The Certification Mark for Onsite Sustainable Energy Technologies

MCS 012

Product Certification Scheme Requirements: Pitched Roof Installation Kits

Issue 2.3

This Standard has been approved by the Standards Management Group of the Microgeneration Certification Scheme.

This Standard was prepared by the Microgeneration Certification Scheme Working Group 10 'Roofing Issues'.

REVISION OF MCS PRODUCT SCHEME DOCUMENTS

The MCS Product Scheme documents will be revised by issue of revised editions or amendments. Details will be posted on the website at www.microgenerationcertification.org

Technical or other changes which affect the requirements for the approval or certification of the product or service will result in a new issue. Minor or administrative changes (e.g. corrections of spelling and typographical errors, changes to address and copyright details, the addition of notes for clarification etc.) may be made as amendments.

The issue number will be given in decimal format with the integer part giving the issue number and the fractional part giving the number of amendments (e.g. Issue 3.2 indicates that the document is at Issue 3 with 2 amendments).

Users of this Standard should ensure that they possess the latest issue and all amendments.

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FOREWORD

The following document contains provisions which, through reference in this text, constitute normative or informative provisions of this document [MCS 012]. At the time of publication, the editions indicated were valid. All documents are subject to revision, and parties applying this document [MCS 012] are encouraged to investigate the possibility of applying the most recent editions of the documents referenced.

The following document [MCS 012 issue 2.3] is a minor update to [MCS 012 issue 2.2, published 10/01/2018]. Issue 2.3 is available for reference from the date of publication [18/09/2018].

Newly certified products shall comply with [MCS 012 issue 2.3] from the date of publication [18/09/2018]. Issue 2.3 is mandatory from [18/03/2019] for manufacturers or importers who have products currently certified to Issue 2.2.

MCS committed to working with industry when it first published MCS 012 issue 1.0 on 16th March 2012, and a formal review of this Standard is currently being undertaken. Industry feedback is still requested with regards to exceptions which may not fall under the remit of MCS 012.

1. INTRODUCTION

- This document identifies the evaluation and assessment requirements and practices for the purposes of certification and listing of installation kits and individual components for pitched roof mounted Solar PV Modules and Solar Collectors. Certification and listing of products is based on evidence acceptable to the Certification Body: that the product meets the Standard;
- that the manufacturer has staff, processes and systems in place to ensure that the product delivered meets the Standard.

And on:

- periodic audits of the manufacturer and / or supplier, including testing as appropriate;

- compliance with the contract with the Certification Body for listing and approval including agreement to rectify faults as appropriate.

2. SCOPE

This Scheme provides ongoing independent, third party assessment and approval of companies who wish to demonstrate that their pitched roof installation kits or components meet and continue to meet the requirements of this standard.

The requirements of this Scheme document are not applicable to installations on flat roofs which will be covered by a separate document.

2.1 General Requirements

2.1.1 Products which require the use of through bolts are only eligible for certification to MCS 012 subject to meeting the following requirements:

1. The bolt or flashing shall not transfer any load on the slates / tiles (excluding metal tiles or sheets) beneath;
2. The system shall not rely on site applied silicone, mastic or other similar type sealants as the sole method to provide a weather-tight seal;
3. The system must durably seal every layer of roof covering that is perforated by the bolt system;
4. The system shall not rely on a sealing washer or plate that presses down on the slate/tile (excluding metal tiles or sheets) to ensure a weather tight seal;
5. The bolt fixings shall not be into battens.

NOTE: This wording takes precedence over Section 4.3.9 bullets 1-5 in the MCS PV Guide.

2.2 Definitions

2.2.1 Roof installation kit - a collection of parts or components designed to mount (a) Solar Collector(s) or PV Module(s) on the roof of a building. The kit comprises all parts required to provide a structurally stable fixing and ensure the weathertightness, and fire performance of the roof meets the requirements of the building regulations.

2.2.2 Roof integrated installations - an installation where the Solar Collector or PV Module replaces some or all of the roof covering. Including PV tiles or Thin-film PV modules bonded to roof coverings such as standing seam roof sheets.

2.2.3 Above roof installations - an installation where the Solar Collector or PV Module is mounted above the roof covering and fixed to the underlying roof structure through the roof covering.

2.2.4 Bespoke building integrated installations - a bespoke PV unit that is manufactured in varying sizes, shapes and configurations for the purpose of being built into the fabric of a building - such as PV glazing, PV façade units or PV shading units. Furthermore, a BBIPV product is one that is tailored and manufactured to a specific project, with a size and configuration specific to that project.

2.2.5 Solar panel - this document uses the term solar panels as a collective term for solar thermal collectors and PV modules.

2.2.6 Component* – an identifiable part of the solar system which may be sourced separately and made available on the market, for example:

- Brackets/roof hooks
- Rails/profiles
- Joiners
- Clamps
- Clips
- Rafter bolts

*The Component may require the use of a Solar Panel during testing to provide an indication of the intended use of the component so that this can be specified on the MCS Certificate for the component. The Solar Panel is not to be tested directly.

3. APPLICATIONS TO JOIN THE SCHEME

3.1 Applications should be made to an accredited Certification Body operating this Scheme, who will provide the appropriate application form and details of the applicable fees.

4. MANAGEMENT SYSTEMS CERTIFICATION

4.1 Manufacturers and /or suppliers* shall operate a certified documented manufacturing quality control system, in accordance with the requirements of MCS 010 “Generic Factory Production Control Requirements”.

* The factory production control exercised by the manufacturers of the various components must be confirmed as adequate in all cases.

4.2 Where a supplier is gathering together various components manufactured by other companies, for sale as a kit, it may be possible to restrict the audit to the supplier’s office, provided that they can demonstrate that they have adequate procedures in place to confirm that the quality of these components is being maintained. Should this prove not to be the case, then further audits may be required at some or all of the manufacturing locations.

4.3 The level of control operated for individual components should be commensurate with the nature and significance of these components. For example, that exercised over a standard screw and nut combination may be lower than those for specialised fixing brackets.

5. CERTIFICATION AND APPROVAL

5.1 Certification and approval is based on the following:

a) Evidence of compliance with:

Roof performance tests for solar thermal collectors and PV modules (see Appendix A)

5.2 Evidence of compliance is generally accepted as independent third party testing by a UKAS (or equivalent) accredited test laboratory. However, other evidence of compliance may be considered at the discretion of the Certification Body (see document MCS 011 'Testing Acceptance Criteria').

b) Verification of the establishment and maintenance of the manufacturing company's quality management system in accordance with the Factory Production Control requirements (FPC).

c) Review of the technical documentation relating to the material, product or component.

5.3 Applications for a range of common products (product families) will be dealt with on a case by case basis. For example, where one or more characteristics are the same for products with similar design, construction and functionality then the results of tests for these characteristics on one product may be applied to other similar products, as agreed between the manufacturer/supplier and the Certification Body.

5.4 A certificate can be awarded following:
(i) demonstration of satisfactory compliance with this Scheme document, taking into account any limitations imposed and other appropriate guidelines and satisfactory verification/assessment of the manufacturer's Factory Production Control and technical documentation, and
(ii) the submission of a complete MCS012 Performance Data Template including all relevant fields to the Scheme Administrator by the Certifying Body.

Note: Please refer to the example column given in the template as a guideline.

5.5 Certificates are valid from the date of issue and are maintained and held in force subject to satisfactory completion of the requirements for maintenance of certification (see Item 10), but remain the property of the issuing Certification Body.

5.6 Details of the manufacturer and the certificated product(s) are listed on the website at www.microgenerationcertification.org, upon receipt of a completed MCS012 Performance Data Template as provided for in Section 5.4.

6. TECHNICAL DOCUMENTATION

6.1 Technical documentation for the product must be submitted for review. This documentation shall be presented in English, and shall be such that it can be assured that the products submitted for test are equivalent to those that are to be manufactured for normal production. The documentation must consist of the following as a minimum:

a) Details of intended use, application, classifications and restrictions (such as minimum roof pitch) required;

b) Manufacturing drawings and/or specifications including tolerances, issue and revision numbers;

c) The revision number of the product;

d) Raw material and components specifications;

e) Details of the quality plan applied during manufacture to ensure ongoing compliance;

f) Where historical test data is requested to be considered for the application, full test report and details of any existing approvals (Note: each application will be dealt with on a case by case basis, and further information about the acceptance of previous testing is available on request);

g) Installation, use and maintenance instructions.

7. PERFORMANCE CRITERIA

The performance may be declared for whole systems tested or for individual components, where appropriate and when those components are to be offered for incorporation into a wide range of systems. In the latter case all uses of the components must be clarified, and it is the responsibility of those supplying the whole system to show the whole system also satisfies the performance criteria.

7.1 Resistance to wind uplift

7.1.1 A maximum wind uplift resistance shall be declared when assessed in accordance with Section 4 of Appendix A.

7.2 Fire

7.2.1 A fire rating shall be declared in accordance with Section 5.1 of Appendix A, except for above roof mounting kits satisfying the requirements of Section 5.2 of Appendix A.

7.3 Weathertightness

7.3.1 The mounting of the solar panels on or in the roof shall not decrease the weather performance of the declared roof types when tested in accordance with section 6 of Appendix A.

7.4 Installation instructions

7.4.1 Guidance must be given on compatible solar panels and roof systems. The information provided to the installer must clearly indicate how the kit is installed with different solar panels and roof types including the type and number of fixings and maximum recommended spacing of brackets/rails.

7.4.2 In particular, the following information shall be clearly and prominently shown in the product installation instructions:

- The maximum wind load the system achieved when assessed according to this document, using the standard procedure and fixing details as described in the manufacturer's instructions;
- For products that can be used with a variety of different solar panels these instructions should clearly describe the array design constraints (e.g. maximum module area, fixings per m² etc) that need to be met in order to achieve the stated wind load result.

8. CERTIFICATE CONTENT

8.1 Certificates shall contain the name and address of the manufacturer/supplier, model and reference number of the roof installation kit or components the test standard, a unique certificate reference number and the issue number and date.

8.2 In addition, the certificate will include the following information:

- Roofing substrates compatible with the system and any minimum requirements e.g. minimum timber size;
- Minimum permissible roof pitch;
- Whether the product is suitable for use as in roof or above roof installations;
- Maximum design wind uplift resistance as defined in Section 4.2.1 of Appendix A (this may be a single value or a table of values for different installation configurations);
- The value of the partial (safety) factor(s) that have been used in determining the wind uplift resistance for the product as defined in section 4.2.1 of Appendix A;
- Fire test result in accordance with Section 5 of Appendix A (for roof integrated only or where an above roof system is assessed for use on combustible substrates).

9. MAINTENANCE OF CERTIFICATION AND LISTING

Certificates and listing are maintained and held in force subject to satisfactory completion of the below requirements for maintenance of certification.

9.1 Supplier / manufacturer audits

9.1.1 Certification is maintained through annual FPC quality system audits*, which shall include a detailed check that the product being manufactured is to the same specification as the product tested.

* Carried out in accordance with the principles discussed in Section 5.

9.2 Product audits

9.2.1 Product audits will be conducted as follows:

- review of the product technical data files including materials;
- review of end of line tests in accordance with the manufacturer's quality plan;
- repeat testing of elements from the product standard as appropriate to confirm that the product continues to meet the requirements for certification and listing.

10. CERTIFICATION MARK AND LABELLING

10.1.1 All approved products listed under this Scheme shall be traceable to identify that they have (and marked with a label to confirm that the product has) been tested and certificated in accordance with the requirements of the test standard. See below for details.

10.1.2 The supplier shall use (the) Certification Mark(s) (only) in accordance with the Certification Body's instructions.

10.1.3 An example of the Certification Mark that can be used for this Scheme is as follows:

APPROVED PRODUCT

MCS

Certificate Number MCS "XXX"

"Description of the Technology certificated"

10.1.4 Where 'XXX' is the certificate number and the logo of the Certification Body issuing the certification would sit in the right hand box.

10.1.5 Companies may only use the Mark while the certification is maintained

APPENDIX A

Pitched roof performance tests for solar thermal collectors and PV modules

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A1. INTRODUCTION

With the drive for low energy buildings and the greater functionality of roofs, solar panels are being used in ever increasing numbers. It is important that, whilst providing additional functionality, the solar panel systems do not degrade the fundamental function of the roof, which is the long-term protection of the building interior from the elements.

NOTE: This document uses the term solar panels as a collective term for solar thermal collectors and PV modules.

A2. SCOPE

This document specifies the test procedures which shall be used to demonstrate the performance of solar panels and/or their installation kits or individual components under the action of:

- Wind loads – resistance to wind uplift forces
- Fire – resistance to external fire
- Rainfall and wind driven rain – weather-tightness

These procedures apply to ‘in roof’ and ‘above roof’ systems fixed to pitched roofs. They do not apply to systems mounted inclined above flat roofs or mounted on vertical walls.

The results of these tests shall be compared with the required performance. The informative annexes provide some guidance on the performance levels necessary.

Satisfactory performance in the tests described in this document does not necessarily imply compliance with the requirements of the Building Regulations.

The results of the roof mounting kit's performance against the test procedures shall be made publicly available on the MCS product certificate holder's website.

A3. INSTALLATION INSTRUCTIONS

The product and installation kit must come with installation instructions. The installation instructions must be followed when preparing the product and installation kit for test.

A4. RESISTANCE TO WIND UPLIFT

A4. 1 Test method

In the absence of a test method specifically for assessing the uplift resistance of solar panels, the test method shall follow the principles and, where appropriate, the details of BS EN 14437: 2004 (Determination of the uplift resistance of installed clay or concrete tiles for roofing — Roof system test method) (Reference 1). *Note that a trial test, as specified in BS EN 14423: 2004, is not always necessary – this should be decided by the test house, depending on the system.* Appendix 1 shows a typical PV system under test.

The test shall determine the wind uplift resistance and the following details shall be followed:

I. Where the flashing or sealing kits provide any uplift resistance then these should be included in the test.
II. The roof pitch shall be 45deg +/- 2 degrees.
III. A minimum of one solar panel should be tested (or two if shared components are employed) and the test shall be repeated a minimum of three times with new fixings each time.
IV. 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, as shown in Appendix 1.
V. 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 real construction. The minimum requirements of BS 5534: 2014+A1:2015 shall also be satisfied.
VI. Where there is a choice of fixing positions, the most onerous (weakest) shall be tested.
VII. The test roof should include all components of typical construction, including the adjacent tiles. Alternatively, technical justification shall be provided as to why these are omitted.

A4.2 Test criteria

A4.2.1 Method

The characteristic value[1] of the uplift resistance shall be determined from the measured failure loads and reported.

(1) The characteristic value has a prescribed probability of not being attained in a hypothetical unlimited test series. This is defined in Annex D of BS EN 14437: 2004 for a 95% confidence limit of being attained.

For design purposes the characteristic uplift resistance load shall be divided by an appropriate partial factor (safety factor) from the relevant Euro-Code:

- For failure in steel or metal components – EN 1993-1-1: 2005 Design of steel structures — General rules and rules for buildings.
- For failure in timber – EN 1995-1-1: 2004 Design of timber structures — General rules and rules for buildings.

The certificate shall declare the maximum design uplift resistance in kilo Pascals (kPa) for systems or Newtons (N) for individual fixings – the characteristic resistance divided by the partial factor for the failure mode in the test.

In summary:

- Ultimate Limit State (the system actually fails i.e. failure criteria a, b or c below):
    - For failure in a metal component the partial factor is 1.1
    - For pull out from a metal component (eg. self-tapping screw or rivet) the partial factor is 1.25
    - For failure in a timber component or pull out from a timber component the partial factor for design against wind loads is 1.44[2]

(2) This value has taken into account the influence of load duration and other parameters in-line with EN1995-1 Table 2.2 and clause 2.3.1.

- Serviceability Limit State (no failure but the system is no longer fit for purpose, i.e. failure criteria d or e below).
    - The partial factor is 1.0

As written, the failure criteria specified in BS EN 14437: 2004 are not appropriate to solar systems and MCS 012 failure criteria shall be taken as follows:

a) Breakage of a mechanical component between the panel and the roof structure.
b) Pulling out or breakage of the connection of the mechanical fixing to the roof.
c) Breakage of elements of the solar panel.
d) If the maximum displacement of any roofing element exposes the under-roof then the maximum deflection shall be 75 millimetre (mm).
e) The remaining displacement of any roofing element after releasing the force to zero exceeds 5mm and degrades the weathertightness of the roof. (When the 5mm limit is achieved, the test should be continued until the applied load is at least 1.5 times the load measured at the 5mm limit or until ultimate failure occurs. This is to ensure that the design resistance derived does not exceed the ultimate resistance divided by the appropriate partial factor).

NOTE:

1. *Annex 1 gives guidance regarding the required uplift resistance for a given site*
2. *When assessing the adequacy of the system, partial factors must also be applied to the design loads, increasing them in accordance with Tables A1.1 and A1.2 of EN 1990: 2002. For the design against wind uplift the partial factor for self-weight shall be 1.0 and for wind suction loads 1.5. However, in normal use solar panels may be designated with a lower consequence of failure than for the supporting building structure, in accordance with Table B1 of EN 1990: 2002 + A1:2005 Consequence Class CC1. As a result the partial factor for design wind loads may be multiplied by 0.9 (Factor K_{FI} for Reliability Class RC1* from Table *B3 of EN 1990: 2002 + A1: 2005) giving a net increase of 1.35 applied to the design wind suction loads.*

A4.2.2 Alternative methods

Where it can be demonstrated that alternative methods provide equivalent or conservative (safe) values of the resistance to wind uplift then these may be used. Alternative methods may be appropriate when testing individual components.

Depending upon the failure mode and the method of mounting other acceptable methods may include:

i) DD CEN TS 15087: 2005 Determination of the uplift resistance of installed clay and concrete interlocking tiles for roofing – Test method for mechanical fasteners. (Reference 9)

NOTE: This test method may be appropriate for some designs of roof integrated systems. It is not suitable for above-roof systems.

ii) ISO 9806: 2006 Thermal solar systems and components — Solar Collectors — Test methods, or BS EN 61215: 2005, or EN 61646: 2008 providing the mounting arrangement complies with the requirements of Clause 4.1 v) and vi) above.

iii) Validation by calculation alone. In some simple cases it may be possible to validate the system against wind loads by calculation only. However, this is often not possible because, for instance, a) the failure modes are not wholly predictable, b) tabulated fastener withdrawal loads from standards are often not applicable due to the fastener diameter/timber thickness ratio.

A5. FIRE PERFORMANCE

The test requirements are different for roof integrated and above roof systems.

A5.1 Roof integrated Systems

Roof integrated systems shall be tested in accordance with BS 476-3: 2004 (Reference 3) or DD ENV 1187: 2002 Test 4 (Reference 11), and the rating must be declared. Appendix 2 shows the test arrangement.

NOTE:

i) Applying this test to solar systems is not without its problems and guidance is provided in Annex C (normative) of BS 476-3: 2004.

ii) Past experience suggests that the flashings around and between the panels often pose the greatest risk due to unprotected gaps.

iii) For large systems it may be necessary to test more than one section to ensure the most vulnerable areas are all tested.

A5.1.1 Alternative Methods

Where the PV module forms part of the fire barrier for the fire test, the certificate must also state:

a) The make and model of each module that the fire testing of the system has been performed with, and the rating in each case.
b) That the fire performance rating applies only to the roofing kit when used with the family of modules (family as referenced within MCS005) from which the tested module(s) came, or other modules that have identical material specification and design of: frame, coversheet, encapsulant, backing sheet and sealant.

NOTE:

(i) Work is ongoing to define the module characteristics that would conserve the fire rating when substituting one type of module for another. Section A5 1.1 provides interim guidance.

(ii) An alternative means for an installer to achieve a fire rating is to use a substrate with an independent fire rating (for example a barrier material with AA rating) beneath a roofing kit/module combination that does not have a declared fire rating. It is important to be able to verify that the system achieves a sufficient rating as a whole.

A5.2 Above-roof Systems

If the solar system is only used on roofs whose outer covering is non-combustible, as defined in the Building Regulations, then in general no external fire test is required, otherwise the solar system together with the outer roof covering shall be tested in accordance with BS 476-3: 2004 or DD ENV 1187: 2002 Test 4. The Certification Body is to specify whether an external fire test is required in consultation with the manufacturer.

An external fire test is required on the fixings into the roof if these are perceived as increasing the fire risk to the roof, for instance by large increases in the gaps between roofing components.

A6. WEATHERTIGHTNESS

A6.1 General

The presence of the solar panel system must not decrease the weather performance of the roof covering or the roof structure.

The manufacturer/supplier shall declare which generic product classes their system can be used with:

- Profiled or flat single lapped tiles (profiled are recommended for test)
- Plain tiles (double lapped product)
- Double lapped slates (natural or synthetic)
- Profiled metal sheets or standing seam roof coverings
- Any other generic roofing type

Where a single flashing kit is specified for use with more than one generic class of roof covering, then the class representing the worst case shall be tested. If the worst class is not certain then other generic classes shall also be tested.

Note: Based on past experience the biggest risks of water entry are as follows:

Roof integrated systems:

i) The risk of water entry over the flashing kit which is around, between and, in some cases, under the panels. This water entry can be, for instance, at the interface with the roof covering, at the interface with the panels, or through joints in the flashings.

ii) Water entry through the roof covering related to increased gapping of the roofing elements due to the presence of the solar panel system, including its fixing system.

iii) Penetrations through the underlay can also pose a risk. Such penetrations must not jeopardise the role of the underlay, as specified in BS 5534: 2014+A1:2015 (Sections 4.9 and 6.2) and should therefore be sealed in an appropriate and durable manner, preferably with a purpose designed product.

Above roof systems:

i) Water entry via the penetrations through the outer roof covering.

ii) Spray entry through any gaps in the outer-roof covering created by the mounting arrangement.

iii) Penetrations through the underlay can also pose a risk. Such penetrations must not jeopardise the role of the underlay, as specified in BS 5534:2014+A1:2015 (Sections 4.9 and 6.2) and should therefore be sealed in an appropriate and durable manner, preferably with a purpose designed product.

A6.2 Test methods

The test methods address the leakage mechanisms.

A6.2.1 Roof integrated systems

A6.2.1.1 Test Procedure

The principles of the draft European wind driven rain test for roofs (PD CEN/TR 15601:2012) shall be used to determine the wind driven rain performance of the roof integrated solar panel systems.

The test shall be carried out at the minimum pitch of the tile/solar panel combination.

CEN TR15601 specifies 4 different wind-rain combinations (A – D), covering a range of severe UK coastal conditions (referred to as N. European coastal in CEN TR 15601). These conditions are summarised in Appendix 3.

For solar panels, provided **all** unprotected gaps caused by the mounting and installation arrangement are no greater than those pre-existing in the roof covering before the installation of the solar panels, then only Test D is mandatory; providing there is no reason to believe the gapping will increase due to wind. Tests A – C are then optional.

NOTE:
Test D is the test with the largest rainfall rate (225mm / hour). Since the limit on the flashing is often the water carrying capacity, this is a sensible compromise, addressing the highest risk leakage mechanism.

If only Test D is to be carried out then a simplified test facility may be used, which does not have the pressure chamber, suction device, or fan system required in CEN TR15601.

If the installation of the system creates unprotected gaps larger than those pre-existing then, as a minimum, wind-rain combinations B and D must be tested.

The test specimen shall be constructed in accordance with the manufacturer's laying specifications (complete with tiles or other outer roof covering elements) but without the roofing underlay present, so that any water entry may be observed and collected. The tiles or roofing elements used shall be well established in the market with known satisfactory field performance.

The test specimen shall be mounted in the test apparatus and subjected to the chosen wind-rain combination. In the case of wind-rain combinations A, B and C, a uniform suction pressure is then applied to the underside of the test specimen, in increasing steps (one step every five minutes) until a leakage rate of 10 grams per square metre per 5-minute ($g/m^2/5min$) time step is observed. The amount of suction required to bring about this level of leakage is the test result for that wind-rain combination and provides a measure of the rain tightness of the system.

In the case of wind-rain combination D there is no applied suction, as this is simulating a zero wind condition. The test specimen is subjected to the Test D rainfall for 2 minutes and any water entry is noted and weighed.

The quantity of water running onto the top of the solar panel ('run-off water') shall be adjusted to simulate the worst case (widest panel and longest rafter length of roof). The minimum simulated additional rafter length above the solar panel shall be 5 metres (m).

NOTE:

Due to the complexity and size of solar systems, it can be difficult to get a whole panel or panels onto the test rig for test. It is often necessary to make up special samples which ensure the most vulnerable parts of the solar array are tested. It is necessary to ensure that all joints and other vulnerable parts of the test sample are representative of normal production. Alternatively, more than one configuration should be tested in order to ensure that one of each joint and interface type is tested.

A6.2.1.2 Test Criteria

The performance of the surrounding roof covering elements which are unaffected by the presence of the solar panels shall be taken as a benchmark against which to judge the performance of the solar panels. To be acceptable the solar panel system shall have a level of performance at least equal to that of the unaffected roofing elements, or equal to that of any other roofing element of known acceptable performance. If necessary a reference test shall be carried out with the test roof constructed wholly of roofing elements. The reference test must be carried out at the same laboratory as the test on the solar panel system.

For wind-rain combinations A, B and C, the comparison shall be made on the basis of the level of suction necessary to bring about a leakage rate of $10g/m^2/5min$ time step. The higher the level of suction required the better the performance of the system.

For wind combination D, the comparison shall be made on the basis of any water entry during the two minute test period.

A6.2.2 The performance of underlay penetrations

The sealing arrangement for the underlay penetrations shall be tested for weather-tightness. This shall be done with the underlay system fitted in place of the solar panel and tiles. The test shall follow the same test procedure as the Test D of Section A6.2.1.1 but should use a rainfall rate of 50 millimetres per hour (mm/hr) instead of 225mm/hr. In addition there should be no direct rainfall, only run-off water applied at the top of the inclined roof rig, assuming a rafter length of 5m. The product shall be deemed to have passed the test if there is no water leakage through the joint with the underlay after five minutes.

Note: Appendix 4 shows an example of an underlay sealing device undergoing a test.

A6.2.3 Above Roof Systems

Provided **all** unprotected gaps caused by the mounting and installation arrangement are no greater than those pre-existing in the roof covering before the installation of the solar panels, then only the weathertightness of the outer surface penetrations and the underlay penetrations need be tested.

The penetrations through the outer surface shall be tested in accordance with Section A6.2.3.1, whilst the penetrations through the underlay shall be tested in accordance with Section A6.2.2.

If the installation of the system creates unprotected gaps lager than those pre-existing, then the system, including the solar panels, shall be tested in accordance with Section A6.2.1.1 and no separate test is required for the penetrations through the outer roof covering.

A6.2.3.1 Weathertightness of the penetrations through the outer surface

Carry out Test D (Section A6.2.1.1) on the outer roof covering, with one or more penetrations installed but without the solar panel system in place. There should be no dripping from the penetration into the batten space during the two minute test period.

For some designs of penetrations a simpler ‘impermeability test’ can be considered as equivalent and sufficient. This simple test follows the principles of the water impermeability test in BS EN 490: 2011 or BS EN 491: 2011 (European concrete tile standard and associated test methods – References 7 and 8).

A7. TEST REPORT

The test report shall include the following details:

A7.1 Product and System Details:

Solar panel:

- Manufacturer
- Model
- Dimensions
    - Specify roof integrated or above roof design:
- Supplied by (company/person)
- Date received
- Laying instructions – publication date/version/edition

Flashing kit (where appropriate):

- Manufacturer
- Model
- Supplied by (company / person)
- Fitting instructions – publication date/version/edition

Outer roof penetrations/fixings (where appropriate):

- Manufacturer
- Model
- Supplied by (company / person)
- Fitting instructions – publication date/version/edition

Roof covering elements included in tests:

- Manufacturer
- Model

Performance parameters tested:

	Yes / No	Test dates
Resistance to wind uplift		
Fire performance		
Weather tightness		

A7.2 Resistance to wind uplift

Specify all details of the system considered:

(All details influencing the uplift resistance are to be given, including all timber sizes, fixings, roof covering elements and fixings of those.)

State method of assessment:

BS EN 14437: 2004	DD CEN TS15087: 2005	EN 12975-2: 2006 or EN 61215: 2005 or EN 61646: 2008	Calculation	Other

State the results and conclusions including all failure modes found or considered. When an appropriate EN standard or equivalent is used, the reporting should be in accordance with that Standard.

A7.3 Fire performance

Where required, report the results in accordance with BS 476-3: 2004 or DD ENV 1187: 2002 Test 4.

A7.4 Weathertightness

A7.4.1 Roof integrated systems:

State whether whole panels with flashing tested or sections.

(in the case of a section of a panel state the reason and the specific items tested)

Manufacturer's declaration of generic product classes the system is suitable for:

Generic class	Yes/No	Minimum pitch specification
Profiled or flat single lapped tiles		
Plain tiles		
Double lapped slate (natural and synthetic)		
Profiled metal sheets or standing seam		
Any other generic class (state)		

Roof covering elements used as a reference (manufacturer, model, pitch and headlap)

Gapping information

Roof covering elements (without solar system):

- Maximum unprotected gapping (mm to an accuracy of ±1.0mm)

Solar system:

- Maximum unprotected gapping (mm to an accuracy of ±1.0mm)

Tests carried out and result:

Test	Test pitch		Test Result for system	Test Result for Reference product
A		Applied suction (Pascal (Pa)) at leakage rate at10g/m2/5min		
B		Applied suction (Pa) at leakage rate (Pa) at 10g/m^2/5min		
C		Applied suction (Pa) at leakage rate (Pa) at 10g/m^2/5min		
D		Leakage observed after 2 min		

Additional Rafter length simulated (m)

Panel width simulated if greater than physical width of panel tested (m)

Performance assessment compared with test criteria

A7.4.2 Underlay penetration (both roof integrated and above roof solar systems)

Product specification (underlay seal):

Manufacturer of product used

Model

Supplied by (company/person)

Underlay used in the test (manufacturer/product name)

Test result

A7.4.3 Above roof systems

If the whole system is tested then report in accordance with the roof integrated system.

If only the outer roof penetrations are tested then report as follows:

Gapping information

Roof covering elements (without solar system):

Maximum unprotected gapping (mm to an accuracy of ±1.0mm)

Solar system (roof covering elements with outer roof penetrations fitted):

Maximum unprotected gapping (mm to an accuracy of ±1.0mm)

Test carried out

Test result

Performance assessment compared with criteria

A8. REFERENCES

- BS EN 14437: 2004 Determination of the uplift resistance of installed concrete or clay tiles for roofing-roofing system test method
- BS 5534:2014+A1:2015 Slating and tiling for pitched roofs and vertical cladding – Code of practice
- BS 476-3: 2004 Fire tests on building materials and structures — Classification and method of test for external fire exposure to roofs
- BS EN 13501-1: 2007 Fire classification of construction products and building elements — Classification using test data from reaction to fire tests
- BS EN 13501-5: 2005 Fire classification of construction products and building elements — Classification using data from external fire exposure to roofs tests
- PD CEN/TR 15601:2012 Hygrothermal performance of buildings — Resistance to wind-driven rain of roof coverings with discontinuously laid small elements — Test Method
- BS EN 490: 2011 Concrete roofing tiles and fittings for roof covering and wall cladding — Product specifications
- BS EN 491: 2011 Concrete roofing tiles and fittings for roof covering and wall cladding — Test methods
- DD CEN TS15087: 2005 Determination of the uplift resistance of installed clay and concrete interlocking tiles for roofing — Test method for mechanical fasteners
- EN 12975-2: 2006 Thermal solar systems and components — Solar collectors — Test methods
- DD ENV 1187: 2002 Test methods for external fire exposure of roofs
- BS 6399-2: 1997 Loading for buildings. Code of practice for wind loads
- EN 1991-1-4: 2005 Eurocode 1. Actions on Structures. General actions. Wind loads.
- BRE Digest 489 Wind loads on roof-based photovoltaic systems

Appendix 1

Test arrangement for carrying out tests to BS EN 14437: 2004

Figure A1.2 Typical PV System undergoing a wind uplift test according to the principles of BS EN 14437 : 2004

Appendix 2

Annexes A and C of BS 476 -3 : 2004

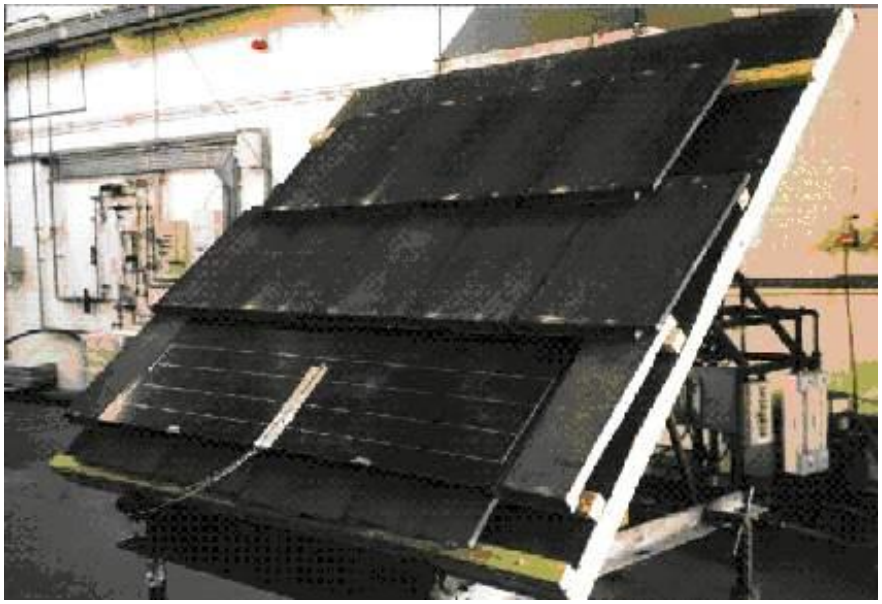

Figure: A2.1 A typical PV system ready for testing to BS 476-3 2004.

Appendix 3

Test procedure for wind driven rain performance based upon PD CEN/TR 15601:2012

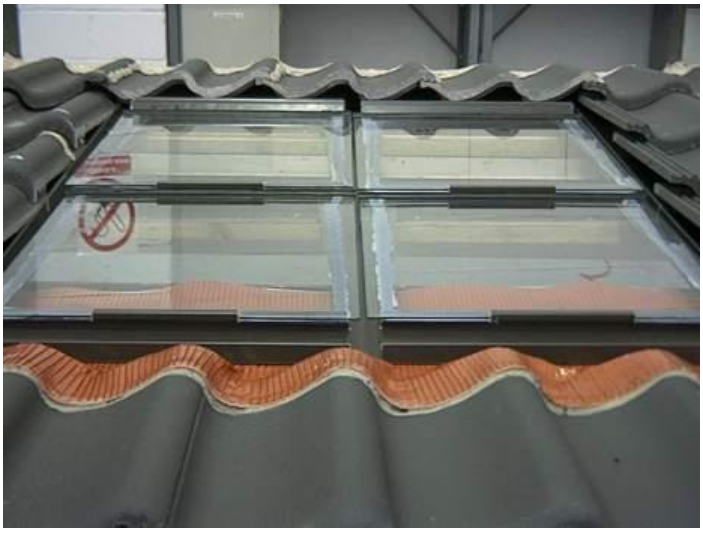

Figure A3.1 A PV system laid ready for wind driven rain tests

1.1 Rain and Wind Driven Rain Effects

A solar energy specimen is fitted into the wind-driven rain apparatus, the external surface of the 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 sides of the test specimen is increased or decreased in specific steps. Water leakage through the test specimen which may occur at certain air pressure differences is observed and measured.

1.1.1 Test specimens

Samples for the test specimen shall comply with the product specifications and be representative of normal production.

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.

1.1.2 Preparation of the test specimen

Construct the test specimen according to the manufacturer/supplier's specification representative of its intended use (such as roof pitch, fixing systems, etc). 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 to influence the test results. The surround shall be prepared and installed so that any water penetration through the test specimen is readily detectable.

1.1.3 Apparatus

The test apparatus shall consist of:

- a pressure chamber sealed to the underside of the test specimen and connected to a pressure generator, as specified in 1.1.4 below;
- a fan system to create wind on the outside of the test specimen, as specified in 1.1.5 below;
- a facility for generating rain, as specified in 1.1.6 below;
- provisions for creating run-off water as specified in 1.1.7 below; and
- a facility for observation and measurement of leakage as specified in 1.1.8 below.

NOTE. Apparatus of different design may produce different wind driven rain test results, but can produce consistent comparisons of performance between different roof covering products.

1.1.4 Pressure chamber

The pressure generator connected to the pressure chamber shall be capable of creating a stable negative or positive pressure difference, maintained for five minutes ±10seconds (s), across the test specimen. The pressure difference shall be measured to a maximum inaccuracy of 1% or 2.5Pa, whichever is greater. The volume of the pressure chamber shall be sufficient to ensure uniform pressure

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

1.1.5 Fan system

The fan system shall be capable of generating wind directed parallel to the longitudinal axis of the test specimen. The wind flow may be horizontal or parallel to the surface of the test specimen. The spatial variation of the wind speed shall be not more than 10% over the test specimen. Calibrate the fan system for spatial variation of the wind speed, by taking measurements at not less than 9 positions uniformly distributed at a height of 200 + 10 mm over a flat boarded area which replaces the test specimen, at the relevant roof pitch. The calibration wind speed shall be 10 + 0.5 metre per second (m/s) at the centre of the test specimen.

The wind speed (V_i) shall be measured to a maximum inaccuracy of 0.5 m/s.

The turbulence intensity (t) in the oncoming wind shall be less than 10 %.

NOTE: The turbulence intensity t (%) is expressed as t = 100u/U, where u and U are the RMS and mean wind speeds respectively, measured over a duration of not less than 5 minutes for this purpose.

RMS (root mean square) wind speed $u = \sqrt{\frac{\sum_{i=1}^{n}(V_i^2 - U)}{n-1}}$

Mean wind speed $U = \frac{\sum_{i=1}^{n} V_i}{n}$

Where V_i is the individual wind speed;

n is the number of measurements

1.1.6 Rain generating facility

The facility shall be capable of supplying a stable rain rate. The spatial variation shall be not more than ±35% over the area of the test specimen during a time period of 5 min±10s. During the same time period of 5min ±10s the rainfall rate shall vary by not more than ±2%. The rain droplet size shall be representative of natural rain, predominantly in the range of 0.6mm to 2.5mm diameter.

The variation of rainfall over the specimen can be measured using rain collectors with an area of 0.10 square metre (m^2) to 0.20 m^2 in area and arranged so that they do not collect any run-off water during calibration. To calibrate the rain falling directly on the test specimen, replace the test specimen with a flat board which incorporates the rain collectors in its upper surface. The calibration should be carried out for each wind-rain combination used. The rain shall be measured to a maximum inaccuracy of 3% or 0.2 mm/h, whichever is larger.

NOTE 1. Water droplets introduced into a high velocity air stream tend to break up over distance. Accordingly it is recommended that the droplets are introduced far enough above the test specimen for this process to be completed and for the droplets to achieve the required velocity prior to impact with the test specimen.

NOTE 2: A variation of ±35% in wind driven rain distribution when combined with run-off water (see 8.3.3.4) results in a combined variation of not more than 10%.

1.1.7 Run-off water

Run-off water shall be evenly distributed across the top of the test specimen. The run-off rate shall not vary by more than 10% over the width of the test specimen. The quantity of run-off water shall be measured to a maximum inaccuracy of 3%.

The run-off rate R_{ro} shall be calculated by the formula:

$$R_{ro} = R_{test}\, W\, L / 60$$

where:

R_{ro} is the run-off rate, in litres per minute (l/m);

R_{test} 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.

1.1.8 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 minimise 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 15° from the horizontal towards the lower collecting apparatus during testing.

1.2 Test Procedure

Carry out the test in an environment with a temperature of between 5 degrees Celsius (°C) to 35°C with the test specimen installed in the apparatus at the specified roof pitch. Seal the edges of the test specimen as appropriate to prevent leakage of water or air into or out of the pressure chamber. The test specimen shall be surface dry before each test.

Select and continuously apply the relevant wind speed, rain-fall rate, and amount of run-off water for each wind-rain combination as specified in Table 6.1

Table 6.1 Wind-rain conditions for Northern Europe Coastal climate zone

Climate zone	Wind-rain combination	Test conditions +	
		Approach Wind speed Vr (m/s)	Rainfall on horizontal Rh (mm/h)
Northern Europe Coastal	A	5	110
	B	13	60
	C	25	6
	D	0	225

+ Note: See PD CEN/TR 15601:2012 for the methodology to determine the wind and rain over the roof surface, as a function of roof pitch.

In summary these combinations are:

Combination A: Low wind speed with severe rainfall rate
Combination B: High wind speed with high rainfall rate
Combination C: Severe wind speed with low rainfall rate
Combination D: Maximum rainfall rate with no wind (deluge)

In the wind-rain combinations A, B and C, measure initially the pressure difference with the pressure box closed and adopt this pressure difference as the reference zero for subsequent pressure changes during the test. Then reduce the pressure in the box in steps of not less than 5 Pa and maintain each pressure step for 5 minutes + 10 seconds, until leakage is observed. Measure the amount of leakage water at each pressure step, or continuously, up to the reference leakage rate.

In the deluge test, Combination D, apply the rainfall and run-off without wind and with the pressure box open to the atmosphere, for 2 minutes + 10 seconds. Observe any leakage and measure the amount of leakage water.

NOTE 1: The sub-test may be continued at greater pressure differences to observe more leakage.

NOTE 2: Fine spray may leak through the joints in certain types of solar energy specimens. Its occurrence should be recorded. Such fine spray may or may not be regarded as leakage depending on the leakage criterion adopted.

Appendix 4

An example of an underlay sealing ring in test for water-tightness

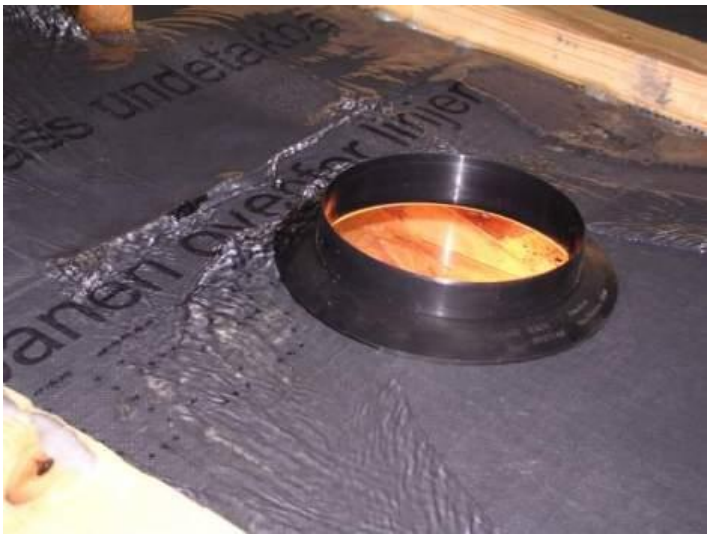

Figure: A4.1 An underlay sealing ring in test and subject to a very large volume of water.

(This product is designed to seal around a rigid pipe and when used with a smaller flexible pipe a durable flashing material is used to make the seal between the lip of the sealing ring and the flexible pipe.)

Informative Annexes

Annex 1

Resistance to Wind Uplift

2. System Requirements

2.1 System requirement Design Loads

The method of mechanical fixing of the collectors to the roof, and the fixing components, must be adequate to resist the design loads derived from the relevant parts of BS 6399 or EN 1991-1. These design loads relate to dead and imposed loads, wind loads and other environmental loads such as snow loads. The fixings shall be capable of resisting these loads, preferably without maintenance for their full service lifetime.
The test method described is intended to assess the adequacy of the fixings against wind uplift loads only.

2.2 Design wind speed

The design wind speed (and wind dynamic pressure) is used to calculate the design wind load and may either be:

a) determined using BS 6399-2 : 1997 or EN 1991-1-4 : 2005 for a particular site in question;

Or;

b) taken as a sensible upper estimate which will cover all buildings up to three storeys in height anywhere in the UK, provided that topographical features (eg; hills and valleys) are not significant. *A 1 second gust wind speed with an annual probability of 0.02 and equal to 58 ms^{-1} is suggested.*

Where topographical features are significant the design wind speed must be checked using BS 6399-2 : 1997 or EN 1991-1-4 : 2005.

2.3 Design wind loads

BRE Digest 489 “Wind loads on roof-based photovoltaic systems” also provides additional guidance on deriving the wind loads on the solar panels and their fixings.

The design wind load shall then be derived as follows:

I. For roof integrated designs;
II. For air permeable roof integrated systems, which replace roof tiles, BS 5534: 2014+A1:2015[1] may be used to derive the design wind loads acting on the collectors and fixings. BS 5534: 2014+A1:2015 takes account of the reduction in the wind loads due to the air permeability of the installed panels and surrounding roof tiles. BS 5534: 2014+A1:2015 also presents the principles and a test methodology for measuring the level of air permeability;
III. For non air permeable systems use BS 6399-2: 1997 or BS EN 1991-1-4: 2005 to derive the design wind loads;
IV. For on-roof systems, the wind loads shall be assessed using BS 6399-2: 1997 or EN 1991-1-4: 2005.

Additional guidance is given in BRE Digest 489.

2.4 Other requirements not tested

In addition the collector fixings have to:

- possess sufficient shear strength to resist gravitational sliding of the panel due to its weight and imposed snow loads;
- withstand other effects such as fatigue loading due to variation in the wind forces and differential thermal movements;
- resist abrasion against roof tiles and other nearby materials;
- be resistant to corrosion due to rain and accumulated debris.

These properties are not tested in the test method proposed.

AMENDMENTS ISSUED SINCE PUBLICATION

Document Number:	Amendment Details:	Date:
Issue 1.0	First Issue	16/03/2012
Issue 1.1	Update to date of implementation from 16/09/2012 to 31/03/2014	21/06/2013
Issue 1.2	Scope and definitions clarified	16/12/2013
Issue 2.0	A5.1.1 Alternative Methods for fire testing	02/11/2015
Issue 2.1	Updated implementation timeline in FOREWARD	05/04//2016
Issue 2.2	Updated references, Minor clarifications to A2 Scope, A4.2.1 Method, A5.1.1, A7.2.	10/01/2018
Issue 2.3	Update Clause 5.4 and Clause 5.6	18/09/2018