



APPLICATION OF TEST DATA
For
WIND PRESSURE TESTING OF WALL ASSEMBLIES
WITH FOAM SHEATHING AND VINYL SIDING PRODUCTS

Results from this test program will be used by the FSC to verifying a design approach for applications where vinyl siding is installed over foam sheathing. This 5-step design approach addresses both positive and negative design wind pressures. Positive design wind pressures are generally lower in magnitude than negative design wind pressures and they act in a direction from outside to inside (i.e., push the siding and exterior sheathing into the framing toward the building interior). Negative design wind pressures act in an outward direction (suction) and work to pull the siding and sheathing away from the wall framing. Both load conditions must be addressed by design as required by code.

For vinyl siding, positive wind pressures have generally been ignored because the vinyl resistance is higher in this direction (does not rely on nail attachment and nail tab strength) and the design wind pressure magnitude is lower. However, for foam sheathing both wind pressure loading conditions must be considered. In the negative pressure loading, the foam sheathing acts with and bears against the vinyl siding and its attachments. Thus, the two components act as a system in resisting the greater portion of wind pressure acting on the foam sheathing layer as well as the smaller portion acting on the vinyl siding layer. In the positive pressure direction and because the greater wind pressure differential acts across the foam sheathing layer (due to its air-barrier quality) it gets pushed inward independently from the siding which is more air-permeable and flexible.

These effects are appropriately addressed in the design methodology. Thus, the design methodology represents a general advancement in the application of design wind pressures to multi-layered building envelop systems and determination of resistance of those layers. The key to practical and accurate solutions is the use of pressure equalization factors (PEF) that determine the portion of wind load that occurs on individual layers of a wall based on the relative stiffness and air-permeability of each layer in response to dynamic wind pressure pulses that occur in actual wind events. In addition, system effects must be properly addressed as explained in the design method that follows.

STEP 1: Determine Approved Ultimate Negative Pressure Value for Selected Vinyl Siding Product

$$P_{v,ult} = P_{v,eff} \times 1.5 \times PEF_v$$

where,

$P_{v,ult}$ = a vinyl siding product's tested peak (ultimate) negative pressure resistance value
(based on ASTM D2506, average of 3 tests)

- $P_{v,eff}$ = a vinyl siding's effective design pressure resistance for use with a "solid" wall assembly per ASTM D3679, Annex A, Section A1.2.2); this value is typically reported in ICC-ES Evaluation Reports for vinyl siding products
- 1.5 = safety factor per ASTM D3679 (and ASTM E330) for non-structural building envelop components (e.g. cladding, curtain walls, windows and doors, etc.)
- PEF_v = pressure equalization factor associated with $P_{v,eff}$ value reported in vinyl siding manufacturer's ICC-ES Evaluation Report; the value may be either 0.5 or 0.36 depending on which version of ASTM D3679 was used by ICC-ES in approving a specific vinyl siding product's $P_{v,eff}$ value (confirmation required); on occasion the ICC-ES Evaluation Report may additionally include the $P_{v,ult}$ value.

NOTE: The negative pressure test results in accordance with Table 1 will be compared to the $P_{v,ult}$ value determined above using $P_{v,eff}$ values reported in the applicable vinyl siding manufacturer's ICC-ES Evaluation Report. To the extent that the tests with foam sheathing and vinyl siding combined indicate a consistent increase in ultimate pressure resistance over vinyl siding alone, a modest strength increase factor (greater than 1.0) may be proposed (see Step 3 below).

STEP 2: Select Appropriate PEF_{vf} for Application of Vinyl Siding Over Foam Sheathing

**TABLE 2.
Pressure Equalization Factors (PEF_{vf})
for use with Vinyl Siding and Foam Sheathing Cladding System¹**

Wall Assembly Condition	PEF_{vf} for Vinyl Siding + Foam Sheathing Cladding System	Typical Application
(W1) Vinyl siding + less than or equal to 1/2"-thick exterior foam sheathing + ≥1/2" interior GWB)	0.5	Building exterior walls with minimum 1/2" GWB interior finish
(W2) Vinyl siding + greater than or equal to 1/2"-thick exterior foam sheathing + ≥1/2" interior GWB	0.7	Building exterior walls with minimum 1/2" GWB interior finish
(W3) Vinyl siding + foam sheathing (any thickness) placed directly against structural sheathing or concrete/masonry wall	0.4 ²	Building exterior walls with wood structural panel sheathing on light-framing or masonry/concrete walls
(W4) Vinyl siding + foam sheathing (any thickness) and no interior finish	1.0 ³	Gable roof end wall enclosing unfinished attic space

Table Notes:

1. The recommended Pressure Equalization Factors (PEF) in Table 2 are based on a review of recognized literature addressing dynamic wind pressure equalization effects on relevant wall assemblies (refer to Attachment A). This consideration of pressure equalization effects, as discussed in Attachment A, is in accordance with general guidance provided in ASCE 7-05 Section 6.5.2.2. The PEF values in Table 2 are based on the same test data used in ASTM D3679-06a (Annex A1) for vinyl siding applied to various wall systems; however, the PEF factors in Table 2 are based on peak dynamic pressure differentials occurring across the exterior sheathing layer, not just the vinyl siding (refer to Attachment A).
2. The 0.4 value is based on an assumption that the pressure differential across a dual-layer exterior sheathing (foam sheathing over structural sheathing) is shared equally by both layers. Thus, the PEF is determined as follows: $0.7 \times \frac{1}{2} = 0.35$, round up to 0.4. This dual-layer sheathing condition was not addressed in the reviewed literature on pressure equalization effects (refer to Attachment A).
3. A PEF of 1.0 is for the condition of no (or negligible) pressure reduction across the foam sheathing and vinyl siding system because the system is essentially acting as a single, composite layer in the negative pressure (wind load) direction. In the positive pressure direction a small pressure reduction (e.g., PEF of ~0.95) may be applicable to the foam sheathing layer acting alone (bending inward separately from the siding). However, this "single wall" condition was not addressed in the reviewed literature on pressure equalization effects (refer to Attachment A).

STEP 3: Determine Effective Negative Pressure Design Value for Vinyl Siding and Foam Sheathing Cladding System

$$P_{vf,ult} = P_{v,ult} \times F$$

and

$$P_{vf,eff} = P_{vf,ult} / (1.5 \times PEF_{vf})$$

where,

$P_{vf,ult}$ = ultimate negative pressure resistance of vinyl siding and foam sheathing cladding system as adjusted by F, if applicable.

$P_{v,ult}$ = as defined in Step 1

F = system strength adjustment factor based on ratio of $P_{vf,ult}$ test results to $P_{v,ult}$ test results (assumed to be 1.0 unless otherwise determined based on test results).

$P_{vf,eff}$ = effective design negative pressure resistance of vinyl siding and foam sheathing cladding system.

PEF_{vf} = applicable pressure equalization factor from Table 2 (Step 2).

STEP 4: Determine Allowable Positive Pressure Design Value for Foam Sheathing (applicable only when foam sheathing spans across an open stud cavity)

In the positive pressure direction, foam sheathing and siding do not necessarily act as a composite system in resisting the applied wind load and each layer should be considered to independently resist its portion of the total design wind pressure acting across the overall wall system. When the foam sheathing is not backed by a structural sheathing or a “solid” wall (e.g., concrete/masonry), then it must independently resist its share of the positive wind pressure differential (wind load) across the wall system in accordance with the use of PEF_{vf} factors of Table 2.

The design positive pressure resistance of foam sheathing shall be determined as follows based on ASTM C203-05a index bending strength (unless the test program indicates other failure modes can limit foam sheathing resistance to positive wind pressure):

(A) The applied bending stress, f_b , from design wind pressure load is determined as follows (assuming simple span beam theory and isotropic homogenous material):

$$f_b = M/S$$

where,

$M = 1/8 w L^2$ = bending moment for single span or continuous two span between studs (lb-in)

L = stud spacing or span of foam sheathing (inches)

$w = p \times b \times 1ft^2/144in^2 \times PEF_{vf} = p \times 12in \times 1/144 \times PEF_{vf} = p \times 1/12 \times PEF_{vf}$ = uniform line load on 12-in unit width, b, of foam sheathing (lb/in)

p = design wind pressure (psf) per ASCE 7-05 or IRC Table R301.2(2)

$S = 1/6 b t^2 = 1/6 (12 in) t^2 = 2 t^2$ = section modulus of 12-in unit width of foam sheathing (in^3)

t = thickness of foam sheathing (in)

(B) Determine allowable design stress, $F_{b,all}$, for the foam sheathing material as follows:

$$F_{b,all} = F_{b,ult} / 1.5$$

where,

$$F_{b,ult} = (F_r) \times R$$

F_r = modulus of rupture (extreme fiber stress at peak flexural load) based on average of three ASTM C203 tests (3-point loading) for the foam sheathing product under consideration¹

R = system effect based on ratio of positive pressure peak capacity of wall specimens tested in accordance with Table 1 to that determined from ASTM C203 tests for the respective foam sheathing materials included in the test plan. (to be determined).

(C) Determine effective positive pressure design value, $p_{vf,eff}$

Using equations for steps A and B above, solve for the maximum allowable design wind pressure as follows:

$$F_{b,all} \geq f_b$$

$$(F_r \times R)/1.5 \geq M/S = 1/8 w L^2 / (2 t^2) = 1/16 (p \times 1/12 \times PEF_{vf}) L^2 / t^2 = 1/192 [(p \times PEF_{vf}) L^2 / t^2]$$

$$p_{vf,eff} = 128 t^2 (F_r \times R) / (L^2 \times PEF_{vf}) \quad \leftarrow \text{Use this equation}$$

With data provided to define t (foam sheathing thickness, in), F_r (ASTM C203 modulus of rupture, psi, for the given foam sheathing product and thickness with facings, if applicable), R (system factor as described above), L (stud spacing, in), and PEF_{fv} (pressure equalization factor per Table 2), the effective positive pressure design resistance, $p_{vf,eff}$, can be determined and then compared to required wind pressure load in Step 5.

STEP 5: Compare Effective Design Values for Negative ($P_{vf,eff}$) and Positive ($p_{vf,eff}$) Pressure Resistance to Required Pressure Load (Table 3) to Determine Wind Speed and Exposure Limit

**TABLE 3
Design Wind Pressure Load
Per IRC Table R301.2(2)
(psf)¹**

Wall Pressure Zone	90 mph				100 mph				110 mph			
	Exposure B		Exposure C		Exposure B		Exposure C		Exposure B		Exposure C	
	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.
End	14.6	-19.5	20.4	-27.3	18.0	-24.1	25.2	-33.7	21.8	-29.1	30.5	-40.7
Interior	14.6	-15.8	20.4	-22.1	18.0	-19.5	25.2	-27.3	21.8	-29.1	30.5	-33.0

1. Table values are based on ASCE 7 components and cladding wind loads as presented in 2006 IRC Table R301.2(2) for a mean roof height of 30 feet, an effective tributary area, a , of 10 sq ft, and an enclosed building. For a greater or lesser mean roof height, multiply table values by an appropriate factor from IRC Table R301.2(3). To determine design wind pressure for a wind speed outside the range of Table 3, multiply the design pressure for 100 mph wind speed by $(V/100)^2$ where V is the wind speed of interest.

¹ For some foam sheathing products, the F_r value may differ depending on bending direction along long dimension or short dimension of the foam sheathing panel. Thus, the appropriate F_r value to use will depend case-specifically on the orientation of these foam sheathing panels relative to framing members (horizontal vs. vertical application of panels relative to wall studs).

