BUILDING SCIENCE

Installation of lightweight semi-flexible photovoltaic modules with DOWSIL™ 895 Structural Glazing Sealant

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Introduction

Lightweight semi-flexible photovoltaic modules are an innovative solution that can reduce the weight load and installation costs of solar panels on roofs. They use thin and flexible substrates that can be bonded directly to the building envelope using adhesives, eliminating the need for metal frames and brackets.

However, lightweight modules also require careful selection and application of adhesives that can withstand harsh environmental conditions and provide a strong and durable bond between the module and the substrate. The adhesives must also be compatible with the materials used in the module and the building, and not cause any degradation over time. Conversely the substrate materials should not have any negative impact on the adhesives.

This technical manual provides guidance and best practices for the installation of lightweight photovoltaic modules on flat or low inclination roofs using DOWSIL™ 895 Structural Glazing Sealant, a high-performance silicone structural sealant.

By following the recommendations and instructions in this manual, you will be able to achieve a successful and long-lasting installation of lightweight photovoltaic modules with DOWSIL™ 895.

Before application

Substrate identification

Long term bonding can only be assured if the substrate is known and adhesion of the adhesive on this substrate has been tested thoroughly. The identification of the component should not only provide the type of material and of surface finish, but also the brand, model and batch number of the component.

Joint design

The joints are applied parallel to the short edge of the module, over the complete width of the modules. The geometry of joints has to be calculated taking into account the various loads and the local building code.

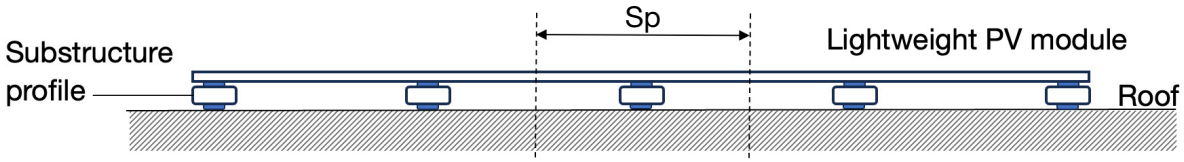
The joint geometry is determined as follows:

A. Calculation for joint bite (width of the joint)

The load to consider to calculate the bite is wind load. In the calculations, a design wind load Wd is used. In Europe, this design wind load has to be determined following the methodology prescribed by Eurocode EN 1991-4, 'Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions'. Consult a structural engineer familiar with calculation of wind loads to determine Wd.

1. Determine the basic configuration of joints and identify where, along the length of the module, a joint will come. That is determined by the minimum spacing between substructure profiles as given by the module manufacturer, and sometimes also by the geometry of the roof. There must be an equal spacing between the substructure profiles.

2. Consider each module part delimited by the center lines between two substructure profiles as a module segment supported by one joint. Sp is the width of the module part, and it corresponds to the spacing distance between substructure profiles.



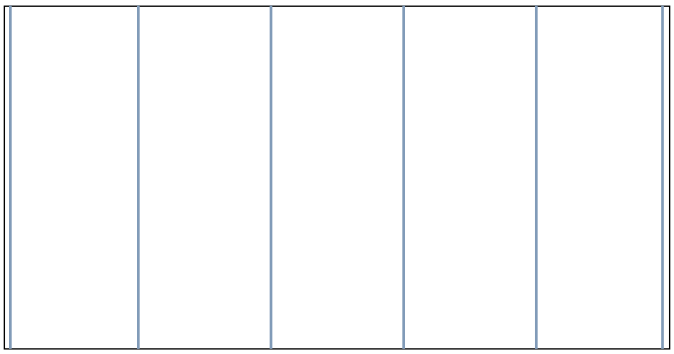
Schematic cross-section of assembly with lightweight PV module (not to scale)

3. With the design wind load and the spacing Sp, calculate the minimum joint bite (width of the joint) using the formula with

$$bite = \frac{Sp\ x\ W_d}{R_d}$$

and R_d the adhesive design strength. R_d is 140 000 Pa for DOWSIL™ 895.

Note that this calculated bite has to be used for all joints, including those at the edges of the module even though the part of the module supported by that join is not as wide as the other parts. Also note that joints should not be wider than 30 mm. If the calculation returns a bite value higher than 30 mm, change the assembly design to include more substructure profiles.



Example of joint configuration

The necessary joint bite might vary depending on the position of the PV modules as gust winds are higher on the edges and at the corner of the roof (see Eurocode EN 1991-4). Often the bite will be rounded off upward to a round number. The utilization is then defined as the ratio between the minimum bite and the real bite. It is recommended to aim for utilization of less than 80%.

B. Calculation of joint thickness

The thickness of the joint should be determined based on the shear stress expected from the different thermal expansion behavior between the PV laminate and the supporting structure, or the supporting structure and the roof (depending on the joint being considered).

$$Minimum\ thickness\ (mm) = \frac{(CTE_1 - CTE_2) \times \Delta T \times \frac{l(mm)}{2} \times E}{3 \times \tau_{design}}$$

Here, CTE is the coefficient of thermal expansion (what is relevant here is the difference in CTE between the two substrates that are being joined together). ΔT is the difference between the highest temperature the joint will undergo minus the temperature at which the joint was made, or between the temperature at which the joint was made and the lowest temperature, whichever difference is the largest in absolute value. E is the Young modulus of the adhesive (0.9 MPa for DOWSIL™ 895 Structural Glazing Sealant), l is the length of the shortest component being bonded, and τ_{design} is the design shear strength of the adhesive (0.14 MPa for DOWSIL™ 895). Length l corresponds to the module width when considering the substructure-module joint, and to the length of the substructure profile when considering the roof-substructure profile joint.

If the calculation returns a thickness value of less than 3 mm, a joint thickness of 3 mm has to be selected.

Check list and samples for lab testing

All information on the project is entered in a checklist (see annex), which is then sent to your Dow Technical distributor or Dow technical service. Samples of all components in contact with the adhesive (lightweight module, substructure profile, roof component if applicable) should be sent to a Dow Construction Laboratory for testing, except if the component (type, brand and model) is listed as approved by Dow.

Lightweight module installation

Once your Dow Technical Distributor or Dow Technical Specialist approves the design and the components, the installation project can start. If both the substructure and the lightweight modules need to be installed, the substructure installation should be done at least three days before the module installation.

The following steps should be followed:

1. Cleaning

Substrates to be bonded must be clean, dry and free from loose debris or dirt to enable proper adhesion to the substrate. DOWSIL™ R-40 Universal Cleaner is the preferred cleaning solvent but local regulations concerning solvent use should be consulted.

How to clean

A. Thoroughly clean all surfaces of loose debris. Moisture or contaminants on the surface may have an adverse effect on adhesion to the substrate.

B. Pour a small quantity of cleaner into a working container. A clear plastic solvent-resistant squeeze bottle works best for this purpose. Do not apply cleaner directly from the original container to not contaminate the entire container.

C. Wipe the joint surfaces using a clean, absorbent lint-free cloth with sufficient force to remove dirt and contaminants. Allow the cleaner to dry until all the solvent evaporates. This typically takes 5 to 30 minutes depending on room temperature and humidity.

2. Primer application

Depending on the substrate, a primer may or may not be needed. If a primer is to be applied, verify the product is in date and primer is in good condition.

A. Surface must be clean and dry. Primer application should commence within four (4) hours of cleaning.

B. Pour a small amount of primer into a clean, dry container and apply primer from the container rather than directly from the can to avoid contamination.

C. Apply a thin, uniform layer of primer by brush to the panel surfaces where the DOWSIL™ Adhesive will be applied.

D. Allow the primer to dry. Check the proper primer drying time for the specific primer. For primer P, the drying time is 30 min.

E. Apply a spacer tape and the DOWSIL™ Adhesive within four (4) hours of primer application.

If needed, fresh silicone may be removed using DOWSIL™ R-40 Universal Cleaner. Cleaned surfaces and primed surfaces need to be protected from re-contamination

3. Tape or spacer application

In order to avoid excessive shear stress on the joint from differential thermal expansion, a minimum joint thickness is required. It is therefore important to control the thickness of the joint.

For this a spacer should be used. A spacer tape is a good option for this. Once cleaning and priming has been completed and the surface is dry, apply a tape with appropriate thickness in a region adjacent to where the joint will come. A continuous spacer tape is the safest, but short segments of tape are acceptable, positioned at the ends of the joint area and intermediate locations. For a 1080 mm wide module, three 10 cm segments of tape are sufficient. Press hard onto the tape to ensure proper adhesion. To avoid contamination of the adhesive surface, do not remove the upper protective layer from the tape until the panel is ready for installation. An alternative to tape in places close to the long edge is to use a setting block with well-defined thickness, which potentially can be removed after adhesive cure and re-used in subsequent installations.

For horizontal installation of panels or with slope below 5° on a windless day, any tape or spacer with documented compatibility with the DOWSIL™ Adhesive may be used. Never install lightweight modules in strong winds.

Other methods for control of the bondline than those described here can be used, but in all cases it is the applicator's responsibility to ensure that the minimum thickness is obtained everywhere.

4. DOWSIL™ 895 Structural Glazing Sealant

After cleaning, priming (if required) and spacer installation, the DOWSIL™ Adhesive may then be applied in the gluing area. Apply the DOWSIL™ Adhesive in a continuous operation using caulking gun, allowing a minimum of 10 mm distance from the spacer tape if used. A positive pressure is needed to ensure the right amount of silicone is applied. A V-shaped nozzle is recommended to better control the shape and size of the silicone bead and the ultimate joint size. Select the V-shaped nozzle type that will result in the bead geometry with the required cross-section. Extrude the silicone with a minimal angle between the nozzle and the surface to achieve the required joint dimensions. Sufficient adhesive needs to be dispensed, so that during the subsequent bonding, some material is squeezed out and the minimum bite is achieved. Using the V-shaped nozzle of the type RD 07 V-seam nozzle S15 creates an adhesive silicone bead with triangular cross-section with 10 mm base, which results in a 12 mm wide joint after bonding if the thickness is controlled to 3mm. This is a convenient geometry in many projects.

DOWSIL™ 895 Structural Glazing Sealant must be applied within 4 to 8 hours after priming (check the technical datasheet of the primer for the exact maximum period) or cleaning (if there is no priming). Should this be exceeded, the surface must be re-cleaned and re-primed before applying the silicone adhesive. If a tape is used for spacing, remove the protective layer from the tape only after the silicone application.

For the adhesive application, caulking guns can be used, either fully manual, pneumatic or electric. Options to use a pump for one-part sealants exist. Consult your Dow representative to get advice on options.

5. Substructure / lightweight module bonding

IMPORTANT: The bonding must be carried out before the silicone begins to form a skin – usually within fifteen to thirty minutes, depending on temperature and humidity.

Substructure bonding

Position the substructure profile by pressing and correcting if needed. Allow to cure for at least 72h before proceeding to bonding the module.

Lightweight module bonding

Position the panel by gently pressing and correcting if needed. Apply only very gentle force in the solar cell areas and always apply force on a large area, to avoid areas of high pressure creating cracks or breaking the cells. Once in position, apply further gentle pressure to ensure that the spacer is in good contact with the inner face of both the panel and the substrate. Make sure that the sealant spreads and squeezes out slightly under the gentle pressing movement.

6. Warranty

Dow provides various types of warranty depending on the material, application and the customer's requirements.

The product warranty for DOWSIL™ 895 Structural Glazing Sealant states that the material will retain its properties over a given time period, for instance that the material will not become brittle. This type of warranty does not cover any aspects of the performance of the material in a given application. One condition to benefit from this warranty is that the procedure to apply the DOWSIL™ Adhesive as laid down in this technical manual is strictly followed, and that only materials are used that have been shown to be compatible with the DOWSIL™ Adhesive.

In some cases, Dow can provide a performance warranty for the adhesive, which guarantees that there will be no loss of cohesion and adhesion. The condition for this is that the procedure to apply the DOWSIL™ Adhesive as laid down in this technical manual (including substrate testing in a Dow laboratory) is strictly followed and that a logbook is kept with all critical information on the project and the application.

Ask your Dow representative for more information if a warranty is required.

Quality control DOWSIL™ 895 Structural Glazing Sealant

In order to detect problems early and avoid poor application, the applicator has to carry out some quality checks at the beginning and during the application. The two tests to be performed are tack-free-time and peel tests. The tests and the results have to be documented in a logbook. The tests need to be done whenever the application of a new project is started and whenever one starts with a new batch of DOWSIL™ Adhesive material or substrate material.

Please also make sure the minimum recommended thickness of the adhesive is well applied along the entire application.

Tack-free time

Tack-free time is a simple method of confirming the quality of silicone adhesive. Extrude a small amount of DOWSIL™ 895 onto a substrate. After 60 minutes, the skin of the silicone should be fully cured and leave no visible marks when touched.

Please contact your Dow Technical Distributor or Dow Technical Specialist if full cure of the silicone skin is not observed within the stated time frame.

Peel test

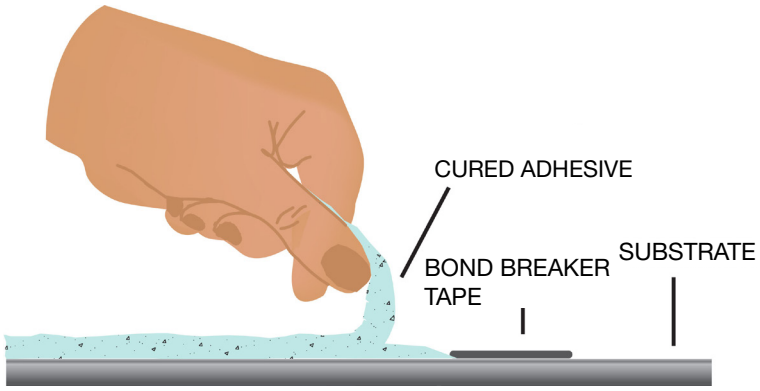
Peel testing is a simple, effective test that verifies silicone adhesion to a substrate. This test should be performed one (1) week in advance on three (3) samples for all substrates to which DOWSIL™ 895 Structural Glazing Sealant will be applied (except the components that are listed as approved by Dow. Leading lightweight PV modules are approved by Dow - ask your Dow representative).

The peel test needs to be carried out on all the substrates and should be done for each sealant batch that is used. For some Dow approved substrates (ask your Dow representative which ones), the peel tests is recommended but not required.

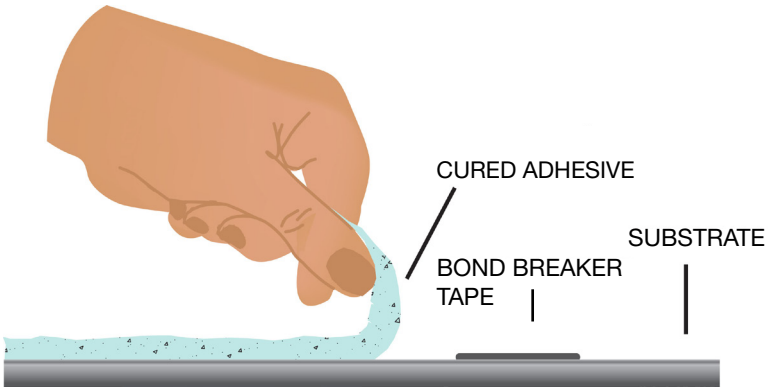
1. Properly clean and prime the test substrate and place a piece of polyethylene sheet or bond breaker tape across the flat surface.
2. Apply a bead of DOWSIL™ 895 Structural Glazing Sealant and tool to form a strip that is approximately 20 cm long, 15 mm wide and 6 mm thick. At least 4 cm of the silicone adhesive should be applied on the polyethylene sheet or bond breaker tape.
3. After one week of cure at 20°C and 50% RH, hold firmly a 4 cm tab of the silicone adhesive that overlays the polyethylene sheet and pull at a 180° angle. Peel back 1-2 cm of silicone, leaving the remainder in place for additional testing. If the adhesive tears within itself, this is called 100% cohesive failure. If the adhesive releases from the substrate, the sample indicates 100% adhesive failure. A minimum of 70% cohesive failure is required. If less than 70% cohesive failure is achieved, please consult your Dow Technical Distributor or Dow Technical Specialist for advice.
4. In case of negative test results, please consult your Dow Technical Distributor or Dow Technical Specialist.
5. Complete the results of all tests in the daily quality log

The test structures should be kept on the roof (bonded directly or indirectly to the roof) until the end of life of the PV system. Information on the location of specific peel tests (can be pictures) should be provided in the documentation sent in for issuance of a performance warranty.

Peel adhesion test: Cohesive failure



Peel adhesion test: Adhesive failure



Project checklist

Bonding of lightweight PV modules with DOWSIL™ 895 Structural Glazing Sealant

Dear Customer,

Please use this spreadsheet to give us the details of the project that you are planning. This is critical information that we need for the warranty process. Please send completed form to your Dow distributor.

Project name and location	
Project start date (dd/mm/yyyy)	
Estimated completion date (dd/mm/yyyy)	
Project description	
Project surface (total module surface)	

PV module manufacturer	
PV module model	
PV module nominal power	

Applicator technical contact name	
Phone number	
Email	

Module dimensions	
Length (mm)	
Width (mm)	
Number of joints per module	
Spacing between joints (mm)	

Roof material	
Roof slope (°)	

Design windload (Pa)	

Proposed bite (joint width) (mm)	
Proposed thickness (mm)	

Substructure profile type and model	
Length of individual substructure profile (m)	
Linear coefficient of thermal expansion of profile (1/°C)	
Substructure profile tested/approved by Dow? (Y/N)	
Document ID number	

Bonding to roof component included this project?	

Existing/new roof component (Existing/new)	

Roof component type and model	
Linear coefficient of thermal expansion of roof component (1/°C)	
Tested/approved by Dow? (Y/N)	
Document ID number	

Laboratory test sample checklist

Dear Customer,

This spreadsheet will help you give us the exact project details and substrate descriptions for testing. Please fill out the checklist as much as you can, as it will guide us in choosing the right testing methods. Please print and send the completed checklist along with your testing samples to our Laboratory in Seneffe, Belgium, and send an electronic copy of the file to your Dow distributor.

Sample address:

Dow Silicones Belgium S.R.I.
Construction laboratory
Parc Industriel Zone C- Rue Jules Bordet B-7180 Seneffe - Belgium

Substrate requirements

Size and number of the needed samples
For every silicone type to be tested

Solar module	6 pieces, 20 cm x 20 cm
Aluminum, steel or PVC profiles	6 pieces, 20 cm long
Adhesive tapes	8 pieces, 20 cm long
Roofing materials (membrane)	6 pieces, 20 cm x 20 cm
Accessories (setting blocks, spacers, etc, in close proximity to the silicone sealant	3 pieces each

Aging conditions	Details
ETAG 002 Paragraph 8.3.2.4(6)	28 days at Room Temperature
	7 days in Water Immersion at 23°C
	7 days in Water Immersion at 55°C
	21 days UV aging
IEC 61215	1000 hours at Damp Heat (85°C, 85% RH)
	200 Thermal Cycles
	50 Thermal Cycles + 10 Humidity Freeze Cycles

Contact and project details

Company name	
Company address	
Country	
Contact person	
Tel.	
Email	
Project name	
Project address	
Job number	

Sealant to be tested

DOWSIL™ 895 Structural Glazing Sealant	
Other DOWSIL™ Adhesive Sealant	
Other DOWSIL™ Adhesive Sealant	
Other DOWSIL™ Adhesive Sealant	

Surface treatment

DOWSIL™ R40 Cleaner	
Other cleaner	
Other DOWSIL™ 1200 Primer	
Other DOWSIL™ Primer	
Other Primer	

Substrate description

Substrate 1

Substrate type	
Supplier name	
Batch number	
Substrate description / Gluing side	
Date of sample shipment	
Number of the samples	

Substrate 2

Substrate type	
Supplier name	
Batch number	
Substrate description / Gluing side	
Date of sample shipment	
Number of the samples	

Substrate 3

Substrate type	
Supplier name	
Batch number	
Substrate description / Gluing side	
Date of sample shipment	
Number of the samples	

Substrate 4

Substrate type	
Supplier name	
Batch number	
Substrate description / Gluing side	
Date of sample shipment	
Number of the samples	

Please print and send the completed checklist along with your testing samples to our Laboratory in Seneffe, Belgium

Quality Log

Company name and address	
Project name and address	
PV module manufacturer	
PV module model	
PV module power	
Roof material	
Substructure profile type and model	
Lot number cleaner + Expiry date	
Lot number primer + Expiry date (if applicable)	

Date	Temperature and humidity	Adhesive lot number + expiry date	Peel test (% cohesive failure) after one week			Tack-free time (min)	Person responsible for the test	Location on roof
			On PV module	On roof material	On substructure profile			

For more information

Learn more about Dow's full range of building solutions, including service and support, at **dow.com/buildingscience.**

Dow has sales offices, manufacturing sites and science and technology laboratories around the globe. Find local contact information at **dow.com/contactus.**

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