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External fire exposure to roofs in combination with photovoltaic (PV) arrays — Test method(s)

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National foreword

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English Version

External fire exposure to roofs in combination with photovoltaic (PV) arrays - Test method(s)

Exposition des toitures équipées de modules photovoltaïques (PV) à un feu extérieur - Méthode(s) d'essai

Externe Feuereinwirkung auf Dächer in Kombination mit Photovoltaik (PV)-Arrays - Testmethode (n)

This Technical Report was approved by CENELEC on 2016-09-05.

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Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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European foreword

This document (CLC/TR 50670:2016) has been prepared by CLC/TC 82 “Solar Photovoltaic Energy Systems”.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Framing components of the PV modules that are made of polymeric materials are not covered within this document and will have to be addressed in a future revision.

Introduction

This CENELEC Technical Report (TR) defines test methods for the assessment of external fire exposure to photovoltaic (PV) arrays. The determination of such fire behaviour is important when photovoltaic systems are installed on roofs to evaluate if an intensification of a fire threat can be expected. With this regard, explicitly roof-integrated PV is not part of this TR.

The scenario of burning brands that are released from a neighbouring building is well defined for plain roofing assemblies through the classification standard of EN 13501-5 and the relevant test methods of CEN/TS 1187. Accordingly, the methods described herewith focus on PV modules and the influence to roof substructures in general and address tilted and flat-roof installations from burning droplets and radiant heat after ignited through a gas burner.

Roofing assemblies and substructures are exemplary replaced by calcium carbonate plates to allow free monitoring and characterization of the potential burning behaviour of PV modules.

This Technical Report also encounters potential burning brands that may reach spaces between the PV array and roof in a realistic installation.

This Technical Report does not contain information on the level of acceptable performance, but on observations and measurements.

This Technical Report enters new fields of expertise and displays accordingly the current state of best knowledge basing on available data in the industry. More technical data and test results will be generated to further develop the TR.

CAUTION — The attention of all persons concerned with managing and carrying out these tests is drawn to the fact that fire testing can be hazardous and that there is a possibility that toxic and/or harmful smoke and gases can be evolved during the test. An assessment of all potential hazards and risks to health should be made and safety precautions should be identified and provided. Written safety instructions should be issued. Appropriate training should be given to all relevant personnel. Laboratory personnel should ensure that they follow written safety instructions at all times.

1 Scope

This Technical Report provides test methods for the assessment of external fire exposure to roofs in combination with photovoltaic (PV) arrays which characterize potential impacts of PV arrays to an existing fire rating of roofs from an external fire exposure. The performance of roofs without PV to external fire exposure is defined in CEN/TS 1187.

The test methods of CLC/TR 50670 are only applicable to roof added installations. Building integrated PV is not covered by this standard.

The test method refers to PV modules as test specimens without a specific mounting system as well as combinations of PV modules with particular mounting systems on tilted roofs and flat roofs.

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 ISO 13943:2010, *Fire safety — Vocabulary (ISO 13943:2008)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 13943:2010 and the following apply.

3.1
PV array
mechanically integrated assembly of modules or panels and its support structure

Note 1 to entry: An array does not include its foundation, tracking apparatus, thermal control, and other such components.

[SOURCE: IEC 61277, modified]

3.2
external fire
progression and extent of sustained flaming across the exposed surface of the specimen

[SOURCE: CEN/TS 1187:2012]

3.3
tilted roof
roof with an inclination angle of at least 15°

3.4
flat roof
roof with an inclination less than 15°

3.5
roof covering
uppermost layer of a roof

Note 1 to entry: This layer can comprise single layer or multiple layer coverings.

[SOURCE: CEN/TS 1187:2012]

3.6
fire penetration
appearance on the underside of the specimen of any sustained flaming or glowing due to combustion, including the occurrence of any flaming droplets falling from the underside

Note 1 to entry: Charring and/or discolouration are not to be regarded as fire penetration (for tests 1 and 3).

[SOURCE: CEN/TS 1187:2012, modified]

3.7
damaged material
material that has been burnt, charred, melted or otherwise visually changed by heat

Note 1 to entry: Discolouration and soot deposits are not to be regarded as damaged material.

[SOURCE: CEN/TS 1187:2012, modified]

3.8
calcium carbonate plate
board/plate made of calcium carbonate or calcium silicate

3.9
product
PV Module about which information is required

[SOURCE: CEN/TS 1187:2012, modified]

3.10
specimen
representative section of the roof/roof covering prepared for the purpose of the test

[SOURCE: CEN/TS 1187:2012]

3.11
test deck
test deck on which the PV module will be mounted

3.12
exposed surface
external surface of the specimen which is subject to the heating conditions of the test

[SOURCE: CEN/TS 1187:2012]

3.13
underside
bottom surface of the PV module

[SOURCE: CEN/TS 1187:2012, modified]

3.14
sustained flaming
flames arising from an observed location, which persist for 5 s or longer

[SOURCE: CEN/TS 1187:2012]

3.15
opening
appearance during the test of any hole greater than 25 mm² in area or any crack greater than 2 mm wide, which penetrates completely through the specimen and which would allow burning materials to fall through the PV module

3.16
flaming droplets or debris
burning material falling from the specimen that continues to burn on the calcium silicate for at least 5 s

3.17
lateral flame spread
length of damaged material of the PV module, expressed in mm as measured from the centre of the wood gas burner.

3.18
roof pitch
inclination of the roof surface to the horizontal

[SOURCE: CEN/TS 1187:2012]

4 General

The test methods derive from potential scenarios of external fires on the combined installation of a PV array on roofs.

The following test methods generally describe external fires:

— on top of a PV array;

— between a PV array and a tilted roof;

— between a PV array and a flat-roof.

This test method is divided into its applicability to different PV array applications on roofs. Accordingly, the fire reaction of PV modules in combination with sub-constructing materials is simulated.

The test methods apply to single modules with minimum sizes of 500 mm by 1 000 mm.

For PV arrays on roof coverings with a fire classification of construction products according to the list of ‘deemed to satisfy’, no further testing is required.

5 Test apparatus

5.1 Gas burner

The gas burner is defined as the source of ignition to be placed on the test deck according to Clause 6. The design and dimensions of the gas burner have been derived from findings and test results within research and development and best practical knowledge to suit the following requirements.

The gas burner is made of a stainless tube with an external diameter of (15,0 ± 0,1) mm and an internal diameter of (13,0 ± 0,1) mm, ending in a square part with 265 mm side length. The supply tube shall have a length of at least 500 mm.

In the square part of the burner, 32 holes with a diameter of 1,3 mm are drilled, 8 holes at each side. The holes are oriented to the inside of the burner. Half of the holes have an upward inclination of 45° and half of the holes have a downward inclination of 45° with respect to the burner plane.

The gas supplied to the burner shall be propane with a purity of 95 % or higher. The propane mass flow rate shall be (324 ± 20) mg/s, generating a heat output of (15 ± 1) kW (the net heat of combustion of propane is 46 360 kJ/kg) for 10 min as demanded in Clause 6. A suitable mass flow controller shall be used to ensure that the flow rate is maintained throughout the test.

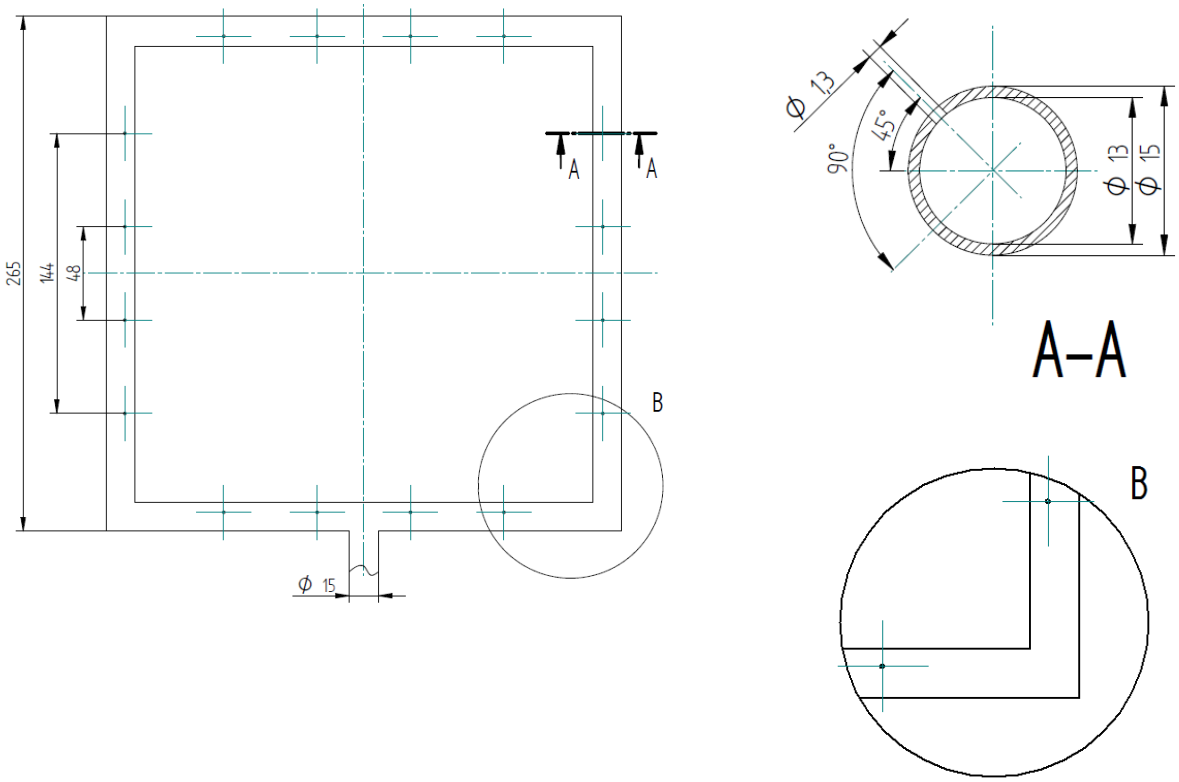

Figure 1 — Dimensions and design of the gas burner

5.2 Test environment and measurements

Testing shall be carried out in a draught free area. The ambient temperature within the laboratory shall be (20 ± 10) °C prior to the start of each fire test. If any measures are taken to remove products of combustion from the test laboratory, they shall be in operation during the calibration period and maintained during the test.

5.3 Conditioning

At the time of the test, the specimens shall be conditioned to constant mass in an atmosphere of (23 ± 2) °C and (50 ± 5) % relative humidity. The specimen shall be mounted in the test frame and tested as soon as possible after leaving the conditioning atmosphere. The time between leaving the conditioning atmosphere and testing shall not exceed 4 h.

5.4 Test deck

The test deck simulates an exemplary roof covering. The purpose is to allow a free observation of the burning behaviour of the PV module and potential influence from this towards underlying roofing material.

The test deck shall consist of profiled steel or wood battens for trapezoidal construction to simulate a roof and according inclination. The construction shall allow a continuous top deck layer which allows the installation of sub-constructing mounting materials to fixate PV modules as described in Clause 6. The top deck shall be composed of non-flammable calcium carbonate plates forming a homogenous surface. The calcium carbonate plates shall be calcium silicate boards with a density of (800 ± 150) kg/m³ and a thickness of (12 ± 3) mm.

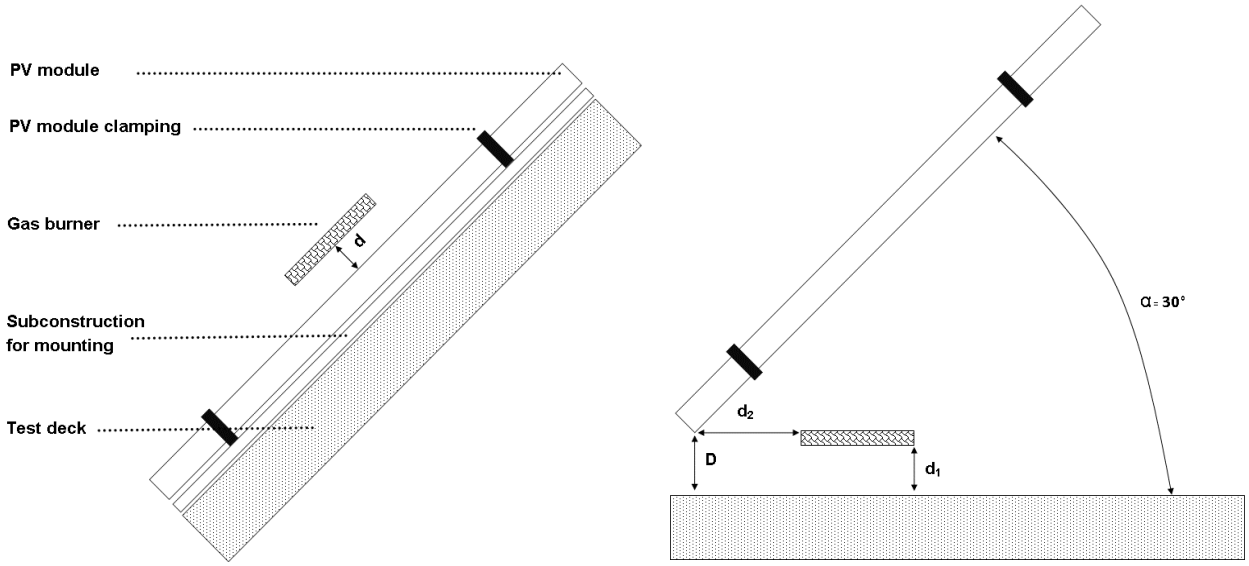

Figure 2 — Exemplary test deck and definitions of test components

6 Test procedures

6.1 General

The PV modules shall comply with the appropriate product standards in respect of the appropriate sampling plan, or, in absence of a standard sampling plan, shall be selected at random from a representative population. The specimens shall be representative in all details of practical application (except for the standard test deck), with regards both the support and the type and calcium silicate plate.

The modules are installed in portrait orientation. For each of the following test procedures different PV modules of the same identical type shall be used. Each test procedure is carried out three times.

The mounting hardware with regards to fixation is to be used as recommended by the manufacturer.

The mounting of the module shall not obstruct the flame application to the sample, e.g. through mounting beams or any fixations.

For each test sequence and orientation, one PV module is mounted on the test deck.

6.2 Placement of source of ignition on top of the PV module

The gas burner has to be applied at the top of the module (exposed surface), centred to the module's surface. The burner shall be positioned in parallel to the module, with a distance of d = 10 mm measured from the underside of the burner.

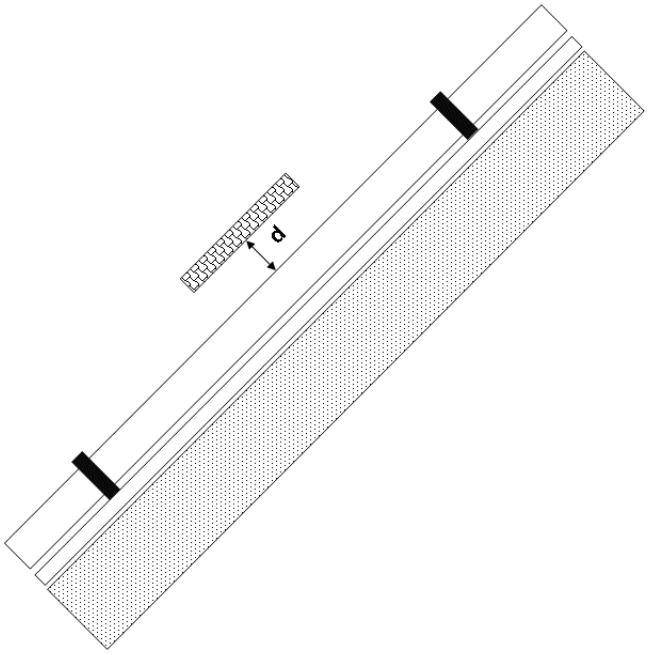

Figure 3 — Placement of source of ignition on top of the PV module

The slope of the simulated roof deck (test deck) shall be 45°. The PV module shall be mounted parallel to the roof deck.

The gas burner shall be adjusted to provide a flow rate of (324 ± 20) mg/s, generating a heat output of (15 ± 1) kW for a duration of 10 min.

6.3 Placement of source of ignition between PV module and pitched-roofs

The gas burner has to be applied between the backside of the PV module (exposed surface), and the test deck surface, centred in the module's width module and placed at the lowest edge of the module. The burner shall be positioned in parallel to module, with a distance of d = 10 mm measured from the underside of the burner to the test deck surface. The PV module is to be installed roof-parallel with a distance of D=150 mm with respect to the test deck surface.

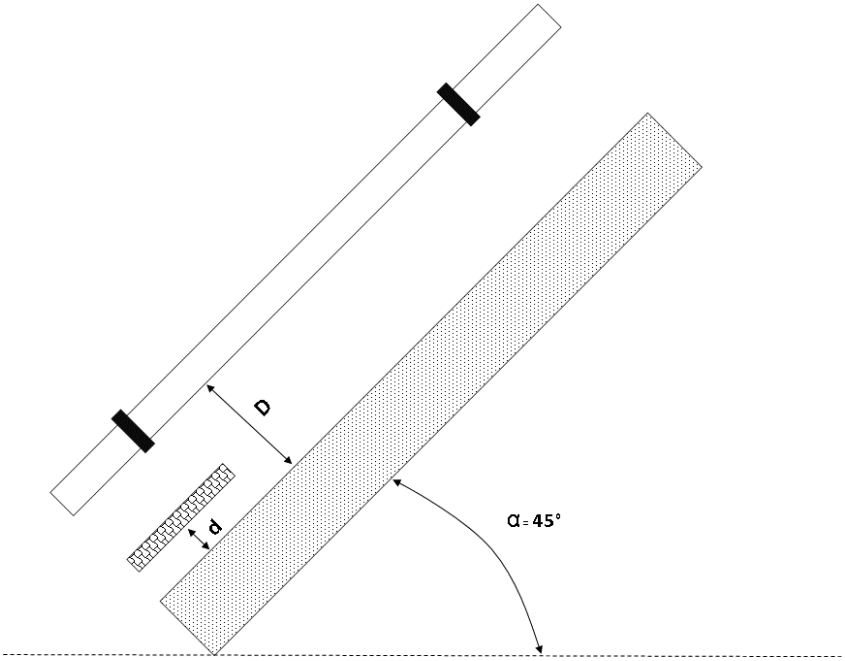

Figure 4 — Placement of source of ignition between the PV module and pitched-roofs

The slope of the simulated roof deck (test deck) shall be 45°.

The gas burner shall be adjusted to provide a flow rate of (324 ± 20) mg/s, generating a heat output of (15 ± 1) kW for a duration of 10 min.

6.4 Placement of source of ignition between PV module and flat roofs

The gas burner has to be applied at lowest edge of the module between the backside of the module (exposed surface) and the top of the test deck surface, centred in the module's width and placed at a distance of d_2 = 120 mm from the lowest edge of the module. The burner shall be positioned in parallel to the test deck, with a distance of d_1 = 80 mm measured from the underside of the burner to the test deck surface. The lowest edge of the module shall have a distance to the test deck of D=150mm.

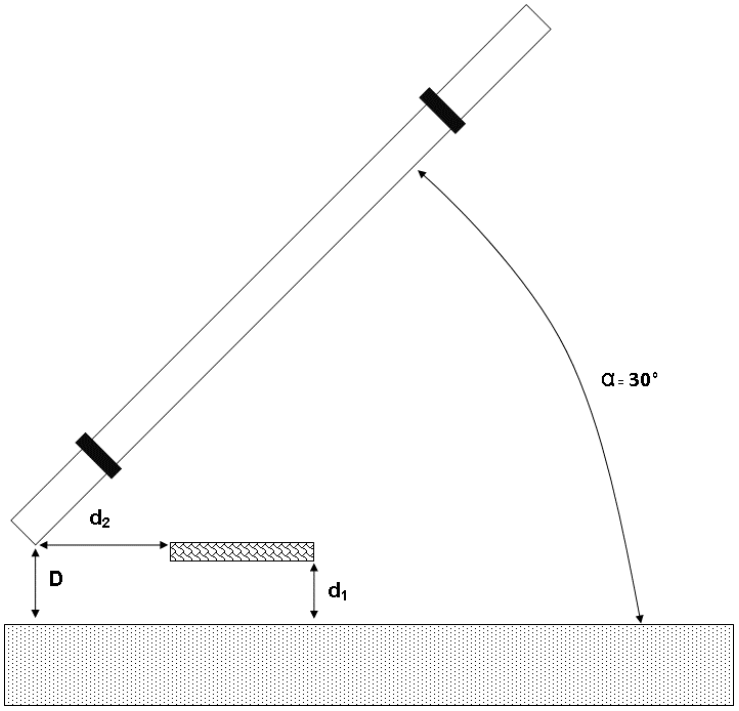

Figure 5 — Placement of source of ignition between PV module and flat roofs

The PV module is to be installed with an inclination of 30° to the test deck or at the minimum module inclination as defined in the installation instructions if lower than 30°. The slope of the simulated roof deck (test deck) shall be 0°.

The gas burner shall be adjusted to provide a flow rate of (324 ± 20) mg/s, generating a heat output of (15 ± 1) kW for a duration of 10 min.

7 Observations and measurements

7.1 General

All time observations are expressed in minutes and seconds elapsed from the start of the test.

The fire performance for modules with/without mounting systems in combination with simulated roof coverings shall be recorded and reported at least as follows:

Observations of the burning characteristics and damaged material of the PV module or panel during after the exposure to the gas flame.

The report shall contain the following observations during the tests:

7.2 Placement of source of ignition on top of the PV module

— Lateral flame spread to any edge of the modules;

— openings in the module;

— burning droplets (burning > 10 s);

— time of (and if) sustained flaming occurs after the test.

7.3 Placement of source of ignition between PV module and pitched-roofs

— No lateral flame spread to any edge of the modules;

— openings in the module;

— burning droplets (burning > 10 s);

— time of (and if) sustained flaming occurs after the test.

7.4 Placement of source of ignition between PV module and flat roofs

— No lateral flame spread to any edge of the modules;

— openings in the module;

— burning or glowing droplets (burning >10 s);

— time of (and if) sustained flaming occurs after the test.

8 Reporting

The reporting of the conducted tests shall comprise:

— name and address of the testing laboratory;

— date and identification number of the report;

— name and address of the sponsor;

— purpose of the test;

— method of test procedure according to Clause 6;

— method of sampling;

— name of manufacturer or supplier of the product;

— name or other identification marks of the product;

— date of supply of the product;

— description of the specimens, including substrate, mounting system and attachment;

— conditioning of the specimens;

— date of test;

— test results:

  — test duration;

  — flame spread to lateral directions and updwards/downwards;

  — (burning) droplets;

  — burn-through of module (size and diameter).

Bibliography

CEN/TS 1187, *Test methods for external fire exposure to roofs*

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

IEC 61277, *Terrestrial photovoltaic (PV) power generating systems — General and guide*

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