



<b>Prüfbericht-Nr.:</b> <i>Test report no.:</i>	300100178.001	<b>Auftrags-Nr.:</b> <i>Order no.:</i>	3001 00178	Seite 1 von 25 Page 1 of 25
<b>Kunden-Referenz-Nr.:</b> <i>Client reference no.:</i>	2330545	<b>Auftragsdatum:</b> <i>Order date:</i>	08/04/2021	
<b>Auftraggeber:</b> <i>Client:</i>	Ennogie Aps, Orebygardvej 16, 7400 Herning, Denmark			
<b>Prüfgegenstand:</b> <i>Test item:</i>	Building integrated pitchroof installation kits			
<b>Bezeichnung / Typ-Nr.:</b> <i>Identification / Type no.:</i>	Ennogie Solardach, more details in the summary (clause 4) and photo appendix			
<b>Auftrags-Inhalt:</b> <i>Order content:</i>	Wind lift test following MCS 012			
<b>Prüfgrundlage:</b> <i>Test specification:</i>	EN 14437:2004 Determination of uplift resistance of installed clay or concrete tiles for roofing - Roof system method			
<b>Wareneingangsdatum:</b> <i>Date of sample receipt:</i>	15/03/2022, 26/08/2022	Detaillierte Fotodokumentation siehe Anlage zu diesem Bericht  Detailed photo documentation see appendix to this report		
<b>Prüfmuster-Nr.:</b> <i>Test sample no.:</i>	see page 4			
<b>Prüfzeitraum:</b> <i>Testing period:</i>	30/08/2022 - 01/09/2022			
<b>Ort der Prüfung:</b> <i>Place of testing:</i>	Am Grauen Stein, 51105 Köln, Germany			
<b>Prüflaboratorium:</b> <i>Testing laboratory:</i>	TÜV Rheinland Solar GmbH			
<b>Prüfergebnis*:</b> <i>Test result*:</i>	Siehe Sonstiges / See Other			
<b>geprüft von:</b> <i>tested by:</i>		<b>genehmigt von:</b> <i>authorized by:</i>		
<b>Datum:</b> <i>Date:</i>	06/10/2022	<b>Ausstellungsdatum:</b> <i>Issue date:</i>	06/10/2022	
<b>Stellung / Position:</b>	Sachverständige(r)/Expert	<b>Stellung / Position:</b>	Reviewer	
<b>Sonstiges / Other:</b>	-			
<b>Zustand des Prüfgegenstandes bei Anlieferung:</b> <i>Condition of the test item at delivery:</i>	Prüfmuster vollständig und unbeschädigt <i>Test item complete and undamaged</i>			
* Legende:	1 = sehr gut P(ass) = entspricht o.g. Prüfgrundlage(n)	2 = gut F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	3 = befriedigend N/A = nicht anwendbar	4 = ausreichend N/T = nicht getestet
* Legend:	1 = very good P(ass) = passed a.m. test specification(s)	2 = good F(ail) = failed a.m. test specification(s)	3 = satisfactory N/A = not applicable	4 = sufficient N/T = not tested
Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens. <i>This test report only relates to the a. m. test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.</i>				

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**Anmerkungen**  
Remarks

<b>A</b>	<p>Alle eingesetzten Prüfmittel waren zum angegebenen Prüfzeitraum gemäß eines festgelegten Kalibrierungsprogramms unseres Prüfhauses kalibriert. Sie entsprechen den in den Prüfprogrammen hinterlegten Anforderungen. Die Rückverfolgbarkeit der eingesetzten Prüfmittel ist durch die Einhaltung der Regelungen unseres Managementsystems gegeben. Detaillierte Informationen bezüglich Prüfkonditionen, Prüfequipment und Messunsicherheiten sind im Prüflabor vorhanden und können auf Wunsch bereitgestellt werden.</p> <p><i>The equipment used during the specified testing period was calibrated according to our test laboratory calibration program. The equipment fulfils the requirements included in the relevant standards. The traceability of the test equipment used is ensured by compliance with the regulations of our management system. Detailed information regarding test conditions, equipment and measurement uncertainty is available in the test laboratory and could be provided on request.</i></p>
<b>B</b>	<p>Wie vertraglich vereinbart, wurde dieses Dokument nur digital unterzeichnet. Der TÜV Rheinland hat nicht überprüft, welche rechtlichen oder sonstigen diesbezüglichen Anforderungen für dieses Dokument gelten. Diese Überprüfung liegt in der Verantwortung des Benutzers dieses Dokuments. Auf Verlangen des Kunden kann der TÜV Rheinland die Gültigkeit der digitalen Signatur durch ein gesondertes Dokument bestätigen. Diese Anfrage ist an unseren Vertrieb zu richten. Eine Umweltgebühr für einen solchen zusätzlichen Service wird erhoben.</p> <p><i>As contractually agreed, this document has been signed digitally only. TUV Rheinland has not verified and unable to verify which legal or other pertaining requirements are applicable for this document. Such verification is within the responsibility of the user of this document. Upon request by its client, TUV Rheinland can confirm the validity of the digital signature by a separate document. Such request shall be addressed to our Sales department. An environmental fee for such additional service will be charged.</i></p>
<b>C</b>	<p>Prüfklausel mit der Note * wurden an qualifizierte Unterauftragnehmer vergeben und sind unter der jeweiligen Prüfklausel des Berichts beschrieben. Abweichungen von Prüfspezifikation(en) oder Kundenanforderungen sind in der jeweiligen Prüfklausel im Bericht aufgeführt.</p> <p><i>Test clauses with remark of * are subcontracted to qualified subcontractors and described under the respective test clause in the report.</i> <i>Deviations of testing specification(s) or customer requirements are listed in specific test clause in the report.</i></p>
<b>D</b>	<p>Die Entscheidungsregel für Konformitätserklärungen in diesem Prüfbericht basiert auf der "Null-Grenzwert-Regel" und der "Einfachen Akzeptanz" gemäß ILAC GC8:2019 und IEC Guide 115:2021, es sei denn, in der auf Seite 1 dieses Berichts genannten angewandten Norm ist etwas anderes festgelegt oder vom Kunden gewünscht. Dies bedeutet, dass die Messunsicherheit nicht berücksichtigt wird und daher auch nicht im Prüfbericht angegeben wird.</p> <p><i>The decision rule for statements of conformity in this test report is based on the "Zero Guard Band Rule" and "Simple Acceptance" in accordance to ILAC GC8:2019 and IEC Guide 115:2021, unless otherwise specified in the applied standard mentioned on Page 1 of this report or requested by the customer. This means that measurement uncertainty is not taken in account and hence also not declared in the test report.</i></p>

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**Produktbeschreibung**  
Product description

1	<b>Produktdetails</b> Product details	Ennogie Solardach (building integrated pitched roof PV mounting system)
2	<b>Verwendete Materialien</b> Used materials	N/A
3	<b>Adresse(n) der Fertigungsstätte(n)</b> Address(es) of the manufacturing site(s)	N/A
4	<b>Sonstiges</b> Other	Test sample(s), as well sample information, description, product details and intended usage was provided by customer. Throughout this report a point is used as the decimal separator.
5	<b>Prüfmusterbereitstellung</b> Test sample obtaining	<input checked="" type="checkbox"/> Sending by customer <input type="checkbox"/> Sampling by TÜV Rheinland Group  <input type="checkbox"/> others:
6	<b>Zusammenfassung der Prüfergebnisse</b> Summary of test results  <p>This report describes the tests performed to determine the characteristic wind uplift resistance of the roof integrated mounting system from Ennogie Aps following MCS012.</p> <p>The system was tested each time with four test samples (PV modules which are already fixed to the Ennogie "Light rails")*:</p> <ul style="list-style-type: none"> <li>• The two lower test samples were fixed on the eaves side with in total three "4x35mm EPDM sealing screws" by screwing directly through the Ennogie rails into the batten.</li> <li>• The upper side of the four test samples was fixed each time with four "4x35mm EPDM sealing screws" in the mounting brackets, which are fixed with rivets to the Ennogie "light rails".</li> <li>• The lower side of the upper two test samples was fixed by placing the test samples above the lower test samples and sliding the cut-out over the shoulder rivet of the lower test sample.</li> </ul> <p>The mounting was done following to the instruction of the customer. Compare the "Light rails mounting guide rev. 02B", provided by the customer (appendix A).</p> <p>*9 of the in total 12 tested test samples were already used in former project 300100541 (PV Modules according to type label of FG NEX SOLAR, Type " DM1500-130BE": approximate size: 1200x600mm x7.5mm).</p> <p>As in total 12 test samples are required for the three to be performed test, the customer shipped another three test samples. These three test samples are of another module type (according to type label "Ennogie EN-115B": approximate size: 1200x600mm x7.5mm), the used mounting rails, fixed to the modules are according to Ennogie however the same.</p> <p>Please note: While on eleven of the test samples a continuous adhesive tape was used to fix the PV modules to the "Ennogie light rails", on test sample "HV2022003207" mainly silicone seems to have been used to fix the PV module to the "Ennogie light rails". However no further information on the used materials was provided by the customer.</p> <p>When installed as described in this report the design uplift resistance is <b>1744 Pa</b>.</p> <ul style="list-style-type: none"> <li>• Each time the four PV modules were placed on 7 battens with 55 x 40mm which are mounted on rafters with dimension of 60 x 60mm.</li> <li>• The approximate distances between the 7 battens were as follows (starting from eaves side; Dimensions are from bottom edge to bottom edge): 500mm, 310mm, 445mm, 345mm, 390mm, 450mm</li> <li>• The mounting system was installed on rafters with dimension of 60x60mm at a distance from rafter to rafter of approx. 670mm (Dimension from left rafter edge to left rafter edge).</li> </ul> <p>MCS012 does not have pass/fail criteria for the wind uplift resistance pf PV mounting systems.</p>	

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**Produktbeschreibung**  
*Product description*

Remarks:

The test results presented in this report are only applicable to the mounting system as tested.

This test report includes measurement reports and a photo documentation in the appendix.

Throughout this report a *point* is used as the decimal separator.

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<b>Absatz</b> Clause	<b>Anforderungen - Prüfungen /</b> Requirements - Tests	<b>Messergebnisse –</b> <b>Bemerkungen /</b> Measuring results - Remarks	<b>Ergebnis</b> Result

<b>7</b>	<b>List of test samples</b>		
Sample no.	Sample SN	Remarks / constructional characteristics (e.g. cell, backsheet, frame type)	
HV2022003196	8076772128800777	DM152O-130BE, 1300x665*	—
HV2022003197	8076772128800780	DM152O-130BE, 1300x665*	
HV2022003198	8076772128800435	DM152O-130BE, 1300x665*	
HV2022003199	8076772128800808	DM152O-130BE, 1300x665*	
HV2022003200	8076772128800782	DM152O-130BE, 1300x665*	
HV2022003201	8076772128800835	DM152O-130BE, 1300x665*	
HV2022003202	8076772128800829	DM152O-130BE, 1300x665*	
HV2022003203	8076772128800779	DM152O-130BE, 1300x665*	
HV2022003204	8076772128800784	DM152O-130BE, 1300x665*	
HV2022003205	06927115N2110251594	EN-115B, 1300x665*	
HV2022003206	06927115N2110250390	EN-115B, 1300x665*	
HV2022003207	06927115N2109170064	EN-115B, 1300x665*	

Remarks: \*Depth of mounting rails: approx. 21.7mm respectively 21mm.  
 Dimensions of PV-laminate only: 1200mm x 600mm x 7.5

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8	<b>Details of the test specimens and installation for EN 14437</b>		
	<p>The test specimen comprises screws and four PV modules which are already fixed to the Ennogie light rails (module type “DM150O-130BE” respectively module type “Ennogie EN-115B”).</p> <p>Details of the system and installation procedures are included in Appendix A. Figures 01-06 show photos of the system installed in the TÜV Rheinland test rig. Compare also the other photos of the photo appendix for pictures of the testing.</p>		
8.1	<b>Details of the tests carried out</b>		
	<p>The test will be performed following EN 14437:2004 which is a test method originally designed for test wind uplift resistance of roof tiles and slates. The tests are carried out on a simulated roof structure comprising rafters at a roof pitch of 0°. Figures 01-06 show the TÜV Rheinland test rig with the installed system ready for test.</p> <p>The test samples were laid on the test rig as they would be installed on a roof. Pneumatic rams with suction cups were attached to the PV-modules to apply a force to simulate wind uplift loads.</p> <p>The test requirements are following the standards as below:</p> <ul style="list-style-type: none"> <li>• Where the flashing or sealing kits provide any uplift resistance then these should be included in the test. (As no influence of the frontgrill, eaves plate, verge sheets is expected in this particular set up in upwards direction, testing was done without these. Ridge sheet was also not provided.)</li> <li>• Deviating from the standard the roof pitch is tested at 0° ± 2°.</li> <li>• A minimum of one solar panel should be tested and the test shall be repeated three times with new fixing each time.</li> <li>• The uplift load shall be applied using a cable(s) or equivalent methods to provide uniform loads. This/these may be fixed to the solar collector by drilling a hole(s) through the collector or by using suction cup devices attached to the glass cover plate.</li> <li>• The detailed construction of the test rig in terms of the batten sizes, rafter spacing and all fixings shall satisfy the minimum specification (worst case) of the manufacturer/supplier of the solar panel and all materials shall be of a quality typical of the real construction.</li> <li>• Where there is a choice of fixing positions, the most onerous (weakest) shall be tested.</li> </ul> <p>The testing was performed three times. Each time new test samples and screws were used for the next test. The load was applied in increments of 500 respectively 250 Pa. After each load was applied it was removed and the residual deflection was measured. The maximum deflection under load and the residual deflection were measured at the following locations:</p> <ul style="list-style-type: none"> <li>• Measurement 1: 2750</li> <li>• Measurement 2: 2750</li> <li>• Measurement 3: 2500</li> </ul> <p>The loading cycles were repeated in increasing load increments until failure occurred; where failure is defined as one of the following:</p> <ul style="list-style-type: none"> <li>• Breakage of a mechanical fixing between PV-module and support frame</li> <li>• Pull-out or breakage of the mechanical connection between the support frame and the roof structure</li> <li>• Breakage of the PV-module</li> <li>• The residual displacement exceeds 5mm after releasing the applied load.</li> </ul> <p>The maximum displacement exceeds 75mm</p>		

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8.2	Test procedure		
	Test date:	30/08/2022 – 31/08/2022	—
	Examiner:	Schwarze, Kolter	—
	Index Number of test rick:	2424	—
	Roof pitch [ °]:	0°	—
	Test date:	30/08/2022 – 31/08/2022	—
	Tiles/Sheets type, (LxW) [mm]:	No tiles used.	—
	Battens (WxD) [mm]:	55x40	—
	Distance of battens	See the summary (section 4)	—
	Rafter (WxD) [mm]:	60x60	—
	Rafter distance [mm]:	See the summary (section 4)	—

Supplementary information: -

Tensile [Pa]	Under load displacement			Tensile [Pa]	Residual displacement		
	Displace ment 1 [mm]	Displace ment 2 [mm]	Displace ment 3 [mm]		Displace ment 1 [mm]	Displace ment 2 [mm]	Displace ment 3 [mm]
0	–	–	–	0	–	–	–
500	-5	-1	-5	500	-1	0	-1
1000	-7	-6	-8	1000	-1	-1	-1
1500	-10	-11	-12	1500	-1	-2	-1
2000	-14	-18	-17	2000	0	-3	-2
2250	-16	-21	-20	2250	0	-1	-2
2500	-18	-24	-22	2500	0	-1	-2
2750	-20	-30	-26	2750	0	-1	-2
2850	–	–	–	2850	–	–	–

**Remark:** At 2850Pa in the middle between the two module rows all four mechanical fixings (mounting brackets), connecting the panels to the wooden substructure, were broken. Compare the photos attached.

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Absatz Clause	Anforderungen - Prüfungen / Requirements - Tests	Messergebnisse – Bemerkungen / Measuring results - Remarks	Ergebnis Result
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Tensile [Pa]	Under load displacement			Tensile [Pa]	Residual displacement		
	Displace ment 1 [mm]	Displace ment 2 [mm]	Displace ment 3 [mm]		Displace ment 1 [mm]	Displace ment 2 [mm]	Displace ment 3 [mm]
0	–	–	–	0	–	–	–
500	-7	-8	-5	500	0	-1	0
1000	-10	-12	-8	1000	0	-1	0
1500	-14	-19	-11	1500	0	-1	0
2000	-18	-25	-16	2000	0	0	0
2250	-21	-29	-19	2250	0	-2	0
2500	-23	-32	-21	2500	-1	-2	0
2750	-27	-37	-24	2750	-2	-1	0
2850	–	–	–	2850			

**Remark:** At 2850Pa in the middle between the two module rows all four mechanical fixings mounting brackets, connecting the panels to the wooden substructure, were broken. Compare the photos attached. PV panels and screws were replaced before starting the second cycle.

Tensile [Pa]	Under load displacement			Tensile [Pa]	Residual displacement		
	Displace ment 1 [mm]	Displace ment 2 [mm]	Displace ment 3 [mm]		Displace ment 1 [mm]	Displace ment 2 [mm]	Displace ment 3 [mm]
0	–	–	–	0	–	–	–
500	-6	-6	-6	500	-1	1	-1
1000	-10	-12	-10	1000	-1	1	-2
1500	-14	-18	-14	1500	-2	0	-2
2000	-19	-25	-20	2000	-2	0	-2
2250	-21	-28	-23	2250	-3	0	-4
2500	-24	-32	-27	2500	-3	-1	-3
2750	-27*	-37*	-32*	2750	-3*	-2*	-3*
2850	–	–	–	2850	–	–	–

**Remark:** \*At 2750Pa the adhesive between PV laminate (HV20220003206) and mounting rail detached. Compare the photos attached. PV panels and screws were replaced before starting the third cycle.



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8.3	<b>Test results</b>		
	<p>In the first two tests the failure occurred at the same position of the mounting system. In both cases in the middle between the two module rows all four mechanical fixings (mounting brackets), connecting the panels to the wooden substructure, were broken. In the third test the adhesive between PV laminate (HV20220003206) and mounting rail detached.</p> <p>The failure tensile loads from Test 1, 2 and 3 are :</p> <ul style="list-style-type: none"> <li>• Test 1: 2750 Pa</li> <li>• Test 2: 2750 Pa</li> <li>• Test 3: 2500 Pa</li> <li>• The residual deflection did not exceed 5mm in any time.</li> <li>• The under pressure displacement did not reach the 75 mm in any time.</li> <li>• Failure pull out of metal components (partial factor 1.25)</li> </ul> <p>The characteristic mean wind uplift resistance will be calculated according to EN 14437:2004 as following:</p> $R_k = R_x - k_n s_x$ $R_x = \frac{1}{n} \sum R_i$ $s_x = \sqrt{\frac{1}{n-1} \sum (R_i - R_x)^2}$ <p>determined</p> <p>test</p> <p><math>R_x</math> is the mean uplift resistance</p> <p><math>s_x</math> is the standard deviation of the resistance</p> <p><math>k_n</math> is the statistical factor = 3.37 (for sample size of 3 from Table D.1 in EN 14437)</p> <p><math>R_i</math> is the individual measured value from each</p> <p>Partial factor    1.1 for failure metal components                      1.25 for failure by pull out of metal components                      1.44 for failure in timber or by pull out from timber components                      1.0 no failure, but the system exceed the limits of deviation</p>		

Absatz Clause	Anforderungen - Prüfungen / Requirements - Tests	Messergebnisse – Bemerkungen / Measuring results - Remarks	Ergebnis Result
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8.4	Test calculation		
	Test no.	Failure tensile load [Pa]	—
	Test 1	2750	—
	Test 2	2750	—
	Test 3	2500	—
	$R_x$	2666.7	—
	$s_x$	144.3	—
	$k_n s_x$	486.4	—
	$R_k = R_x - k_n s_x$		—
	Characteristic wind uplift resistance $R_k$	2180.2	—
	Partial factor	1.25	—
	<b>design uplift resistance</b>	1744Pa	—

Supplementary information: -

--- Ende des Prüfberichts / End of Test Report ---

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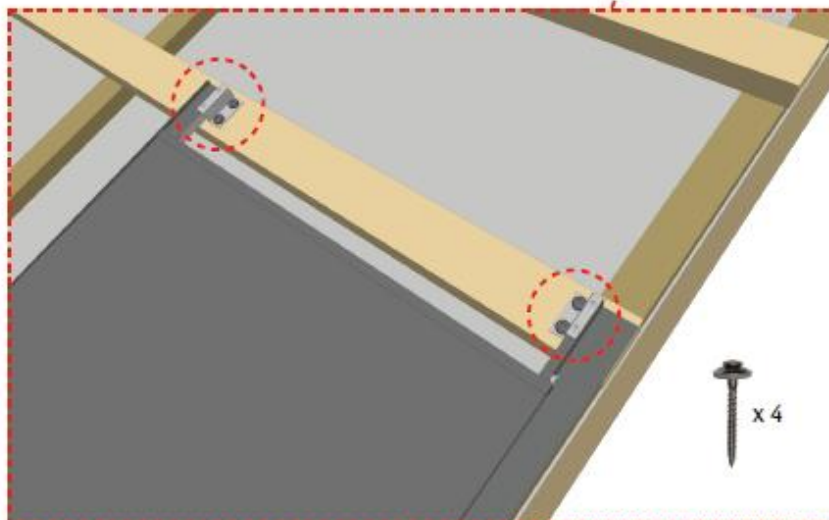
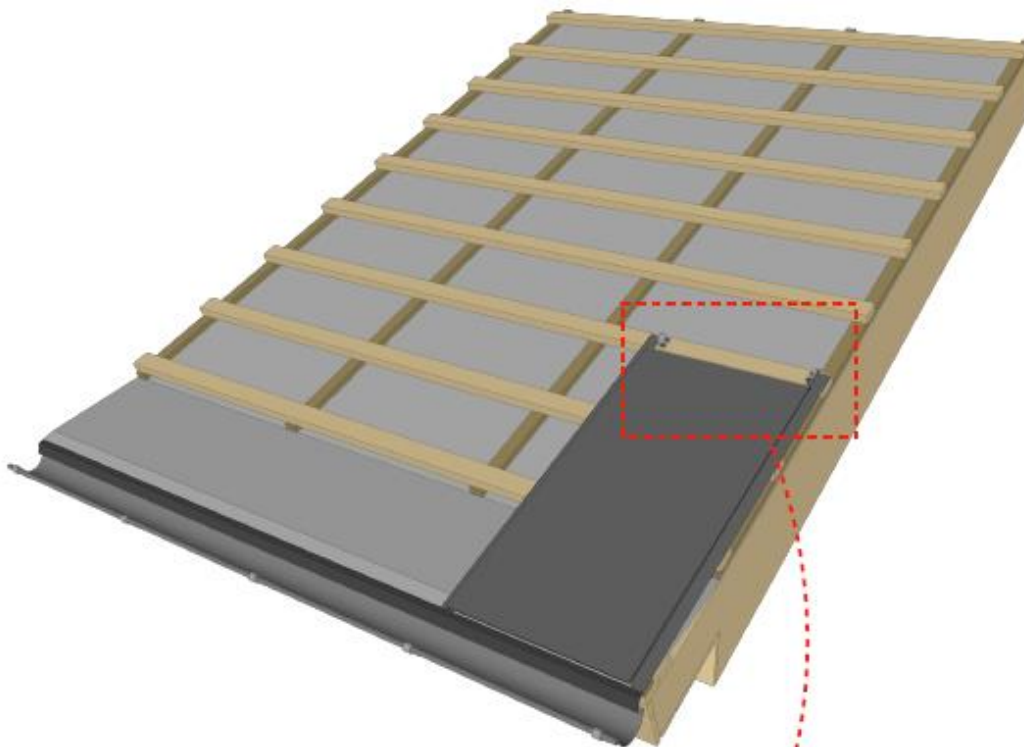
**ZUSATZ-DOKUMENTATION**  
ADDITIONAL DOCUMENTATION

**Appendix A: technical documentation (26-09-2022 Rev.02B**

26-09-2022  
Rev.02B



**Ennogie Lightrail Installation manual**



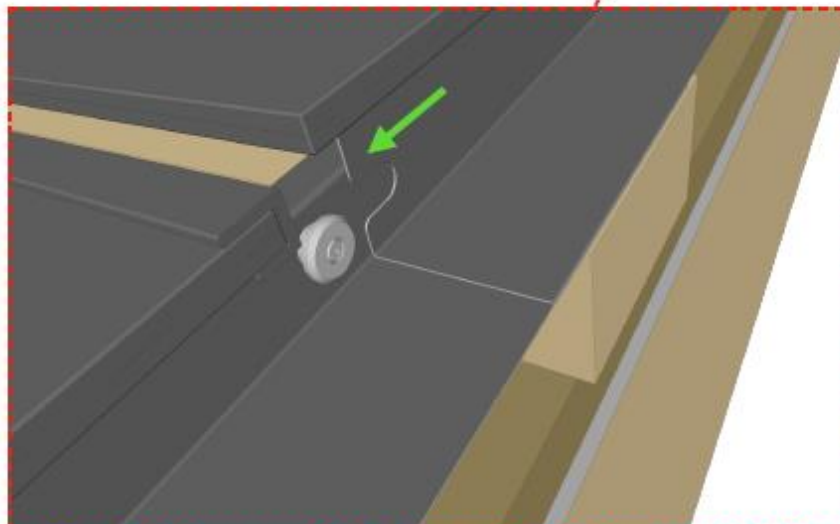
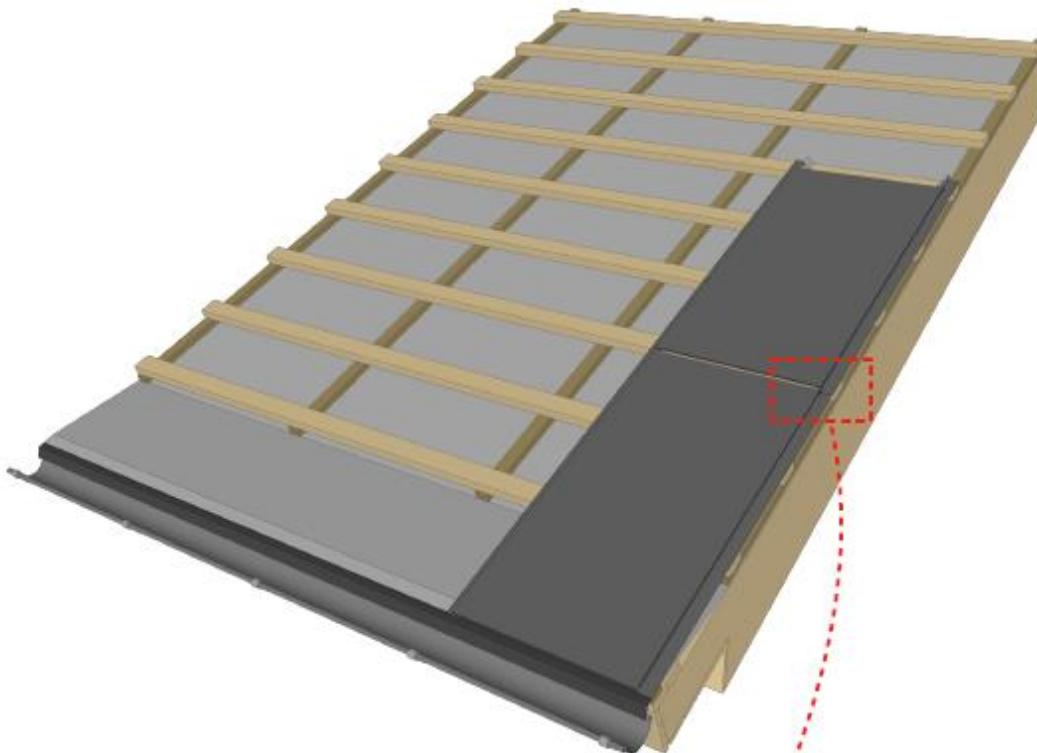
First module is placed in lower right corner of the roof and attached with 4 x 35 mm EPDM sealing screws.

ZUSATZ-DOKUMENTATION  
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Ennogie Lightrail installation manual



The next module is placed above and pulled into place by sliding the cutout over the shoulder rivet.

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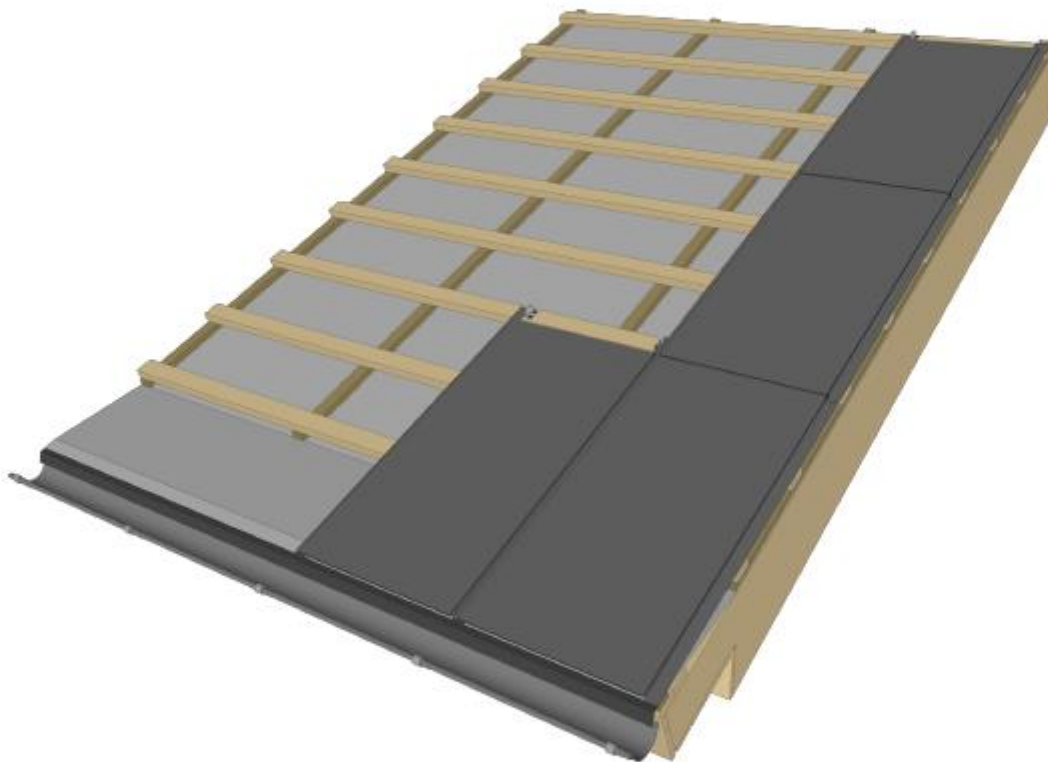
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**ZUSATZ-DOKUMENTATION**  
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**Ennogie Lightrail Installation manual**



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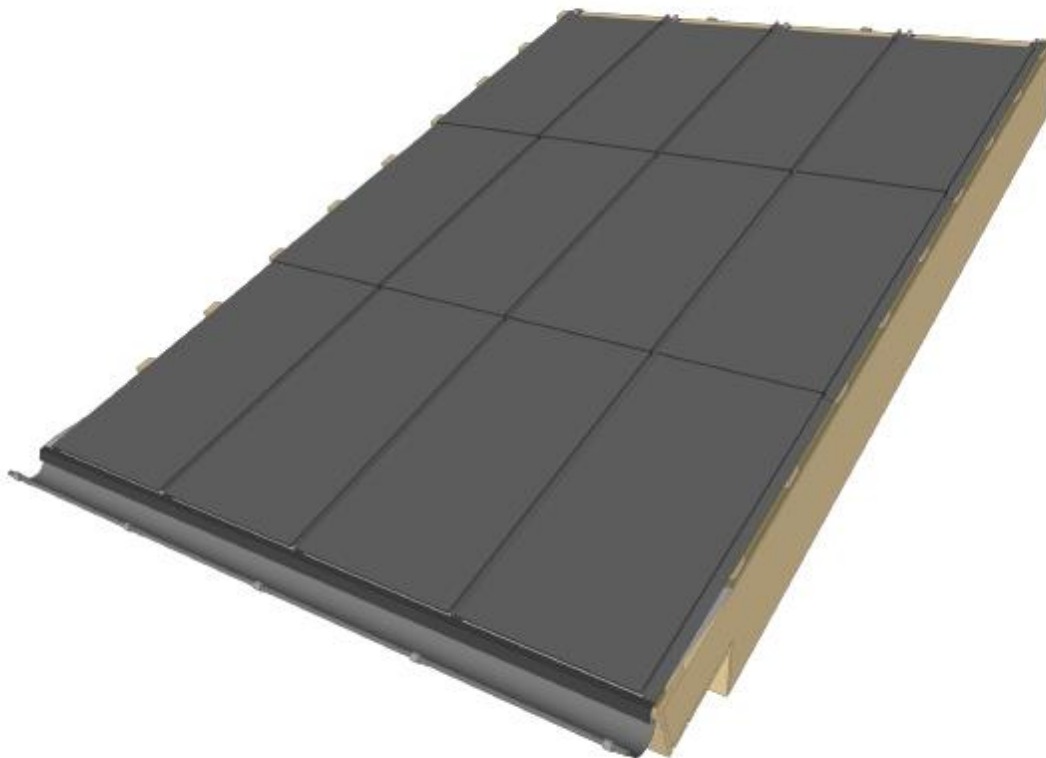
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**Ennogie Lightrail Installation manual**



Mount the remaining modules.



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**FOTO-DOKUMENTATION**  
PHOTO DOCUMENTATION

**Appendix B: Photos**



*Fig. 1: installed system prior to start testing*



*Fig. 2: details of installed system prior to start testing*

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**FOTO-DOKUMENTATION**  
PHOTO DOCUMENTATION



*Fig. 3: details of installed system prior to start testing*



*Fig. 4: details of installed system prior to start testing*



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**FOTO-DOKUMENTATION**  
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*Fig. 5: details of installed system prior to start testing*



*Fig. 6: details of installed system prior to start testing*

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**FOTO-DOKUMENTATION**  
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*Fig. 7: system while testing at 2500 Pa*



*Fig. 8: system while testing at 2500 Pa*

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**FOTO-DOKUMENTATION**  
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*Fig. 9: system while testing at 2500 Pa*



*Fig. 10: system while testing at 2500 Pa*



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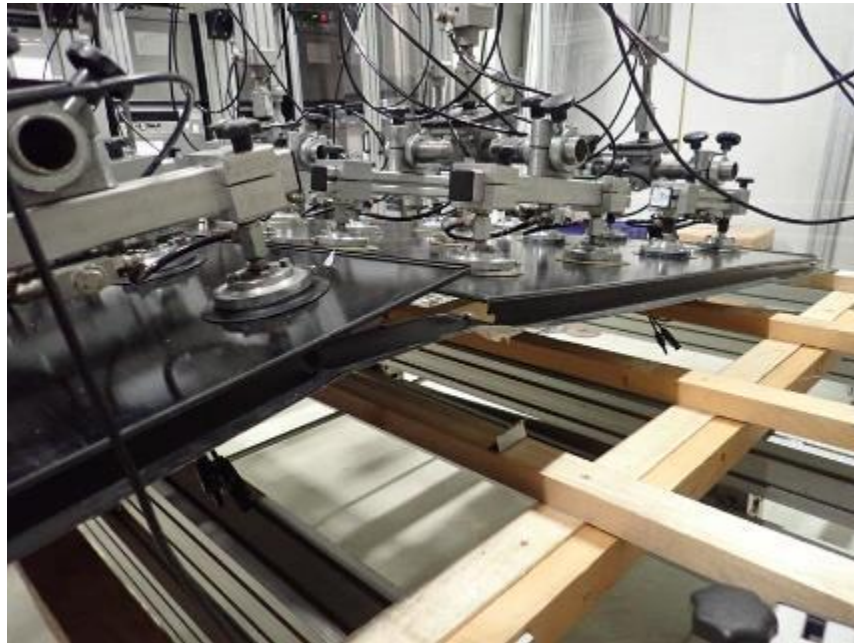


Fig. 11: failure first test at 2750 Pa



Fig. 12: failure first test at 2750 Pa

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Fig. 13: failure first test at 2750 Pa

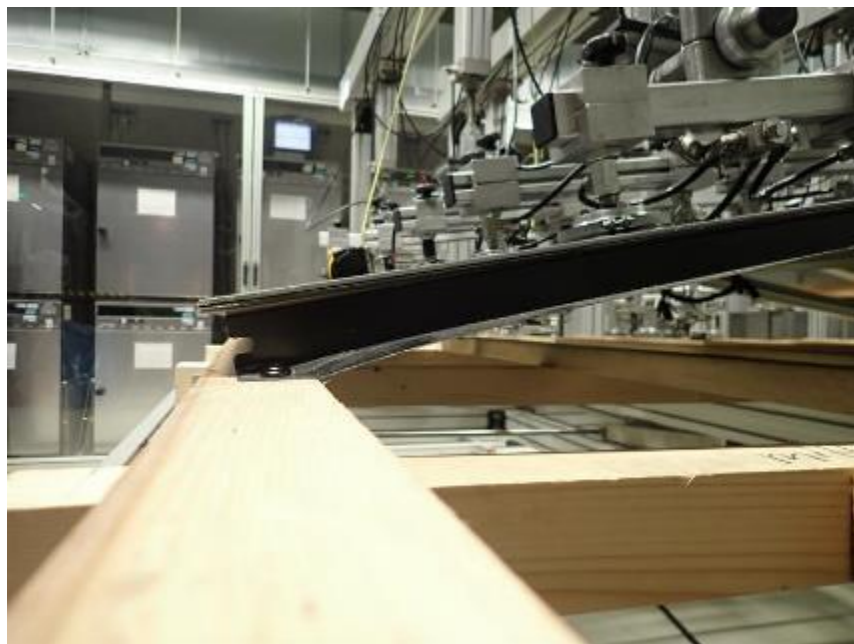


Fig. 14: failure first test at 2750 Pa

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*Fig. 15: failure second test at 2750 Pa*



*Fig. 16: failure second test at 2750 Pa*



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*Fig. 17: failure second test at 2750 Pa*



*Fig. 18: failure second test at 2750 Pa*

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Fig. 19: failure third test at 2500 Pa



Fig. 20: failure third test at 2500 Pa



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Fig. 21: failure third test at 2500 Pa



Fig. 22: failure third test at 2500 Pa