PRODUCT APPROVAL SUPPORTING CALCULATIONS

Series/Model F-4500 Fiberglass Folding Doors (Impact)

REPORT NO.: 27226.01-107-16

RENDERED TO: Jeld-Wen Windows & Doors
3737 Lakeport Blvd
Klamath Falls, Oregon

PREPARED BY: Michael D. Stremmel, P.E.
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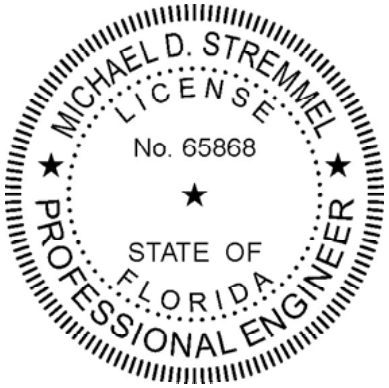
DATE: 9/29/2023



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Michael D. Stremmel, P.E.
Senior Project Engineer
FL PE 65868
FL REG 37122

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SCOPE:
Molimo, LLC was contracted by Jeld-Wen Windows & Doors to evaluate alternate installation methods for their F-4500 Fiberglass Folding Doors (Impact). The evaluation is based on physical testing and product certifications.

Reference standards utilized in this project include:

Florida Building Code. International Code Council.

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

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

ICC-ES Report ESR-1976 ITW Buildex TEKS Self-Drilling Fasteners. ICC Evaluation Service.

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

The anchorage analysis presented herein does 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 the 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 s is not owned, operated or controlled by any company manufacturing or distributing products it tests or labels.
- Michael 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.
- Michael 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

Table 1 summarizes the various F-4500 Fiberglass Folding Doors (Impact) 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	Size (W x H)	Performance
F-4500 Fiberglass Folding Impact Door (Through Frame Installation)	Intertek Report No. Q2461.01-301-47 (Rev. 0, 8/8/23)	106-3/4" x 79-1/4"	+50 / -55 psf Wind Zone 3 Impacts

Testing documented in Table 1 was conducted by Intertek of Fresno, California (Florida Department of Business & Professional Regulation Test Lab No. TST2609, IAS Certificate of Accreditation TL-264) and certified by NAMI under certification number NI015728.01 (Expires 6/30/2027).

As-Tested Installation Analysis

For air/water/structural testing, the test specimen was secured to a Douglas-Fir wood test buck with #8 wood screws (1-1/2" min embedment) at the head and jambs and a continuous bed of silicone at the sill. The as tested installation method is evaluated on Pages 5 through 7. These capacities will be used to prove acceptable anchors and substrates for the product.

Alternate Anchorages

Calculations on Pages 8 through 15 determine the design capacity of alternate installation anchorages for the product.

Anchorages Requirements

As-tested spacing must be maintained. It must be determined that the anchorages are not overloaded for the approved product size and design pressures. Calculations presented on Page 14 show the alternate anchorages are acceptable for the established product performance.

Anchorage requirements established by this report are accurately presented in Drawing D1000257.

As-Tested Installation – Through Frame to Wood

Jamb Installation

Anchor: #8 Wood Screw

Details: 3/4" thick wood frame (G = 0.42)
No shim space was utilized

Substrate: Douglas-Fir wood test buck (G = 0.46 min.)

Wood Screw Capacity (Shear)

Z' = 111 lb (See Page 6)

Design Capacity of the Connection = 111 lb

Head Installation

Anchor: #8 Wood Screw

Details: 0.063" aluminum frame (6063-T5)
No shim space was utilized

Substrate: Douglas-Fir wood test buck (G = 0.46)

Wood Screw Capacity (Shear)

Z' = 128 lb (See Page 7)

Bearing Capacity (of #8 screw on aluminum frame)

$P_b = 2\ D\ t\ F_{tu} = 2(0.164")(0.063")(22{,}000\ psi) = 454\ lb$

$P_{allow} = 454\ lb / 3.0 = 151\ lb$

Design Capacity of the Connection = 128 lb

Lateral Design Strength of Wood Connections

Data

Project: F-4500 Folding Door
Comments: As-Tested (Jamb)
1-1/2" min embedment

Fastener

Fastener	=	#8 Wood Screw	
Shank Dia	=	0.164	in.
Root Dia.	=	0.131	in.
F_{yb}	=	90,000	psi
Fastener length	=	2.250	in.

Main Member

Material	=	Douglas Fir (South)	
G	=	0.46	
θ	=	90	
F_e	=	4,000	psi
Thickness	=	1.500	in.

Side Member

Material	=	SPF	
G	=	0.42	
θ	=	90	
F_{es}	=	3,350	psi
Thickness	=	0.719	in.

Calculations

Lateral Bearing Factors

D	=	0.131	in.	k_1	=	0.6618	
ℓ_m	=	1.203	in.	k_2	=	1.2340	
K_θ	=	1.25		k_3	=	1.29	
K_D	=	2.20		R_d	=	2.20	(Mode I_m, I_s)
R_e	=	1.194		R_d	=	2.20	(Mode II)
R_t	=	1.67		R_d	=	2.20	(Mode III_m, III_s, IV)

Lateral Design Values, Z

Mode I_m	=	287	lbf	
Mode I_s	=	143	lbf	
Mode II	=	95	lbf	
Mode III_m	=	104	lbf	
Mode III_s	=	69	lbf	<== Minimum Value
Mode IV	=	82	lbf	

Adjustment Factors

C_D	=	1.6	C_Δ	=	1.0
Wet Service Factor			Is fastener installed in end grain?		No
Fabrication/In-Service		Dry/Dry	C_{eg}	=	1.00
C_M	=	1.0	Is fastener part of a diaphragm?		No
In service temperature		T≤100˚F	C_{di}	=	1.0
C_t	=	1.0	Is fastener toe-nailed?		No
C_g	=	1.0	C_{tn}	=	1.00

Adjusted Design Value, Z

Z' = 111 lbf

Lateral Design Strength of Wood Connections

Data

Project: F-4500 Folding Door
Comments: As-Tested (Head)
1-1/2" min embedment

Fastener

Fastener	=	#8 Wood Screw	
Shank Dia	=	0.164	in.
Root Dia.	=	0.131	in.
F_{yb}	=	90,000	psi
Fastener length	=	2.250	in.

Main Member

Material	=	Douglas Fir (South)	
G	=	0.46	
θ	=	90	
F_e	=	4,000	psi
Thickness	=	1.500	in.

Side Member

Material	=	6063 T5 Aluminum	
G	=	N/A	
θ	=	90	
F_{es}	=	27,500	psi
Thickness	=	0.063	in.

Calculations

Lateral Bearing Factors

D	=	0.131	in.	k_1	=	1.3798	
ℓ_m	=	1.500	in.	k_2	=	0.5616	
K_θ	=	1.25		k_3	=	11.45	
K_D	=	2.20		R_d	=	2.20	(Mode I_m, I_s)
R_e	=	0.145		R_d	=	2.20	(Mode II)
R_t	=	23.81		R_d	=	2.20	(Mode III_m, III_s, IV)

Lateral Design Values, Z

Mode I_m	=	357	lbf	
Mode I_s	=	103	lbf	
Mode II	=	142	lbf	
Mode III_m	=	155	lbf	
Mode III_s	=	80	lbf	<== Minimum Value
Mode IV	=	113	lbf	

Adjustment Factors

C_D	=	1.6	C_Δ	=	1.0
Wet Service Factor			Is fastener installed in end grain?		No
Fabrication/In-Service		Dry/Dry	C_{eg}	=	1.00
C_M	=	1.0	Is fastener part of a diaphragm?		No
In service temperature		T≤100˚F	C_{di}	=	1.0
C_t	=	1.0	Is fastener toe-nailed?		No
C_g	=	1.0	C_{tn}	=	1.00

Adjusted Design Value, Z

Z' = 128 lbf

Alternate Installation – Strap Anchor to Wood

Anchor: (2) #8 x 1-1/2" Flat head screw securing the strap to the substrate
1/4" max shim space

Details: 20 gauge (0.036" thick) 33 KSI steel strap anchor w/ two #8 screws securing the strap to the frame
3/4" thick wood frame -- or -- 0.063" 6063-T5 Aluminum

Substrate: Spruce-Pine-Fir 2x Wood Substrate (G = 0.42 min.)

Wood Screw Capacity (Shear)

Z' = 122 lb (See Following Page)

Bending of #8 x 1-1/2" flat head screw

L = 1/4" (maximum shim space)

$S = \pi d^3 / 32 = \pi (0.131")^3 / 32 = 0.000221$ in^3

$F_b = (1.3)(0.6 F_y) = (1.3)(0.6)(90{,}000$ psi$) = 70{,}200$ psi (1.3 for weak axis bending)

$F_b = M / S = (V)(L/2) / S$ (L/2 for guided bending)

$V = 2 S F_b / L = (2)(0.000221$ in3$)(70{,}200$ psi$) / 1/4"$

V = 124 lb

Bearing Capacity (of #8 screw on aluminum frame)

$P_b = 2 D t F_{tu} = 2(0.164")(0.063")(22{,}000$ psi$) =$ 454 lb

$P_{allow} = 454$ lb $/ 3.0 =$ 151 lb

Bearing Capacity (of strap anchor)

$P_b = 2.7 D t F_{tu} = 2.7(0.164")(0.036")(45{,}000$ psi$) = 717$ lb

$P_{allow} = 717$ lb $/ 3.0 =$ 239 lb

Design Capacity of the Connection = 122 lb per screw (244 lb total)

Lateral Design Strength of Wood Connections

Data

Project: F-4500 Folding Door
Comments: Anchor Strap Detail
1-1/2" min embedment

Fastener

Fastener	=	#8 Wood Screw	
Shank Dia	=	0.164	in.
Root Dia.	=	0.131	in.
F_{yb}	=	90,000	psi
Fastener length	=	1.500	in.

Main Member

Material	=	SPF	
G	=	0.42	
θ	=	90	
F_e	=	3,350	psi
Thickness	=	1.500	in.

Side Member

Material	=	ASTM A 653, Grade 33 Steel	
G	=	N/A	
θ	=	90	
F_{es}	=	61,850	psi
Thickness	=	0.033	in.

Calculations

Lateral Bearing Factors

D	=	0.131	in.	k_1	=	0.7630	
ℓ_m	=	1.139	in.	k_2	=	0.5398	
K_θ	=	1.25		k_3	=	23.87	
K_D	=	2.20		R_d	=	2.20	(Mode I_m, I_s)
R_e	=	0.054		R_d	=	2.20	(Mode II)
R_t	=	34.52		R_d	=	2.20	(Mode III_m, III_s, IV)

Lateral Design Values, Z

Mode I_m	=	227	lbf	
Mode I_s	=	122	lbf	
Mode II	=	93	lbf	
Mode III_m	=	111	lbf	
Mode III_s	=	77	lbf	<== Minimum Value
Mode IV	=	108	lbf	

Adjustment Factors

C_D	=	1.6	C_Δ	=	1.0
Wet Service Factor			Is fastener installed in end grain?		No
Fabrication/In-Service		Dry/Dry	C_{eg}	=	1.00
C_M	=	1.0	Is fastener part of a diaphragm?		No
In service temperature		T≤100°F	C_{di}	=	1.0
C_t	=	1.0	Is fastener toe-nailed?		No
C_g	=	1.0	C_{tn}	=	1.00

Adjusted Design Value, Z

Z' = 122 lbf

Alternate Installation – Through-Frame to Concrete

Anchor: 3/16" Tapcon Anchor
- 1-1/4" min embedment
- 2-1/2" min edge distance
- 3" min anchor spacing
- 1/4" max shim space

Details: Through the Wood or Aluminum Frame
- 3/4 " thick wood frame
- 0.063" thick aluminum frame (6063-T5)

Substrate: 3,000 psi Concrete

Anchor Capacity (Shear of 3/16" Tapcon)

$P_{ss} / \Omega =$ 181 lb (NOA-No. 21-0201.06)

Bearing Capacity (of Wood frame)

$P_b = F_e D t / K_D = (3{,}350 \text{ psi})(0.170")(0.719")/(10(0.170) + 0.5) =$ 194 lb

Bearing Capacity (of Aluminum frame)

$P_b = 2 D t F_{tu} = 2(0.170")(0.063")(22{,}000 \text{ psi}) = 471$ lb

$P_{allow} = 471 \text{ lb} / 3.0 =$ 157 lb

Bending Capacity (of 3/16" Tapcon)

L = 1/4" (maximum shim space)

$S = \pi d^3 / 32 = \pi (0.170")^3 / 32 = 0.000482 \text{ in}^3$

$F_b = (1.3)(0.6 F_y) = (1.3)(0.6)(137{,}000 \text{ psi}) = 106{,}860$ psi (1.3 for weak axis bending)

$F_b = M / S = (V) (L/2) / S$ (L/2 for guided bending)

$V = 2 S F_b / L = (2)(0.000482 \text{ in3})(106{,}860 \text{ psi}) / 1/4"$

V = 412 lb

Design Capacity of the Connection = 157 lb

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

Alternate Installation – Through-Frame to CMU Block

Anchor: 3/16" Tapcon Anchor
- 1-1/4" min embedment
- 2-1/2" min edge distance
- 3" min anchor spacing
- 1/4" max shim space

Details: Through the Wood or Aluminum Frame
- 3/4 " thick wood frame
- 0.063" thick aluminum frame (6063-T5)

Substrate: CMU Block

Anchor Capacity (Shear of 3/16" Tapcon)

$P_{ss} / \Omega =$ 135 lb (NOA-No. 21-0201.06)

Bearing Capacity (of Wood frame)

$P_b = F_e D t / K_D = (3{,}350 \text{ psi})(0.170")(0.719")/(10(0.170) + 0.5) =$ 194 lb

Bearing Capacity (of Aluminum frame)

$P_b = 2 D t F_{tu} = 2(0.170")(0.063")(22{,}000 \text{ psi}) = 471$ lb

$P_{allow} = 471 \text{ lb} / 3.0 =$ 157 lb

Bending Capacity (of 3/16" Tapcon)

L = 1/4" (maximum shim space)

$S = \pi d^3 / 32 = \pi (0.170")^3 / 32 = 0.000482 \text{ in}^3$

$F_b = (1.3)(0.6 F_y) = (1.3)(0.6)(137{,}000 \text{ psi}) = 106{,}860$ psi (1.3 for weak axis bending)

$F_b = M / S = (V) (L/2) / S$ (L/2 for guided bending)

$V = 2 S F_b / L = (2)(0.000482 \text{ in3})(106{,}860 \text{ psi}) / 1/4"$

V = 412 lb

Design Capacity of the Connection = 135 lb

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

Alternate Installation – Strap Anchor to Concrete

Anchor: 3/16" Tapcon Anchor
- 1-1/4" min embedment
- 2-1/2" min edge distance
- 3" min anchor spacing
- 1/4" max shim space

Details: 20 gauge (0.036" thick) 33 KSI steel strap anchor w/ two #8 screws securing the strap to the frame

3/4" thick wood frame -- or -- 0.063" 6063-T5 Aluminum

Substrate: 3,000 psi Concrete

Anchor Capacity (Shear of 3/16" Tapcon)

$P_{ss} / \Omega =$ 181 lb (NOA-No. 21-0201.06)

Bearing Capacity (of 3/16" Tapcon on strap anchor)

$P_b = 2.7\ D\ t\ F_{tu} / \Omega = 2.7(0.170")(0.036")(45{,}000\ psi) / 3.0 =$ 247 lb

Bearing Capacity (of #8 screw on strap anchor)

$P_b = 2.7\ D\ t\ F_{tu} / \Omega = 2.7(0.164")(0.036")(45{,}000\ psi) / 3.0 =$ 239 lb

Bearing Capacity (of #8 screw on wood frame)

$P_b = F_e\ D\ t\ / K_D = (3{,}350\ psi)(0.164")(0.719")/(10(0.164) + 0.5) =$ 184 lb

Bearing Capacity (of #8 screw on Aluminum frame)

$P_b = 2\ D\ t\ F_{tu} / \Omega = 2(0.170")(0.063")(22{,}000\ psi) / 3.0 =$ 157 lb

Bending Capacity (of 3/16" Tapcon)

L = 1/4" (maximum shim space)

$S = \pi\ d^3 / 32 = \pi\ (0.170")^3 / 32 = 0.000482\ in^3$

$F_b = (1.3)(0.6\ F_y) = (1.3)(0.6)(137{,}000\ psi) = 106{,}860\ psi$ (1.3 for weak axis bending)

$F_b = M / S = (V)\ (L/2) / S$ (L/2 for guided bending)

$V = 2\ S\ F_b / L = (2)(0.000482\ in3)(106{,}860\ psi) / 1/4"$

V = 412 lb

Design Capacity of the Connection = 157 lb (one concrete anchor per strap)

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

Alternate Installation – Strap Anchor to CMU Block

Anchor: 3/16" Tapcon Anchor
- 1-1/4" min embedment
- 2-1/2" min edge distance
- 3" min anchor spacing
- 1/4" max shim space

Details: 20 gauge (0.036" thick) 33 KSI steel strap anchor w/ two #8 screws securing the strap to the frame

3/4" thick wood frame -- or -- 0.063" 6063-T5 Aluminum

Substrate: CMU Block

Anchor Capacity (Shear of 3/16" Tapcon)

$P_{ss} / \Omega =$ 135 lb (NOA-No. 21-0201.06)

Bearing Capacity (of 3/16" Tapcon on strap anchor)

$P_b = 2.7\ D\ t\ F_{tu} / \Omega = 2.7(0.170")(0.036")(45{,}000\ psi) / 3.0 =$ 247 lb

Bearing Capacity (of #8 screw on strap anchor)

$P_b = 2.7\ D\ t\ F_{tu} / \Omega = 2.7(0.164")(0.036")(45{,}000\ psi) / 3.0 =$ 239 lb

Bearing Capacity (of #8 screw on wood frame)

$P_b = F_e\ D\ t\ / K_D = (3{,}350\ psi)(0.164")(0.719")/(10(0.164) + 0.5) =$ 184 lb

Bearing Capacity (of Aluminum frame)

$P_b = 2\ D\ t\ F_{tu} / \Omega = 2(0.170")(0.063")(22{,}000\ psi) / 3.0 =$ 157 lb

Bending Capacity (of 3/16" Tapcon)

L = 1/4" (maximum shim space)

$S = \pi\ d^3 / 32 = \pi\ (0.170")^3 / 32 = 0.000482\ in^3$

$F_b = (1.3)(0.6\ F_y) = (1.3)(0.6)(137{,}000\ psi) = 106{,}860\ psi$ (1.3 for weak axis bending)

$F_b = M / S = (V)\ (L/2) / S$ (L/2 for guided bending)

$V = 2\ S\ F_b / L = (2)(0.000482\ in3)(106{,}860\ psi) / 1/4"$

V = 412 lb

Design Capacity of the Connection = 135 lb (one concrete anchor per strap)

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

Alternate Installation – Strap Anchor to Wood (Cap Installation)

Anchor: Two #8 x 1-1/2" Flat head screw securing the strap to the substrate

Details: 20 gauge (0.036" thick) 33 KSI steel strap anchor w/ two #8 screws securing the strap to the frame
0.719" thick wood frame
3/4" thick wood frame -- or -- 0.063" 6063-T5 Aluminum

Substrate: Spruce-Pine-Fir 2x Wood Substrate (G = 0.42 min.)

Wood Screw Capacity (Withdrawal)

W' = 1.6(82 lb/in)(1.5 in) = 197 lb

Pull-over Capacity (of #8 screw on strap)

$P_{nov} = 1.5\ t\ d\ F_{tu} = 1.5\ (0.036")(0.332")(45{,}000\ psi) = 806\ lb$

$P_{allow} = 806\ lb / 3.0 =$ 268 lb

Bearing Capacity (of #8 screw on wood frame)

$P_b = F_e\ D\ t\ /K_D = (3{,}350\ psi)(0.164")(0.719")/(10(0.164) + 0.5) =$ 184 lb

Bearing Capacity (of #8 screw Aluminum frame)

$P_b = 2\ D\ t\ F_{tu}\ /\ \Omega = 2(0.170")(0.063")(22{,}000\ psi)\ /\ 3.0 =$ 157 lb

Bearing Capacity (of #8 screw on strap anchor)

$P_b = 2.7\ D\ t\ F_{tu} = 2.7(0.164")(0.036")(45{,}000\ psi) = 717\ lb$

$P_{allow} = 717\ lb / 3.0 =$ 239 lb

Design Capacity of the Connection = 157 lb (one screw)

Design Capacity of the Connection = 314 lb (two screws)

Anchorage Requirements

Series/Model: F-4500 Fiberglass Folding Impact Doors

Test Unit Size: 106-3/4" x 79-1/4"

Design Pressure: +50.0 / -55.0 psf

Through-Frame Installation Method

Through frame installation method is validated by the test

Through Frame Anchor Capacity = 111 lb / anchor (Head)
= 128 lb / anchor (Jamb)

Alternate Installation Methods

Strap Anchor to Wood = 122 lb / anchor – 244 lb total (Head or Jamb)

Through-Frame to Concrete = 157 lb (Head)
= 181 lb (Jamb)

Through-Frame to CMU Block = 135 lb (Head or Jamb)

Strap Anchor to Concrete = 157 lb (Head)
= 181 lb (Jamb)

Strap Anchor to CMU Block = 135 lb / anchor (Head or Jamb)

Strap Anchor to Wood (Cap Installation) = 157 lb / anchor (Head)
= 184 lb / anchor (Jamb)

Minimum Alternate Installation Capacity = 135 lb

135 lb > 111 lb **Head Alternate Anchorages OK at tested spacing**

135 lb > 128 lb **Jamb Alternate Anchorages OK at tested spacing**

Molimo™
Architectural Product Testing

Project No.: 27226.01-107-16
Project Name: F-4500 Fiberglass Folding Doors (Impact)
Date: 9/29/2023

Revision Log

Rev. #	Date	Page(s)	Revision(s)
0	9/29/2023	All	Original Report Issue