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Solar Connections
McHenry, Illinois

Structural Testing Report
Standing Seam Roof Panel Connection
Testing

Book 1 of 1
Calculation Release #1

Prepared for
Solar Connections International
McHenry, Illinois

Larson Engineering, Inc.
Appleton, Wisconsin
Project Number 33180135.000

Table 1: Uplift Test Results

| Identification | Style | Substrate | Clamp Type | Set Screw Count | Ultimate Load (lbs) | Allowable (lbs) |
|----------------------------|-----------------|-----------|------------|-----------------|---------------------|-----------------|
| Firestone UC3 | Single Lock | 22 | Mini | 1 | 1,053 | 527 |
| | | 24 | Mini | 1 | 830 | 415 |
| Berridge Zee | Double Lock | 22 | Std | 2 | 1,722 | 861 |
| | | 24 | Std | 2 | 1,201 | 601 |
| Berridge | Double Lock | 24 | Mini | 1 | 1,046 | 523 |
| Peterson | Snap Lock | 24 | Std | 2 | 1,303 | 652 |
| Firestone | Snap Lock | 0.032 | Std | 2 | 1,086 | 543 |
| McElroy T238 | T-seam | 24 | Wide | 1 | 971 | 486 |
| | | 24 | Wide | 2 | 1,232 | 616 |
| M&E Zip Rib | Bulb Style | 0.032 | Wide | 1 | 837 | 419 |
| | | 0.032 | Wide | 2 | 1,601 | 801 |
| | | 24 | Wide | 1 | 1,369 | 685 |
| Berridge Cee | Cee Lock | 24 | Wide | 1 | 1,129 | 565 |
| | | 24 | Wide | 2 | 1,498 | 749 |
| | | 22 | Wide | 1 | 1,187 | 594 |
| | | 22 | Wide | 2 | 1,362 | 681 |
| Central States Horizon Loc | 1" Nail Strip | 26 | KLoc Mini | 1 | 933 | 467 |
| | | 26 | KLoc Mini | 2 | 1,282 | 641 |
| DMI N515 | 1.5" Nail Strip | 24 | KLoc | 2 | 1,531 | 766 |

Notes:

1. Tabulated values are based upon testing performed by Element Materials Technology on February 28, 2018, Report #: ENB023261P
2. Allowable load capacities listed are calculated using an applied safety factor of 2.
3. The testing and tabulated loads are for the connection of the clamp to the appropriate roof panel only.
4. The design of the building's roof panels for the applied loading are the responsibility of the Engineer of Record for the project.

Table 2: Shear Test Results

| Identification | Style | Substrate | Clamp Type | Set Screw Count | Ultimate Load (lbs) | Allowable (lbs) |
|----------------------------|---------------|-----------|------------|-----------------|---------------------|-----------------|
| Firestone UC3 | Single Lock | 22 | Mini | 1 | 1,005 | 503 |
| | | 24 | Mini | 1 | 839 | 420 |
| Berridge Zee | Double Lock | 22 | Std | 2 | 2,036 | 1,018 |
| | | 24 | Std | 2 | 1,318 | 659 |
| | | 24 | Wide | 1 | 1,289 | 645 |
| | | 24 | Wide | 2 | 1,706 | 853 |
| Peterson | Snap Lock | 24 | Std | 2 | 1,594 | 797 |
| McElroy T238 | T-seam | 24 | Wide | 1 | 1,262 | 631 |
| | | 24 | Wide | 2 | 1,410 | 705 |
| M&E Zip Rib | Bulb Style | 0.032 | Wide | 1 | 1156 | 578 |
| | | 0.032 | Wide | 2 | 2,006 | 1,003 |
| Berridge Cee | Cee Lock | 22 | Wide | 1 | 1,237 | 619 |
| | | 22 | Wide | 2 | 1,529 | 765 |
| Central States Horizon Loc | 1" Nail Strip | 26 | KLoc Mini | 1 | 663 | 332 |
| | | 26 | KLoc Mini | 2 | 1,353 | 677 |

- Notes:
1. Tabulated values are based upon testing performed by Element Materials Technology on February 28, 2018, Report #: ENB023261P
 2. Allowable load capacities listed are calculated using an applied safety factor of 2.
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Report Number: ENB023261P
Client Reference: 2017-56

Shear and Uplift Load Capacity of Roof Clamps

Prepared by:

Electronic original

A handwritten signature in black ink, appearing to read 'Rob Evans', written over a white background.

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INTRODUCTION AND OBJECTIVE

Solar Connections provided various mock-up roof panels for testing with different seam profiles and clamp types. Each panel was to have a clamp installed and then tested for maximum load capacity by either shear or uplift load directions. An example of a panel with a clamp installed is shown in Figure 1. The assemblies were to be tested for maximum shear and uplift load capacity. Uplift was to be a tensile load to the clamp, perpendicular to the panel surface. Shear was to be a side load to the clamp, parallel to the panel surface, along the axis of the seam.

TESTS AND RESULTS

Samples

Mock-up roof panel samples were constructed of various base materials including 26, 24, and 22 gauge steel, and 0.032 inch thick aluminum. These were formed into various seam profiles including Double Lock, Single Lock, Snap Lock, Nail Strip, Bulb Style, T-Seam, and Cee Lock. Each seam profile was identified with specific clamps that were to be used with it. The clamp types included Standard, Wide, Mini, Kloc, Kloc Mini. Clamps were to either have one or two set screws, but not all combinations were available for the current testing.

Fixtures

For the uplift tests, the panels were clamped to the base of the test machine and the load applied with a socket head cap screw installed in the clamp. The uplift test setup is shown in Figure 2. For the shear tests, the panels were clamped to an angle bracket that was clamped to the base of the test machine. The load was applied with a C-shaped fixture that was similar to the shape of the clamps. The load was applied along the axis of the seam, parallel to the panel. The shear test setup is shown in Figure 3.

Tests

Load was applied at a rate of 0.5 inches per minute until excessive slippage or deformation was observed. It should be noted that there was no distinct failure point for most assemblies. The uplift tests were generally stopped due to excessive deformation or visible slipping of the set screws against the base metal. In the uplift direction, the maximum recorded loads ranged from 694 to 1,854 pounds. The shear tests were generally stopped due to visible slipping of the set screws against the base metal. In the shear direction, the maximum recorded loads ranged from 574 to 2,949 pounds. The results are listed in Tables 1 and 2.

EQUIPMENT

| Element Equipment ID | Description | Calibration Date | Calibration Due |
|----------------------|-------------|------------------|-----------------|
| 006-04-0004 | Load Cell | 5/31/17 | 5/31/18 |
| 008-04-0091 | LVDT | 5/31/17 | 5/31/18 |

If you have any questions concerning the contents of this report, please contact the author. It should be noted that it is our policy to retain components and sample remnants for 30 days from the date of this report, after which time they will be discarded. Please contact the author of this report should you wish to make alternate arrangements for disposition of the material.

Table 1: Uplift Test Results

| Identification | Style | Substrate | Clamp Type | Set Screw Count | Peak Load (lbs) | Average (lbs) |
|----------------------------|-----------------|-----------|------------|-----------------|-----------------|---------------|
| Firestone UC3 | Single Lock | 22 | Mini | 1 | 1,363 | 1,156 |
| | | | | 1 | 1,192 | |
| | | | | 1 | 914 | |
| | | 24 | Mini | 1 | 821 | 830 |
| | | | | 1 | 824 | |
| | | | | 1 | 846 | |
| Berridge Zee | Double Lock | 22 | Std | 2 | 1,854 | 1,766 |
| | | | | 2 | 1,732 | |
| | | | | 2 | 1,712 | |
| | | 24 | Std | 2 | 1,163 | 1,201 |
| | | | | 2 | 1,187 | |
| | | | | 2 | 1,254 | |
| Berridge | Double Lock | 24 | Mini | 1 | 1,041 | 1,046 |
| | | | | 1 | 1,048 | |
| | | | | 1 | 1,050 | |
| Peterson | Snap Lock | 24 | Std | 2 | 1,428 | 1,303 |
| | | | | 2 | 1,312 | |
| | | | | 2 | 1,169 | |
| Firestone | Snap Lock | 0.032 | Std | 2 | 1,104 | 1,086 |
| | | | | 2 | 1,044 | |
| | | | | 2 | 1,109 | |
| McElroy T238 | T-seam | 24 | Wide | 1 | 939 | 971 |
| | | | | 1 | 1,006 | |
| | | | | 1 | 969 | |
| | | 24 | Wide | 2 | 1,230 | 1,232 |
| | | | | 2 | 1,191 | |
| | | | | 2 | 1,275 | |
| M&E Zip Rib | Bulb Style | 0.032 | Wide | 1 | 866 | 837 |
| | | | | 1 | 766 | |
| | | | | 1 | 878 | |
| | | 0.032 | Wide | 2 | 1,591 | 1,601 |
| | | | | 2 | 1,636 | |
| | | | | 2 | 1,576 | |
| Berridge Cee | Cee Lock | 24 | Wide | 1 | 1,348 | 1,499 |
| | | | | 1 | 1,390 | |
| | | | | 1 | 1,759 | |
| | | 24 | Wide | 1 | 1,179 | 1,129 |
| | | | | 1 | 1,126 | |
| | | | | 1 | 1,083 | |
| 24 | Wide | 2 | 1,703 | 1,567 | | |
| | | 2 | 1,527 | | | |
| | | 2 | 1,470 | | | |
| Berridge Cee | Cee Lock | 22 | Wide | 1 | 1,222 | 1,187 |
| | | | | 1 | 1,191 | |
| | | | | 1 | 1,149 | |
| | | 22 | Wide | 2 | 1,716 | 1,480 |
| | | | | 2 | 1,398 | |
| | | | | 2 | 1,327 | |
| Central States Horizon Loc | 1" Nail Strip | 26 | KLoc Mini | 1 | 945 | 933 |
| | | | | 1 | 694 | |
| | | | | 1 | 945 | |
| | | | | 1 | 918 | |
| | | | | 1 | 996 | |
| | | | | 1 | 1,099 | |
| | | 26 | KLoc Mini | 2 | 1,272 | 1,338 |
| | | | | 2 | 1,449 | |
| | | | | 2 | 1,292 | |
| DMI N515 | 1.5" Nail Strip | 24 | KLoc | 2 | 1,574 | 1,531 |
| | | | | 2 | 1,574 | |
| | | | | 2 | 1,444 | |

Table 2: Shear Test Results

| Identification | Style | Substrate | Clamp Type | Set Screw Count | Peak Load (lbs) | Average (lbs) |
|----------------------------|---------------|-----------|------------|-----------------|-----------------|---------------|
| Firestone UC3 | Single Lock | 22 | Mini | 1 | 1,002 | 1,005 |
| | | | | 1 | 953 | |
| | | | | 1 | 1,061 | |
| | | 24 | Mini | 1 | 1,459 | 1,046 |
| | | | | 1 | 792 | |
| | | | | 1 | 887 | |
| Berridge Zee | Double Lock | 22 | Std | 2 | 2,949 | 2,340 |
| | | | | 2 | 1,943 | |
| | | | | 2 | 2,130 | |
| | | 24 | Std | 2 | 1,294 | 1,318 |
| | | | | 2 | 1,370 | |
| | | | | 2 | 1,290 | |
| | | 24 | Wide | 1 | 1,233 | 1,289 |
| | | | | 1 | 1,344 | |
| | | | | 1 | 1,291 | |
| | | 24 | Wide | 2 | 1,835 | 1,706 |
| | | | | 2 | 1,617 | |
| | | | | 2 | 1,667 | |
| Peterson | Snap Lock | 24 | Std | 2 | 1,631 | 1,594 |
| | | | | 2 | 1,632 | |
| | | | | 2 | 1,520 | |
| McElroy T238 | T-seam | 24 | Wide | 1 | 1,203 | 1,262 |
| | | | | 1 | 1,121 | |
| | | | | 1 | 1,462 | |
| | | 24 | Wide | 2 | 1,333 | 1,410 |
| | | | | 2 | 1,445 | |
| | | | | 2 | 1,453 | |
| M&E Zip Rib | Bulb Style | 0.032 | Wide | 1 | 1,202 | 1,156 |
| | | | | 1 | 1,136 | |
| | | | | 1 | 1,131 | |
| | | 0.032 | Wide | 2 | 2,063 | 2,006 |
| | | | | 2 | 2,016 | |
| | | | | 2 | 1,937 | |
| Berridge Cee | Cee Lock | 22 | Wide | 1 | 1,258 | 1,237 |
| | | | | 1 | 1,093 | |
| | | | | 1 | 1,360 | |
| | | 22 | Wide | 2 | 1,393 | 1,529 |
| | | | | 2 | 1,582 | |
| | | | | 2 | 1,611 | |
| Central States Horizon Loc | 1" Nail Strip | 26 | KLoc Mini | 1 | 666 | 663 |
| | | | | 1 | 574 | |
| | | | | 1 | 726 | |
| | | | | 1 | 708 | |
| | | | | 1 | 725 | |
| | | | | 1 | 578 | |
| | | 26 | KLoc Mini | 2 | 1,151 | 1,353 |
| | | | | 2 | 1,520 | |
| | | | | 2 | 1,388 | |

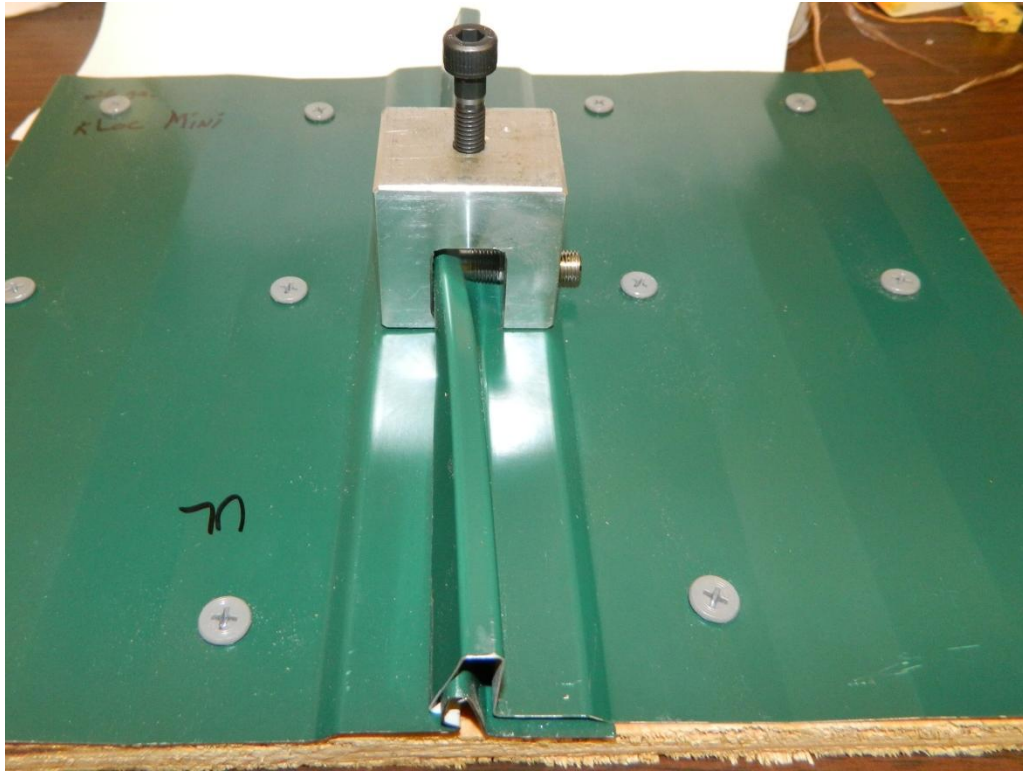


Fig. 1 - An example of a roof panel mock-up with clamp installed.



Fig. 2 - The uplift test setup is shown.



Fig. 3 - The shear test setup is shown.