BS EN 50583-2:2016

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Photovoltaics in buildings

Part 2: BIPV systems

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National foreword

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Photovoltaik im Bauwesen - Teil 2: BIPV-Anlagen

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European foreword

This document (EN 50583-2:2016) has been prepared by CLC/TC 82 "Solar photovoltaic energy systems".

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2016-10-12
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1 Scope

This document applies to photovoltaic systems that are integrated into buildings with the photovoltaic modules used as construction products. It focuses on the properties of these photovoltaic systems relevant to essential building requirements as specified in the European Construction Product Regulation CPR 89/106/EEC, and the applicable electro-technical requirements as stated in the Low Voltage Directive 2006/95/EC / or CENELEC standards. This document references international standards, technical reports and guidelines. For some applications in addition national standards (or regulations) for building works may apply in individual countries, which are not explicitly referenced here.

The document is addressed to manufacturers, planners, system designers, installers, testing institutes and building authorities.

This document does not apply to concentrating or building-attached photovoltaic systems. [1]

This document addresses requirements on the BIPV systems in the specific ways they are intended to be mounted but not the BIPV modules as construction products, which is the topic of EN 50583-1.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 410, *Glass in building — Determination of luminous and solar characteristics of glazing*

EN 1027, *Windows and doors — Watertightness — Test method*

EN 1990, *Eurocode: Basis of structural design*

EN 1991 (all parts), *Eurocode 1: Actions on structures*

EN 1993 (all parts), *Eurocode 3: Design of steel structures*

EN 1995 (all parts), *Eurocode 5: Design of timber structures*

EN 1999 (all parts), *Eurocode 9: Design of aluminium structures*

EN 12179, *Curtain walling — Resistance to wind load — Test method*

prEN 12488, *Glass in buildings — Glazing recommendations — Assembly principles for vertical and sloping glazing*

EN 12519, *Windows and pedestrian doors — Terminology*

EN 12600, *Glass in building — Pendulum test — Impact test method and classification for flat glass*

EN 12758, *Glass in building — Glazing and airborne sound insulation — Product descriptions and determination of properties*

EN 13022 (all parts), *Glass in building — Structural sealant glazing*

EN 13116, *Curtain walling — Resistance to wind load — Performance requirements*

EN 13119, *Curtain walling —Terminology*

EN 13363-1, *Solar protection devices combined with glazing — Calculation of solar and light transmittance — Part 1: Simplified method*

[1] For the definition building-attached photovoltaic systems refer to 3.2

EN 13363-2, *Solar protection devices combined with glazing — Calculation of total solar energy transmittance and light transmittance — Part 2: Detailed calculation method*

EN 13501-2, *Fire classification of construction products and building elements — Part 2: Classification using data from fire resistance tests, excluding ventilation services*

EN 13501-5, *Fire classification of construction products and building elements — Part 5: Classification using data from external fire exposure to roofs tests*

EN 13830, *Curtain walling — Product standard*

EN 13956, *Flexible sheets for waterproofing — Plastic and rubber sheets for roof waterproofing — Definitions and characteristics*

EN 14351-1, *Windows and doors — Product standard, performance characteristics — Part 1: Windows and external pedestrian doorsets without resistance to fire and/or smoke leakage characteristics*

EN 14500, *Blinds and shutters — Thermal and visual comfort — Test and calculation methods*

EN 14782, *Self-supporting metal sheet for roofing, external cladding and internal lining — Product specification and requirements*

EN 14783, *Fully supported metal sheet and strip for roofing, external cladding and internal lining — Product specification and requirements*

EN 15804, *Sustainability of construction works — Environmental product declarations — Core rules for the product category of construction products*

CEN/TR 15941, *Sustainability of construction works — Environmental product declarations — Methodology for selection and use of generic data*

EN 15942, *Sustainability of construction works — Environmental product declarations — Communication format business-to-business*

EN 15978, *Sustainability of construction works — Assessment of environmental performance of buildings — Calculation method*

EN 16002, *Flexible sheets for waterproofing — Determination of the resistance to wind load of mechanically fastened flexible sheets for roof waterproofing*

EN 50583-1, *Photovoltaics in buildings – Part 1: BIPV modules*

HD 60364-7-712, *Electrical installations of buildings — Part 7-712: Requirements for special installations or locations — Solar photovoltaic (PV) power supply systems (IEC 60364-7-712)*

CLC/TS 61836, *Solar photovoltaic energy systems — Terms, definitions, symbols (IEC/TS 61836)*

EN 62446, *Grid connected photovoltaic systems — Minimum requirements for system documentation, commissioning tests and inspection (IEC 62446)*

EN ISO 6946, *Building components and building elements — Thermal resistance and thermal transmittance — — Calculation method (ISO 6946)*

EN ISO 12543-1, *Glass in building — Laminated glass and laminated safety glass — Part 1: Definitions and description of component parts (ISO 12543-1)*

EN ISO 12543-2, *Glass in building — Laminated glass and laminated safety glass — Part 2: Laminated safety glass (ISO 12543-2)*

EN ISO 12543-3, *Glass in building — Laminated glass and laminated safety glass — Part 3: Laminated glass (ISO 12543-3)*

EN ISO 12543-4, *Glass in building — Laminated glass and laminated safety glass — Part 4: Test methods for durability (ISO 12543-4)*

EN ISO 12543-5, *Glass in building — Laminated glass and laminated safety glass — Part 5: Dimensions and edge finish (ISO 12543-5)*

EN ISO 12543-6, *Glass in building — Laminated glass and laminated safety glass — Part 6: Appearance (ISO 12543-6)*

prEN ISO 14439, *Glass in building — Glazing requirements — Use of glazing blocks (ISO/DIS 14439)*

EN ISO 12631, *Thermal performance of curtain walling — Calculation of thermal transmittance (ISO 12631)*

ETAG 002, *Guideline for European Technical Approval for Structural Sealant Glazing Systems – SSGS*

N 0068/CEN-TC128-WG3-N0068 TR *Renewable energy systems for roof structural connections*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1990, EN ISO 12543 (Parts 1 to 6), EN 12519, EN 13119, EN 13956, EN 14782, EN 14783, EN 13022, EN 16002, CLC/TS 61836, and the following apply.

Annex-specific definitions are included in the annexes themselves.

NOTE Additional information are provided in the Low Voltage Directive 2006/95/EC, the Construction Product Regulation 305/2011 and the Electromagnetic Compatibility Directive ECD 2004/108/EC.

3.1
Building-Integrated Photovoltaic system
BIPV system
photovoltaic systems are considered to be building-integrated, if the PV modules they utilize fulfil the criteria for BIPV modules as defined in EN 50583-1 and thus form a construction product providing a function as defined in the European Construction Product Regulation CPR 305/2011

3.2
Building Attached Photovoltaic system
BAPV system
photovoltaic systems are considered to be building attached, if the PV modules they utilize do not fulfil the criteria for BIPV modules as defined in EN 50583-1

Note 1 to entry: Further important information on this type of photovoltaic system on roofs is provided by the Technical Report by CEN/TC 128/WG3 - Solar energy systems for roofs: Requirements for structural connections to solar panels.

4 Requirements

4.1 General

As BIPV systems contain electrical components, the systems are subject to the applicable electro-technical requirements as stated in the Low Voltage Directive 2006/95/EC / or CENELEC standards. BIPV systems shall be designed such that they do not contradict the requirements of HD 60364-7-712 for PV systems.

The essential requirements defined in the LVD 2006/95/EC are:

1. Protection against hazards arising from the electrical equipment,

2. Protection against hazards which may be caused by external influences on the electrical equipment.

As electrical systems, BIPV systems are subject to the applicable electro-technical requirements as stated in the Electromagnetic Compatibility Directive ECD 2004/108/EC / or CENELEC standards.

The essential requirements defined in the ECD 2004/108/EC are:

3 Protection requirements:

Equipment shall be so designed and manufactured, having regard to the state of the art, as to ensure that:

(a) the electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment or other equipment cannot operate as intended;
(b) it has a level of immunity to the electromagnetic disturbance to be expected in its intended use which allows it to operate without unacceptable degradation of its intended use.

4 Specific requirements for fixed installations:

Installation and intended use of components
A fixed installation shall be installed applying good engineering practices and respecting the information on the intended use of its components, with a view to meeting the protection requirements set out in Point 1. Those good engineering practices shall be documented and the documentation shall be held by the person(s) responsible at the disposal of the relevant national authorities for inspection purposes for as long as the fixed installation is in operation.

As BIPV systems contain components that are used as construction products, these components are subject to the Essential Requirements as specified in the European Construction Product Regulation CPR 305/2011.

The essential requirements defined in the CPR 305/2011 are:

5. Mechanical resistance and stability;
6. Safety in case of fire;
7. Hygiene, health and the environment [2];
8. Safety and accessibility in use;
9. Protection against noise;
10. Energy economy and heat retention;
11. Sustainable use of natural resources.

The specific requirements on BIPV modules, which arise from these general CPR requirements, are treated in EN 50583-1.

The integration of photovoltaics into an existing construction product to create a BIPV module necessarily changes the properties with respect to the original construction product. New evaluation of a BIPV system containing the BIPV module with respect to a basic requirement of the CPR is necessary only if an essential characteristic of the BIPV module needed to meet this basic requirement is changed with respect to the original construction product.

As construction products, BIPV modules and their mounting structure, frame and fastenings have to be designed to comply with the wind, snow and mechanical loads as well as other requirements set out in the Eurocodes EN 1990, EN 1991, EN 1993, EN 1995 and EN 1999.[3]

This standard distinguishes between BIPV systems with modules that contain at least one pane of glass and those that do not. In addition to naming the general requirements, this standard classifies BIPV systems with modules containing glass into five different categories (depending on the intended mounting type). Specific normative references are listed for each category.

[2] As per Directive 2011/65/EU of the European parliament from 8th June 2011, photovoltaic modules have been exempted from the ROHS directive.

[3] Note the findings of CEN/TC128 WG3 – N0068 – TR renewable energy systems for roof structural connections.

4.2 BIPV Systems with modules containing glass pane(s)

4.2.1 General

Additional clauses from EN 13022-1 or ETAG 002 apply to BIPV modules that are used as part of a structural sealant glazing system.

Table 1 — General requirements for all BIPV systems with modules containing glass panes

CPR Requirement	Standards, guidelines, test methods	Comment
1. Mechanical resistance and stability	prEN 12488	Basis of assembly rules for glazing
2. Safety in case of fire	EN 13501-2	Fire classification standards
3. Hygiene, health and the environment		
4. Safety and accessibility in use	EN 13022-2	Only applicable for BIPV systems consisting of BIPV modules or PV insulating glass units to be bonded adhesively which are sold separately from the framework and installed under the responsibility of the designer and assembler. National regulations may define restrictions or additional requirements.[4)]
	ETAG 002	Applicable for structural sealant glazing systems put on the market as a “kit” of components; specified by European Technical Approval or National Approval
	prEN ISO 14439	Applicable if contact of glass and frame cannot be excluded
5. Protection against noise	EN 12758	
6. Energy economy and heat retention		
7. Sustainable use of natural resources	EN 15804 CEN/TR 15941 EN 15942 EN 15978	Additional information is provided in the final Report of IEA-PVPS Task 12

4.2.2 Mounting categories

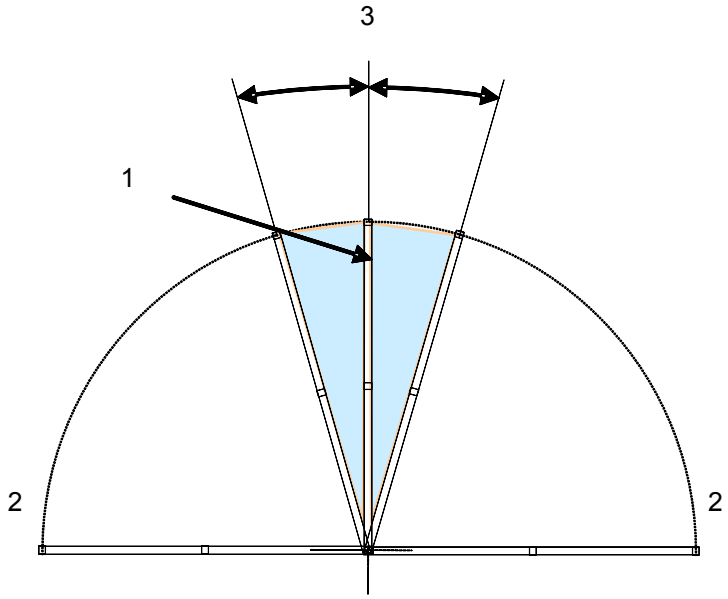
Additional requirements depend on the type of mounting. This standard differentiates five categories - A to E - of mounting according to combinations of the following criteria:

[4)] Structural sealant glazing systems (SSGS) or kits comprising PV modules are in the first consideration a matter of Technical Approvals which set out the requirements for the complete product to be fulfilled by the manufacturer. In the second consideration, PV modules as glass products to be sold separately and installed into or onto a framework or into or onto the building using a structural glazing technique are specified in EN 13022-1. Meeting the requirements of this standard, they are suitable for use in SSGS as defined in ETAG 002 and EN 13022-2.

1. integrated into the building envelope: yes/no
2. accessible yes/no
3. sloped: yes/no

“Not accessible” means that another construction product still provides protection against mechanical impact, even if the PV module has been damaged or removed.

The definition of “sloped glazing” is derived from EN 13830 and prEN 12488 and illustrated below (see Figure 1).



Key

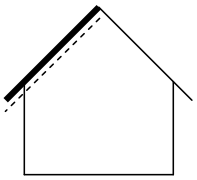
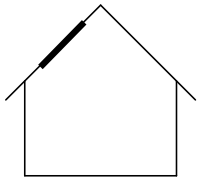
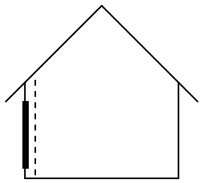
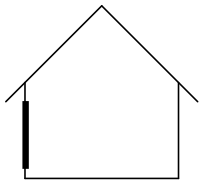
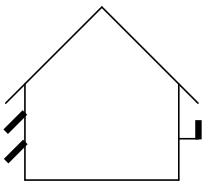
1 vertical glazing
2 angle of glazing considered sloped
3 angle of glazing considered non-sloped ± 15° from vertical

Figure 1 — Angle of glazing considered sloped and non-sloped as per EN 13830 and prEN 12488

Stated explicitly, “non-sloped” refers to the following angles:

$$75° \leq \text{angle} \leq 90° \text{ or } 90° \leq \text{angle} \leq 105° \text{ from horizontal.}$$

Table 2 — Mounting categories A – E

Category A:	**Sloped, roof-integrated, not accessible from within the building**	
	The PV modules are mounted in the building envelope at an angle between 0° and 75° (see Fig. 1) with a barrier underneath preventing large pieces of glass falling onto accessible areas below	
Category B:	**Sloped, roof-integrated, accessible from within the building**	
	The PV modules are mounted in the building envelope at an angle between 0° and 75° (see Fig. 1)	
Category C:	**Non-sloped (vertically) mounted not accessible from within the building**	
	The PV modules are mounted in the building envelope at an angle of between and including both 75° and 90° (see Fig. 1) with a barrier behind preventing large pieces of glass or persons falling to an adjacent lower area inside the building.	
Category D:	**Non-sloped (vertically) mounted accessible from within the building**	
	The PV modules are mounted in the building envelope at an angle of between and including both 75° and 90° (see Fig. 1)	
Category E:	**Externally integrated, accessible or not accessible from within the building**	
	The PV modules are mounted onto the building and form an additional functional layer (as defined in 3.1) exterior to its envelope (e.g. balconies, balustrades, shutters, awnings, louvres, brise soleil etc.).	

4.2.3 Additional requirements for Category A: sloped, roof-integrated, not accessible from within the building

Table 3 — Additional requirements for BIPV systems - Category A

CPR Requirement	Standards, guidelines, test methods	Comment
1. Mechanical resistance and stability	CEN-TC128-WG3-N0068 TR	
2. Safety in case of fire	EN 13501-5	National requirements may demand B_{Roof} (t1), (t2), (t3) or (t4)
3. Hygiene, health and the environment	Rain penetration test according to Annex A.	
4. Safety and accessibility in use		
5. Protection against noise		
6. Energy economy and heat retention	EN 410 and B.2	Calculation of light and solar energy characteristics. Applicable only if underlying layer is transparent or translucent. The PV module in the system is to be characterised in the open circuit condition.
	EN ISO 6946	Calculation of thermal characteristics of roof construction
7. Sustainable use of natural resources		

4.2.4 Additional requirements for Category B: Sloped, roof-integrated, accessible from within the building / Skylight

If the BIPV system is covered by the scope of EN 14351-1 (windows, incl. roof windows, roof windows with external fire resistance and French windows) the tests and classification specified in that standard concerning CPR requirements shall be observed.

Table 4 — Additional requirements for BIPV systems - Category B

CPR Requirement	Standards, guidelines, test methods	Comment
1. Mechanical resistance and stability		National regulations may define restrictions or additional requirements.
2. Safety in case of fire	EN 13501-2 EN 13501-5 EN 14351-1	Fire classification standards (applies to -2 and -5)
3. Hygiene, health and the environment	Rain penetration test according to EN 1027	
4. Safety and accessibility in use		
5. Protection against noise		
6. Energy economy and heat retention	EN 410 and B.2	Calculation of light and solar energy characteristics. The PV module in the system is to be characterised in the open circuit condition.
	EN ISO 6946	Calculation of thermal characteristics of roof construction
7. Sustainable use of natural resources		

4.2.5 Additional requirements for Category C: Non-sloped (Vertically mounted), not accessible from within the building

If the BIPV system is covered by the scope of EN 13830 (curtain walling) the tests and classification specified in that standard concerning CPR requirements shall be observed.

Table 5 — Additional requirements for BIPV systems - Category C

CPR Requirement	Standards, guidelines, test methods	Comment
1. Mechanical resistance and stability	CEN-TC128-WG3-N0068 TR	
	EN 13116	
2. Safety in case of fire	EN 13501-2	Fire classification
3. Hygiene, health and the environment		
4. Safety and accessibility in use		
5. Protection against noise		
6. Energy economy and heat retention	EN 410 and B.2	Calculation of light and solar energy characteristics. Applicable only if interior layer is transparent or translucent. The PV module in the system is to be characterised in the open circuit condition.
	EN ISO 12631	Calculation method for thermal resistance and thermal transmittance of facade construction
7. Sustainable use of natural resources		

4.2.6 Additional requirements for Category D: Non-sloped (Vertically mounted), accessible from within the building

Table 6 — Additional requirements for BIPV systems - Category D

CPR Requirement	Standards, guidelines, test methods	Comment
1. Mechanical resistance and stability	EN 12600	Additional national regulations for fall-proof glazing may apply.
2. Safety in case of fire	EN 13501-2	Fire classification
3. Hygiene, health and the environment		
4. Safety and accessibility in use		
5. Protection against noise		
6. Energy economy and heat retention	EN 410	Calculation of light and solar energy characteristics. The PV module in the system is to be characterised in the open circuit condition.
	EN ISO 12631	Calculation method for thermal resistance and thermal transmittance of facade construction
7. Sustainable use of natural resources		
NOTE If the BIPV system is covered by the scope of EN 14351-1 (windows, incl. roof windows, roof windows with external fire resistance and French windows) the tests and classification specified in that standard concerning CPR requirements needs to be observed. If the BIPV system is covered by the scope of EN 13830 (curtain walling) the tests and classification specified in that standard concerning CPR requirements needs to be observed.		

4.2.7 Additional requirements for Category E: Externally integrated, accessible or not accessible from within the building

Table 7 — Additional requirements for BIPV systems - Category E

CPR Requirement	Standards, guidelines, test methods	Comment
1. Mechanical resistance and stability	CEN-TC128-WG3-N0068 TR	
	EN 12600	Additional regulations for fall-proof glazing in balustrades may apply
2. Safety in case of fire		
3. Hygiene, health and the environment		
4. Safety and accessibility in use		
5. Protection against noise		
6. Energy economy and heat retention	EN 410	Calculation of light and solar energy characteristics. The PV module in the system is to be characterised in the open circuit condition.
	EN 13363	Depending on application. The PV module in the system is to be characterised in the open circuit condition.
	EN 14500	Depending on application. The PV module in the system is to be characterised in the open circuit condition.
7. Sustainable use of natural resources		

4.3 BIPV Systems with modules not containing glass panes

4.3.1 BIPV Systems with modules based on polymer waterproofing sheet

This sub-clause addresses roofing systems containing prefabricated BIPV membranes that typically include a polymer waterproofing sheet as back cover. The following building product standards are applicable for BIPV products that contain polymer waterproofing sheet:

EN 13956 for flexible plastic and rubber sheets

Table 8 — Requirements for BIPV systems with modules based on polymer waterproofing sheet

CPR Requirement	Standards, guidelines, test methods	Comment
1. Mechanical resistance and stability		
2. Safety in case of fire		
	EN 13501-5	National requirements may demand B_{Roof} (t1), (t2), (t3) or (t4)
3. Hygiene, health and the environment	EN 13956	National requirements
4. Safety and accessibility in use	EN 13956	National requirements
	EN 16002	Wind uplift resistance - manufacturer to declare permissible load
5. Protection against noise		National requirements for entire roof
6. Energy economy and heat retention		National requirements for entire roof
7. Sustainable use of natural resources	EN 15804 CEN/TR 15941 EN 15942 EN 15978	Additional information is provided in the final Report of IEA-PVPS Task 12

4.3.2 BIPV systems including BIPV modules based on metal sheet

This sub-clause addresses BIPV systems including prefabricated BIPV modules for use in roofing, which typically include a metal sheet as the back cover. One or more of the following building product standards are applicable for BIPV products that contain metal sheet as the back cover:

EN 14782 for self-supporting metal sheets

EN 14783 for fully supported metal sheets and strips

Table 9 — Requirements for BIPV systems including BIPV modules based on metal sheet

CPR Requirement	Standards, guidelines, test methods	Comment
1. Mechanical resistance and stability		
2. Safety in case of fire		
	EN 13501-5	National requirements may demand B_{Roof} (t1), (t2), (t3) or (t4)
3. Hygiene, health and the environment	EN 14782	
	EN 14783	
4. Safety and accessibility in use	EN 14782	
	EN 14783	
5. Protection against noise		National requirements for entire roof
6. Energy economy and heat retention		National requirements for entire roof
7. Sustainable use of natural resources	EN 15804 CEN/TR 15941 EN 15942 EN 15978	Additional information is provided in the final Report by IEA-PVPS Task 12

4.3.3 BIPV Systems with modules based on other materials

BIPV systems including BIPV modules based on other materials than those defined in 4.3.1 and 4.3.2 have to comply with CPR requirements. More specific requirements can be considered in future versions of this standard.

5 Labelling

Specifications by European and national regulations shall be observed.

NOTE IEC TS 62548 “Photovoltaic (PV) arrays - Design requirements” contains relevant specifications.

6 System documentation, commissioning tests and inspection

The documentation should follow the guidelines given in EN 82079-1. Instructions for storage, handling, erection, fixation, operation, maintenance, dismounting and recycling of the BIPV system are to be stated. The information required for system documentation, commissioning tests and inspection as specified by EN 62446 shall be provided.

Specifications by European and national regulations for documentation of building works shall be observed.

Annex A
(informative)

Resistance to wind-driven rain of BIPV roof coverings with discontinuously laid elements - Test method

A.1 Introduction

The test method characterises the degree of wind-driven and deluge rain penetration through a BIPV roof with regard to rain intensity, roof angle, wind speed and climatic zones. The results indicate the boundary conditions for the use of a BIPV roof and provide an indication for selecting the appropriate layer underneath the building-integrated PV modules (e.g. sarking membrane). The defined test method can be used for BIPV modules mounted as specifically defined in category A, 4.2.1.

Parts of the prescribed test method are defined as in CEN/TR 15601:2012.

A.2 Scope

This test method describes a method to determine the resistance to wind-driven rain of a BIPV pitched roof system corresponding to category A, 4.2.1.

The test method is applicable for a kit of discontinuously laid BIPV modules in combination with adjacent mounting-relevant fixtures, sealants, joints and connections to regular surrounding roofing/building components.

NOTE Valuable information concerning the permeability of discontinuously laid BIPV modules can be found in the Annex NB.A of NEN-EN1991-1-4/NB.

A.3 Terms and definitions

For the purposes of Annex A, the following terms and definitions apply.

test specimen
assembled array of roof-integrated PV modules as used for complete roof or roofing component replacement over which the rain penetration is to be observed or measured

samples
PV modules used for roof integration

reference leakage rate
leakage rate of (10 g/m^2)/5 min; 5 min being the duration of a single test step in the sub-test

effective testing area
minimum testing area of the specimen

set of tests
consisting of sub-tests B and D, (and optionally sub-test A and C), for an appropriate climate zone, roof pitch and laying specification

A.4 Symbols and units

For the purposes of Annex A, the following symbols and units apply.

Table A.1 – Symbols and units used in Annex A

Symbol	Quantity	Unit
f	wind speed factor relating u and u_s	-
I_u	turbulence intensity	%
L	simulated additional rafter length above the test specimen	m
R_h	rainfall rate on a horizontal plane	mm/h
R_{ro}	run-off rate	l/min
R_t	rainfall rate on the roof surface	mm/h
u	wind speed approaching the roof	m/s
u_t	terminal velocity of rain drops	m/s
σ_g	standard deviation of the turbulent fluctuations in the wind speed	m/s
$\bar{u}$	mean wind speed approaching the roof	m/s
u_s	wind speed over test specimen	m/s
W	the effective width of the test specimen	m
α	roof pitch	degree°
θ	angle of incidence of rain	degree°

A.5 Principle

A test specimen is fitted into the wind-driven rain apparatus, the external surface of the test specimen is exposed to wind and continuously sprayed with water, and run-off water is continuously applied at the top of the specimen. At the same time an air pressure difference between the upper and lower surfaces of the test specimen is increased or decreased in specific steps.

Water leakage through the test specimen, which can occur at certain air pressure differences, is observed and/or measured.

A.6 Test specimen

A.6.1 Test specimen samples

Samples for the test specimen shall comply, where relevant, with the appropriate product standard in respect of the appropriate sampling plan, or, in absence of a standard sampling plan, shall be selected at random from a representative production lot.

A.6.2 Dimension of the test specimen

The dimensions of the test specimen shall be as large as necessary to be representative of the intended use.The test specimen shall include at least one of every type of joint between the solar energy specimen and the surrounding roof surface (where appropriate). In some cases with large solar energy specimens, it might not be possible to test all of the joints simultaneously in the same test. In such cases the testing shall be repeated to ensure that each joint is fully tested. The minimum number of tests shall be one. The test specimen shall include all representative joints, where this is not possible then additional tests will be required to test each joint separately.

The minimum dimensions of the test specimen shall be 1, 5 m x 1,5 m or shall comprise a minimum of 9 roof covering elements.

NOTE Depending on the system / product to be tested it may be necessary to seal the laps or joins of the adjacent elements, whereby these sealed elements are outside of the effective area of the test specimen.

When the testing of products with such a size that they exceed the dimensions of the test set-up, if possible, a reduction of the elements can be performed, however, in such a way that the mutual connections between the products (elements, the adapters and any other test elements) are representative continue.

A.6.3 Number of sets of tests

The number of sets of tests shall be at least one.

A.6.4 Preparation of test specimen

Construct the test specimen according to the roofing specification representative of its intended use (such as roof pitch, lap and the influence of fixing systems where appropriate).

The test specimen may be built in a surrounding frame to facilitate transport and fitting to the opening of the driving rain test apparatus. The joint between test specimen and surrounding frame shall be sealed to prevent water leakage during the test, without disturbance to the normal occurring gaps in the specimen.

If a frame is used, it shall be able to resist the pressures applied during the test without deflecting to an extent that would influence the test results. The surround shall be prepared and installed so that any water penetration through the unsealed area of the test specimen is readily detectable.

The test specimen shall be conditioned to be surface dry before each test.

A.7 Apparatus

A.7.1 General

The test apparatus shall consist of:

- a suction chamber sealed to the underside of the test specimen and connected to a suction fan, as specified in A.7.2;
- a fan system to create wind on the outside of the test specimen, as specified in A.7.3;
- an installation capable of generating rain on the outside of the specimen, as specified in A.7.4;
- provisions for creating run-off water on the outside of the test specimen, as specified in A.7.5;
- facility for observation and measurement of leakage as specified in A.7.6.

A.7.2 Suction chamber

The suction fan connected to the suction chamber shall be capable of creating a stable pressure difference, maintained for 5 min ± 10 sec, across the test specimen. The pressure difference shall be measured to a maximum inaccuracy of 1 % or 2,5 Pa, whichever is greater. The height and shape of the suction chamber shall be sufficient to ensure uniform pressure conditions.

It shall be possible, when required, to seal the connection between the suction chamber and the suction fan (e.g. by providing a valve which can be closed or opened).

A water collector shall be provided, connected to the suction chamber, capable of recording the amount of leakage water during any pressure step in the test, to a maximum inaccuracy of 2 % or 1 g, whichever is greater. The surfaces of the suction chamber shall allow leakage water to flow freely into the water collector.

A.7.3 Fan system

The fan system shall be capable of generating wind in the direction of the eaves to the ridge. The wind flow shall be horizontal or parallel to the surface of the inclined test specimen.

Calibrate the fan system for spatial variation of the wind speed, by taking measurements at not less than 9 positions uniformly distributed over the effective testing area, at a height of (200 ± 10) mm over a flat boarded area which replaces the test specimen for the purposes of the calibration at the relevant pitch roof. The calibration wind speed shall be (10 ± 0,5) m/s at the centre of the test specimen.

The spatial variation of the wind speed shall be not more ± 15 % over the effective testing area.

Wind speed shall be measured to a maximum inaccuracy of 0,5 m/s.

The turbulence intensity I_u in the oncoming wind shall be less than 10 % at each position. The turbulence intensity I_u (%) is expressed as $I_u = 100\sigma_g / \bar{u}$, where σ_g and $\bar{u}$ are the standard deviation of the turbulent fluctuation in the wind speed and mean wind speeds respectively, measured over a duration of not less than 5 min for this purpose.

Mean wind speed

$$\overline{u} = \frac{\sum_{i=1}^{n} u_i}{n} \qquad \text{(A.1)}$$

Standard deviation

$$\sigma_g = \sqrt{\frac{\sum_{i=1}^{n} (u_i - \overline{u})^2}{n-1}} \qquad \text{(A.2)}$$

where

u_i are individual wind speed measurements;

n is the number of wind speed measurements

A.7.4 Rain generation installation

The installation shall be capable of supplying a stable rainfall rate (± 5 %) as given in Table A.3 for the roof pitch under test. The spatial variation shall be not more than ± 35 % over the effective testing area during a period of 5 min.

The rain droplet size shall be representative of natural rain, predominantly in the range of 0,6 mm to 2,5 mm diameter. It has to be ensured that the falling rain droplets have the appropriate velocity when hitting the test specimen.

To calibrate the rain falling directly on the test specimen, replace the test specimen with a flat board which incorporates rainfall-measuring devices in its upper surface. The measuring devices shall each be between 0,1 m² and 0,2 m² in plan area and arranged so that they do not collect any run-off water during calibration. The rain shall be measured to a maximum inaccuracy of 3 % or 0,2 mm/h, whichever is larger.

Calibrate the uniformity of rain distribution for each roof pitch and each test A, B, C and D (see A.9) as appropriate.

A.7.5 Run-off water

Run-off water, to simulate the rafter length of the roof above the position of the test specimen, shall be evenly distributed across the top of the test specimen with a maximum deviation of not more than 10 % over the width of the test specimen, by taking measurements at not less than 3 positions uniformly distributed over the width of the test specimen. The quantity of run-off water shall be measured to a maximum inaccuracy of 3 %.

Precautions should be taken to avoid non-representative distribution of run-off water on the uppermost course of roof-covering elements which, for example, could cause premature leakage through their sidelaps.

NOTE As a precaution, the sidelaps in the uppermost course of roofing elements may be sealed.

A.7.6 Observation and measurement of leakage

The pressure chamber shall be provided with:

a) a transparent under-surface for clear visual observation of the nature and position of leakages which may appear on the underside of the test specimen during the test;

b) an apparatus to continuously collect and measure the amount (by weight or by volume) of leakage water which may fall from the test specimen into the pressure chamber during the test.

To minimize surface tension, absorption and retention of water on the internal surfaces of the pressure chamber, the surfaces shall be smooth, non-absorbent and inclined at a vertical angle of not less than 10° from the horizontal towards the lower collecting apparatus during testing.

The degree of water penetration through the effective testing area shall be evaluated as:

1. No moisture at the rear of the specimen
2. Entering of fine spray
3. Moisture at the rear of the specimen
4. Rain drops or rain penetration at the rear of the specimen

A.8 Test procedure

A.8.1 General

Carry out the test in an environment with a temperature of between 5 °C and 35 °C with the test specimen installed in the apparatus at the specified roof pitch.

Seal the edges of the test specimen to prevent leakage of water or air into or out of the suction chamber. Such seals shall not affect the headlaps and sidelaps of the unsealed areas of the test specimen.

Select and continuously apply the relevant wind speed, rain-fall rate, and amount of run-off water according to the conditions specified in A.8.2. The test specimen shall be surface dry before testing.

In the wind-driven rain sub-tests (A, B and C), measure initially the pressure difference with the suction chamber closed and adopt this pressure difference as the reference datum for subsequent pressure changes during the sub-test. Then reduce the pressure in the box in steps of not less than 10 Pa and maintain each pressure step for 5 min ± 10 sec. Measure the amount of leakage water (if any) at each pressure step, or continuously, up to the reference leakage rate.

NOTE 1 The test can be continued to greater pressure differences to observe additional leakage rates.

In the deluge sub-test (D), apply the rainfall and run-off without wind (suction fan turned off) and with the suction chamber open to the atmosphere, for 2 min ± 10 sec. Observe any leakage and measure the amount of leakage water.

Fine spray can enter through joints in certain types of discontinuously laid elements, producing small amounts of water on the test specimen or on the surface of the suction chamber. Its occurrence shall be recorded

NOTE 2 Such fine spray may or may not be regarded as leakage depending on the performance requirements.

A.8.2 Test conditions

A.8.2.1 General

A set of tests shall consist of sub-tests B and D (and optionally sub-tests A and C), carried out with the following wind-rain combinations as defined in Table A.3 for appropriate climate zones:

- Sub-test A: Low wind speed with severe rainfall rate;
- Sub-test B: Low wind speed with high rainfall rate;
- Sub-test C: Severe wind speed with low rainfall rate;
- Sub-test D: Maximum rainfall rate with no wind (deluge).

A.8.2.2 Wind speed modification for roof pitch

To derive the wind speed over the test specimen a modification to the wind speed shall be applied to allow for the effect of roof pitch, by $u_s = u \times f$. Values of *f* are given in Table A.2.

f wind speed factor relating u_s and u_f [-]
u wind speed approaching the roof [m/s]
u_s wind speed over test specimen [m/s]

Table A.2 – Wind speed modification factor

Roof pitch (degrees)	f
15,0	0,85
17,5	0,81
20,0	0,80
25,0	0,76
30,0	0,71
35,0	0,67
40,0	0,60
45,0	0,54
f values for other intermediate roof pitches are obtained by interpolation.	

A.8.2.3 Run-off water

The run-off rate R_{ro} (l/min) shall be calculated by the formula:

$$R_{ro} = R_t . W . L / 60 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (A.3)$$

where

R_t is the rainfall on the roof surface, in mm/h;

W is the effective width of the test specimen, in m;

L is the simulated additional rafter length above the test specimen, in m.

Unless otherwise specified, L shall be not less than 5 m.

Table A.3 – Wind and rain test conditions

Climate zone	Sub-test	Test conditions				
		Wind speed U [m/s]	Rainfall R_h [mm/h]	Roof pitch α [^{0}]	Wind speed on roof surface u_s [m/s]	Rainfall on roof surface R_t [mm/h] (tolerance ± 5 %)
Northern Europe, coastal	A	5	110	15,0 17,5 20,0 25,0 30,0 35,0 40,0 45,0	4,3 ± 0,5 4,1 ± 0,5 4,0 ± 0,5 3,8 ± 0,5 3,6 ± 0,5 3,4 ± 0,5 3,0 ± 0,5 2,7 ± 0,5	124 126 127 129 130 129 128 126
	B	13	60	15,0 17,5 20,0 25,0 30,0 35,0 40,0 45,0	11,1 ± 0,5 10,5 ± 0,5 10,4 ± 0,5 9,9 ± 0,5 9,2 ± 0,5 8,7 ± 0,5 7,8 ± 0,5 7,0 ± 0,5	85 89 92 99 104 109 113 116
	C	25	6	15,0 17,5 20,0 25,0 30,0 35,0 40,0 45,0	21,3 ± 0,5 20,3 ± 0,5 20,0 ± 0,5 19,0 ± 0,5 17,8 ± 0,5 16,8 ± 0,5 15,0 ± 0,5 13,5 ± 0,5	13 14 15 17 19 20 22 23
	D	0	225	15,0 17,5 20,0 25,0 30,0 35,0 40,0 45,0	0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5	217 215 211 204 195 184 172 159

Table A.3

Climate zone	Sub-test	Test conditions				
		Wind speed U [m/s]	Rainfall R_h [mm/h]	Roof pitch α [^{0}]	Wind speed on roof surface u_s [m/s]	Rainfall on roof surface R_t [mm/h] (tolerance ± 5 %)
Central Europe	A	4	200	15,0 17,5 20,0 25,0 30,0 35,0 40,0 45,0	3,4 ± 0,5 3,2 ± 0,5 3,2 ± 0,5 3,0 ± 0,5 2,8 ± 0,5 2,7 ± 0,5 2,4 ± 0,5 2,2 ± 0,5	217 219 220 220 219 217 213 207
	B	10	130	15,0 17,5 20,0 25,0 30,0 35,0 40,0 45,0	8,5 ± 0,5 8,1 ± 0,5 8,0 ± 0,5 7,6 ± 0,5 7,1 ± 0,5 6,7 ± 0,5 6,0 ± 0,5 5,4 ± 0,5	167 172 176 185 192 197 202 204
	C	15	8	15,0 17,5 20,0 25,0 30,0 35,0 40,0 45,0	12,8 ± 0,5 12,2 ± 0,5 12,0 ± 0,5 11,4 ± 0,5 10,7 ± 0,5 10,1 ± 0,5 9,0 ± 0,5 8,1 ± 0,5	13 14 15 16 17 18 19 20
	D	0	300	15,0 17,5 20,0 25,0 30,0 35,0 40,0 45,0	0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5	290 286 282 272 260 246 230 212

Table A.3

Climate zone	Sub-test	Test conditions				
		Wind speed U [m/s]	Rainfall R_h [mm/h]	Roof pitch α [^{0}]	Wind speed on roof surface u_s [m/s]	Rainfall on roof surface R_t [mm/h] (tolerance ± 5 %)
Southern Europe	A	2	248	15,0 17,5 20,0 25,0 30,0 35,0 40,0 45,0	1,7 ± 0,5 1,6 ± 0,5 1,6 ± 0,5 1,5 ± 0,5 1,4 ± 0,5 1,3 ± 0,5 1,2 ± 0,5 1,1 ± 0,5	254 253 252 248 243 235 226 215
	B	8	166	15,0 17,5 20,0 25,0 30,0 35,0 40,0 45,0	6,8 ± 0,5 6,5 ± 0,5 6,4 ± 0,5 6,1 ± 0,5 5,7 ± 0,5 5,4 ± 0,5 4,8 ± 0,5 4,3 ± 0,5	201 206 210 217 222 226 228 229
	C	20	6	15,0 17,5 20,0 25,0 30,0 35,0 40,0 45,0	17,0 ± 0,5 16,2 ± 0,5 16,0 ± 0,5 15,2 ± 0,5 14,2 ± 0,5 13,4 ± 0,5 12,0 ± 0,5 10,8 ± 0,5	11 12 13 14 16 17 18 19
	D	0	415	15,0 17,5 20,0 25,0 30,0 35,0 40,0 45,0	0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5 0 ± 0,5	401 396 390 376 359 340 318 293

NOTE Values of R_t in Table A.3 are calculated by Formula (4):

$$R_t = R_h (\cos \alpha + \tan \theta \ \sin \alpha) \quad \ldots\ldots (4)$$

where α is the roof pitch,

with θ according to Formula (5):

$$\theta = \tan^{-1} \{u / (4{,}505\ R_h^{0.123})\} \quad \ldots\ldots (5)$$

Values of R_t for intermediate roof pitches are obtained by interpolation.

A.9 Evaluation and expression of test results

During the test leakage of the test specimen shall be continuously observed from the underside of the test specimen, recording any fine spray, wetting on the underside, and leakage. The amount of leakage water and the corresponding test conditions shall be recorded. The description of leakage may be supplemented with diagrams and photographs.

The cases, in which leakage exceeding fine spray and wetting on the underside occur, are considered as being too severe for the application. In any case, the reference leakage rate of (10 g/m²)/5 min shall not be surpassed.

A.10 Test report

The test report shall contain the following:

a. Reference to this technical standard for BIPV modules EN 50583 and application category A;

b. Identification of the BIPV roof covering:

   1. Name, manufacturer or supplier of the BIPV modules and mounting system;
   2. Short description of the mounting setup and interconnection of the BIPV modules;
   3. Serial numbers of the BIPV modules and if available of the mounting type;
   4. Date and form in which the BIPV modules and mounting system arrived at the laboratory, including fixing devices, if any;
   5. Handling, storage and conditioning of the elements before testing.

c. Test procedure:

   1. Turbulence intensity of the apparatus;
   2. Calibration of the fan system, rain generating and run-off water devices;
   3. Method of preparation and laying of the test specimen, including dimensions, and sealing of the edges;
   4. Sub-Test conditions B and D (and optionally A and C) and the climate zone or appropriately derived wind-rain conditions;
   5. Roof pitch;
   6. Any deviation from this standard and any incidents which may have influenced the results;
   7. Date of test;
   8. Name and signature of technician responsible for the test.

d. Results:

   1. Description of the continuous visual observation of the underside of the test specimens for the wind-rain sub-tests A, B, C and D as appropriate;
   2. Description of the water penetration through the effective testing area, evaluated as:
      i) No moisture at the rear of the modules;
      ii) Entering of fine spray;
      iii) Moisture at the rear of the modules;
      iv) Rain drops or rain penetration at the rear of the modules;

      The measured amount of accumulated water at the rear of the modules shall be stated for each test sequence.
   3. The suction pressure applied to the underside of the test specimen at which the reference leakage rate occurs;

4. Increments of underside pressure and the corresponding leakage rate;
5. Amount of leakage water measured in the deluge rain for sub-test D;
6. Where appropriate, the comparison of the performance of the product in the test specimen with the performance of a reference product in another test specimen using the same apparatus.

Bibliography

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