Window Installation Calculations

T500 Single Hung Window

Report Q5273.01-122-34

Rendered to:

QUAKER WINDOWS & DOORS
504 Highway 63 South
Freeburg, Missouri 65035

Prepared by:

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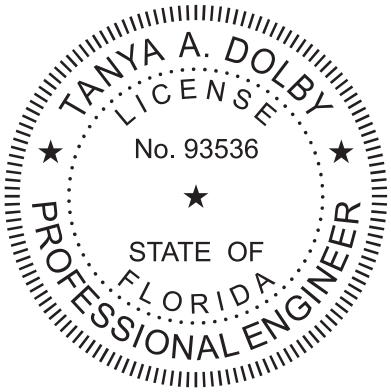

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Scope

Architectural Testing, Inc., an Intertek company, was contracted by Quaker Windows & Doors to evaluate alternate installation methods for their T500 Single Hung windows. 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 with 2018 Supplement*. American Wood Council, 2018.

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

AISI S100-16(2020) *North American Specification for the Design of Cold-Formed Steel Structural Members, 2016(Reaffirmed 2020)*. American Iron and Steel Institute, 2020.

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, Architectural Testing, Inc. hereby certifies the following:

- Architectural Testing 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.
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Analyses

Summary of Test Results

The following table summarizes the various T500 Single Hung 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
T500 Single Hung	C5558.01-801-47	NI011475-R4	60" x 99"	+/- 50.0 psf

Testing documented in Table 1 was conducted by the Architectural Testing laboratory in Plano, Texas (Florida Department of Business & Professional Regulation Test Lab No. TST1910, IAS Accredited Laboratory TL-331).

As-Tested Installation Analysis

For air/water/structural testing, the test specimen was secured to a 2x Spruce-Pine-Fir buck with #6 x 1-5/8" wood screws through the nail fin. The as-tested installation method is evaluated on page 5 and the established design capacity summarized in Table 2.

Table 2 As-tested Anchorage Design Capacities.

Test	Connection	Capacity
Air/Water/Structural Test	#6 x 1-5/8" Wood Screw Through Nail Fin 3" from each corner; 11-1/2" on center at jambs 13" on center at head and sill	75 lb

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

Alternate Anchorages

Pages 6 and 7 present the calculation of alternate anchorages for the windows. The alternate anchorage capacities are summarized in Table 3.

Table 3 Alternate Anchorage Capacities for Fin Installation

Substrate	Anchor	Capacity	Comments
Wood S-P-F 2x	#10 x 2" Wood Screw	103 lb	1. Limited by Pull-Over 2. 1-1/2" Minimum Penetration 3. 1/4" Maximum Shim Space 4. Min Wood blocking, G = 0.55
18 Gauge Steel Stud	#10-16 TEKS Screw	103 lb	1. Limited by Pull-Over 2. Minimum 18 gauge 33 KSI Steel 3. Full penetration +3 threads 4. 1/4" Maximum Shim Space

The #10 x 2" wood screw has more capacity than the as-tested installation method. Thus, the #10 x 2" wood screw may be used for installation to wood at the as-tested spacing. Calculations presented in page 8 show all evaluated anchors are not overloaded for the approved window size and design pressure.

Thus, #10 x 2" wood screws installed to wood and #10-16 TEKS screws installed to steel stud as specified in Table 3 are approved alternate installations for the subject window with the anchors installed at the as-tested spacing.

As-Tested Nail Fin Installation to Wood

#6 x 1-5/8" Wood Screw

0.062" thick 6063-T6 Aluminum Nailing Fin

Spruce-Pine-Fir 2x Wood Substrate Minimum (G=0.55)

ASD Withdrawal

Withdrawal of #6 PH Wood Screw

W' = 2,850(G^2)(D)(Cd)(Cm)(Ct)(Ceg)(Ctn)(L)
W' = 2,850 (0.55^2)(0.1365'')(1.6)(0.7)(0.7)(1.00)(1.0)(1.50'')
W' = 138 lb

Adjustment Factors

Load Duration Factor - Ten Minutes, Cd = 1.6
Moisture Factor - Fabrication > 19% and In-Service > 19%, Cm = 0.7
Temperature Factor - 100°F < T ≤ 125°F, Ct = 0.7
End Grain Factor - No, Ceg = 1.00
Toe Nail Factor - No, Ctn = 1.0

Allowable Tension of #6 x 1-5/8" Wood Screw
W = 1.6(1.625"-0.062")(69 lb/in) (NDS, Table 11.2B)
W = 173 lb

Pull-Over of #6 x 1-5/8" Wood Screw
$P_{nov} = C_{pov}t_1F_{tu1}(D_{ws}-D_h)/3.0$
P_{nov} = 1.0(0.0625")(30,000 psi)(0.270" - 0.1495")/3.0
P_{nov} = 75 lb

Capacity of Connection is 75 lb

Alternate Nail Fin Installation to Wood

#10 Pan Head Wood Screw

1-1/2" Minimum Penetration

1/16" thick 6063-T6 Aluminum Nailing Fin

G = 0.55 Minimum SYP 2x Wood Blocking

¼" maximum shim space

ASD Withdrawal

Withdrawal of #10 PH Wood Screw

$W' = 2{,}850(G^2)(D)(Cd)(Cm)(Ct)(Ceg)(Ctn)(L)$
W' = 2,850 (0.55^2)(0.190'')(1.6)(0.7)(0.7)(1.00)(1.0)(1.50'')
W' = 193 lb

Adjustment Factors

Load Duration Factor - Ten Minutes, Cd = 1.6
Moisture Factor - Fabrication > 19% and In-Service > 19%, Cm = 0.7
Temperature Factor - 100°F < T ≤ 125°F, Ct = 0.7
End Grain Factor - No, Ceg = 1.00
Toe Nail Factor - No, Ctn = 1.0

Pull-Over of #10 PH Wood Screw

$P_{nov} = C_{pov}t_1F_{tu1}(D_{ws}-D_h)/3.0$
P_{nov} = 1.0(0.0625")(30,000 psi)(0.365" – 0.201")/3.0
P_{nov} = 103 lb

Calculated Capacity of Connection is 103 lb

Alternate Nail Fin Installation to Steel Stud

#10-16 TEKS Screw

Full Penetration +3 Threads

1/16" thick 6063-T6 Aluminum Nailing Fin

Minimum 18 Gauge 33 KSI Steel Stud (Qualifies thicker and stronger steel)

¼" maximum shim space

Allowable Tension of #10-16 TEKS Screw

V_a = 885 lb (ESR-1976)

Pull-Over of #10-16 TEKS Screw in Nail Fin

$P_{nov} = C_{pov}t_1F_{tu1}(D_{ws}-D_h)/3.0$

$P_{nov} = 1.0(0.0625")(30{,}000\ psi)(0.365" - 0.201")/3.0$

P_{nov} = 103 lb

Pull-Out of #10-16 TEKS Screw in Steel Stud

$P_{not} = 0.85t_cdF_{u2}/3.0$

$P_{not} = 0.85(0.0478")(0.190")(45{,}000\ psi)/3.0$

P_{not} = 116 lb

Capacity of Connection is 103 lb

Anchorage Loads

Window Size:	60" wide by 99" tall
Design Pressure:	+/- 50 psf
As-tested Anchor Spacing:	11-1/2" on center at jambs 13" on center at head and sill
Anchors:	9 each jamb; 5 head; 5 sill; 28 total anchors
Maximum Load to Anchor:	(60")(99")(50 psf/144)/(28 anchors) = 74 lb/anchor

Maximum Load to Anchor < Minimum Anchor Capacity; Anchorages OK

Glass Analysis

Analysis 1

Load Resistance Report

October 29, 2023

Details

Selected standard: ASTM E1300 Extended Basic

Glazing Construction (Double Glazed Insulating Unit)

Exterior Lite Properties (3/16 in. Monolithic)

Construction: 3/16 in. (AN)

Airspace Properties

Thickness: 0.625 in.

Interior Lite Properties (3/16 in. Monolithic)

Construction: 3/16 in. (AN)

Load Resistance

Short Duration (3 Sec)

Description	NFL	GTF	LSF	LR
Exterior Lite	46.9 psf	0.900	1/0.500	84.4 psf
Interior Lite	46.9 psf	0.900	1/0.500	84.4 psf

Comparisons

Scenario 1

50.0 psf 3.00 sec <= 84.4 psf OK

Approximate center of glass deflection

Exterior Lite 0.43 in.

Interior Lite 0.43 in.

Notes

Load resistance values are computed in accordance with ASTM E1300-16 Section 6.2 and are based on non-factored load values calculated in a manner consistent with those presented in ASTM E1300-16.

TEKS Screw References

TABLE 5—FASTENER STRENGTH OF SCREWS[1, 2, 3, 4, 5]

SCREW DESIGNATION	DIAMETER (in.)	ALLOWABLE FASTENER STRENGTH		NOMINAL FASTENER STRENGTH	
		Tensile, P_{ts}/Ω (lbf)	Shear, P_{ss}/Ω (lbf)	Tensile, P_{ts} (lbf)	Shear, P_{ss} (lbf)
10-16	0.190	885	573	2654	1718
12-14	0.216	1184	724	3551	2171
12-24	0.216	1583	885	4750	2654
1/4-14	0.250	1605	990	4816	2970
1/4-28	0.250	1922	1308	5767	3925

For **SI:** 1 inch = 25.4 mm, 1 lbf = 4.45 N.

[1]For tension connections, the least of the allowable pull-out, pullover, and fastener tension strength found in Tables 2, 3, and 5, respectively, must be used for design.
[2]For shear connection, the lower of the allowable shear (bearing) and the allowable fastener shear strength found in Table 4 and 5, respectively, must be used for design.
[3]See Section 4.1 for fastener spacing and end distance requirements.
[4]Nominal strengths are based on laboratory tests
[5]To calculate LRFD values, multiply nominal strength values by the LRFD Φ factor of 0.5.

TABLE 22.11 (Spaced Threads)

6063-T6											
Nominal Thread Diameter & Thread Per Inch	D Nominal Thread Diameter (Inch)	Aluminum Thickness (Inches)										
		0.038	0.060	0.072	0.080	0.094	0.125	0.156	0.188	0.250	0.312	0.375
		Allowable Pullout (Pounds)										
#8-18	0.1640	53	83	100	132	155	235	350	468	669	835	1004
#10-16	0.1900	61	96	116	153	180	239	372	509	775	968	1163
#12-14	0.2160	--	110	132	174	204	271	374	530	833	1100	1322
1/4-14	0.2500	--	127	152	201	236	314	433	614	964	1273	1530
5/16-12	0.3125	--	--	--	--	--	--	--	809	1334	1860	2296
3/8-12	0.3750	--	--	--	--	--	--	--	971	1601	2232	2755

6063-T6		
F_U (Tensile Ultimate Strength)	30000	psi
F_Y (Tensile Yield Strength)	25000	psi

Shading indicates transition region.

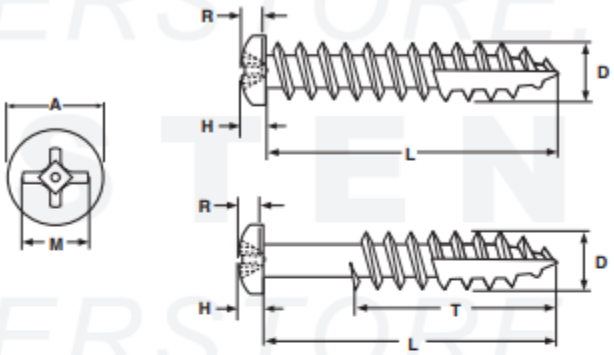
NOTE 32:
1. *Each table lists allowable pull-out (internal threads) values. $S_F = 3.0$ for $D \leq 0.25$"; $S_F = 2.5$ for $D \geq 0.3125$". Fastener allowable strength (basic tension and external threads) needs to be checked separately.*
2. *For pilot hole sizes refer to tables 21.1 to 21.7*
3. *Fastener pullout not shown for aluminum thickness less than approximately 2 threads, unless tested at a lesser thickness.*
4. *Multiple fastener connections and embrittlement need to be checked separately.*

Appendix

WOOD SCREWS

Pan Head w/ Phillips Recess

TYPE-17 DEEP THREAD



PAN PHILLIPS RECESS DEEP THREAD WOOD SCREW WITH TYPE-17 POINT

Nominal Diameter & Threads per Inch	A		H		R		M	D		T		Torque Kg/cm (Steel screws)	Recess Size
	Head Diameter		Head Height		Recess Penetration Depth		Recess Diameter	Major Diameter		Threaded Length			
	Max	Min	Max	Min	Max	Min	Ref	Max	Min	L ≤ 1"	L > 1"	Min	
6-13	0.270	0.256	0.097	0.087	0.080	0.055	0.159	0.142	0.131	Full thread	2/3 thread	21	#2
7-12	0.296	0.281	0.106	0.096	0.089	0.064	0.170	0.158	0.147	Full thread	2/3 thread	28	#2
8-11	0.322	0.306	0.115	0.105	0.097	0.071	0.175	0.169	0.159	Full thread	2/3 thread	37	#2
10-9	0.373	0.357	0.133	0.122	0.113	0.089	0.192	0.194	0.185	Full thread	2/3 thread	55	#2
12-8	0.425	0.407	0.151	0.139	0.124	0.098	0.252	0.230	0.213	Full thread	2/3 thread	64	#3

Tolerance on Length		
	Up to 5/8"	± 0.03
	Over 5/8 to 1.5"	± 0.05
	Over 1.5 to 2.75"	± 0.06
	Over 2.75"	± 0.09

Description	An externally threaded fastener with a dome-shaped head, cross recess and a single lead thread. The shank has a reduced diameter and a chip cavity cut out where the final several threads end at the tip.	
Applications / Advantages	The deeper thread design offers greater resistance to pull-out forces. Popular in fastening cabinet hardware in locations that do not require the head to countersink. The chip cavity (or auger point) are designed to attach hinges to the edge of hardwood face frames.	Used in environments where corrosion resistance is neccesary. The type-17 point enables the screw to more easily penetrate the material into which it's fastened. Can be used in particle board, wood and some plastics.
Material	C1018 - 1022 case-hardened steel	18-8 Stainless Steel
Surface Hardness	Vickers 450 HV minimum	-
Case Depth	0.004" - 0.009"	-
Torque	See values in above table	-
Plating	See Appendix-A for plating information	Stainless deep thread screws are usually supplied without additional finish.

Tap & Clearance Drill Sizes				Tap Drill				Clearance Drill			
Screw Size	Major Diameter	Threads Per Inch	Minor Diameter	75% Thread for Aluminum, Brass, & Plastics		50% Thread for Steel, Stainless, & Iron		Close Fit		Free Fit	
				Drill Size	Dec. Eq.	Drill Size	Dec. Eq.	Drill Size	Dec. Eq.	Drill Size	Dec. Eq.
0	.0600	80	.0447	3/64	.0469	55	.0520	52	.0635	50	.0700
1	.0730	64	.0538	53	.0595	1/16	.0625	48	.0760	46	.0810
		72	.0560	53	.0595	52	.0635				
2	.0860	56	.0641	50	.0700	49	.0730	43	.0890	41	.0960
		64	.0668	50	.0700	48	.0760				
3	.0990	48	.0734	47	.0785	44	.0860	37	.1040	35	.1100
		56	.0771	45	.0820	43	.0890				
4	.1120	40	.0813	43	.0890	41	.0960	32	.1160	30	.1285
		48	.0864	42	.0935	40	.0980				
5	.125	40	.0943	38	.1015	7/64	.1094	30	.1285	29	.1360
		44	.0971	37	.1040	35	.1100				
6	.138	32	.0997	36	.1065	32	.1160	27	.1440	25	.1495
		40	.1073	33	.1130	31	.1200				
8	.1640	32	.1257	29	.1360	27	.1440	18	.1695	16	.1770
		36	.1299	29	.1360	26	.1470				
10	.1900	24	.1389	25	.1495	20	.1610	9	.1960	7	.2010
		32	.1517	21	.1590	18	.1695				
12	.2160	24	.1649	16	.1770	12	.1890	2	.2210	1	.2280
		28	.1722	14	.1820	10	.1935				
		32	.1777	13	.1850	9	.1960				
1/4	.2500	20	.1887	7	.2010	7/32	.2188	F	.2570	H	.2660
		28	.2062	3	.2130	1	.2280				
		32	.2117	7/32	.2188	1	.2280				
5/16	.3125	18	.2443	F	.2570	J	.2770	P	.3230	Q	.3320
		24	.2614	I	.2720	9/32	.2812				
		32	.2742	9/32	.2812	L	.2900				
3/8	.3750	16	.2983	5/16	.3125	Q	.3320	W	.3860	X	.3970
		24	.3239	Q	.3320	S	.3480				
		32	.3367	11/32	.3438	T	.3580				
7/16	.4375	14	.3499	U	.3680	25/64	.3906	29/64	.4531	15/32	.4687
		20	.3762	25/64	.3906	13/32	.4062				
		28	.3937	Y	.4040	Z	.4130				
1/2	.5000	13	.4056	27/64	.4219	29/64	.4531	33/64	.5156	17/32	.5312
		20	.4387	29/64	.4531	15/32	.4688				
		28	.4562	15/32	.4688	15/32	.4688				
9/16	.5625	12	.4603	31/64	.4844	33/64	.5156	37/64	.5781	19/32	.5938
		18	.4943	33/64	.5156	17/32	.5312				
		24	.5114	33/64	.5156	17/32	.5312				
5/8	.6250	11	.5135	17/32	.5312	9/16	.5625	41/64	.6406	21/32	.6562
		18	.5568	37/64	.5781	19/32	.5938				
		24	.5739	37/64	.5781	19/32	.5938				
11/16	.6875	24	.6364	41/64	.6406	21/32	.6562	45/64	.7031	23/32	.7188
3/4	.7500	10	.6273	21/32	.6562	11/16	.6875	49/64	.7656	25/32	.7812
		16	.6733	11/16	.6875	45/64	.7031				
		20	.6887	45/64	.7031	23/32	.7188				
13/16	.8125	20	.7512	49/64	.7656	25/32	.7812	53/64	.8281	27/32	.8438
7/8	.8750	9	.7387	49/64	.7656	51/64	.7969	57/64	.8906	29/32	.9062
		14	.7874	13/16	.8125	53/64	.8281				
		20	.8137	53/64	.8281	27/32	.8438				
15/16	.9375	20	.8762	57/64	.8906	29/32	.9062	61/64	.9531	31/32	.9688
1	1.000	8	.8466	7/8	.8750	59/64	.9219	1-1/64	1.0156	1-1/32	1.0313
		12	.8978	15/16	.9375	61/64	.9531				
		20	.9387	61/64	.9531	31/32	.9688				

Revision Log

Rev. #	Date	Page(s)	Revision(s)
0	10/30/23	N/A	Original report issue