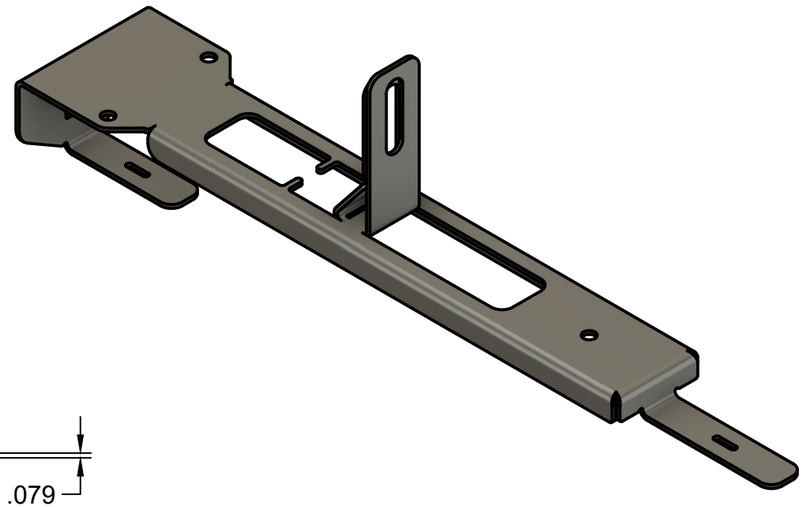
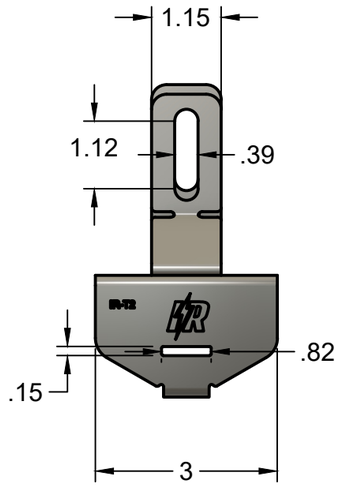
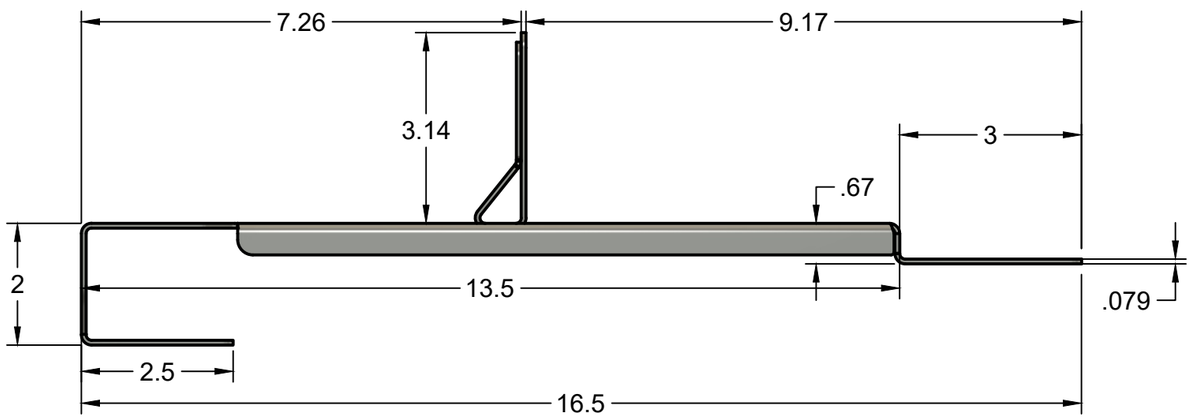


Top View





Back View



Side View

PROJECT	IntegraRack	
TITLE	IR-T1 No Penetration TileBallast™ Solar Module Mounting System	
	IR-T1TB1031	
APPROVED Paul Budge 08/02/2024	SIZE B	CODE
CHECKED Paul Budge 08/02/2024	DWG NO	REV
DRAWN Jeff Glauser 08/01/2024	SCALE 1:2.5	WEIGHT 1lb 3oz
	SHEET 1/1	

IR-T1 TileBallast Roof Mount				
PART NAME	PART NUMBER	DESCRIPTION	MATERIAL	COATING
IR-T1	IR-T1TB0031	No penetration TileBallast™ Roof Mount	.079" [2mm] A1008 Carbon Steel	Black Zinc Electroplated

Maximum Solar Module Size		
24 SQFT		
IR-T1 Spacing For Rails	**Maximum Wind Speed**	**Maximum Snow Load**
One Mount Every 6 ft	120 MPH	10 LBS/SQFT
One Mount Every 4 ft	160 MPH	15 LBS/SQFT

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Mr. Paul Budge
Diversi-Tech Corp – IntegraRack
PO Box 910758
St. George, UT 84791

Subject: Witness of Wind Tunnel Testing on IntegraRack Products at the George E Boeing Aeronautics Department (Kirsten Wind Tunnel) at the University of Washington

Dear My. Budge,

This letter summarizes the wind tunnel testing that was witnessed at the Kirsten Wind Tunnel (KWT) on November 8th, 2024. Testing took place at KWT on the University of Washington campus at 3900 7th Ave NE, Seattle, WA. Cara Winter was the manager of the facility and testing was performed and overseen by Test Engineers Stuart Dickson and Miguel Salguero. A detailed analysis and calculations of test data is outside the purview of this report and can be provided by KWT personnel.

The wind tunnel data summarized in this report, mechanical material stress testing and solar mount adhesion testing performed by PNL, and simulated wind/snow load model data was extrapolated on product datas sheets by IntegraRack for various product configurations and solar angles for the following IntegraRack solar panel products: TileBallast, BallastRack, BallastRack DR, MultiBallast, MultiBallast DB, H Module Brack, and the IR-F2 Bonding Clamp.

A total of 8 runs were performed on IntegraRack products. Test Runs 1 through 3 were performed with the IR-D1 bracket (See Figures 1-4) with an installed 18 SF solar panel on a simulated roof incline. Run 1 was performed to tare KWT's system through the full 0 to 110 degree rotation of the test platform with the simulated roof and panel installed. The roof surface had been installed at an approximate 5 – 6 degree incline (See Figure 1). The solar panel was mounted at 0 degrees relative to the roof surface with a general height of 5 in from the roof surface. at all four corners of the panel. Test Runs 4 and 5 were performed on the same panel and bracket with the panel height adjusted and installed at an angle with the front corners set to 3-1/2 in. and the back corners set to a height of 6 in. from the roof surface.

Test Runs 2 through 5 included rotating the test setup from 0 to 110 degrees while KWT instrumentation recorded test data. Wind speed was increased until limitations of KWT instrumentation prevented it from being increased further. Four load cells, Omega model LC103B-250 lb Class N10, were installed between the IntegraRack bracket and the roof surface to monitor and record loads applied to the brackets throughout testing (See Figures 5-10). The load cells were labeled LC0-1, LC0-2, LC5-3, and LC5-4 with LC0 being installed at the leading edge and LC5 being installed at the back edge.

The maximum load at a bracket recorded during Test Runs 2 and 3 was 75.015 lbf at a wind speed of 157.67 MPH when the panel was at a rotation point of 60 degrees. No damage or deformation was noted

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to any bracket during or after the test runs and all hardware was found to be secure upon completion of each test (See Figures 11-13).

Test Runs 6 through 8 were performed on the IR Ballast Racks (See Figures 14-32). The simulated roof structure was removed and the frames and panel were mounted directly to the KWT test platform. These runs were performed at a set angle with no platform rotation during the test run. Two load cells were used for the test setups and were mounted at the brackets at the leading edge of the test platform at the wind intake side.

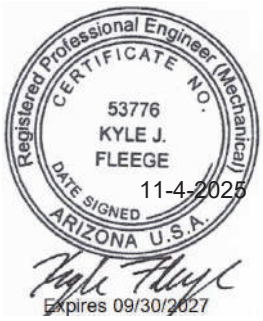
Run 6 was performed on the IR18C with the solar panel at an approximate 18 degree angle (Figures 24-25). The maximum load at a bracket recorded during Test Run 6 was 168.59 lbf at a wind speed of 101.59 MPH. Runs 7 and 8 were performed on the IR30C with the solar panel at a 30 degree angle (Figures 30-32) with Run 7 having the solar panel mounted and aligned with the wind direction to produce maximum forces on the frame and Run 8 being run in an orientation 90 degrees offset from Run 7. The maximum load at a bracket was during Test Run 7 and was 183.38 lbf at a wind speed of 81.138 MPH. Run 7 was stopped when the drag limit of the KWT test apparatus was reached. The solar frame experienced shaking under wind load but no damage was found to any part and all bolts were found to still be tight and in place after the test run. Run 8 was pitch limited by the KWT test apparatus. Similar to Run 7 the frame and solar panel had experienced shaking under load but no damage to the frame or panel was noted and all bolts and connections remained tight.

Test data tables provided by KWT and photos of testing throughout the Test Runs have been attached.

Respectfully submitted,

PHOENIX NATIONAL LABORATORIES, LLC





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Test data tables provided by Kirsten Wind Tunnel tests are shown below:

RUN	TEST	TP	PSI	QA	QC	SPEEDMPH	LC0-1	LC0-2	LC5-3	LC5-4	DB	LB
2	2379	3	0.0001	16.775	17.799	84.38	1.1732	0.9254	12.114	13.537	0	0
2	2379	4	9.9998	16.676	17.693	84.13	3.3832	0.1309	13.25	12.918	0	0
2	2379	5	20	16.788	17.813	84.414	6.5054	-1.2426	14.882	15.703	0	0
2	2379	6	30	14.846	15.752	79.391	8.6943	-2.5876	11.917	15.932	0	0
2	2379	7	40	15.216	16.144	80.374	10.566	-3.614	9.2887	17.334	0	0
2	2379	8	50	15.91	16.881	82.19	12.154	-4.7729	5.8138	18.225	0	0
2	2379	9	60	17.543	18.614	86.311	15.831	-4.7168	3.432	19.871	0	0
2	2379	10	70	18.075	19.177	87.609	15.929	-2.9647	1.6713	17.613	0	0
2	2379	11	80	19.807	21.015	91.718	16.576	-0.2715	1.6043	16.188	0	0
2	2379	12	90	26.487	28.103	106.081	20.349	2.4846	2.6014	20.856	0	0
2	2379	13	100	27.443	29.117	107.995	23.246	3.9239	1.6397	26.417	0	0
2	2379	14	110	28.046	29.758	109.19	30.304	4.9443	0.4954	31.084	0	0

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Test data tables provided by Kirsten Wind Tunnel tests are shown below:

RUN	TEST	TP	PSI	QA	QC	SPEEDMPH	LC0-1	LC0-2	LC5-3	LC5-4	DB	LB
3	2379	2	-0.0001	46.765	49.618	141.561	1.1642	2.3972	36.627	39.938	0	0
3	2379	3	10	47.13	50.006	142.153	7.9853	-0.2581	42.362	39.215	0	0
3	2379	4	20	48.375	51.327	144.054	17.809	-5.1282	48.033	50.868	0	0
3	2379	5	30	50.382	53.456	147.043	28.671	-12.013	46.107	61.281	0	0
3	2379	6	40	52.966	56.198	150.773	36.485	-22.577	33.65	68.344	0	0
3	2379	7	50	54.38	57.698	152.791	44.03	-28.356	17.304	72.349	0	0
3	2379	8	60	57.878	61.409	157.674	56.195	-27.306	4.63	75.015	0	0
3	2379	9	70	56.226	59.656	155.402	54.153	-16	-2.0357	62.293	0	0
3	2379	10	80	53.778	57.059	151.975	48.502	-4.0685	-2.0692	49.307	0	0
3	2379	11	90	57.92	61.454	157.771	47.213	3.5417	-0.5077	50.257	0	0
3	2379	12	100	54.454	57.777	152.979	46.905	6.1752	-4.2226	55.18	0	0
3	2379	13	110	36.199	38.408	124.779	34.937	5.9472	-9.3307	38.454	0	0

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Test data tables provided by Kirsten Wind Tunnel tests are shown below:

RUN	TEST	TP	PSI	QA	QC	SPEEDMPH	LC0-1	LC0-2	LC5-3	LC5-4	DB	LB
5	2379	3	0.0003	14.845	15.03	77.742	43.468	45.917	33.192	35.332	0	0
5	2379	4	10	14.115	14.291	75.806	39.406	45.863	32.548	33.352	0	0
5	2379	5	20	14.301	14.479	76.302	41.216	49.171	36.107	33.865	0	0
5	2379	6	30	15.476	15.669	79.377	43.323	49.791	40.199	30.547	0	0
5	2379	7	40	15.792	15.989	80.181	40.37	44.513	37.812	28.348	0	0
5	2379	8	50	15.441	15.633	79.284	34.815	34.07	29.669	27.254	0	0
5	2379	9	60	14.604	14.787	77.107	25.852	21.071	18.666	23.403	0	0
5	2379	10	70	15.452	15.644	79.315	19.532	11.214	10.48	19.561	0	0
5	2379	11	80	15.788	15.985	80.173	13.097	5.1532	4.4544	14.183	0	0
5	2379	12	90	15.937	16.136	80.55	10.261	2.0128	0.5043	11.748	0	0
5	2379	13	100	14.945	15.131	77.998	9.7597	-1.4293	-4.2425	10.805	0	0
5	2379	14	110	15.231	15.421	78.745	10.539	-5.6497	-13.113	8.2362	0	0

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Test data tables provided by Kirsten Wind Tunnel tests are shown below. Blockage corrections to calculate DB and LB ARE APPROXIMATION and were provided by KWT Test Engineers using a simplified version of Shindo's method, outlined in "Simplified Tunnel Correction Method" by Shojiro Shindo, American Institute of Aeronautics and Astronautics, Inc.< Washington DC, 1994: Journal of Aircraft Volume 32, Number 1, Pages 210-213. LB is the lift value and DB is the drag value after wind-off zero values have been subtracted.

RUN	TEST	TP	PSI	QA	QC	SPEEDMPH	LC0-1	LC0-2	LC5-3	LC5-4	DB	LB
6	2379	2	-0.0006	19.964	25.663	101.585	-206.622	-168.586	0.6796	0	244.379	363.911
6	2379	3	-0.0005	19.922	25.611	101.499	-206.361	-167.906	0.5212	0.0001	243.946	363.13
6	2379	4	-0.0005	18.132	23.265	96.748	-185.481	-146.788	-0.5698	0	220.212	326.42
6	2379	5	-0.0004	14.927	19.087	87.632	-146.747	-110.624	1.6089	0	178.639	262.798
6	2379	6	-0.0004	10.021	12.738	71.584	-89.117	-53.252	1.1724	-0.0001	116.858	169.83

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RUN	TEST	TP	PSI	QA	QC	SPEEDMPH	LC0-1	LC0-2	LC5-3	LC5-4	DB	LB
7	2379	2	-0.0001	10.101	16.001	80.229	-165.145	-179.17	-0.0654	0	239.012	297.932
7	2379	3	0	10.304	16.363	81.138	-170.329	-183.382	1.6992	0	245.281	304.603
7	2379	4	0	4.9808	7.7789	55.942	-70.106	-82.668	1.1755	0	113.803	142.75

RUN	TEST	TP	PSI	QA	QC	SPEEDMPH	LC0-1	LC0-2	LC5-3	LC5-4	DB	LB
8	2379	2	90.001	10.165	11.329	67.503	-1.1756	-7.5189	-1.3941	0	51.808	28.96
8	2379	3	90	15.002	16.716	81.993	-13.771	-17.132	0.1391	0	76.302	40.688
8	2379	4	90	17.966	20.011	89.723	-21.883	-23.854	0.307	0	91.033	50.149
8	2379	5	90	24.873	27.701	105.599	-45.078	-38.33	-0.174	0	125.875	68.707
8	2379	6	90	27.029	30.099	110.103	-53.423	-43.1	0.5537	0	136.673	76.038
8	2379	7	90	31.751	35.352	119.364	-71.986	-54.265	-0.7512	0	160.314	91.156
8	2379	8	90	39.784	44.294	133.708	-102.541	-76.2	0.5756	0	200.798	112.886

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Figure 1: Run 1 through 3 simulated roof setup

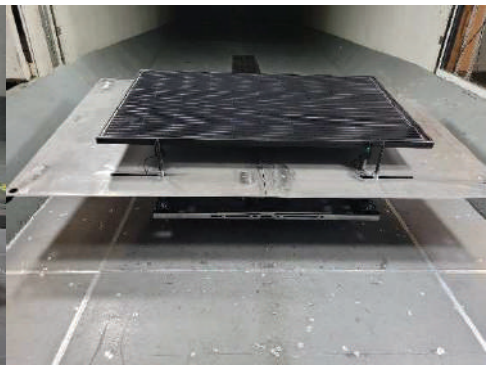

Figure 2: Run 1 through 3 setup with panel



Figure 3: Bracket at leading edge LC0-1, LC0-2

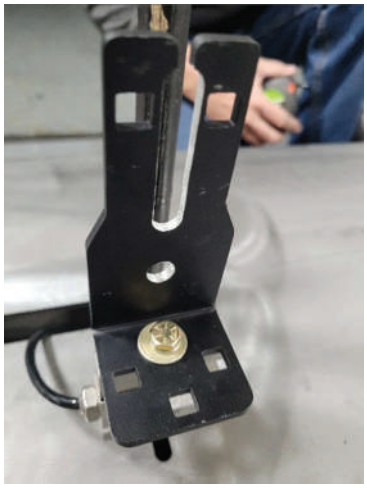

Figure 4: Bracket at back edge LC5-3, LC5-4

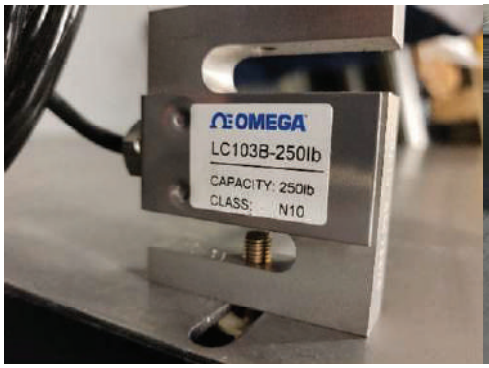

Figure 5: Load Cell Model used for tests

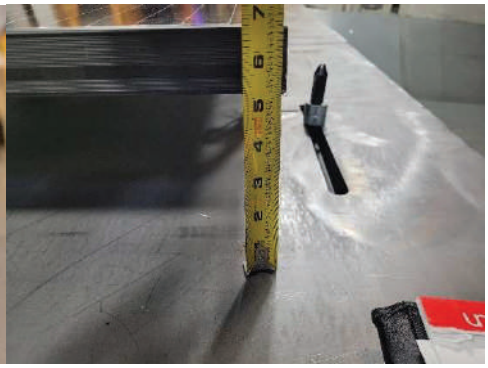

Figure 6: Height from roof to panel, Runs 2 & 3



Figure 7: LC0-1 Location



Figure 8: LC0-2 Location



Figure 9: LC5-3 Location

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Figure 10: LC5-4 Location

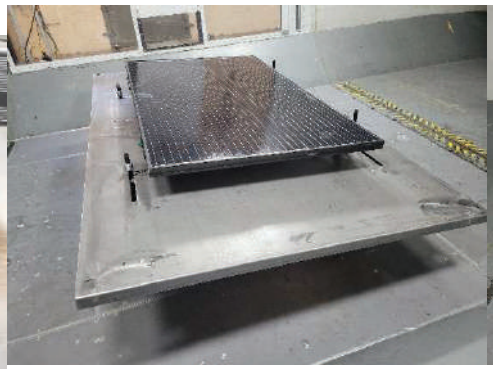

Figure 11: Setup after Run 2, 109 mph winds. No damages or loose hardware noted.



Figure 12: Setup after Run 2, 109 mph winds. No damages or loose hardware noted



Figure 13: Setup after Run 2, 109 mph winds. No damages or loose hardware noted



Figure 14: Setup for Run 6 with IR Ballast Frame

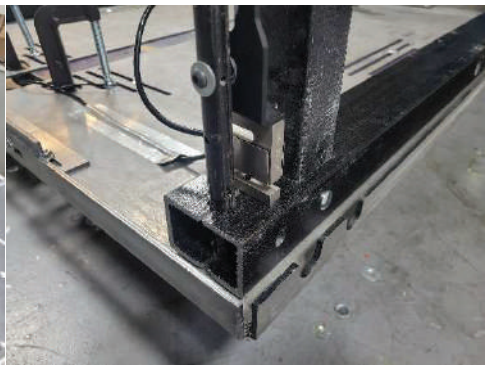

Figure 15: Load cell location at leading edge, LC0-1 & LC0-2



Figure 16: Test setup for Run 6

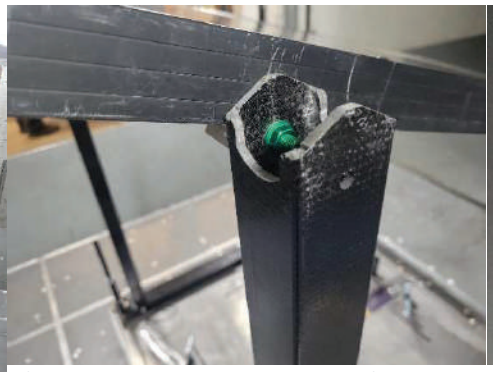

Figure 17: IR Ballast frame connection to solar panel

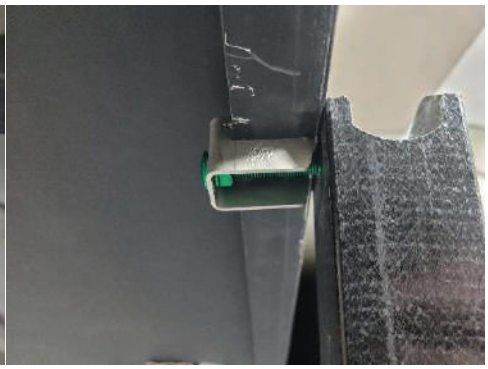

Figure 18: IR Ballast frame connection to solar panel

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Figure 19: Test setup for Run 6



Figure 20: Solar panels total length, Run 6 through 8

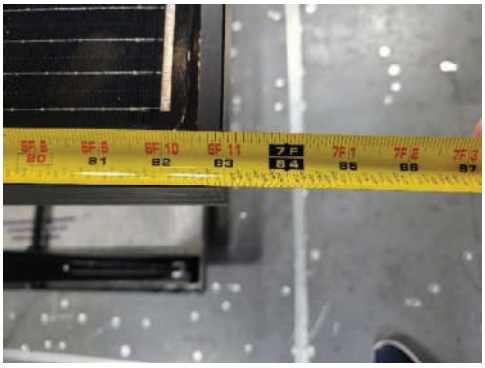

Figure 21: Solar panels total length 83 in.



Figure 22: Solar panels width, Run 6 through 8



Figure 23: Total width 41-1/4 in.



Figure 24: Run 6 trailing edge leg height



Figure 25: Run 6 leading edge leg height

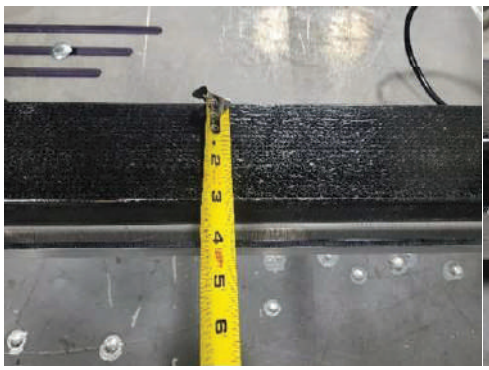

Figure 26: Frame base support width

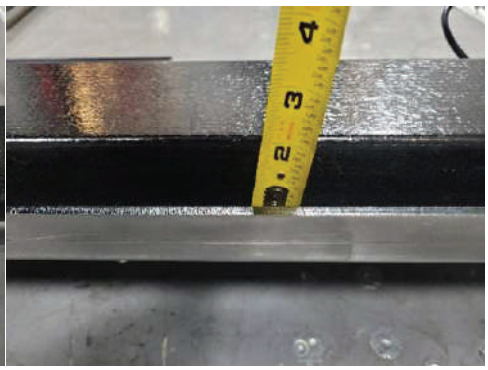

Figure 27: Frame base support height

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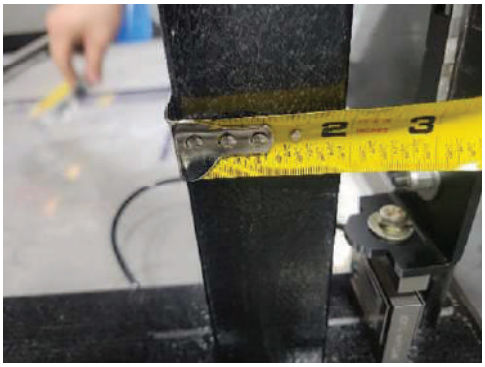

Figure 28: IR Ballast rack leg width 1



Figure 29: IR Ballast rack leg width 2



Figure 30: Runs 7 - 8 Test setup



Figure 31: Run 7 trailing edge leg height



Figure 32: Run 7 Leading edge leg height

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March 7, 2024
Mr. Paul Budge
Diversi-Tech Corp - IntegraRack
PO Box 910758
St. George, UT 84791

Subject: Compression, Horizontal, and Uplift Load Testing on the Universal L Foot Bracket (PN IR-DMLF2000) & IR-T1 No Penetration Tile Roof Bracket (IR-FCTR1500)

Dear Mr. Budge,

Please find included our test reports for the compression load test, horizontal load test, and combined uplift load testing of the Universal L Foot Bracket (PN IR-DMLF2000) & IR-T1 No Penetration Tile Roof Bracket (IR-FCTR1500) performed at our laboratory at 941 S. Park Lane, Tempe, AZ on 10/04/2023. The solar panels were installed on the tile roof using a total of 4 brackets

The compression load test was performed using dead weight provided by water filled plastic jugs that were weighed on our Instron 5985 test machine and had an average weight of 45.31 lbf. Test loads up to 815.58 lbf, equivalent to 38.00 psf force applied to the solar panels, were applied by evenly distributing the dead weight on the solar panel. Brackets were inspected before, during, and after the load test. Under load the brackets deflected downwards towards the roof but did not come into contact with the tile. Once the weight was removed the brackets were inspected and found to have lifted back to their original position and no visual permanent damage was noted. Test run details are shown in the table below.

COMPRESSION TEST LOAD INFORMATION			
TEST LOAD 1:	11 Jugs = 498.41 lbf = 23.22 psf	**TEST LOAD 2:**	17 Jugs = 770.27 lbf = 35.88 psf
TEST LOAD 3:	18 Jugs = 815.58 lbf = 38.00 psf		

COMPRESSION TEST LOAD BRACKET AND PANEL VISUAL DEFLECTION OBSERVATIONS			
NO.	**NO LOAD - INITIAL VISUAL BRACKET SPACING**	**AT LOAD 1 (498.41 lbf) VISUAL BRACKET SPACING**	**AT LOAD 2 (770.27 lbf) VISUAL BRACKET SPACING**
1	No contact	No contact	No contact
2	No contact	No contact	No contact
3	No contact	No contact	No contact
4	No contact	No contact	No contact

The horizontal load test was conducted using a Weightronic Digital Dynamometer (Model OCS-Y) and chain hoist. A horizontal load of at least 500 lbf was applied at the center of the crossbeam that was attached to the panel brackets. The test specimen held the load and no damage or permanent deformation was noted as shown in the test observations table shown below.

HORIZONTAL LOAD TEST TO > 500 lbf - VISUAL TEST OBSERVATIONS						
	INITIAL		UNDER TEST LOAD (500 lbf)		AFTER LOAD REMOVAL	
NO.	BRACKET DEFORMATION	PANEL DEFORMATION	BRACKET DEFORMATION	PANEL DEFORMATION	BRACKET DEFORMATION	PANEL DEFORMATION
1	None	None	Moderate	Moderate	None	None
2	None	None	Moderate	Moderate	None	None
3	None	None	Moderate	Moderate	None	None
4	None	None	Moderate	Moderate	None	None

The uplift load test was conducted using a Weightronic Digital Dynamometer (Model OCS-Y) and chain hoist. An uplift load of 710 lbf, equivalent to a 33.08 psf uplift force evenly applied to the solar panels, was applied at the center of the crossbeam that was attached to the four panel brackets. The test specimen held the load and no damage or permanent deformation of the test brackets was noted as shown in the test observations table shown below.

UPLIFT TENSILE LOAD TO 710 lbf - VISUAL TEST OBSERVATIONS						
	INITIAL		UNDER UPLIFT TEST LOAD (710 lbf)		AFTER LOAD REMOVAL	
NO.	BRACKET DEFORMATION	PANEL DEFORMATION	BRACKET DEFORMATION	PANEL DEFORMATION	BRACKET DEFORMATION	PANEL DEFORMATION
1	None	None	Moderate	Moderate	None	None
2	None	None	Moderate	Moderate	None	None
3	None	None	Moderate	Severe	None	None
4	None	None	Moderate	Moderate	None	None

Test reports with additional details, photos, and sketches of the test setup and load points have been attached.

Respectfully submitted,
PHOENIX NATIONAL LABORATORIES, INC.

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LABORATORY TEST REPORT

Compression Load Test
Ceramic Tile Roof

CLIENT	CLIENT PROJECT REF. NO.	CLIENT ORDER NO.
Diversi-Tech Corporation	Bracket Test - Vertical Load	per S.A.

MATERIAL SUBMITTED BY	PNL PROJECT NO.	S.O. NO.	PNL LAB NO.	TEST DATE	REPORT DATE
Client	26-231261	001	ML845913	10/04/2023	10/13/2023

SAMPLE DESCRIPTION	TECHNICIANS
Tile roof w/ Universal L Foot Bracket & IR-T1 No Penetration Tile Roof Bracket	TR, MC, DG

TEST DATA & EQUIPMENT INFORMATION

TEMPERATURE:	88 °F ± 3 °F	**HUMIDITY:**	15%
TEST SPECIMEN SIZE:	Tile roof: 39.375 in. x 78.500 in.	**TEST SPECIMEN AREA:**	21.465 ft^2
COMPRESSION TYPE:	Fixed weight; applied with Water Jugs	**AVERAGE FORCE PER JUG:**	45.31 lbf
BRACKET COMPONENT 1:	Universal L Foot Bracket	**BRACKET PART NO. 1:**	IR-DMLF2000
BRACKET COMPONENT 2:	IR-T1 No Penetration Tile Roof Bracket	**BRACKET PART NO. 2:**	IR-FCTR1500

COMPRESSION TEST LOAD INFORMATION

TEST LOAD 1:	11 Jugs = 498.41 lbf = 23.22 psf	**TEST LOAD 2:**	17 Jugs = 770.27 lbf = 35.88 psf
TEST LOAD 3:	18 Jugs = 815.58 lbf = 38.00 psf		

BRACKET AND PANEL VISUAL DEFLECTION OBSERVATIONS

NO.	NO LOAD - INITIAL VISUAL BRACKET SPACING	AT LOAD 1 - VISUAL BRACKET SPACING	AT LOAD 2 - BRACKET SPACING	AT LOAD 3 - VISUAL SPACING
1	No contact	No contact	No contact	No contact
2	No contact	No contact	No contact	No contact
3	No contact	No contact	No contact	No contact
4	No contact	No contact	No contact	No contact

REMARKS:

TECHNICIAN_____ REVIEWED BY_____

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LABORATORY TEST REPORT

Compression Load Test
Ceramic Tile Roof

CLIENT	CLIENT PROJECT REF. NO.	CLIENT ORDER NO.
Diversi-Tech Corporation	Bracket Test - Vertical Load	per S.A.

MATERIAL SUBMITTED BY	PNL PROJECT NO.	S.O. NO.	PNL LAB NO.	TEST DATE	REPORT DATE
Client	26-231261	001	ML845913	10/04/2023	10/13/2023

SAMPLE DESCRIPTION	TECHNICIANS
Tile roof w/ Universal L Foot Bracket & IR-T1 No Penetration Tile Roof Bracket	TR, MC, DG

TEST PROCEDURE/DESCRIPTION

The test specimen consisted of the solar panels, brackets, railing and the simulation tile roof. The bracket locations were visually examined for gap spacing to ensure there was no contact between the roof tile and the bracket. At each location a sheet of paper was slid beneath the bracket to verify open spacing between the tile and bottom of the bracket. After the initial inspection the compressive load was applied using plastic jugs filled with water. Four jugs were randomly selected and weighted to determine an average weight per jug of 45.31 lbf. Load was applied evenly by even distribtuion of 11 water jugs across the test specimen. After the first load was applied, the gaps between the brackets and tile roof were examined. Additional load was applied with 17 jugs and then 18 jugs. At 18 jugs the gap between the bracket and the roof was too tight to fit the sheet of paper underneath due to geometry of the tile roof but the bracket was not in contact with the roof. After the final load test, all the weights were removed and the test specimen was visually examined for any permanent damage or deforamtion.

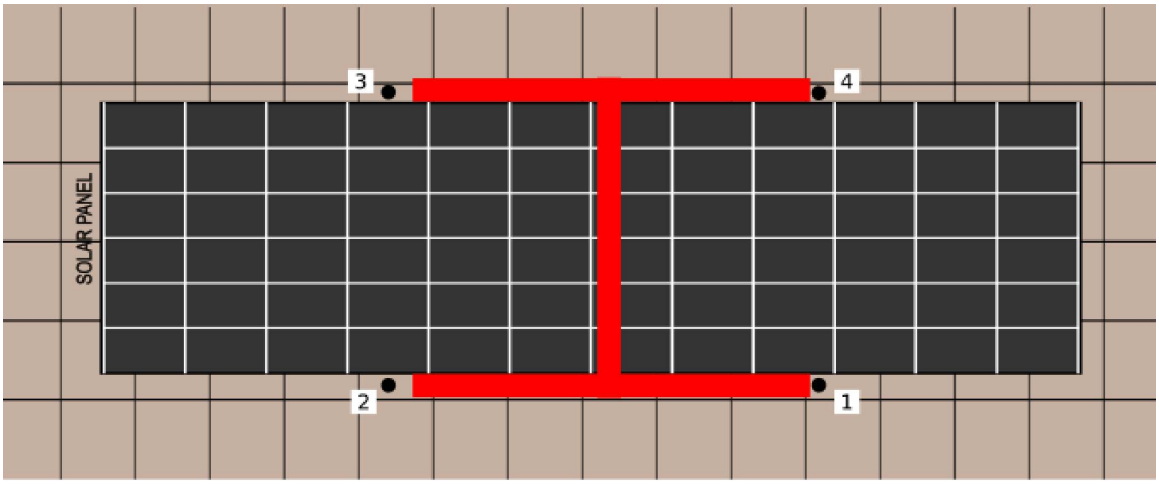
DEAD WEIGHT & DEFLECTION MEASUREMENT EQUIPMENT INFORMATION

EQUIPMENT MODEL:	Instron 5985 UTM [SN 1246]	**CALIBRATION DATE:**	07/25/2023
LOAD CELL:	2 kN (449.6 lbf) [SN 138082]	**CALIBRATION DATE:**	07/25/2023
EQUIPMENT MODEL:	Mitutoyo Digital Caliper [SN 14199376]	**CALIBRATION DATE:**	10/04/2023

DEAD WEIGHT MEASUREMENTS

NO. 1 (lbf)	NO. 2 (lbf)	NO. 3 (lbf)	NO. 4 (lbf)	AVERAGE (lbf)
45.45	45.65	44.69	45.46	45.31

VISUAL DEFORMATION LOCATION SKETCH



● Bracket/Panel Gap Spacing Check

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LABORATORY TEST REPORT

Compression Load Test
Tile Roof

CLIENT		CLIENT PROJECT REF. NO.		CLIENT ORDER NO.	
Diversi-Tech Corporation		Bracket Test - Vertical Load		per S.A.	
MATERIAL SUBMITTED BY	PNL PROJECT NO.	S.O. NO.	PNL LAB NO.	TEST DATE	REPORT DATE
Client	26-231261	001	ML845912	10/04/2023	10/13/2023
SAMPLE DESCRIPTION					TECHNICIANS
Tile roof w/ Universal L Foot Bracket & IR-T1 No Penetration Tile Roof Bracket					TR, MC, DG

PHOTOS



PHOTO 1: Overview of solar panel and tile roof deck - before tests

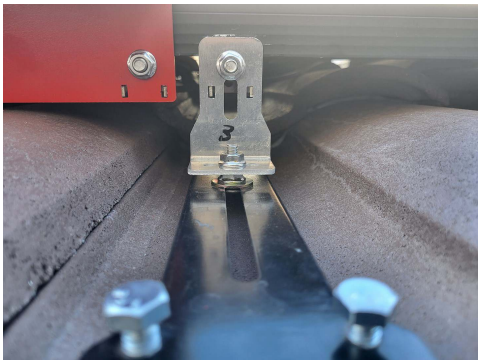

PHOTO 2: Typical Bracket - before tests



PHOTO 3: Load 1



PHOTO 4: Load 1 - Bracket under load



PHOTO 5: Load 2

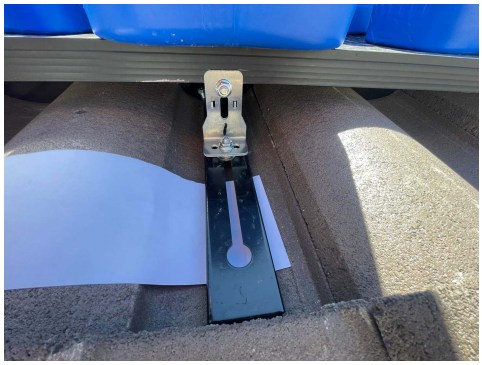

PHOTO 6: Load 2 - Bracket under load



PHOTO 7: Unloaded - after tests



PHOTO 8: Unloaded - after tests



PHOTO 9: Unloaded Bracket - after tests

Note: Bracket photos are typical of all locations

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LABORATORY TEST REPORT

Horizontal Load Test
Ceramic Tile Roof

CLIENT	CLIENT PROJECT REF. NO.	CLIENT ORDER NO.
Diversi-Tech Corporation	Bracket Test - Horizontal Load	per S.A.

MATERIAL SUBMITTED BY	PNL PROJECT NO.	S.O. NO.	PNL LAB NO.	TEST DATE	REPORT DATE
Client	26-231261	001	ML845913	10/04/2023	10/13/2023

SAMPLE DESCRIPTION	TECHNICIANS
Tile roof w/ Universal L Foot Bracket & IR-T1 No Penetration Tile Roof Bracket	TR, MC, DG

TEST PROCEDURE/DESCRIPTION

The test specimen consisted of the solar panels, brackets, railings and the simulation roof. The test specimen was initially visually examined for any damage or permanent deformation prior to testing. The horizontal load was applied after initial inspection was completed. The horizontal load was applied using a chain hoist and a digital dynamometer. The load was applied at the center of the crossbeam. The crossbeam was attached to the solar panel brackets. After the load was applied the specimen was examined for any damages or deformation while under load. After examination the horizontal load was released and the test specimen was examined again for any permanent deformation or damage.

TEST DATA & EQUIPMENT INFORMATION

TEMPERATURE:	88 °F ± 3 °F	**HUMIDITY:**	15% ± 5%
TEST SPECIMEN SIZE:	Tile roof: 39.375 in. x 78.500 in.	**TEST SPECIMEN AREA:**	21.465 ft^2
LOAD TYPE:	Tensile/Pull, applied with chain hoist	**TEST LOAD:**	>500 lbf
EQUIPMENT TYPE:	Weightronic Dynamometer	**EQUIPMENT MODEL:**	OCS-Y / 3000 kg Max.
BRACKET COMPONENT 1:	Universal L Foot Bracket	**BRACKET PART NO. 1:**	IR-DMLF2000
BRACKET COMPONENT 2:	IR-T1 No Penetration Tile Roof Bracket	**BRACKET PART NO. 2:**	IR-FCTR1500

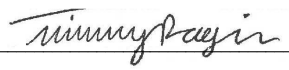
VISUAL TEST OBSERVATIONS

	INITIAL		UNDER TEST LOAD (500 lbf)		AFTER LOAD REMOVAL	
NO.	**BRACKET DEFORMATION**	**PANEL DEFORMATION**	**BRACKET DEFORMATION**	**PANEL DEFORMATION**	**BRACKET DEFORMATION**	**PANEL DEFORMATION**
1	None	None	Moderate	Moderate	None	None
2	None	None	Moderate	Moderate	None	None
3	None	None	Moderate	Moderate	None	None
4	None	None	Moderate	Moderate	None	None

OBSERVATIONS

After removal of test load all brackets returned to original position with no permanent deformation noted.

The solar panel did not show any signs of permanent damage or deformation.

TECHNICIAN 

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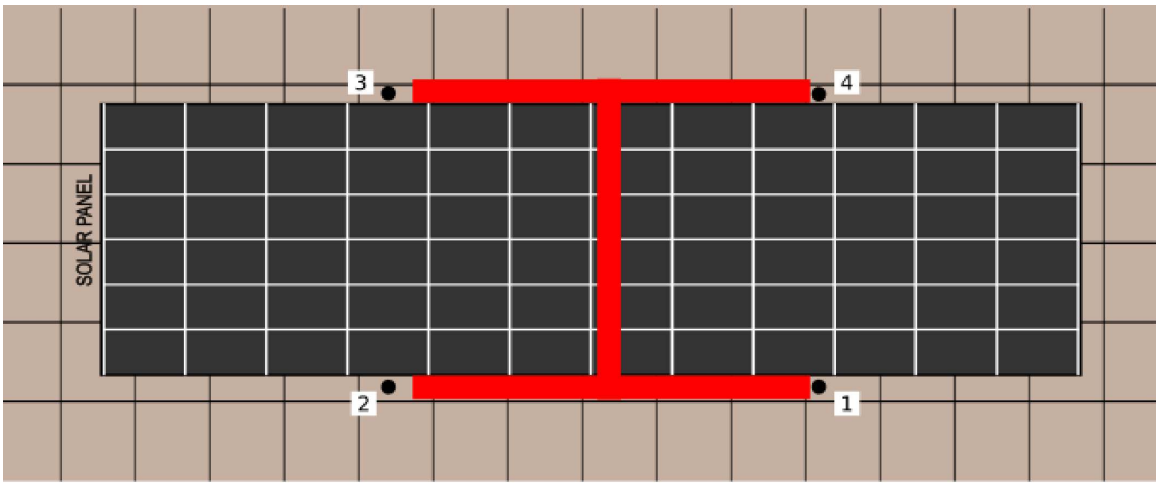
LABORATORY TEST REPORT

Horizontal Load Test
Ceramic Tile Roof

CLIENT		CLIENT PROJECT REF. NO.		CLIENT ORDER NO.	
Diversi-Tech Corporation		Bracket Test - Horizontal Load		per S.A.	
MATERIAL SUBMITTED BY	PNL PROJECT NO.	S.O. NO.	PNL LAB NO.	TEST DATE	REPORT DATE
Client	26-231261	001	ML845913	10/04/2023	10/13/2023
SAMPLE DESCRIPTION					TECHNICIANS
Tile roof w/ Universal L Foot Bracket & IR-T1 No Penetration Tile Roof Bracket					TR, MC, DG

SKETCH



● Bracket/Panel Gap Spacing Check

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LABORATORY TEST REPORT

Horizontal Load Test
Ceramic Tile Roof

CLIENT		CLIENT PROJECT REF. NO.		CLIENT ORDER NO.	
Diversi-Tech Corporation		Bracket Test - Horizontal Load		per S.A.	
MATERIAL SUBMITTED BY	PNL PROJECT NO.	S.O. NO.	PNL LAB NO.	TEST DATE	REPORT DATE
Client	26-231261	001	ML845913	10/04/2023	10/13/2023
SAMPLE DESCRIPTION					TECHNICIANS
Tile roof w/ Universal L Foot Bracket & IR-T1 No Penetration Tile Roof Bracket					TR, MC, DG

PHOTOS



PHOTO 1: Overview of solar panel and tile roof deck - before tests



PHOTO 2: Bracket with no load



PHOTO 3: Test setup for horizontal pull load



PHOTO 4: Applied load



PHOTO 5: Bracket under load



PHOTO 6: Test setup after test

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LABORATORY TEST REPORT

Uplift Tensile Load Test
Ceramic Tile Roof

CLIENT	CLIENT PROJECT REF. NO.	CLIENT ORDER NO.
Diversi-Tech Corporation	Bracket Test - Uplift Load	per S.A.

MATERIAL SUBMITTED BY	PNL PROJECT NO.	S.O. NO.	PNL LAB NO.	TEST DATE	REPORT DATE
Client	26-231261	001	ML845913	10/04/2023	10/13/2023

SAMPLE DESCRIPTION	TECHNICIANS
Tile roof w/ Universal L Foot Bracket & IR-T1 No Penetration Tile Roof Bracket	TR, MC, DG

TEST PROCEDURE/DESCRIPTION

The test specimen consisted of the solar panels, brackets, railing, and the simulation tile roof. The test specimen was visually examined for any damage or permanent deformation prior to testing. The uplift tensile pull load was applied after initial inspection was completed. Uplift load was applied using a chain hoist and a digital dynamometer. The load was applied at the center point of the cross beam. The cross beam was attached to the solar panel brackets. After the load was applied the specimen was examined for any damages or deformation. After examination the vertical load was released and the test specimen was examined again for any permanent deformation.

TEST DATA & EQUIPMENT INFORMATION

TEMPERATURE:	88 °F ± 3 °F	**HUMIDITY:**	15% ± 5%
TEST SPECIMEN SIZE:	Tile roof: 39.375 in. x 78.500 in.	**TEST SPECIMEN AREA:**	21.465 ft^2
LOAD TYPE:	Uplift tensile, applied with chain hoist	**TEST LOAD:**	710 lbf
EQUIPMENT TYPE:	Weightronic Dynamometer	**EQUIPMENT MODEL:**	OCS-Y / 3000 kg Max.
BRACKET COMPONENT 1:	Universal L Foot Bracket	**BRACKET PART NO. 1:**	IR-DMLF2000
BRACKET COMPONENT 2:	IR-T1 No Penetration Tile Roof Bracket	**BRACKET PART NO. 2:**	IR-FCTR1500

VISUAL TEST OBSERVATIONS

	INITIAL		UNDER UPLIFT TEST LOAD (710 lbf)		AFTER LOAD REMOVAL	
NO.	**BRACKET DEFORMATION**	**PANEL DEFORMATION**	**BRACKET DEFORMATION**	**PANEL DEFORMATION**	**BRACKET DEFORMATION**	**PANEL DEFORMATION**
1	None	None	Moderate	Moderate	None	None
2	None	None	Moderate	Moderate	None	None
3	None	None	Moderate	Severe	None	None
4	None	None	Moderate	Moderate	None	None

OBSERVATIONS

After removal of the uplift test load all brackets returned to original position with no permanent deformation noted.

The solar panel did not show any signs of permanent damage or deformation.

At Bracket No. 3, the tile roof shingle separated at the glue bond from the shingle underneath.

TECHNICIAN Timmy Ragin

REVIEWED BY Kyle Fleyl

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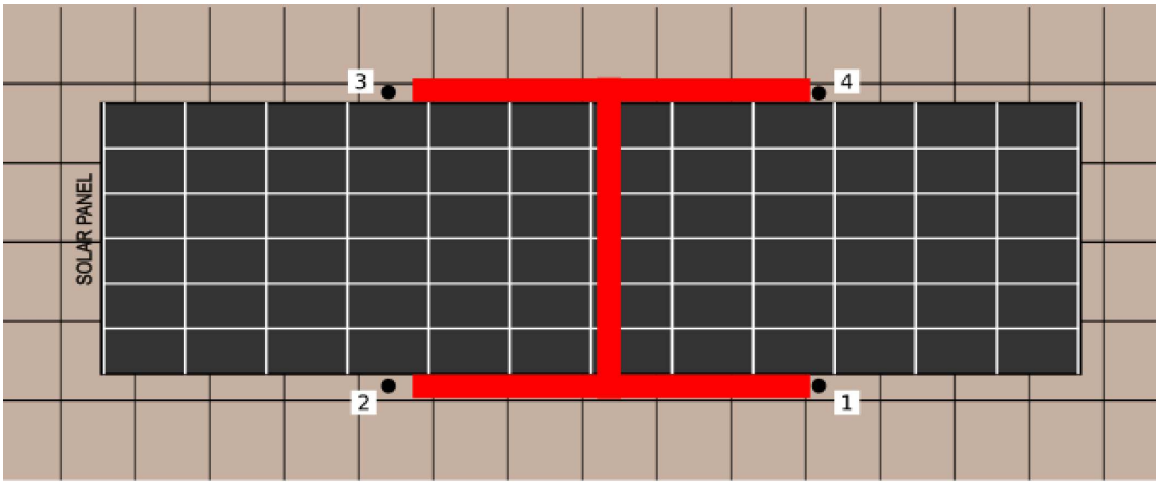
LABORATORY TEST REPORT

Uplift Tensile Load Test
Ceramic Tile Roof

CLIENT		CLIENT PROJECT REF. NO.			CLIENT ORDER NO.
Diversi-Tech Corporation		Bracket Test - Uplift Load			per S.A.
MATERIAL SUBMITTED BY	PNL PROJECT NO.	S.O. NO.	PNL LAB NO.	TEST DATE	REPORT DATE
Client	26-231261	001	ML845913	10/04/2023	10/13/2023
SAMPLE DESCRIPTION					TECHNICIANS
Tile roof w/ Universal L Foot Bracket & IR-T1 No Penetration Tile Roof Bracket					TR, MC, DG

SKETCH



● Bracket/Panel Gap Spacing Check

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LABORATORY TEST REPORT

Uplift Tensile Load Test
Ceramic Tile Roof

CLIENT		CLIENT PROJECT REF. NO.		CLIENT ORDER NO.	
Diversi-Tech Corporation		Bracket Test - Uplift Load		per S.A.	
MATERIAL SUBMITTED BY	PNL PROJECT NO.	S.O. NO.	PNL LAB NO.	TEST DATE	REPORT DATE
Client	26-231261	001	ML845913	10/04/2023	10/13/2023
SAMPLE DESCRIPTION					TECHNICIANS
Tile roof w/ Universal L Foot Bracket & IR-T1 No Penetration Tile Roof Bracket					TR, MC, DG

PHOTOS



PHOTO 1: Overview of solar panel and tile roof deck - before tests



PHOTO 2: Overview of tensile test setup and connection



PHOTO 3: Brackets with no load



PHOTO 4: Test setup



PHOTO 5: Test specimen while under tensile load



PHOTO 6: Dynamometer scale under load



PHOTO 7: Bracket under test load



PHOTO 8: Bracket unloaded after test

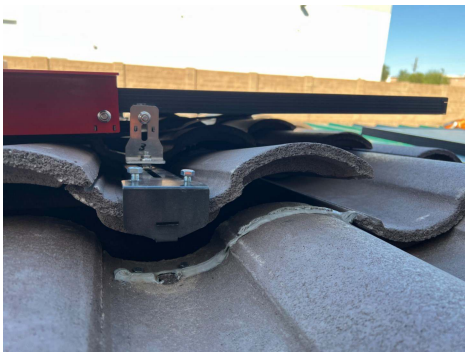

PHOTO 9: Bracket unloaded after test - roof tile bond pulled apart.