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November 2, 2018

Mr. David Tsay
Solar Warehouse
9628 Valley Blvd.
Rosemead, CA 91770

Project Number 1180890C

Subject: SWH Solar Mount Roof Hook
Part #MR-SW-RF5.8LPB, MR-SW5.8LP Laboratory Load Testing

Dear Mr. Tsay:

As requested, Applied Materials & Engineering, Inc. (AME) has completed load-testing the SWH Solar Mount Roof Hook (Part #MR-SW-RF5.8LPB, MR-SW5.8LP); see Appendix A, Figure A1 for product details. The purpose of our testing was to evaluate the compressive and tensile (uplift) load capacity of the SWH Solar Mount Roof Hook attached to a 2"x6" Douglas Fir rafter using two 5/16"Øx3.5" lag screws.

SAMPLE DESCRIPTION

Mockup samples were delivered to our laboratory on October 12, 2018. Mockup configuration consisted of three 18" long rafters at 8"o.c., screwed to 1/2" OSB. The SWH Solar Mount Roof Hook is attached through the OSB into a rafter via two 5/16"Øx3.5" lag screws.

TEST PROCEDURES & RESULTS

1. Compressive Load Test

A total of three tests were conducted for compressive load capacity on October 29, 2018 using a United Universal testing machine. Samples were rigidly attached to the testing machine and a compressive load was applied to each hook. The samples were loaded in compression at a constant rate of axial deformation of 0.10 in. /min. without shock until failure occurred; displacement at maximum load was recorded. Based on the above testing, the average maximum compressive load of the SWH Solar Mount Roof Hook attached to a 2"x6" Douglas Fir rafter using two 5/16"Øx3.5" lag screws was determined to be 315 lbf. Detailed results are provided in Table I and Figure 1. Test setup and mode of failure are provided in Appendix B, Figure B1.

The specific gravity and moisture content of each rafter was tested in accordance with ASTM D2395, Method A (oven-dry). The average specific gravity and average moisture content of the three samples were determined to be 0.391 and 8.9%, respectively.

2. Tensile (Uplift) Load Test

A total of three tests were conducted for tensile (uplift) load capacity on October 29, 2018 using a United Universal testing machine. Samples were rigidly attached to the testing machine and an uplift (tensile) load was applied to each hook. The samples were loaded in tension at a constant rate of axial deformation of 0.10 in. /min. without shock until failure occurred; displacement at maximum load was recorded. Based on the above testing, the average maximum uplift load of SWH Solar Mount Roof Hook attached to a 2"x6" Douglas Fir rafter using two 5/16"Øx3.5" lag screws was determined to be 539 lbf. Detailed results are provided in Table II and Figure 2. Test setup and mode of failure are provided in Appendix B, Figure B2.

The specific gravity and moisture content of the rafter was tested in accordance with ASTM D2395, Method A (oven-dry). The average specific gravity and average moisture content of the three samples were determined to be 0.393 and 8.9%, respectively.

Respectfully Submitted,

APPLIED MATERIALS & ENGINEERING, INC.

Joseph Gapuz
Laboratory Manager

Reviewed by:

REGISTERED PROFESSIONAL ENGINEER
ARMEN TAJIRIAN
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Principal

TABLE I

COMPRESSIVE LOAD TEST RESULTS

SWH SOLAR MOUNT ROOF HOOK
PART #MR-SW-RF5.8LPB, MR-SW5.8LP w/ 5/16"Øx3.5" LAG SCREWS

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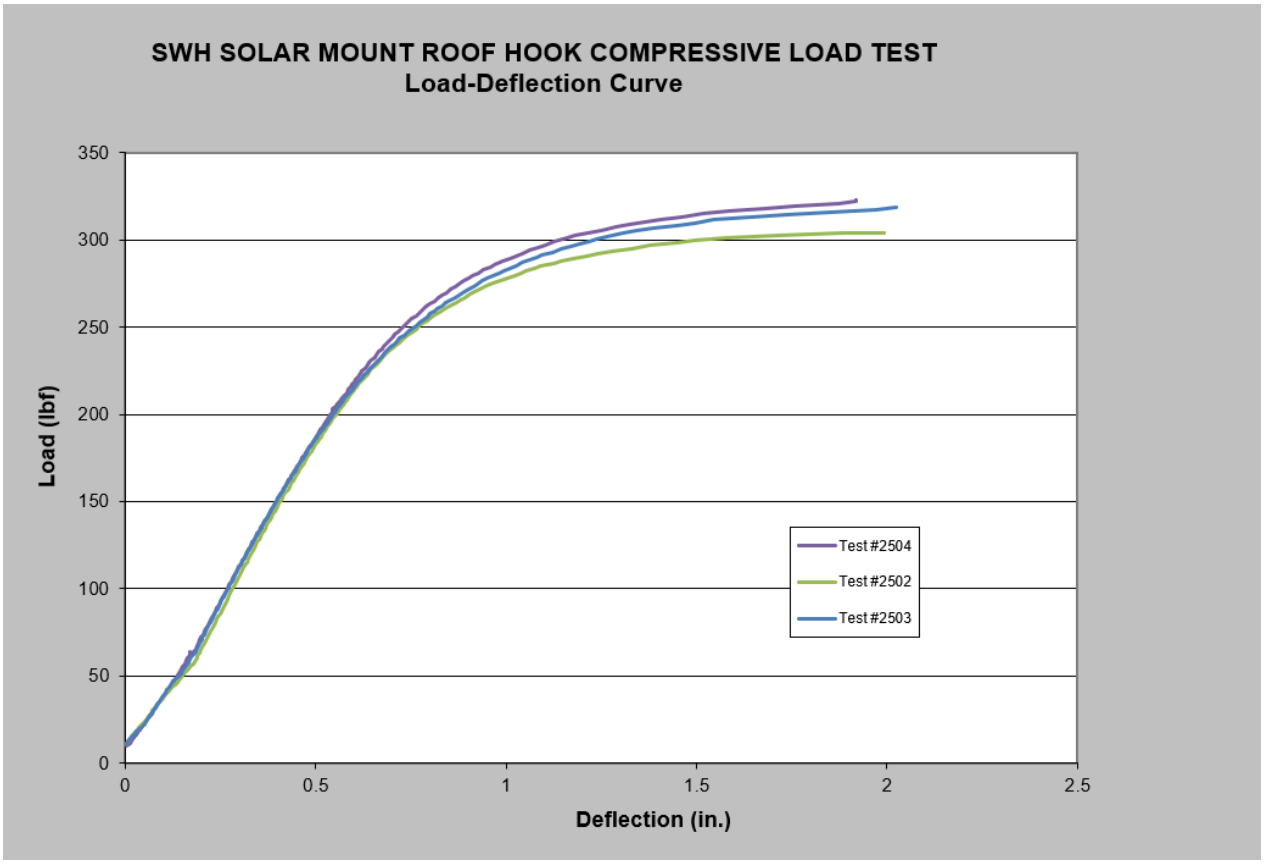
TEST NUMBER	MAXIMUM COMPRESSIVE LOAD (lbf)	DISPLACEMENT AT MAXIMUM LOAD (in.)	MODE OF FAILURE	RAFTER SPECIFIC GRAVITY	RAFTER MOISTURE CONTENT (%)
2502	304	2.0	Hook Contacted Plywood	0.394	8.9
2503	319	2.0		0.395	9.1
2504	323	2.0		0.383	8.8
AVERAGE	**315**	**2.0**	**..**	**0.391**	**8.9**

FIGURE 1



Note: Maximum load recorded at moment L-Foot contacts plywood; see Appendix B for image of failure mode.

TABLE II

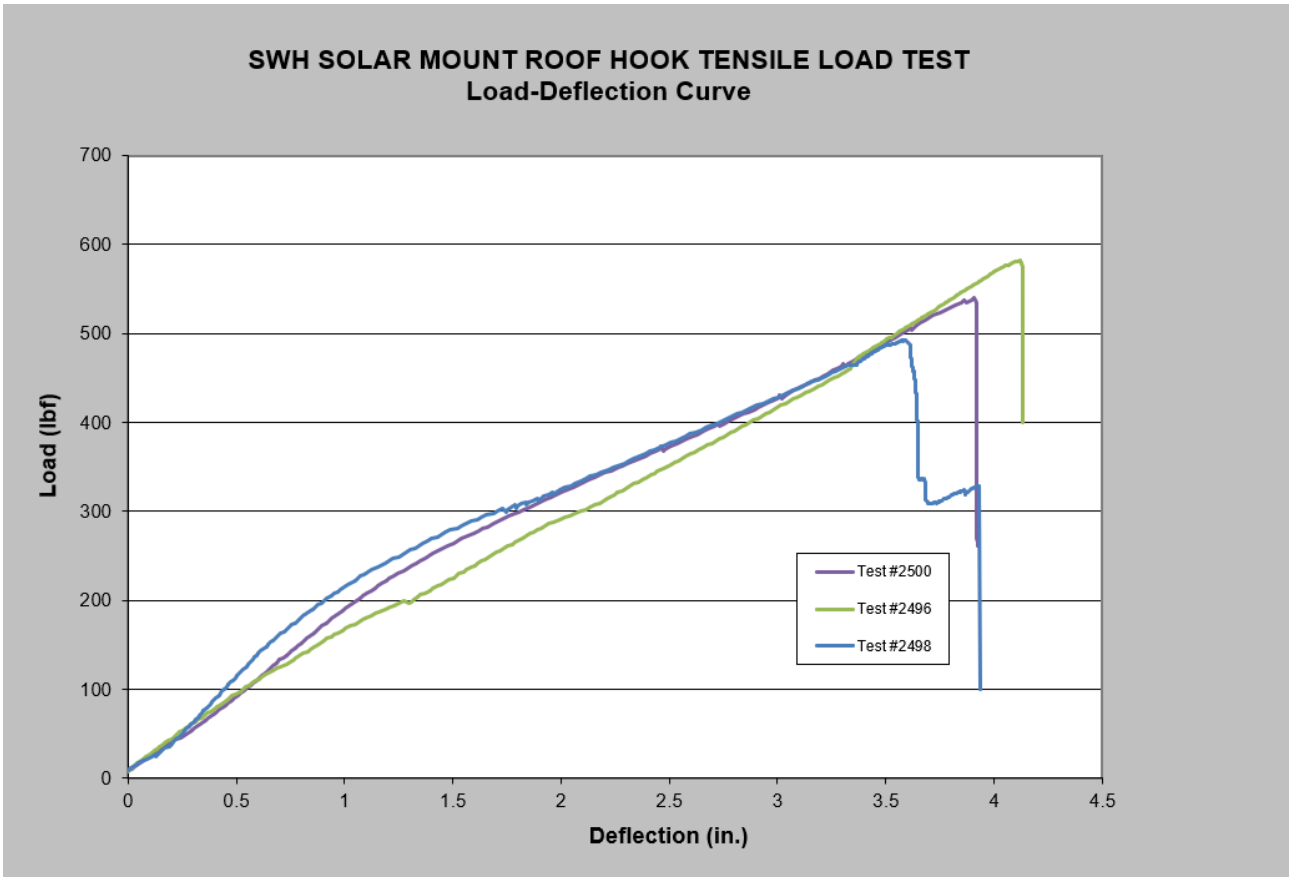
TENSILE (UPLIFT) LOAD TEST RESULTS

SWH SOLAR MOUNT ROOF HOOK
PART #MR-SW-RF5.8LPB, MR-SW5.8LP w/ 5/16"Øx3.5" LAG SCREWS

PROJECT NUMBER 1180860C

TEST NUMBER	MAXIMUM TENSILE LOAD (lbf)	DISPLACEMENT AT MAXIMUM LOAD (in.)	MODE OF FAILURE	RAFTER SPECIFIC GRAVITY	RAFTER MOISTURE CONTENT (%)
2496	582	4.1	Hook Broke	0.390	9.1
2498	493	3.6		0.395	8.7
2500	541	3.9		0.394	8.9
AVERAGE	**539**	**3.9**	**..**	**0.393**	**8.9**

FIGURE 2



REFERENCES

AC13-2010, "*Acceptance Criteria for Joist Hangers and Similar Devices*", ICC Evaluation Service.

AC85-2008, "*Acceptance Criteria for Test Reports*", ICC Evaluation Service.

ASTM D1761-2006, "*Standard Test Methods for Mechanical Fasteners in Wood*", ASTM International.

ASTM D2395-2007, *"Standard Test Method for Specific Gravity of Wood and Wood-Based Materials"*, ASTM International.

APPENDIX A

FIGURE A1

SWH SOLAR MOUNT ROOF HOOK
PART #MR-SW-RF5.8LPB, MR-SW5.8LP w/ 5/16"Øx3.5" LAG SCREWS

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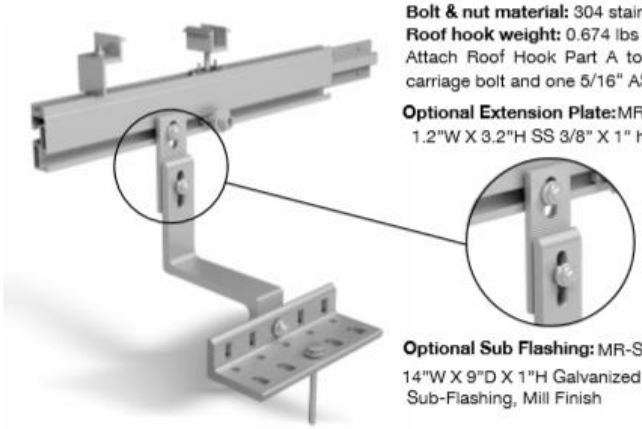
SWH SOLAR WAREHOUSE

SWH Racking System Data Sheet Version 12.10.v2

SWH Solar Mount Roof Hook
Part No. MR-SW-RF5.8LPB, MR-SW5.8LP

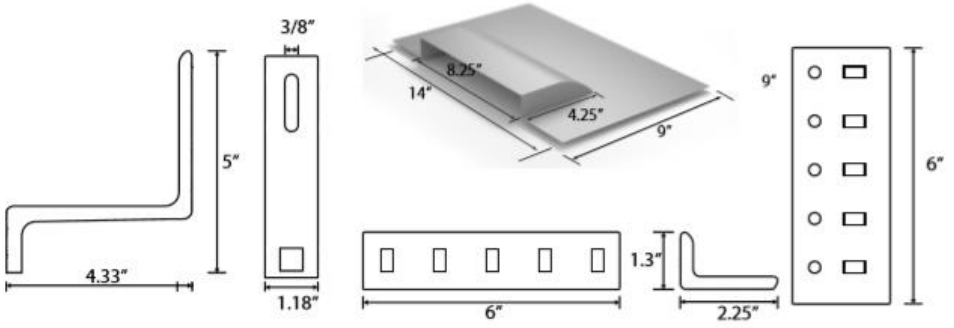
Roof hook material: 6005-T5 extruded aluminum alloy
Finish: Clear or black anodized
Bolt & nut material: 304 stainless steel
Roof hook weight: 0.674 lbs
Attach Roof Hook Part A to Part B with one 5/16" x 1" carriage bolt and one 5/16" ASTM F594 serrated flange nut.

Optional Extension Plate: MR-SW-EP-32, MR-SW-EP-32B
1.2"W X 3.2"H SS 3/8" X 1" hex bolts and flange nuts



Optional Sub Flashing: MR-SW-RF140906G-
14"W X 9"D X 1"H Galvanized Steel Roof Sub-Flashing, Mill Finish

CONFORMS TO UL 2703
ETL CLASSIFIED
Intertek 4009330



Lag pull-out (withdrawal) capacities (lbs) in typical roof lumber (ASD)

	Specific gravity	5/16"lag screw* specifications per inch thread depth
Douglas Fir, Larch	0.50	266
Douglas Fir, South	.46	235
Engelmann Spruce, Lodgepole Pine[1]	.46	235
Hem, Fir, Redwood (close grain)	.43	212
Hem, Fir (North)	.46	235
Southern Pine	.55	307
Spruce, Pine, Fir	.42	205
Spruce, Pine, Fir[2]	.50	266

[1] MSR 1650 f & higher
[2] E of 2 million psi and higher grades of MSR and MEL

Sources: American Wood Council, NDS 2005, Table 11.2a, 11.3.2A.

Notes:
(1) Thread must be embedded in the side grain of a rafter or other structural member integral with building structure.
(2) Lag bolts must be located in the middle third of the structural member.
(3) These values are not valid for wet service.
(4) This table does not include shear capacities. If necessary, contact a local engineer to specifiy lag bolt size with regard to shear forces.
(5) Install lag bolts with head and washer flush to surface (no gap). Do not over-torque.
(6) Withdrawal design values for lag screw connections shall be multiplied by applicable adjustment factors if necessary. See Table 10.3.1 in the American Wood Council NDS for Wood Construction.

**Use flat washers with lag screws.*

APPENDIX B

FIGURE B1

SWH SOLAR MOUNT ROOF HOOK
PART #MR-SW-RF5.8LPB, MR-SW5.8LP w/ 5/16"Øx3.5" LAG SCREWS

COMPRESSIVE LOAD TEST

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Figure B1a. Test Setup

Figure B1b. Typical Failure Mode

FIGURE B2

SWH SOLAR MOUNT ROOF HOOK
PART #MR-SW-RF5.8LPB, MR-SW5.8LP w/ 5/16"Øx3.5" LAG SCREWS

TENSILE (UPLIFT) LOAD TEST

PROJECT NUMBER 1180860C

Figure B2a. Test Setup

Figure B2b. Typical Failure Mode