Molimo™
Architectural Product Testing

PRODUCT APPROVAL SUPPORTING CALCULATIONS

1630 Horizontal Sliding Window – non-Impact

REPORT TO:

MI WINDOWS AND DOORS, LLC
702 WEST MARKET ST
GRATZ, PENNSYLVANIA 17030

REPORT NUMBER: 27488.09d-107-16-R0
REPORT DATE: 12/11/2023

MICHAEL D. STREMMEL
LICENSE
No. 65868
★
STATE OF
FLORIDA
PROFESSIONAL ENGINEER

2023.12.11 13:11:46 -05'00'

This item has been digitally signed and sealed by Michael D. Stremmel, PE on the date adjacent to the seal.

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Michael D, Stremmel, PE
FL PE 65868
FL REG 37122

Scope

Molimo, LLC was contracted by MI Windows and Doors, LLC to evaluate alternate installation methods for their Series 1630 Horizontal Sliding Window. The evaluation is based on physical testing and product certifications. Reference standards utilized in this project include:

Florida Building Code, Building, 8th Edition (2023). International Code Council, 2023.

ANSI/AWC NDS-2018 *National Design Specification (NDS) for Wood Construction*. American Wood Council, 2018.

AISI S100-16 *North American Specification for the Design of Cold-Formed Steel Structural Members, 2016*. American Iron and Steel Institute, 2016.

ADM1-2020, *2020 Aluminum Design Manual*. The Aluminum Association, Inc. 2020.

ICC-ES Report ESR-1976 *ITW Buildex TEKS Self-Drilling Fasteners*. ICC Evaluation Service. 07/2016.

NOA 21-0201.06 *Tapcon Concrete and Masonry Anchors with Advanced Threadform Technology*. Miami-Dade County Product Control Section. 02/01/2022.

The anchorage analyses presented herein do not address the water resistance, water penetration or air infiltration performance of the installation method or the installed product. In addition, the analyses rely on the assumption that the building substrate is capable of withstanding incurred loads.

Certification of Independence

In accordance with Rule 61G20-3 Florida Administrative Code Molimo, LLC hereby certifies the following:

- Molimo, LLC does not have, nor does it intend to acquire or will it acquire, a financial interest in any company manufacturing or distributing products tested or labeled by the agency.
- Molimo, LLC is not owned, operated or controlled by any company manufacturing or distributing products it tests or labels.
- Micheal D. Stremmel, P.E. does not have nor will acquire, a financial interest in any company manufacturing or distributing products for which the reports are being issued.
- Micheal D. Stremmel, P.E does not have, nor will acquire, a financial interest in any other entity involved in the approval process of the product.

Analyses

Summary of Test Results

The following table summarizes the various 1630 Horizontal Sliding Window products and their corresponding performance levels which have been established by testing or product certification.

Table 1 Summary of Test Results

Series/Model	Test Report Number	Product Certification	Size (W x H)	Performance
1630 HS (XOX, Equal Sash) (Fin Install)	H3121.01-801-44 (Rev. -, 06/05/17)	CPD 16746	96" x 53"	+/- 40 psf
1630 HS (XOX, Equal Sash) (Frame Install)	H3121.01-801-44 (Rev. -, 06/05/17)	CPD 16746	96" x 53"	+/- 40 psf
1630 HS (XOX, Equal Sash) (Frame Install)	2959.08-106-12 (Rev. -, 07/18/22)		110" x 63"	7.52 psf Water Test Pressure

Testing documented in Table 1 was conducted by Molimo, LLC of York, Pennsylvania (Florida Department of Business & Professional Regulation Test Lab No. TST11282, IAS Certificate of Accreditation TL-678) and Architectural Testing, Inc. (an Intertek Company) in Plano, Texas (Florida Department of Business & Professional Regulation Test Lab No. TST1910, IAS Certificate of Accreditation TL-331).

As-Tested Installation Analysis
For air/water/structural testing, the test specimen was secured to a pine buck with #8 x 1-5/8" wood screws through the integral PVC nail fin. A test specimen with #8 x 2" screws installed through the window frame was also tested. The as-tested installation methods are evaluated on page 7 to page 13 and the established design capacities are summarized in Table 2.

Table 2 As-tested Anchorage Design Capacities

<table>
<tr><th>Test</th><th>Connection</th><th>Capacity</th></tr>
<tr><td>1630 HS
Air/Water/Structural Test
Nail Fin Install</td><td>#6 x 1-5/8" screws.
Placed 2" from each corner and 16" on center.</td><td>53 lb</td></tr>
<tr><td rowspan="2">1630 HS
Structural Test
Through-Frame Install</td><td><u>Head and Jambs</u>
#10 x 1-5/8" screws.
Placed 4" from each corner and 16" on center.</td><td>114 lb</td></tr>
<tr><td><u>Sill, at each meeting stile</u>
0.075" thick aluminum frame clip.
Secured to buck with two #8 x 1-1/4" screws.
Secured to frame with two #8 x 1/2" screws.</td><td>238 lb</td></tr>
<tr><td rowspan="3">1630 HS
Water Test
Through-Frame Install</td><td><u>Head</u>
#8 x 2" screws.
Placed 4" from each corner and 14" on center.</td><td>114 lb</td></tr>
<tr><td><u>Sill</u>
#8 x 2" screws.
Placed 2" each side of each meeting stile.</td><td>114 lb</td></tr>
<tr><td><u>Jambs</u>
#8 x 2" screws.
Placed 4" from each corner and midspan.</td><td>114 lb</td></tr>
</table>

The capacities presented in Table 2 will be used to prove acceptable alternate anchors and substrates for the windows.

Alternate Anchorages

Calculations on page 14 determine the design capacity of alternate nail fin installation anchorages for the window. The alternate anchorage capacities are summarized in Table 3.

Table 3 Alternate Anchorage Capacities for Nail Fin Installations

Substrate	Anchor	Capacity	Comments
18 Gauge Steel Stud	#10-16 TEKS Screw	104 lb	1. 33 KSI yield strength stud. 2. Full penetration +3 threads. 3. Limited by pull-out capacity.

Calculations on page 15 through page 20 determine the design capacity of alternate through-frame installation anchorages for the window. The alternate anchorage capacities are summarized in Table 4.

Table 4 Alternate Anchorage Capacities for Through-Frame Installation

Substrate	Anchor	Capacity	Comments
18 Gauge Steel Stud	#10-16 TEKS Screw	152 lb	1. 33 KSI yield strength stud. 2. Full penetration +3 threads. 3. Limited by bending of anchor 4. Use two anchors at frame clip. Frame clip capacity is 304 lb.
Concrete	3/16" Tapcon	186 lb	1. Minimum f'_c = 3,000 psi 2. 1-1/2" Minimum Embedment 3. 2" Min. Edge Distance 4. Limited by shear capacity 5. Maximum 1x buck strip 6. Use two anchors at frame clip. Frame clip capacity is 372 lb.
CMU	3/16" Tapcon	135 lb	1. Minimum ASTM C90 CMU 2. 1-1/2" Minimum Embedment 3. 2" Min. Edge Distance 4. Limited by shear capacity. 5. Maximum 1x buck strip 6. Use two anchors at frame clip. Frame clip capacity is 270 lb.

Note: Maximum available length of 3/16" Tapcon anchor is 3-1/4". Use 1/4" x 4" Tapcon anchors for through-frame installations with 1x buck strip.

Anchorage Requirements

It must be determined the anchorages are not overloaded for the approved window size and design pressures. Calculations presented on page 21 show the as-tested spacing is adequate for the minimum anchor capacity reported in this report when the windows are subjected to the maximum design pressures of the products at their approved maximum sizes. Thus, all alternate anchorages proposed by this report may be used for the windows at the as-tested spacing.

Attachments

Appendix A – Revision Log (1 page)

As-Tested Installation – Nail Fin to Wood

#8 x 1-5/8" Wood Screw

PVC Nailing Fin

Spruce-Pine-Fir Wood Substrate Minimum (G=0.42)

Allowable Tension of #8 x 1-5/8" Wood Screw

W = 1.6(1.625"-0.062")(82 lb/in)   (NDS, Table 12.2B)
W = 205 lb

Pull-Over of #8 x 1-5/8" Wood Screw

Validated by Testing (see 2385.03-106-12)

Must maintain anchor spacing and anchor head size

As-tested spacing:	12" on center
As-tested anchor head size:	0.322"

Anchor Placement:	3" from corner; 12" on center
Anchor Quantities:	6 each jamb; 10 head; 10 sill; 32 total
Load to Anchors:	(110")(63")(35 psf/144) = 1,684 lb
Individual Anchor Load:	(1,684 lb)/(32 anchors) = 53 lb (< withdrawal capacity)

Design Capacity of Connection is 53 lb

As-Tested – Through-Frame to Wood

#8 x 2" Wood Screw

PVC Frame; 0.140" thickness at fastener location;

1/4" Maximum Shim Space

Spruce-Pine-Fir Wood Substrate Minimum (G=0.42)

Allowable Shear of #8 x 2" Wood Screw

Z' = 114 lb (Limited by Mode III_s, See Following 2 Pages)

Bearing of #8 x 2" Wood Screw on PVC Frame

$V_a = DtF_p$
V_a = (0.164")(0.140")(10,000 psi)
V_a = 230 lb

Bending of #8 x 2" Wood Screw

L = 1/4" (maximum shim space)
$S = \pi d^3/32 = \pi(0.131)^3/32 = 0.000221 \text{ in}^3$
$F_b = (1.3)(0.6F_y)$ = (1.3)(0.6)(90,000 psi) = 70,200 psi (1.3 for weak axis bending)
$F_b = M/S = (VL/2)/S$ (L/2 for guided bending)
$V = 2SF_b/L$ = (2)(0.000221 in)(70,200 psi)/0.25" = 124 lb.

Capacity of Connection is 114 lb

As-Tested – Through-Frame to Wood (Continued)

Lateral Design Strength of Wood Connections

Data

Fastener

Fastener	=	#8 Wood Screw	
Shank Dia	=	0.164	in.
Root Dia.	=	0.131	in.
F_{yb}	=	90,000	psi
Fastener length	=	2.000	in.

Main Member

Material	=	SPF	
G	=	0.42	
θ	=	90	<= (Angle of load to grain $0^o \leq \theta \leq 90^o$)
F_e	=	3,350	psi
Thickness	=	1.500	in.

Side Member

Material	=	Vinyl (PVC)	
G	=	N/A	
θ	=	90	<= (Angle of load to grain $0^o \leq \theta \leq 90^o$)
F_{es}	=	13,750	psi
Thickness	=	0.140	in.

Calculations

Lateral Bearing Factors

D	=	0.131	in.
ℓ_m	=	1.500	in.
K_θ	=	1.25	
K_D	=	2.20	
R_e	=	0.244	
R_t	=	10.71	
k_1	=	1.0129	
k_2	=	0.6403	
k_3	=	5.74	

As-Tested – Through-Frame to Wood (Continued)

Yield Mode	R_d
I_m, I_s	2.20
II	2.20
III_m, III_s, IV	2.20

Lateral Design Values, Z

Mode I_m	=	299	lbf	
Mode I_s	=	115	lbf	
Mode II	=	116	lbf	
Mode III_m	=	129	lbf	
Mode III_s	=	71	lbf	<====== Minimum Value
Mode IV	=	99	lbf	
C_D	=	1.6		
Wet Service Factor				
Fabrication/In-Service		Dry/Dry		
C_M	=	1.0		
In service temperature		T≤100°F		
C_t	=	1.0		
C_g	=	1.0		
C_Δ	=	1.0		
Is fastener installed in end grain?		No		
C_{eg}	=	1.00		
Is fastener part of a diaphragm?		No		
C_{di}	=	1.0		
Is fastener toe-nailed?		No		
C_{tn}	=	1.00		
Z'	**=**	**114**	**lbf**	

As-Tested – Through-Frame to Wood (Continued)

For Aluminum Frame Clip at Sill

Allowable Shear of #8 x 2" Wood Screw

Z' = 119 lb (Limited by Mode III_s, See Following 2 Pages)

Bearing of #8 x 1/2" Screw on PVC Frame

$V_a = DtF_p$
$V_a = (0.164")(0.140")(10{,}000\ psi)$
$V_a = 266\ lb$

Bearing of #8 x 1/2" Screw on Aluminum Frame Clip

$V_a = 2DtF_u/\Omega$
$V_a = 2(0.164")(0.075")(22{,}000\ psi)/3.0$
$V_a = 180\ lb.$

Wood limits connection to 119 lb /screw; 238 lb for two screws used

As-Tested – Through-Frame to Wood (Continued)

Lateral Design Strength of Wood Connections

Data

Fastener

Fastener	=	#8 Wood Screw	
Shank Dia	=	0.164	in.
Root Dia.	=	0.131	in.
F_{yb}	=	90,000	psi
Fastener length	=	2.000	in.

Main Member

Material	=	SPF	
G	=	0.42	
θ	=	90	<= (Angle of load to grain $0^o \leq \theta \leq 90^o$)
F_e	=	3,350	psi
Thickness	=	1.500	in.

Side Member

Material	=	6063 T5 Aluminum	
G	=	N/A	
θ	=	90	<= (Angle of load to grain $0^o \leq \theta \leq 90^o$)
F_{es}	=	27,500	psi
Thickness	=	0.075	in.

Calculations

Lateral Bearing Factors

D	=	0.131	in.
ℓ_m	=	1.500	in.
K_θ	=	1.25	
K_D	=	2.20	
R_e	=	0.122	
R_t	=	20.00	
k_1	=	0.9754	
k_2	=	0.5536	
k_3	=	10.59	

As-Tested – Through-Frame to Wood (Continued)

Yield Mode	R_d
I_m, I_s	2.20
II	2.20
III_m, III_s, IV	2.20

Lateral Design Values, Z

Mode I_m	=	299	lbf	
Mode I_s	=	123	lbf	
Mode II	=	120	lbf	
Mode III_m	=	133	lbf	
Mode III_s	=	75	lbf	<====== Minimum Value
Mode IV	=	104	lbf	
C_D	=	1.6		
Wet Service Factor				
Fabrication/In-Service		Dry/Dry		
C_M	=	1.0		
In service temperature		T≤100˚F		
C_t	=	1.0		
C_g	=	1.0		
C_Δ	=	1.0		
Is fastener installed in end grain?		No		
C_{eg}	=	1.00		
Is fastener part of a diaphragm?		No		
C_{di}	=	1.0		
Is fastener toe-nailed?		No		
C_{tn}	=	1.00		
Z'	**=**	**119**	**lbf**	

Alternate Installation – Nail Fin to Steel Stud

#10-16 TEKS Screw

PVC Nailing Fin

Minimum 18 gauge 33 KSI Steel Stud

Allowable Tension of #10-16 TEKS Screw

P_{ss}/Ω = 885 lb (ESR-1976)

Pull-Over of #10-16 TEKS Screw

Anchor head size: 0.365" > 0.322" Maintain as-tested spacing.

Pull-Out of #10-16 TEKS Screw

$P_{not} = 0.85 t_c d F_{u2}/\Omega$
P_{not} = 0.85(0.0428")(0.190")(45,000 psi)/3.0
P_{not} = 104 lb

Capacity of Connection is 104 lb

Alternate Installation – Trough-Frame to Steel Stud

#10-16 TEKS Screw

PVC Frame; 0.140" thickness at fastener location

1/4" Maximum Shim Space

Minimum 18 gauge 33 KSI Steel Stud

Allowable Shear of #10-16 TEKS Screw

P_{ss}/Ω = 573 lb (ESR-1976)

Bearing of #10-16 TEKS Screw on Frame

$V_a = DtF_p$
V_a = (0.191")(0.140")(10,000 psi)
V_a = 267 lb

Bearing of #10-16 TEKS Screw on Steel Stud

$V_a = 2.7DtF_{tu}/\Omega$
V_a = 2.7(0.191")(0.0428")(45,000 psi)/3.0
V_a = 331 lb.

Tilting of #10-16 TEKS Screw in Steel Stud

$V_a = 4.2(t_2^3D)^{1/2}F_{tu2}/n_s$
V_a = 4.2(0.0428"^{3} x 0.191")$^{1/2}$(45,000 psi)/3.0
V_a = 244 lb.

Bending of #10-16 TEKS Screw

L = 1/4" (Maximum Shim Space)
$S = \pi d^3/32 = \pi(0.139)^3/32 = 0.000264\ in^3$
$F_b = (1.3)(0.6F_y)$ = (1.3)(0.6)(92,000 psi) = 71,760 psi (1.3 for weak axis bending)
$F_b = M/S = (VL/2)/S$ (L/2 for guided bending)
$V = 2SF_b/L$ = (2)(0.000264 in^3)(71,760 psi)/0.25" = 152 lb.

Capacity of Connection is 152 lb.

Alternate Installation – Trough-Frame to Steel Stud (Continued)

For Aluminum Frame Clip at Sill

Bearing of #8 x 1/2" Screw on PVC Frame

$V_a = DtF_p$
$V_a = (0.164")(0.140")(10{,}000 \text{ psi})$
$V_a = 230 \text{ lb}$

Bearing of #8 x 1/2" Screw on Aluminum Frame Clip at Sill

$V_a = 2DtF_u/\Omega$
$V_a = 2(0.164")(0.075")(22{,}000 \text{ psi})/3.0$
$V_a = 180 \text{ lb.}$

Bearing of #10-16 TEKS Screw on Aluminum Frame Clip at Sill

$V_a = 2DtF_u/\Omega$
$V_a = 2(0.190")(0.075")(22{,}000 \text{ psi})/3.0$
$V_a = 209 \text{ lb.}$

Bending Limits Capacity of Connection to 152 lb x 2 Screws = 304 lb

Alternate Installation – Through-Frame to Concrete

3/16" Tapcon Anchor

1-1/2" Minimum Embedment; 2" Minimum Edge Distance, 3" Minimum Spacing

1/4" Maximum Shim Space

PVC Frame, 0.140" thickness at fastener location

Minimum f'_c = 3,000 psi Concrete

Allowable Shear of 3/16" Tapcon Anchor

P_{ss}/Ω = 186 lb (NOA 21-0201.06)

Bearing of 3/16" Tapcon Anchor on Frame

$V_a = DtF_p$
V_a = (0.170")(0.140")(10,000 psi)
V_a = 238 lb

Bending of 3/16" Tapcon

L = 1/4" (Maximum Shim Space)
$S = \pi d^3/32 = \pi(0.170")^3/32 = 0.000482\ in^3$
$F_b = (1.3)(0.6F_y)$ = (1.3)(0.6)(137,000 psi) = 106,860 psi (1.3 for weak axis bending)
$F_b = M/S = (VL/2)/S$ (L/2 for guided bending)
$V = 2SF_b/L$ = (2)(0.000482 in^3)(106,860 psi)/0.25" = 412 lb.

Capacity of Connection is 186 lb

Qualifies 1/4" Tapcon if longer length anchor is required to achieve minimum embedment.

Alternate Installation – Through-Frame to Concrete (Continued)

For Aluminum Frame Clip at Sill

Bearing of #8 x 1/2" Screw on PVC Frame

$V_a = DtF_p$
$V_a = (0.164")(0.140")(10{,}000 \text{ psi})$
$V_a = 230 \text{ lb}$

Bearing of #8 x 1/2" Screw on Aluminum Frame Clip at Sill

$V_a = 2DtF_u/\Omega$
$V_a = 2(0.164")(0.075")(22{,}000 \text{ psi})/3.0$
$V_a = 180 \text{ lb.}$

Bearing of 3/16" Tapcon on Aluminum Frame Clip at Sill

$V_a = 2DtF_u/\Omega$
$V_a = 2(0.170")(0.075")(22{,}000 \text{ psi})/3.0$
$V_a = 187 \text{ lb.}$

Capacity of Connection is 186 lb x 2 Anchors = 372 lb

Alternate Installation – Through Frame to CMU

3/16" Tapcon Anchor

1-1/2" Minimum Embedment, 2" Minimum Edge Distance, 3" Minimum Spacing

1/4" Maximum Shim Space

PVC Frame, 0.140" thickness at fastener location

Minimum ASTM C90 Concrete Masonry Unit

Allowable Shear of 3/16" Tapcon Anchor

P_{ss}/Ω = 135 lb (NOA 21-0201.06)

Bearing of 3/16" Tapcon Anchor on Frame

$V_a = DtF_p$
V_a = (0.170")(0.140")(10,000 psi)
V_a = 238 lb

Bending of 3/16" Tapcon

L = 1/4" (Maximum Shim Space)
$S = \pi d^3/32 = \pi(0.170")^3/32 = 0.000482\ in^3$
$F_b = (1.3)(0.6F_y)$ = (1.3)(0.6)(137,000 psi) = 106,860 psi (1.3 for weak axis bending)
$F_b = M/S = (VL/2)/S$ (L/2 for guided bending)
$V = 2SF_b/L$ = (2)(0.000482 in^3)(106,860 psi)/0.25" = 412 lb.

Capacity of Connection is 135 lb

Qualifies 1/4" Tapcon if longer length anchor is required to achieve minimum embedment.

<u>Alternate Installation – Through-Frame to CMU</u> (Continued)

For Aluminum Frame Clip at Sill

<u>Bearing of #8 x 1/2" Screw on PVC Frame</u>

$V_a = DtF_p$
$V_a = (0.164")(0.140")(10,000 \text{ psi})$
$V_a = 230 \text{ lb}$

<u>Bearing of #8 x 1/2" Screw on Aluminum Frame Clip at Sill</u>

$V_a = 2DtF_u/\Omega$
$V_a = 2(0.164")(0.075")(22,000 \text{ psi})/3.0$
$V_a = 180 \text{ lb.}$

<u>Bearing of 3/16" Tapcon on Aluminum Frame Clip at Sill</u>

$V_a = 2DtF_u/\Omega$
$V_a = 2(0.170")(0.075")(22,000 \text{ psi})/3.0$
$V_a = 187 \text{ lb.}$

Capacity of Connection is 135 lb x 2 Anchors = 270 lb

Anchorage Requirements

96 x 53 HS – Fin Install

Anchor Placement:	2" from corner; 16" on center
Anchor Quantities:	4 each jamb; 6 head; 6 sill; 20 total
Load to Anchors:	(96")(53")(40 psf/144) = 1,413 lb
Individual Anchor Load:	(1,413 lb)/(20 anchors) = 71 lb
Least Anchor Capacity:	104 lb > 71 lb **OK**

96 x 53 HS – Through-Frame Install

Stile Load Area at Sill:	[(96"/3)(53"/2)]/144 = 5.9 ft^2
Load at Frame Clip:	(40 psf)(5.9 ft^2) = 236 lb
Least Anchor Capacity:	135 lb. **Specify 2 anchors for Frame Clip**
Perimeter Anchors:	6 head, 4 each jamb; 14 total
Load to Anchors:	(96")(53")(40 psf/144) = 1,413 lb
Load to Perimeter Anchors:	1,413 lb – 472 lb = 941 lb
Individual Anchor Load:	(941 lb)/(14 anchors) = 67 lb
Least Anchor Capacity:	135 lb > 67 lb **OK**

Appendix A

Revision Log

Identification	Date	Page & Revision
Original Issue	12/11/23	Not Applicable