Blowing in the wind?

Revised July 2014

How to ensure you are complying with regulations for resistance to wind loads on solar panels.

While it has always been the responsibility of the solar installation company (under building regulations) to ensure that the panels that they install won't blow off the roof, the new Microgeneration Certification Scheme (MCS) standards for PV and thermal solar are making this more explicit than ever. In this briefing we examine what the installer needs to do to make sure that the products they install are adequate for the location and how to demonstrate compliance with the standards.

Calculating the Design Wind Load

The peak velocity wind pressure on a given roof is dependent upon:

- The location in the UK, with wind speeds generally increasing as you head north
- The site altitude above sea level and the building height
- The distance from the sea
- Shelter from other buildings (urban or rural location)
- Topographic features (wind speeds increase as they rise up a hill)

Eurocode 1 (BS EN 1991) is the approved means of calculating the peak velocity pressure.

The peak velocity pressure is multiplied by an appropriate pressure coefficient, taking into account the following features of the installation. For pitched roof:

- The shape of the roof (mono pitch, duo pitch, hipped)
- The roof pitch angle
- The location of the panel on the roof (the roof is divided into zones with different pressures in each)
- Whether the panels are fitted above the roof, integrated with the roof, or fixed as a tile

For flat roof:

- Whether the panels are located in the edge zone, corner zone or central zone of the roof
- Whether there is a parapet around the roof

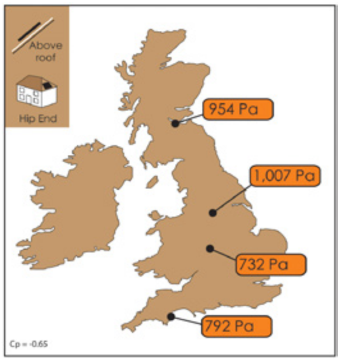
The MCS PV guide provides a simplified version of this calculation, together with pressure coefficients to use. Once the pressure is calculated it is multiplied by a Load Safety Factor (SF_L) of 1.35 to arrive at a Design Load.

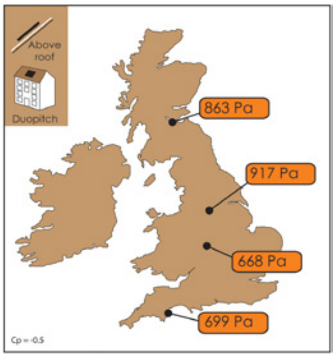
Viridian Solar has reduced this process into easy to use spreadsheets for solar installers (one for pitched roofs and one for flat roofs). A few examples serve to highlight the range of wind uplift design loads that a pitched roof solar installation in the UK might encounter.

Example Locations				
	Edinburgh	Sheffield	Birmingham	Torquay
Basic Wind Speed	25	23	<22	24
Altitude	66m	232m	147m	30
Distance from Sea	2-20km	>20km	>20km	<2km
Location type	Urban	Urban	Urban	Urban

Typical Design Loads

For panels installed above the weather-tight layer of the roof, above-roof panels (including in-roof systems where the panels are installed above a continuous back tray):





Above Roof Panel Installation Design Loads (Wind Uplift)

The pressure coefficient is taken from BRE Digest 489 (above roof systems with a gap of less than 300mm). For installations that are away from the edge zone of the roof the pressure coefficient is -0.5. For the hip end the panels are installed in the edge zone and a pressure coefficient of -0.65 is used.

A Load Safety Factor of 1.35 has been applied to the peak wind load.

For panels installed as part of the weather-tight layer of the roof, in-roof panels:

...continues

In-Roof Panel Installation Design Loads (wind uplift)

The pressure coefficient is taken from Eurocode 1, with the roof pitch set to thirty degrees. For duo pitch roof installations that are away from the edge zone of the roof the pressure coefficient is -0.6. For the hip end the panels are installed in the edge zone and a pressure coefficient of -1.3 is used.

A Load Safety Factor of 1.35 has been applied to the peak wind load.

As can be seen from the diagrams, you don't have to go searching around for extreme examples to achieve rather high design loads.

Assessing the Product for the Location

Once you have the design load for the installation, all the installer has to do is select or design a system of sufficient strength to resist the loads.

Unfortunately, this is where the difficulties can really start.

Material Safety Factor

Product manufacturers should assess the failure load of their product under wind pressure.

The failure load is reduced by a Material Safety Factor (SF_M) which depends on how the panel failed in the tests.

Failures in metal components are more predictable so a lower safety factor of 1.10 is used. Failure in timber components (for example a screw pulling out of a rafter) is more variable as wood is a natural material. Products with a failure load from a failure in a timber component are subject to a higher Material Safety Factor of 1.44.

Material Safety Factor	
Serviceability limit state (e.g. excessive displacement or breakage of roof covering materials)	1.0
Failure in a metal component	1.1
Pull-out from a metal component	1.25
Failure in a timber component, or pull out from a timber component (e.g. roof structure)	1.44
Failure mode unknown or not declared	1.44

The manufacturer should declare either the failure load and appropriate material safety factor or the Ultimate Design Load (which takes into account the material safety factor).

The timber roof members the solar panels are to be attached to also play a prominent role in the resistance to wind suction. If a product's wind resistance was assessed using larger section timber then that product's performance values would not apply when the product is fixed to more slender rafters or battens. Installers need to be especially vigilant on this point, as many solar products have been developed in European countries that use much heavier grade tile battens than the UK.

The manufacturer should also state the minimum dimensions for the timber in the roof structure to which it is attached.

Without this information it is not possible for a solar installer to demonstrate that they have selected a product of sufficient wind resistance.

Unfortunately, many manufacturers do not provide installers with adequate information. For example simply publishing a maximum wind speed is not helpful - is this for installation at absolutely *any* altitude, building height or roof shape?

In Practice

Solar Thermal Panels

Most solar thermal panels are sold as a complete kit including fixings and the kit is tested to EN 12975. This standard does not require that the panel is tested to failure, only to a minimum pressure load of 1,000 Pa. Many manufacturers test only to this level, allowing them to declare a 'pass' and achieve Solar Keymark or MCS panel certification. The panel might have gone on to 3,000 Pa or it might have pulled off the roof at 1,001 Pa.

For products tested to 1,000Pa, the only defensible approach is to use a failure load of 1,000Pa and, since the failure mode is unknown, a worst-case material safety factor of 1.44. In practice, this limits the safe use of such products to situations where the design load is less than 675Pa (1,000/1.44)

Note also that simply increasing the number of fixings to up-rate a solar panel system (without testing) is not permissible because the failure could occur elsewhere, for example between the glazing and the frame.

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Solar Photovoltaic Panels

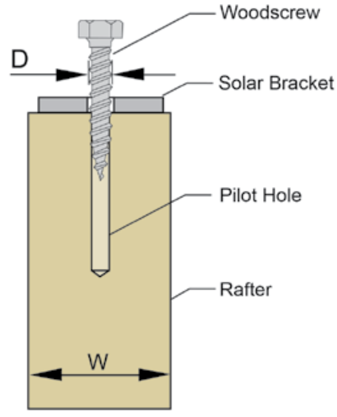
Solar photovoltaic panels are tested in to EN 61215, which normally tests the panels in isolation (without roof hooks). This standard has a similar pass/fail approach to wind loading, this time at 2,400 Pa. If the failure mode is not declared, then (since the test does not take into account the timber fixings), the worst case Material Safety Factor would be 1.25.

For a panel tested to 2,400 Pa without failure, then the safe use limit would be 1,920 Pa (2,400 / 1.25).

The solar installer needs to also consider the safe use limit of the roof fixings and racking, and specify the size and number of each accordingly.

Fixing Brackets

Many roof-fixing brackets have not been tested to ascertain a failure load, instead the failure load has been calculated based on known pull-out forces for wood screws (for example using BS EN 1995-1 or similar).



W > 12 x D

This calculated resistance is only valid where the timber width to which the screw is fixed is greater than or equal to 12 screw diameters. Where rafters are thinner than 12 screw diameters it is necessary to fix noggins to accept the roof hook fixings.

For a bracket based on a calculated screw resistance this limits the screw size to 2.9mm for a 35mm rafter and 4.1mm for a 50mm rafter.

In Roof Systems

There are three generic types of in-roof fixing systems, and each should be treated differently for wind loading calculations.

(a) Tile Format Solar Panels

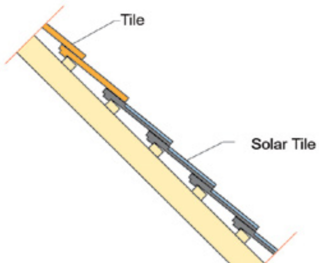
Tile format panels fix to battens like regular roofing tiles and can be considered to lift and vent pressure differences. The pressure coefficient for determining the Design Load should be taken from BS 5534

(b) Integrated Panels

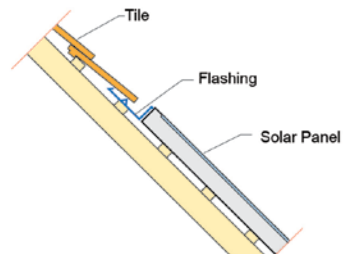
Here the panel itself forms the weather-proof layer, sitting directly on the roofing battens. Pressure coefficients should be taken from Eurocode 1.

(c) Integrated Back-tray

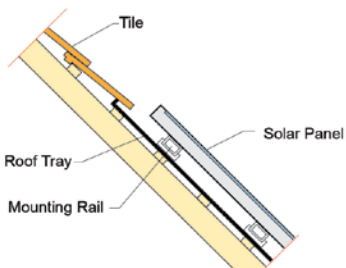
In this format, a plastic or metal sheet is fixed to the roofing battens. A series of mounting blocks are fixed through the sheet to the tile battens and the solar panels mount either directly or indirectly to the blocks. The solar panels should be treated as above-roof for wind loading purposes with pressure coefficients taken from BRE digest 489.



Air Permeable PV Tile



Integrated, nominally airtight



Integrated Backtray

Installers must be especially vigilant where roof integrated systems fix directly to the tile battens. 35mm x 35mm is a common size for tile battens in other European countries, but in the UK the most common thickness is only 25mm.

Wind loading performance values based on batten dimensions greater than those on the roof are not valid and cannot be used. Importers cannot always be relied upon to understand the importance of this distinction and there are a number of products currently being offered to solar installers that specify a batten thickness greater than 25mm. The necessity to add battens of a greater thickness to a standard UK roof is not spelt out to the installer, who would be forgiven for assuming that a product on sale in the UK is suitable for use with common UK building practice.

Clearline in-roof solar panels from Viridian Solar have been tested by the British Board of Agrement for external spread of flame, weatherproofing and wind resistance. All wind resistance tests were performed on UK standard roof build ups (35mm rafter width and 25mm batten thickness). See the product datasheets for more information.

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