INTRODUCTION
This technical bulletin offers guidance on best practice for roof workers installing solar components to traditional pitched roofs, industrial sheet roofs, and flat roofs. The main purpose of the document is to help installers to ensure that when installing solar components into or onto roofs, the finished roof is ‘no worse’ with regards to waterproofing, structural integrity and fire. The document also offers guidance on how to carry out installations in a professional and safe manner and to consider carefully, the options available when installing solar into existing and new roof constructions.

1. PRE-INSTALLATION CONSIDERATIONS

CONDITION OF ROOF BEFORE INSTALLING
Existing roofs should have an expected useful life span of no less than the solar installation. This applies not only to the waterproofing layer, but to all the materials in the build up of the roof. As such any repairs or re-roofing should take place before the solar installation to avoid additional cost and disruption when the roofing works become due.

Consideration must also be given to the ability of an existing roof covering to withstand the work involved in installing the solar system; for example, some old bituminous membranes can become brittle and will tend to tear easily when handled. Similarly, old roof tiles or slates may break very easily and so they must be properly protected to avoid damage when accessing over the roof covering. The installer should ensure that when making good a roof, where re-covering is not required, that they are able to source the necessary materials before commencing work.

WEIGHT, WIND, AND OTHER LOADS
The weight of the panel, including the wind loads should be taken into account when designing a system and checking if the structure is suitable (age of roof, condition, bearing sizes etc). This should be covered at the design and survey stage, especially if some structural work is required.

It should be noted that some traditional ‘cut’ roofs; i.e. those consisting of the standard arrangement of rafters, purlins and ridge trees etc, can be already at or near load capacity already.

NOTE
- Under Part A of the Building Regulations (Structural Stability), if the weight increase is significant (i.e. over 15%) then a structural survey is required to determine whether or not strengthening work is required. Any structural strengthening works must be inspected and approved by a suitably qualified structural engineer or surveyor before the installation can continue. Integrated solar systems; i.e. those which form part of the roof covering, should be considered to avoid adding additional weight to the roof.

Wind loading should be carefully calculated in accordance with BS EN 1991-1-4:2005 to ensure the solar installation will be able to maintain the expected loads placed upon it and to ensure the loads are not transferred to the roof covering.

Some manufacturers may be able to provide a calculation service for wind loading or have information already available as a result of testing. Guidance on calculating wind loads on solar panels is also given in BRE Digest 489 and Annex A of the NHBC Foundation document entitled ‘guide to installation of renewable energy systems on roofs of residential buildings’.

Installers working at height should also be aware of the increased risks when handling solar equipment, particularly in windy conditions (see Health and Safety Guidance (HSG33), and NFRC publications ‘Roofing and Cladding in Windy Conditions’ and ‘Guidance Sheet P – Handling Solar Collectors and other large items on the Roof’).

Where solar panels are fitted to pitched roofs, they generally align with the pitch of the roof and as such the overall wind load on the roof is not increased. However, ‘on-roof’ solar systems may cause localised uplift forces and so the surrounding tiles or slates must be suitably fixed. Also, the uplift force on the panels will be concentrated at the fixing points; i.e. the brackets, so it is
important that the brackets are securely fixed to the roof structure; i.e. to the rafters, not to the tile battens or counter battens. If necessary, the rafters and rafter fixings should be strengthened.

Where solar panels are fitted to a flat roof they will be usually be elevated at an angle to the roof. The wind loading should be considered from all directions to ensure the fixings or ballast used is sufficient to withstand the uplift force.

**PLANNING ISSUES**

In normal circumstances, solar panels are considered to be ‘permitted development’ under planning law so in most cases there is no need to apply for planning permission. With regards to pitched roofs, the panels are not allowed to extend above the ridge line or above the roof surface by more than 200mm. Exceptions exist where the building is listed, or in a World Heritage site or Conservation Area. In these cases, and particularly if the panels are to be mounted on an elevation visible from the highway, then Planning Consent will be required. Ideally in these cases the panels should be mounted on an outbuilding or elevation not visible from the highway.

Also, Local Planning rules require that any development should be in keeping with the amenity of the surrounding area, so consideration should always be given to the location of roof-mounted solar systems. It is worth checking with the Local Authority before the installation as certain conditions may be imposed.

**2. GENERAL GUIDANCE**

**WARRANTIES – ROOF COVERING**

For new roofs, the coverings should normally carry a warranty equal to or greater than the estimated payback period of the solar installation. Where possible, the approximate age of existing roofs should be established and the manufacturer of the main coverings contacted to check on the details covering the any relevant warranties. Where no warranty remains, it is for the installer to provide the appropriate level of warranty on all roofing works based on the condition of the roof during the initial survey. In all cases, the appropriate way of dealing with gaps, small cuts, penetrations etc. should make the roof no worse for fire, water ingress and structural integrity to ensure that the warranty is not negatively affected by the solar installation.

**WARRANTIES – SOLAR INSTALLATION**

Solar installation systems may be provided to include everything in one package including any fixings, flashings and the solar panels, or they may be made up of components from different companies (e.g. rails and brackets from one company, flashings from another and panels separately). The installer must ensure that all products are compatible with each other and the roof to which they are being installed. Whilst it is important to ensure that manufacturers’ instructions are followed, it is equally important to check that any possible conflicts between manufacturers’ instructions are resolved before commencing work.

Generally, manufacturers will not offer a performance guarantee relating to the junctions between the roof coverings and the solar system where the solar system is supplied by a third party, therefore it is important to obtain a suitable performance guarantee from the solar system manufacturer or supplier.

**COMPATIBILITY ISSUES BETWEEN ROOF COVERINGS AND SOLAR SYSTEMS**

Solar installations developed outside the UK may not necessarily be suitable for the typical roof structures found on existing or new buildings. For example, in some countries the rafters on pitched roofs are much wider and this may mean that the fixings were designed to take that into account. Also, some flashings and components may not be compatible with UK roof coverings, or not offer the appropriate range of flashings and components for all of the types of roof coverings that they may be installed with. In particular, it is important to ensure in-roof systems have suitable flashings (where required) for both single lap and double lap products.

**IMPORTANCE OF INSTALLING SOLAR AND ROOFING WORKS IN ONE OPERATION**

Where possible, solar installations should be carried out whilst new roofs are installed or during re-roofing to avoid secondary damage and issues regarding who is responsible for any subsequent defects in the roof. Installations done in ‘one operation’ may offer the added benefit of reduced cost and increased safety due to the availability of full scaffolds and in some cases lifting equipment. Where solar installations to a new roof or recent re-roof are to be retro-fitted by someone other than the original roofing contractor, the roof should be checked and signed off as complete before the solar installation takes place. On existing roofs where the roof is no longer in warranty, the installation should always be done by a person fully competent in that particular discipline of roof work to ensure that the roof is left in the appropriate condition following any installation.

**IMPORTANCE OF ROOFING COMPETENCE IN RETRO-FITTING**

On existing roofs the installation should always be done by a person fully competent in that particular discipline of roof work to ensure
that the roof is left in the appropriate condition following any installation and the work is carried out safely in line with Health and Safety Guidance Note 33 – Health and Safety in Roof work (HSG33). The retro-fitting installer must also accept responsibility for the area of the roof accessed, including any remedial works, during the installation works as well as the installation itself.

MAINTENANCE – OF THE ROOF
Consideration should be given when designing the solar installation, to the possible maintenance of areas of the roof most likely to be affected by adverse weather or blockages (e.g. outlets, valleys, abutments, verges, ridge, chimneys, openings, vents etc). Solar panels should not cover or inhibit the intake of mechanical or passive ventilation products.

MAINTENANCE – OF THE SYSTEM
Consideration should be given when designing the solar installation, to the possible cleaning, checking and/or maintenance required during the systems useful life. Where appropriate, a maintenance plan should form part of the original installers offer to avoid secondary damage caused by others accessing the roof. Special consideration should be given for access for changing the solar sensor in a solar thermal collector as this could be a fairly common requirement over the lifetime of this component.

3. SLATE AND TILE ROOFS

REDUCTION OF GAPS IN SLATE AND TILE ROOFS
Most brackets used for bolt-on systems onto pitched roofs are around 5mm thick and as such will lift the tiles or slates by the same amount unless addressed. Such gaps can increase the risk of driving rain ingress; wind uplift and can appear visually incorrect compared with the rest of the roof. As such, gaps must be reduced to the levels no greater than would normally occur in the product when fixed in conventional roofing works, to ensure the warranties of the roofing materials remain intact. For roof tiles with thick leading edges it may be possible to neatly remove a notch in the underside of a roof tile which matches the thickness and width of the bracket, thereby allowing the tile to sit properly without gaps. Tiles and slates with thinner leading edges will normally need to be cut around the bracket and the area sealed with a suitable flashing detail. Similarly, double-lap tiles will need sealing with a suitable flashing.

When fixing roof tiles to the sides of roof windows, onto valley liners and some other details, it is often necessary to carefully remove one of the tile nibs to ensure the tile lays flat. Providing at least one nib remains, there is no damage to the tile, and the tile is securely fixed then this should normally conform to the manufacturers of the roof tiles and solar panel system respectively.

DEALING WITH SMALL CUTS NEXT TO SOME IN-ROOF SYSTEMS TO PITCHED ROOFS
Where available, wide fittings of slates and tiles should be used to avoid small cuts to the sides of in-roof systems which may become dislodged over time. It is important for installers to seek advice from individual manufacturers with regards to the problem of fixing small cuts.

Alternatively, if the edge tiles need to be cut and this results in the removal of the nail hole, then another hole should be drilled, carefully avoiding the solar system flashings, to accept a nail or preferably a screw fixing.

RISKS ASSOCIATED WITH DRILLING THOUGH DOUBLE-LAP SLATES
Some manufacturers’ instructions may state that slates (both natural and man-made) can be drilled through and made watertight with sealants and/or rubber washers but this is not considered a robust detail and is not an acceptable practice in the UK. There is considerable risk involved in causing damage to the slates, membrane, battens and the rafters, much of which may go unseen due to the overlapping nature of double-lap slates.

PITCHED ROOF UNDERLAY – CORRECT METHOD OF SEALING PENETRATIONS
The number of penetrations of the membrane should be minimised wherever possible. Components exist to take pipes, sensor cables etc through the roof covering and should be used wherever possible, in conjunction with collars, tapes and/or conventional methods of sealing penetrations in membranes. In general, any cuts in the membrane should be made neatly with a minimal sized star-shape cut and the sides folded up to face outwards around the penetration. In addition to using tapes around the opening, an additional piece of the membrane may be installed at a slight angle above the penetration, with the lower edge welted to direct water away.

FIXING TO TIMBER RAFTER AND BATTENS
Please refer to NFRC guidance document FIXING SOLAR PANELS TO TIMBERRAFTERS & BATTENS (PITCHED ROOFS) September 2011 – available as a PDF on request from NFRC.
4. FLAT ROOFS

REINFORCED BITUMEN MEMBRANES (RBM)

Flat roofs covered with Reinforced Bitumen Membranes (RBM) may appear to be ideal for the installation of solar panels but there are a number of factors to be taken into consideration first.

The necessary checks must be made to ensure that the deck and structure are adequate to take the additional permanent loading that will be placed on it as well as the temporary load of the installation process.

The possible effects of the solar installation on the membrane must be fully understood that no damage occurs to the waterproofing qualities of the membrane.

The age of the membrane should be established before installing solar panels and an assessment made of when it is likely to need upgrading. In many cases, it will make commercial sense to perform this task before the solar installation takes place to ensure early, disruptive and costly works including reinstatement of the panels, are avoided.

It may also be necessary to upgrade the insulation to meet current legislation. As with upgrading the membrane, this is a task which should be strongly considered before installing solar panels.

Wherever possible, the membrane should not be punctured in any way. Where this is unavoidable, special consideration should be given to the correct sealing of any piercing, penetration or perforation of the membrane. Work should be carried out by a competent roofing contractor with the skills and knowledge to seal penetrations to recognised industry standards.

If the roof is found to be less than ten years old, it may still carry a guarantee which will almost certainly be affected by installing solar panels. It is essential therefore to liaise with the relevant manufacturer and/or installer to establish the terms of any guarantee, and under what conditions it can remain in place following the installation of solar panels. If the guarantee cannot be maintained, the responsibility for the integrity of the roof covering should rest solely with the solar installer.

NOTE:

- The considerations covered above cannot be dealt with after the installation without taking the whole solar installation off again so it is vital that all necessary checks are made before installing any solar panels onto RBM roof coverings.

SINGLE PLY ROOFING

Flat roofs covered with Single Ply Membranes (SPM) may appear to be ideal for the installation of solar panels but there are a number of factors to be taken into consideration first.

The necessary checks must be made to ensure that the deck and structure are adequate to take the additional permanent loading that will be placed on it as well as the temporary load of the installation process. The potential for damage to the underlying insulation from point loading and regular traffic during installation and maintenance should be considered, with temporary load spreading plates and/or permanent walkway and isolating pads used where necessary. This is particularly important if using rigid plastic bases on PVC membranes to avoid plasticizer migration.

The possible effects of the solar installation on the membrane must be fully understood so no damage occurs to the waterproofing qualities of the membrane.

The age of the membrane should be established before installing solar panels and an assessment made of when it is likely to need upgrading. In many cases it will make commercial sense to perform this task before the solar installation takes place to ensure early, disruptive and costly works including reinstatement of the panels, are avoided.

It may also be necessary to upgrade the insulation to meet current legislation. As with upgrading the membrane, this is a task which should be strongly considered before installing solar panels.

Wherever possible, the membrane should not be punctured in any way. Where this is unavoidable, special consideration should be given to the correct sealing of any piercing, penetration or perforation of the membrane. Any support bracketry should transfer the loads back to the deck or structure rather than to the membrane and insulation which could be at risk of localised compression and damage. Work should be carried out by a competent roofing contractor with the skills and knowledge to seal penetrations to recognised industry standards. If a guarantee is in place, this will need to be a contractor licensed for the particular membrane and
using the correct materials and manufacturers’ details.

It is essential therefore to liaise with the relevant manufacturer and/or installer to establish the terms of any guarantee, and under what conditions it can remain in place following the installation of solar panels. If the guarantee cannot be maintained, the responsibility for the integrity of the roof covering should rest solely with the solar installer.

NOTE

- The considerations covered above, cannot be dealt with after the installation without taking the whole solar installation off again so it is vital that all necessary checks are made before installing any solar panels onto SPM roof coverings.

5. SHEETED ROOFS

FIBRE-CEMENT SHEETING

Systems now exist where thin film solar panels can be fastened to new or recently fixed fibre-cement panels via special adhesives to minimise any additional weight gain. In most cases however, the additional weight should be calculated to ensure this does not affect the roof covering, and the over-tightening of bolts and washers should be avoided as this may cause stress and cracks to the roof sheets. In addition, it is recommended that the manufacturers of the sheets are consulted before using any additional penetrating fixings, to ensure they are not likely to restrict the movement of the sheet and therefore lead to cracks. Over-sheeting or re-roofing may be required where the condition of the roof is a concern. Fibre-cement sheeting is a fragile material so all works must be carried out in line with HSG33.

METAL SHEETED ROOFS

Metal sheeted roofs may be suitable, and indeed ideal in many cases, for new and retro-fitted solar panels but great care must be taken with regards to weight, penetrations and the positioning of fixings as well as the fixing/bracket type. There are many types of metal roof systems and therefore, in each individual case. In all cases the risks to the roofs must be fully assessed by a competent roofing contractor with the assistance of the manufacturer of the roof covering (if known) before appropriate systems can be considered.

6. HEALTH AND SAFETY

FIRE

Retro-fitted PV panels fit on top of what is already an ‘AA’ (e.g. no spread, no penetration) fire-rated material are deemed to be low risk for fire. An increased risk of fire may be a possibility where cheap and/or unregulated in-roof PV panels are used as the wiring is inside the roof and therefore close to timber and possibly other flammable materials. All in-roof PV panels to be installed in the UK should be backed up with test results and full fitting instructions to ensure fire safety. All hard wiring and testing should be carried out by a suitably qualified electrician to ensure that no wiring defects, damaged cables etc add to the risk of fire.

With regard to dealing with a fire in a building with solar panels on the roof, the fire service has strategies in place to deal with such an event; for example, the solar array will be treated as live and fire-fighters will keep hose nozzles a set distance away from the panels to avoid electric shock.

FRAGILITY

Care must be taken when installing solar panels on roofs which may be deemed ‘fragile’ and therefore not designed for direct foot traffic. Where the roof is assessed as safe to walk on, then the appropriate edge protection should be put in place. All roof work should be carried out in line with the advice provided in HGS33.

LIFTING/ACCESS – SAFE METHODS OF LIFTING PANELS TO THE ROOF AND INTO POSITION

Mechanical lifting must be used wherever possible in line with current regulations. Several specific pieces of plant and equipment have been developed specifically for solar panels which should be utilised once their suitability has been properly assessed. These include purpose-made bags for raising solar panels to the roof using a gin wheel and special access platforms with in-built mechanical winches.

Normal manual handling procedures should be followed for carrying solar panels and many panels, especially larger ones, will normally require at least two people per lift.

As with most other roofing works, work activities with solar panels should stop when the average wind speed reaches 23mph.
ELECTRICAL HAZARDS
When installing PV solar panels, a number of additional risks arise with regards to electrical currents. The Electricity at Work Regulations which governs all electrical systems and equipment requires precautions to be taken against injury from electricity. Solar PV panels generate Direct Current (DC) and the inverter changes this into Alternating Current (AC). Whilst both can cause serious injury and even death, the type of injury caused by an electrical shock varies depending on the type of current. AC will throw the person away, whilst DC will cause the person to grab hold of the cable and as such is more dangerous.

However, approved PV systems in the UK are all safely designed male/female connectors which are specifically designed to protect the person installing them from accidental electric shock. The practice of connecting the cables in this way is not considered hard wiring so providing the installer is competent they do not have to be a qualified electrician. However, solar panels will generate a direct current whenever light shines on them and an arc may be produced when connections are separated. When breaking a connected string of modules a lethally strong arc can occur. It is recommended that modules are covered with a lightproof cloth during installation. A qualified and competent electrician is required to complete, test and commission the system after the field cables are fed through to the inside of the roof.

TESTING PV WHILST IN PROGRESS
The roofer should ensure that the solar system is working correctly once installed and before roof access is removed. Ideally, the roofer should also make continuous electrical continuity checks as work progresses so that any fault can be easily identified straight away and eliminated. This is a simple matter of testing with an appropriate volt meter after each solar panel is connected. The solar panel supplier should be able to provide training on how to do this.

SOLAR HEATING SYSTEM FLUID
Most solar heating systems are filled with an antifreeze mixture of propylene glycol solution. A typical dilution is 40% glycol and 60% water to prevent freezing fluid damaging the solar panels and connecting pipes in winter. The propylene glycol can degrade at high temperatures, gradually reducing the freeze-protection, so it is a common requirement to replace the solar system fluid from time to time (a five year cycle is common, but will depend on the size of the system relative to the heating load). Consult the supplier for recommended intervals.

Propylene glycol is not considered hazardous, but should not be released into the environment. Dispose of excess or replaced fluid at your local waste disposal centre following local authority requirements.