 mm	—	0.16
Floors (heat flow down) faced with non-reflective material(4)	13 mm	—	0.16
	20 mm	—	0.18
	40 mm	—	0.20
	90 mm	—	0.22
Walls (heat flow horizontal) faced with non-reflective material(4)	13 mm	—	0.16
	20 mm	—	0.18
	40 mm	—	0.18
	90 mm	—	0.18

APPENDIX C: INSULATING FOAM TECHNICAL DATA

TYTAN PROFESSIONAL Extreme Climate Insulating Foam Sealant Pro 29oz

TYTAN PROFESSIONAL Extreme Climate is an innovative one-component polyurethane foam especially formulated for use in temperature applications from -4°F /-20°C to 100°F /38°C. Excellent for filling, insulating, and sealing of gaps, cracks, and openings in the interior and exterior of buildings. The ground-breaking formula creates a durable airtight seal, and stops cold air infiltration and heat loss. TYTAN PROFESSIONAL Extreme Climate provides a high insulating value, is economical, and saves energy. It has excellent adhesion to most common building materials including wood, glass, metal, masonry, and plastic. TYTAN PROFESSIONAL Extreme Climate is environmentally friendly, contains no CFC's or HCFC's, and it is UL Classified.

FEATURES

- Extreme temperature formula - cures even in freezing weather -4°F (-20°C).
- Low pressure, for windows & doors.
- Designed to cure in low humidity conditions, great for dry climates.
- Economically insulates, fills, seals, and bonds.
- Durable weather seal - stops cold air infiltration and heat loss.
- High insulating value - saves energy and money.
- Bonds and seals popular materials: wood, concrete, plaster, plumbing, etc.
- Certified by UL Canada to Exceed the Requirements of CAN/ULC-S115
- Shelf life 12 months.

APPLICATIONS

++	SEALING FOR WINDOW FITTING
++	SEALING FOR DOOR FITTING
+	FILLING FREE SPACES, CRACKS, GAPS, PIPE PENETRATIONS
+	SEALING ROOF, WALL AND FLOOR JOINTS
+	THERMAL INSULATION
+	ACOUSTIC INSULATION

+++ foam dedicated/recommended for this application; ++ foam suitable for this application; + foam meeting basic requirements; - not suitable for this application

BENEFITS

▲▲	FOAM YIELD
■	FOAM PRESSURE
■	FOAM VOLUME INCREASE (POSTEXPANSION)
■	FOAM FLAMMABILITY
-	FOAM MULTIPOSITIONING
■	FOAM ADHESION TO SURFACE

▲▲▲ high; ▲▲ increased; ■ normal; ▼▼ decreased; ▼▼▼ low; - no application

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TYTAN PROFESSIONAL

APPLICATION CONDITIONS

Can/ applicator temperature [°C] (optimal +20°C)	41°F ÷ 86°F +5°C ÷ +30°C
Ambient/ surface temperature [°C]	-4°F ÷ 100°F -20°C ÷ +38°C

DIRECTIONS FOR USE

Prior to application, read safety instruction presented at the end of TDS and in MSDS.

1. SURFACE PREPARATION

The foam presents ideal adhesion to typical construction materials, such as: brick, concrete, plaster work, wood, metals, styrofoam, hard PVC and rigid PUR.

- Working surface should be cleaned and degreased.
- Secure surfaces exposed to accidental foam contamination.

2. PRODUCT PREPARATION

- Too cold can should be brought to room temperature, e.g. by immersion in warm water with temperature up to +86 F (+30°C) or leaving it in room temperature for at least 24 h.
- Applicator temperature cannot be lower than can temperature.

3. APPLICATION

- Put on protective gloves.
- Vigorously shake the can (10-20 seconds, the valve facing down) to thoroughly mix the components.
- Screw the can onto the applicator.
- Working position of the can is "valve facing down".
- Vertical gaps should be filled with foam starting at the bottom and moving up.
- Do not fill the entire gap – the foam will increase in volume.
- In case of sealing the open woodwork, gaps >1,18 in (3 cm) are not recommended. Gaps >1,97 in (5cm) are unacceptable. Slots wider than 1,18 in (3 cm) from the bottom to fill up from one wall to the other alternately forming a zigzag pattern.
- Should application be interrupted for more than 5 minutes, the applicator nozzle with fresh foam should be cleaned with polyurethane foam cleaner and the can should be shaken prior to application.

4. WORKS AFTER COMPLETION OF APPLICATION

- Immediately after full foam hardening, it should be secured against exposure to UV rays by using e.g. plaster or paints, acrylic, silicon.
- After completion of work, the applicator should be thoroughly cleaned. To this end, a can with the cleaner should be screwed on the applicator and its trigger should be pushed until the moment, when clean fluid starts flowing out.

5. REMARKS / RESTRICTIONS

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DOOR AND WINDOWS FITTING WITHOUT USING MECHANICAL COUPLING IS FORBIDDEN. LACK OF MECHANICAL COUPLINGS MAY CAUSE DEFORMATION OF THE MOUNTED ELEMENT.

- The curing process is dependent on temperature and humidity. The decrease in ambient temperature within 24 h after the application below the minimum application temperature can affect the quality and / or correctness of the seal.
- Hurried attempts at preliminary treatment may cause irreversible changes in foam structure and its stability and may affect deterioration of foam utility parameters.
- Open foam package should be used within 1 week.
- The foam displays lack of adhesion to polyethylene, polypropylene, polyamide, silicone and Teflon.
- Fresh foam should be removed with polyurethane foam cleaner.
- Hardened foam may only be removed mechanically (e.g. with a knife).
- Quality and technical condition of used applicator affect the parameters of final product.
- The foam should not be used in spaces without access of fresh air and poorly ventilated or in places exposed to direct sunlight.

TECHNICAL DATA

Color	
yellow	+

Parameter (+23°C/50% RH) 1)	Value
Nominal value [oz]	29
Capacity (free foaming) [l] (RB024)	48 - 54
Capacity (free foaming) cu [ft]	1,70 - 1,91
Capacity (free foaming) 1/2" [ft]	1243
Capacity (free foaming) 3/8" [ft]	2210
Capacity (free foaming) 1/4" [ft]	4973
Capacity in gap [l] (RB024) 2)	29 - 34
Capacity in gap cu [ft]	1,02 - 1,20
Secondary increase in volume (post-expansion) (TM1010-2012**)	90 - 130
Tack-free time [min] (TM 1014-2013**)	≤ 10
Cutting time [min] (TM 1005-2013**) 3)	≤ 40
Full cure time [h] (RB024)	24
Heat conductivity coefficient (λ) [W/m*K] (RB024)	≤ 0,036
Dimensional stability [%] (TM 1004-2013**)	≤ 5
Flammability class (DIN 4102)	B3
Flammability class (EN 13501-1:2008)	F
R Value (per inch)	4 - 5

1) All given parameters are based on laboratory tests compliant with internal manufacturer's standards and strongly depend on foam hardening conditions (ca, ambient, surface temperature, quality of used equipment and skills of person applying the foam).
2) The value given for a gap with dimensions 30*100*35 (width *length *depth [mm]).
3) The manufacturer recommends to commence finishing works after full hardening is completed, i.e. after 24 h. The result given for a foam strip of 3 cm diameter.
**Producer uses test methods approved by FEICA designed to deliver transparent and reproducible test results, ensuring customers have an accurate representation of product performance. FEICA OCF test methods are available at:

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http://www.feica.com/our-industry/pu-foam-technology-ocf. FEICA is a multinational association representing the European adhesive and sealant industry, including one-component foam manufacturers. Further information at: www.feica.eu

TRANSPORT / STORAGE

Transport temperature	Foam transport period [days]
< -20°C	4
-19°C ÷ -10°C	7
-9°C ÷ 0°C	10

The foam maintains its usability within 12 months from manufacturing date, provided that it is stored in original packaging in vertical position (valve facing up) in a dry place in temperature +5°C do +30°C. Storage in temperature exceeding +30°C shortens the shelf life of the product, adversely affecting its parameters. The product may be stored in temperature -5°C, no longer however than for 7 days (excluding transport). Storage of foam cans in temperature exceeding +50°C or in vicinity of open flame is not allowed. Storage of the product in a position other than recommended may result in jamming the valve. The can cannot be squeezed or pierced even when it is empty. Do not store the foam in the passenger compartment. Transported only in the trunk.
Detailed transport information is included in the Material Safety Data Sheet (MSDS).

The information contained herein is offered in good faith based on Producer's research and is believed to be accurate. However, because conditions and methods of use of our products are beyond our control, this information shall not be used in substitution for customer's tests to ensure that Producer's products are fully satisfactory for your specific applications. Producer's sole warranty is that the product will meet its current sales specifications. Your exclusive remedy for breach of such warranty is limited to refund of purchase price or replacement of any product shown to be other than warranted. Producer specifically disclaims any other expressed or implied warranty of fitness for a particular purpose or merchantability. Producer disclaims liability for any incidental or consequential damages. Suggestions of use shall not be taken as inducements to infringe any patent.

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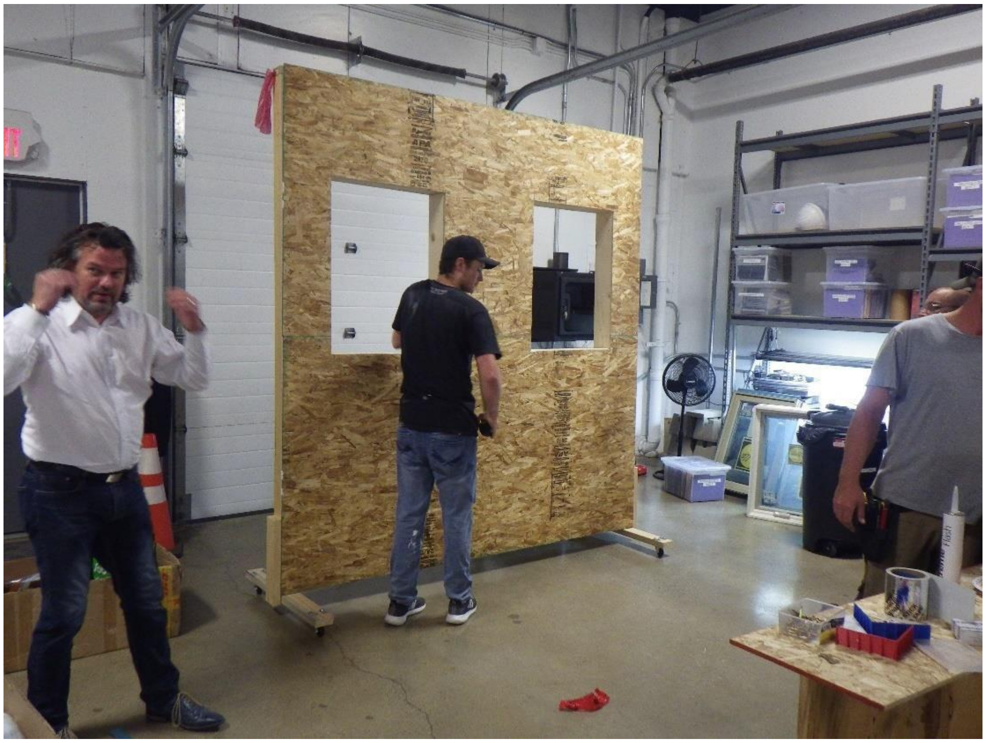
APPENDIX D: PHOTOGRAPHS



Photograph 1: Wall mock-up

Photograph 2: Sheathing membrane

Photograph 3: Fortress corner installation

Photograph 4: Fortress center strip installation – 1st Generation

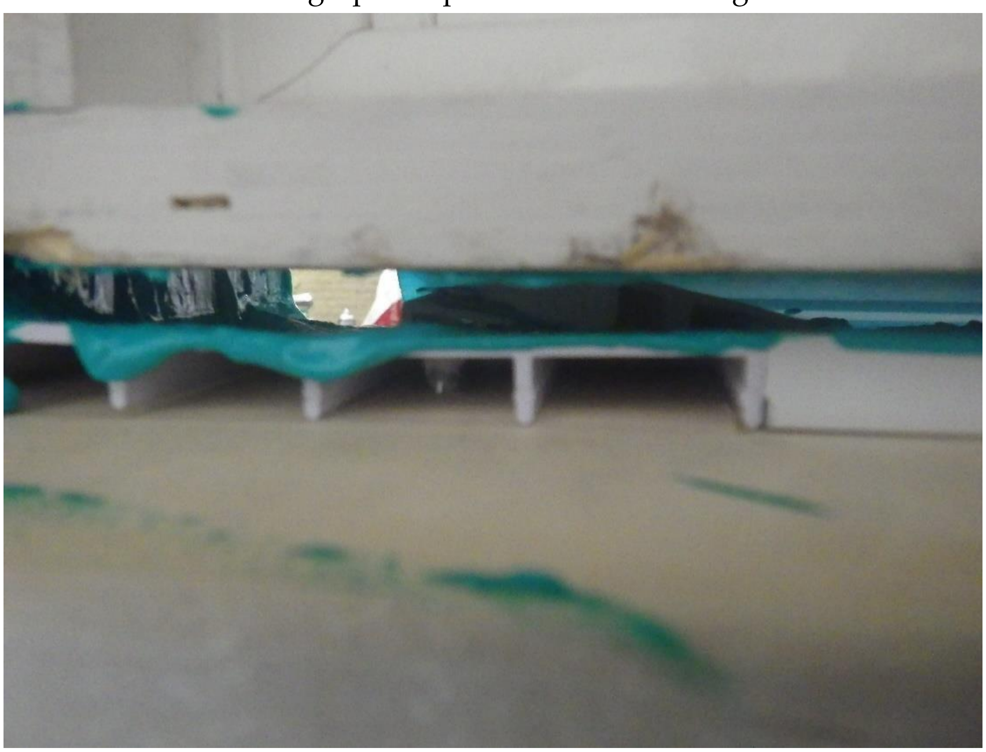
Photograph 5: Fortress center strip installation – 2nd Generation

Photograph 6: Standard location of Fortress. 1 $^{3}/_{8}$ "– 1 ¾" from inside

Photograph 7: Liquid sill membrane

Photograph 8: Specimen A - Shimming

Photograph 9: Specimen B - Shimming



Photograph 10: Specimen A installation. Left corner (from indoor)
Note gap between Fortress and window frame

Photograph 11: Specimen A installation
Right corner (from indoor)

Photograph 12: Specimen A - Water penetration resistance test

Photograph 13: Specimen A – Differential pressure

Photograph 14: Specimen A – test chamber

Photograph 15: Specimen B - Water penetration resistance test

Photograph 16: Specimen B - Water penetration resistance test

Photograph 17: Interior seal installation

Photograph 18: Interior seal installation

Photograph 19: Specimen A with interior seal
Water penetration resistance test

Photograph 20: Specimen B with interior seal

Photograph 21: Specimen B with interior seal
Water penetration resistance test

Designation: E1105 − 15 (Reapproved 2023)

Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference[1]

This standard is issued under the fixed designation E1105; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the resistance of installed exterior windows, curtain walls, skylights, and doors to water penetration when water is applied to the outdoor face and exposed edges simultaneously with a static air pressure at the outdoor face higher than the pressure at the indoor face.

1.2 This test method is applicable to any curtain-wall area or to windows, skylights, or doors alone. It is intended primarily for determining the resistance to water penetration through such assemblies for compliance with specified performance criteria, but it may also be used to determine the resistance to penetration through the joints between the assemblies and the adjacent construction. Other procedures may be appropriate to identify sources of leakage.

1.3 This test method addresses water penetration through a manufactured assembly. Water that penetrates the assembly, but does not result in a failure as defined herein, may have adverse effects on the performance of contained materials such as sealants and insulating or laminated glass. This test method does not address these issues.

1.4 The proper use of this test method requires a knowledge of the principles of pressure measurement.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements, see 7.1.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E331 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference

E547 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference

E631 Terminology of Building Constructions

3. Terminology

3.1 *Definitions*—For definitions of general terms relating to building construction used in this test method, see Terminology E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *specimen, n*—the entire assembled unit submitted for test as installed in the exterior wall of a building.

3.2.1.1 *Discussion*—The test specimen consists of the major components of the assembly, including all joints, cracks, or openings between such components and any panning, receptors, extenders, sills, mullions, or other parts or components used for assembling any installation. The joints between assemblies and the openings into which they are mounted (masonry openings, for example) are not part of the test specimen. However, these joints may be tested by this procedure.

3.2.2 *test pressure difference, n*—the specified difference in static air pressure across the closed and locked or fixed specimen expressed in lbf/ft^2 (pascals).

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[1] This test method is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.51 on Performance of Windows, Doors, Skylights and Curtain Walls.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2.3 *water penetration, n*—penetration of water beyond a plane parallel to the glazing (the vertical plane) intersecting the innermost projection of the test specimen, not including interior trim and hardware, under the specified conditions of air pressure difference across the specimen. For products with non-planer surfaces (domes, vaults, pyramids, etc.) the plane defining water penetration is the plane defined by the innermost edges of the unit frame.

4. Summary of Test Method

4.1 This test method consists of sealing a chamber to the interior or exterior face of specimen to be tested, supplying air to a chamber mounted on the exterior or exhausting air from a chamber mounted on the interior, at the rate required to maintain the test pressure difference across the specimen while spraying water onto the outdoor face of the specimen at the required rate and observing any water penetration.

5. Significance and Use

5.1 This test method is a standard procedure for determining the resistance to water penetration under uniform or cyclic static air pressure differences of installed exterior windows, skylights, curtain walls, and doors. The air-pressure differences acting across a building envelope vary greatly. These factors should be considered fully prior to specifying the test pressure difference to be used.

NOTE 1—In applying the results of tests by this test method, note that the performance of a wall or its components, or both, may be a function of proper installation and adjustment. In service, the performance will also depend on the rigidity of supporting construction and on the resistance of components to deterioration by various causes, vibration, thermal expansion and contraction, and so forth. It is difficult to simulate the identical complex wetting conditions that can be encountered in service, with large wind-blown water drops, increasing water drop impact pressures with increasing wind velocity, and lateral or upward moving air and water. Some designs are more sensitive than others to this upward moving water.

NOTE 2—This test method does not identify unobservable liquid water which may penetrate into the test specimen.

5.2 Laboratory tests are designed to give an indication of the performance of an assembly. Field performance may vary from laboratory performance since the supporting structure for the test specimen, methods of mounting, and sealing in the laboratory can only simulate the actual conditions that will exist in the building. Shipping, handling, installation, acts of subsequent trades, aging, and other environmental conditions all may have an adverse effect upon the performance of the installed product. This field test procedure provides a means for determining the performance of a product once installed in the building.

5.3 The field test may be made at the time the window, skylight, curtain-wall, or door assemblies are initially installed and before the interior of the building is finished. At this time, it is generally easier to check the interior surfaces of the assemblies for water penetration and to identify the points of penetration. The major advantage of testing when assemblies are initially installed is that errors in fabrication or installation can be readily discovered and corrections made before the entire wall with its component assemblies is completed at which time the expense of corrective work may be increased many times.

5.4 The field test may also be made after the building is completed and in service to determine whether or not reported leakage problems are due to the failure of the installed assemblies to resist water penetration at the specified static air pressure difference. Generally it is possible to conduct tests on window, skylight, and door assemblies without too much difficulty, and to identify sources of leakage. A curtain-wall assembly, on the other hand, may not be accessible from the inside without the removal of interior finished walls and ceilings. Even with removal of interior walls and ceilings, it may not be possible to observe curtain-wall surfaces behind spandrel beams. The feasibility of conducting a meaningful static air pressure difference water penetration test on an in-service building must be carefully evaluated before being specified.

5.5 Weather conditions can affect the static air pressure difference measurements. If wind gusting causes pressure fluctuation to exceed ±10 % from the specified test pressure, the test should not be conducted.

5.6 Generally it is more convenient to use an interior mounted pressure chamber from which air is exhausted to obtain a lower pressure on the interior surface of the specimen. A calibrated rack of nozzles is then used to spray water at the proper rate on the exterior surface. Under circumstances where it is desirable to use an exterior-mounted pressure chamber, the spray rack must be located in the pressure chamber and air supplied to maintain a higher pressure on the exterior surface. Exterior chambers are difficult to attach readily and seal to exterior surfaces.

5.7 Even though the equipment requirements are similar, this procedure is *not* intended to measure air infiltration because of the difficulty of isolating the component air leakage from the extraneous leakage through weep holes, mullion joints, trim, or other surrounding materials.

6. Apparatus

6.1 The description of apparatus in this section is general in nature, and any arrangement of equipment capable of performing the test procedures within allowable tolerances is permitted.

6.2 *Major Components* (Fig. 1):

6.2.1 *Test Chamber*—A test chamber or box made of plywood, plastic, or other suitable material and sealed against the test specimen. Test chambers mounted on the interior must be made so that interior surfaces and joints of the specimen can be easily observed for water penetration during the test. No part of the testing chamber shall come in contact with or restrict any point where water penetration may occur. At least one static air pressure tap shall be provided to measure the chamber air pressure versus the ambient (interior-exterior) air pressure and shall be so located that the reading is unaffected by exterior impinging wind, or by the velocity of air supply to or from the chamber. The air supply opening into or exhaust from the chamber shall be arranged so that air does not impinge directly on the test specimen with any significant velocity. A means of access into the chamber may be provided to facilitate adjustments and observations after the chamber has been installed.

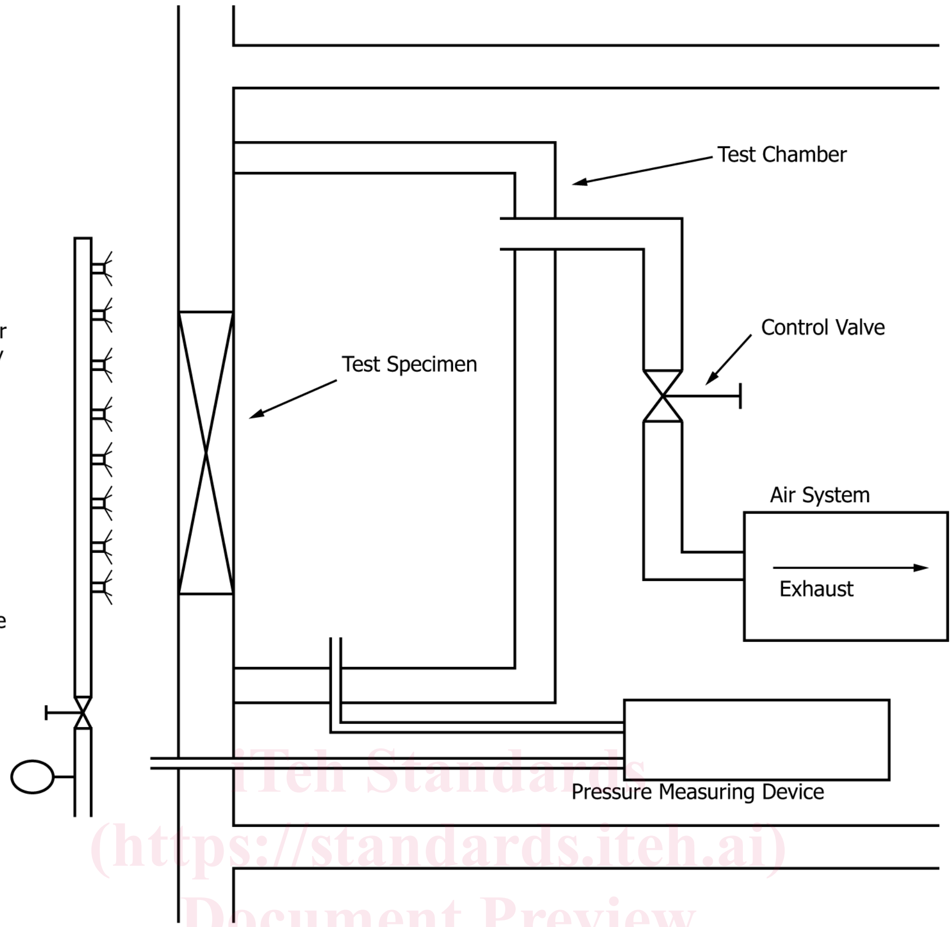

FIG. 1 General Arrangement of Water Penetration Test Apparatus

6.2.2 *Air System*—A controllable blower, compressed air supply exhaust system, or reversible blower designed to supply the required maximum air pressure difference across the specimen. The system must provide essentially constant air flow at a fixed pressure for the required test period.

6.2.3 *Pressure Measuring Apparatus*—A device to measure the test pressure difference within a tolerance of ±2 % or ±0.01 in. (±2.5 Pa of water column), whichever is greater.

6.2.4 *Water-Spray System*—The water-spray system shall deliver water uniformly against the exterior surface of the test specimen at a minimum rate of 5.0 U.S. gal/ft^2·h (3.4 L/m^2·min).

6.2.4.1 The water-spray system shall have nozzles spaced on a uniform grid, located at a uniform distance from the test specimen and shall be adjustable to provide the specified quantity of water in such a manner as to wet all of the test specimen, uniformly and to wet those areas vulnerable to water penetration. If additional nozzles are required to provide uniformity of water spray at the edge of the test specimen, they shall be equally spaced around the entire spray grid.

6.2.4.2 The intake water line to the nozzle grid shall be equipped with a pressure gage and pressure adjusting valve. For field testing, the water pressure shall be adjusted to the same pressure at which the water spray system was calibrated.

7. Hazards

7.1 **Warning—**Glass breakage will not normally occur at the small pressure differences applied in this test method. Excessive pressure differences may occur, however, due to error in operation or gusting wind, therefore, exercise adequate precautions to protect personnel.

7.2 Take whatever additional precautions are necessary to protect persons from water spray, falling objects (which may include tools), the spray system, or even the exterior test chamber.

8. Examination of Test Specimens

8.1 Select and identify the test specimen in accordance with the procedures established in Section 10.

8.2 Conduct a detailed visual examination of the test specimen and the construction adjacent to the test specimen. Record all pertinent observations.

8.3 If the intent is to test an operable window, skylight, or door, the unit should be checked for proper installation by opening, closing, and locking the unit five times prior to testing, with no further attention other than the initial adjustment.

NOTE 3—The purpose of this examination is to record the physical condition of the test specimen and adjacent construction at the time of testing. Examples of pertinent observations to be recorded include; any damage or deterioration observed, missing or broken components, miss-adjustment or weatherstrip or other components, cleanliness of the test specimen, out-of-square installations, and so forth.

9. Calibration

9.1 The ability of the test apparatus to meet the applicable requirements shall be checked by using a catch box, the open face of which shall be located at the position of the face of the test specimen. The calibration device is illustrated in Fig. 2. The catch box shall be designed to receive only water impinging on the plane of the test specimen face and to exclude all run-off water from above. The box shall be 24 in. (610 mm) square, divided into four areas each 12 in. (305 mm) square. Use a cover approximately 30 in. (760 mm) square to prevent water from entering the calibration box before and after the timed observation interval. The water impinging on each area shall be captured separately. A spray that provides at least 20 gal/h (1.26 L/min) total for the four areas and not less than 4 gal/h (0.25 L/min) nor more than 10 gal/h (0.63 L/min) in any one square shall be acceptable.

9.1.1 The water-spray system shall be calibrated at both upper corners and at the quarter point of the horizontal center line (of the spray system). If a number of identical, contiguous, modular spray systems are used, only one module need be calibrated. The system shall be calibrated with the catch boxes at a distance within ±2 in. (51 mm) of the test specimen location from the nozzle. The reference point for location of the spray system from the specimen shall be measured from the exterior glazing surface of the specimen farthest from the spray system nozzles. Recalibrate at intervals necessary in the judgment of the testing agency but not more than six months.

9.1.2 When the calibration is made, record the water pressure on the intake water line to the nozzle grid. When a field test is made, make sure to adjust the water pressure on the intake line to the pressure recorded when the grid was calibrated.

10. Information Required

10.1 The specifying authority shall supply the following information or provide guidance relative to its specification.

NOTE 4—Although the specifying authority is responsible for establishing test specimen sampling, selection, and identification procedures, such procedures or modifications to said unit should be mutually agreed upon by all parties involved prior to testing.

10.1.1 Test specimen sampling, selection, adjustment, and identification.

10.1.2 Test pressure difference(s) to be applied during the test.

10.1.3 Whether uniform or cyclic air pressure difference tests, or both, shall be used. Duration and number of cycles if cyclic test is used.

10.2 Unless otherwise specified, failure criteria of this test method shall be defined as water penetration in accordance with 3.2.3. Failure also occurs whenever water penetrates through the perimeter frame of the test specimen. Water contained within drained flashing, gutters, and sills is not considered failure.

11. Preparation of Test Apparatus

11.1 Fit the test chamber to the perimeter of the test specimen to cover the entire assembly through which a check for water penetration is to be made. Provide suitable support for the test chamber so that it does not contact or restrict any point where water leakage may occur. Seal all joints between the test specimen perimeter and the test chamber. Seal any openings between the test chamber and any air supply or exhaust ducts, pressure taps, or other measuring devices.

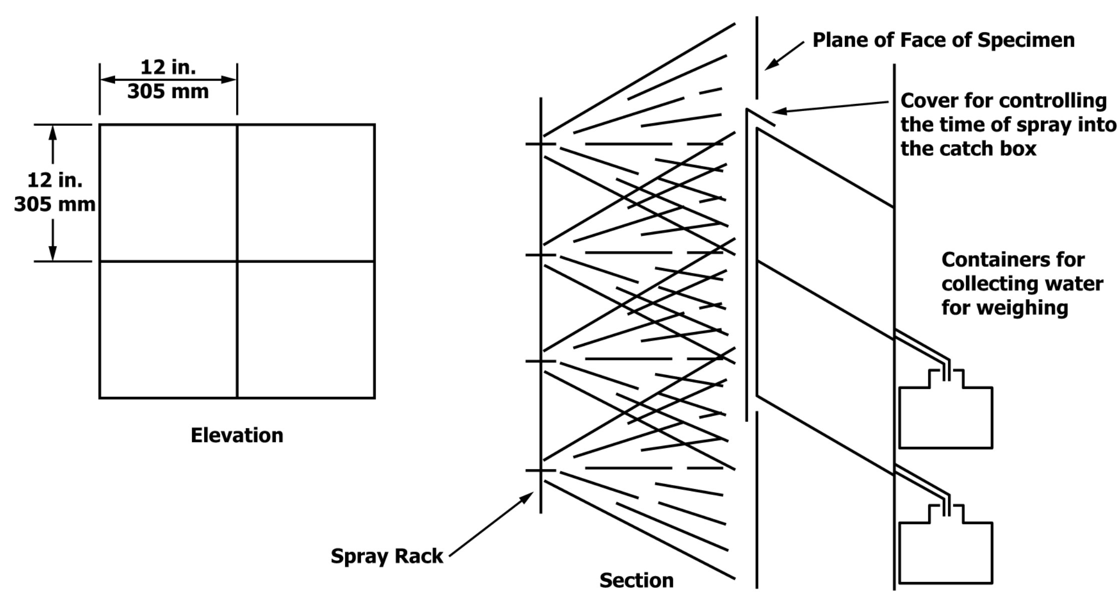

FIG. 2 Catch Box for Calibrating Water-Spray System