REPUBLIC OF RWANDA

RWANDA UTILITIES REGULATORY AGENCY

GUIDELINES FOR SOLAR WATER HEATERS INSTALLATION

November, 2012

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PURPOSE OF THIS DOCUMENT

These guidelines aim to help suppliers, installers and building consent authorities to better understand the installation of solar water heater systems. They provide a range of options as possible performance-based solutions and helps readers to design and evaluate specific performance-based solutions.

1. CITATION

These Guidelines may be cited as the Guidelines for Solar Water Heaters Installation, 2012.

2. TERMS AND DEFINITIONS

In these Guidelines, unless the context otherwise requires;

"Active solar water heating system" means a solar water heating system that utilizes a pump to circulate water through a solar collector to a storage tank or to the point of use;

"Building Standards'' any standards or codes of practice endorsed by the Rwanda National Bureau of Standards or their successors and assignees concerning building activities

"Direct solar water-heating system" means a solar water heating system in which water is heated directly in the collector;

"Indirect solar water-heating system" means a solar water heating system in which a heat transfer fluid in the collector transfers heat to the water through a heat exchanger;

"Minister" means the minister for the time being responsible for energy;

"Passive solar water heating system" means a solar water heating system that uses natural convection to circulate water through a solar collector to a storage tank or to the point of use;

"Premises" means existing, new or alterations and extensions to existing residential or commercial buildings or structures, including but not limited to

a) Small domestic houses

b) All other domestic residences or residential houses;

c) Commercial buildings such as Hotels, Lodges, Clubs, Restaurants, Cafeterias, Laundries, eating places and similar premises;

d) Health institutions such as Hospitals, Health Centres and clinics and similar medical facilities;

e) Educational institutions such as universities, colleges, boarding schools and similar institutions;

"Regulatory Authority" means the Rwanda Utilities Regulatory Agency (RURA)

"Renewable energy" means all non-fossil sources including, but not limited to

a) biomass
b) geothermal
c) hydro-power
d) solar
e) wind and
f) sewage treatment;

"**Rwanda Standard**" means the specification or code of practice declared by the National Bureau of Standards

"Solar collectors" include evacuated tube collectors, and glazed and unglazed flat plate collectors;

"Solar water heating system" (SWH) means a device or system that uses sunlight to heat water and comprises of solar collectors, storage tanks, controls , installation hardware and fittings.

3. TECHNICAL GUIDELINES DURING INSTALLATION DESIGN

The following clauses have been discussed in details during the elaboration of these guidelines;

1. Structure
2. Durability
3. External moisture
4. Hazardous substances and processes
5. Electricity
6. Water supplies
7. Energy efficiency

Some of these clauses may not apply for all installations. For example, hazardous substances and processes may not always apply because some solar water heater installations will not involve the use of hazardous materials.

The objectives of each of these designation clauses are summarized in Table 1

	Designation clauses	**Summarized objectives**
1	Structure	Protect people from injury or loss of amenity and protect other property from damage caused by structural failure.
2	Durability	Ensure that throughout a building's life it will satisfy the other objectives of the Building Code
3	External moisture	Protect people from illness or injury caused by external moisture entering the building.
4	Hazardous substances and processes	Protect people from illness or injury and other property from damage caused by exposure to hazardous building materials.
5	Electricity	Protect people from fire and injury caused by electrical installations.
6	Water supplies	Protect people from illness or injury or loss of amenity caused by water systems.

7	Energy efficiency	Facilitate the efficient use of energy (sourced from a network utility operator).

Table 1: Designation clauses and objectives relevant to solar water heaters

3.1. STRUCTURE

a) Background

Following the government will of saving electrical power consumption, Rwanda Utilities Regulatory Agency has developed guidelines describing how solar collectors especially those larger than 4m2 can be installed safely on roofs.

The ability of a building to support a solar collector depends on the system characteristics and the building design. These Guidelines provide information on how solar collectors can be installed on buildings.

b) Principles

The objectives of roof structuring aim to:

1. Protect people from injury as a result of structural failure. For solar water heating this means: protecting against the building or roof collapsing as a result of a solar collector being installed and causing injury to the occupants, and protecting against solar collectors (or parts) blowing from a roof and causing injury.

2. Protect people from loss of amenity as a result of deformation of the structure. For solar water heaters this means protecting against the roof of a building deflecting (beyond reasonable limits) as a consequence of a solar collector being installed. This deformation could have an impact on the weather tightness of the building either by causing gaps in the roof cladding or changing the way water runs off the cladding. If deformations like this caused leaks this could result in loss of amenity or use of the building.

3. Protect other property from damage caused by structural failure. For solar water heaters this means: protecting against solar collectors blowing from a roof and causing damage to another building, and projecting against the collapse of the roof and damaging other property

c) Guidance

Scope and limitations

The scope of these Guidelines is limited to the installation of solar collectors on timber and /or metallic framed roofs, which meet the criteria in Table 2 below and the site and installation conditions listed.

It is important that the roof structure is examined to determine the most appropriate solution for installing a solar collector.

Table 2: *Structural requirements of these guidelines for roofs supporting solar collectors*

<table>
<tr><td colspan="2">Maximum member span (see Figure 1) for a range of rafter or top chord of truss sizes</td><td>Maximum weight per support point</td><td>Maximum weight of solar collector (including fluid) divided by area of supporting roof (see Figure 5)</td></tr>
<tr><td>Rafter or top chord of truss sizes (mm)</td><td>Maximum member span (mm)</td><td rowspan="3">30 kg</td><td rowspan="3">15 kg/m^2</td></tr>
<tr><td>70 x 35
90 x 35
75 x 40
70 x 45</td><td>1200
1400
1400
1400</td></tr>
</table>

75 x 50 90 x 45 100x40 Larger Rafters	1800 1800 1800 2000		
See size and span requirements for various fixing options		50 kg	15 kg/m^2

The member span is the distance between the centres of the supporting members, as shown in Figure 1.

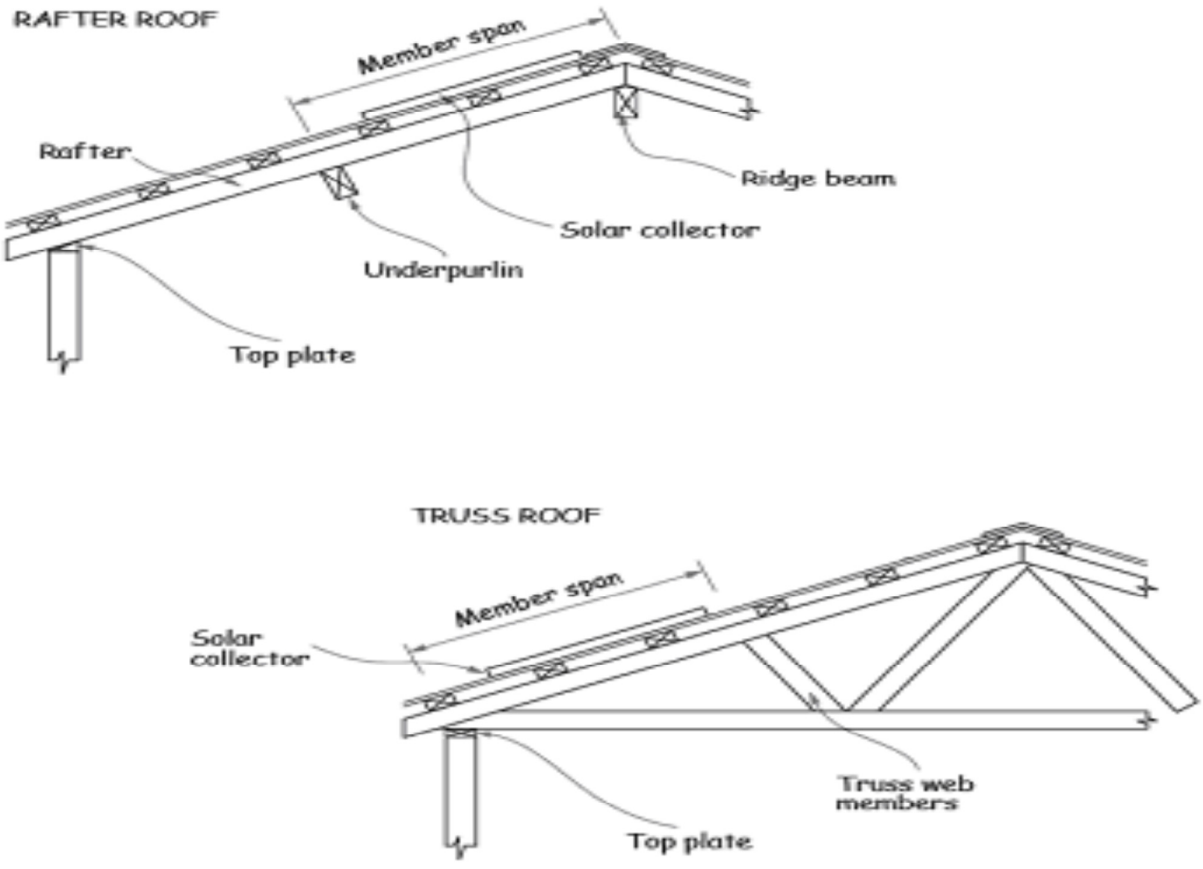

Figure 1: Member spans

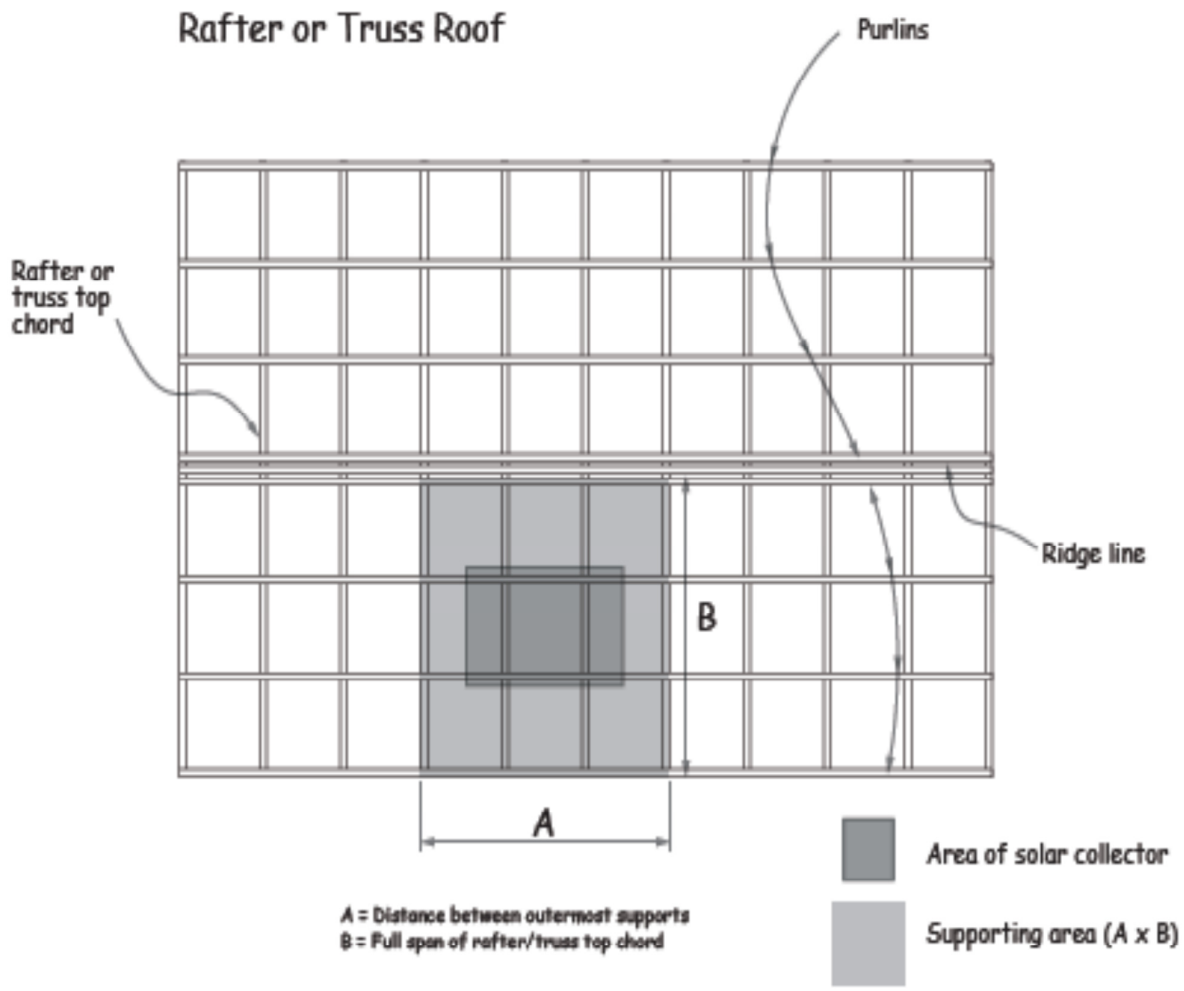

Figure 2 : *Solar collector supporting area*

i. **Note**: The total weight of the solar collector (including fittings and working fluid) divided by the roof area supporting the solar collector should not exceed 15 kg/m^2.

ii. The roof area supporting the solar collector is the full span of the supporting rafters or truss top chords, multiplied by the distance across the roof between the two outermost rafters or truss top chords supporting the solar collector.

iii. The following information is required to demonstrate that this loading requirement is achieved:

- a simple sketch showing: the location and size of the solar collector; the size and spacing of the rafters; and the size and spacing of the purlins, and
- a calculation showing the weight of the solar collector divided by the support area.

d) Site and installation conditions

- The hot water storage tank should not be installed on or above the roof. If the hot water storage tank is installed in the attic space, it should have a maximum size of either: 200 litres for small residential houses or 450 litres for complex buildings
- The roof should have a pitch no steeper than 45°.
- The building should not be in a wind zone where the ultimate limit state design wind speed exceeds 50 m/s
- The design snow loading for the building should be less than 0.5 kPa
- If the solar collector is installed at a different pitch to the pitch of the roof cladding then the solar collector should:
  i. face in the same compass direction as the section of the roof that it is fixed to, and
  ii. be installed at a pitch no steeper than 45°.

e) General requirements

- Solar collectors should have at least four fixing points connecting the solar collector to the building. The outermost fixings should be within 200 mm of the outside edge of the solar collector.
- The solar collector should ideally be positioned centrally on a roof plane. The solar collector should not be located adjacent to eaves, ridge lines or roof edges.
- The roof framing should not be reduced in strength except as a result of drilling for bolts or screws to fix the solar collector to the roof.
- All fixings into timber and /or metal, roof framing should have minimum distances from the centre of the fixing to the edge of the roof framing of:
  - ✓ 20 mm for 8 gauge screws
  - ✓ 25 mm for 14 gauge screws
  - ✓ 40 mm for 10 mm bolts.

f) Options for fixing solar collectors to roofs

There are two decisions that must be made which influence how the solar collector can be fixed to the roof of a house:

1. *Will the solar collector be installed parallel to the roof cladding or will the solar collector be installed at a different pitch from the roof cladding?*

This decision is influenced by the orientation of the roof and the desired trade-off between optimal performance and installation costs. Installations where the solar collectors are parallel to the roof cladding are described in sections **i, ii** and **iii**. Installations where the solar collectors are installed at a different angle from the roof cladding are described in sections **iv** and **v** of these guidelines.

2. *Will the solar collector be installed adjacent to the roof cladding or will it be elevated above the cladding?*

This decision is influenced by the cladding material installed and to some extent the age of the cladding material. Some cladding materials need regular washing and require solar collectors to be elevated above the cladding to allow washing of the cladding material with a brush. Not meeting this requirement may have an impact on the warranty of the roof cladding material.

Installations where the solar collectors are fixed adjacent to the roof cladding are
described in section **i**. of these guidelines. Installations where solar collectors are
elevated above the roof cladding are described in sections **ii**. and **iii**.

i. Direct fixed (adjacent) solar collectors parallel to the roof

- Flat plate solar collectors may be fixed directly to roofs as shown in Figures 3 and 4.
- Evacuated tube solar collectors may be fixed directly to roofs as shown in Figures 5and 6. Note that spacers are often required to separate incompatible materials
- Solar collectors fixed directly to the roof should be fixed into purlins 70 x 45 mm or larger with no fewer than 4, 8 gauge (4 mm) screws.
- Some roof cladding materials need regular washing. If the roof cladding material needs regular washing, the solar collectors may

need to be elevated above the roof cladding. (Installations involving elevated solar collectors are described in sections ii and iii below)

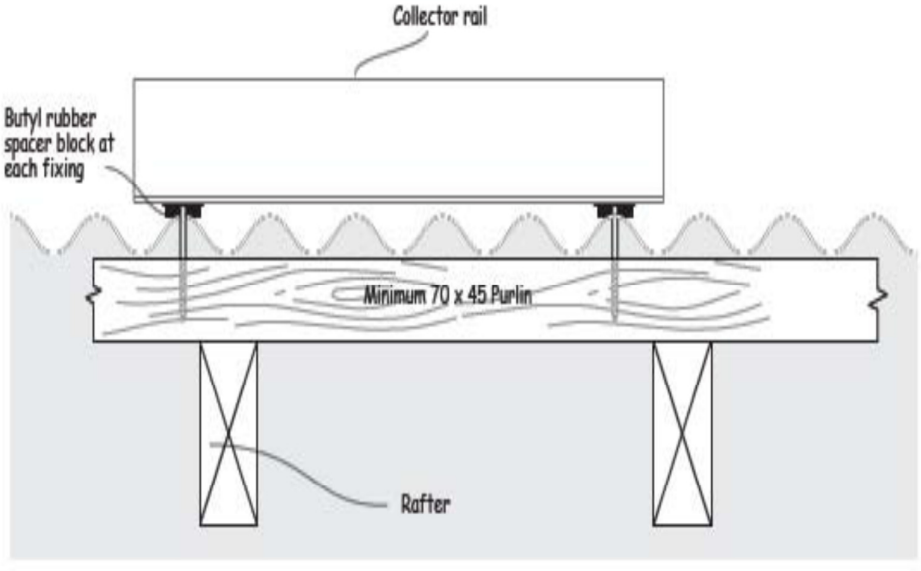

Figure 3 : *Direct fixed flat plate solar collector (section-view)*

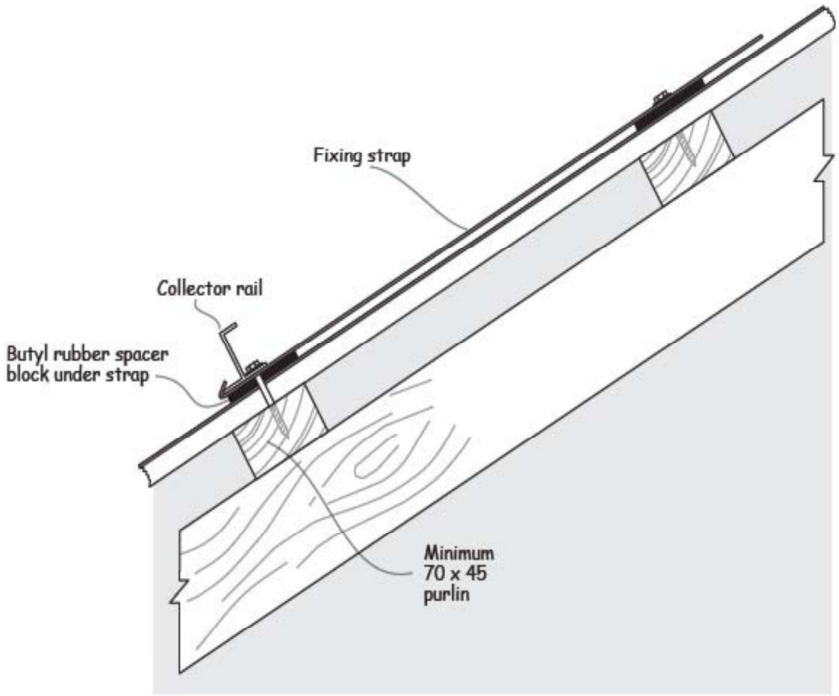

Figure 4 : *Direct fixed flat plate solar collector (elevation view).*

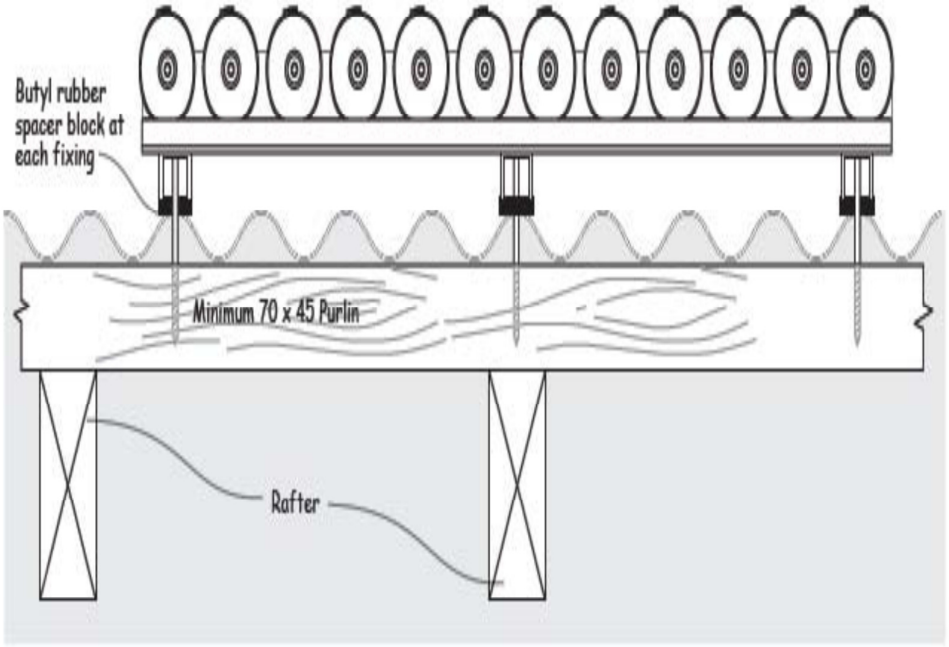

Figure 5: *Direct fixed evacuated tube solar collector (section view)*

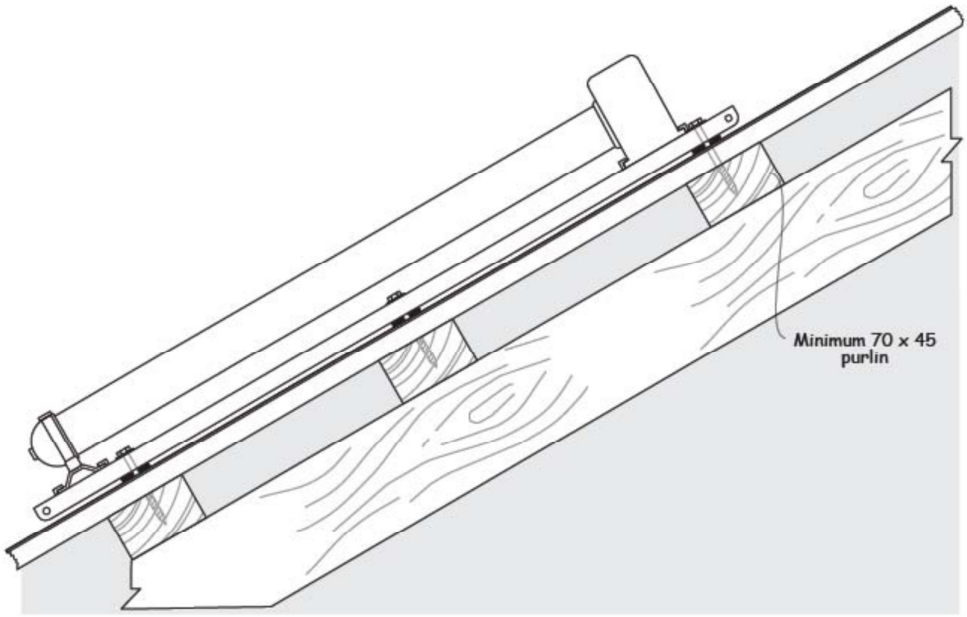

Figure 6: *Direct fixed evacuated tube solar collector (elevation view)*

ii. Elevated solar collector panels parallel to the roof

Solar collector panels mounted parallel to the roof that are elevated up to 50 mm above the roof cladding, may be fixed:

(a) as shown in Figure 7, with 14 gauge screws into:

(i) purlins 70 x 45 mm or larger on their flat, that span no more than 900 mm, or

(ii) rafters or truss top chords 90 x 45 mm or larger, or

(b) as shown in Figure 8, with 10 mm bolts to purlins 90 x 45 mm or larger on their flat spanning no more than 900 mm, or

(c) as shown in Figure 9, with 12 mm bolts welded to 3 mm plate, and screw fixed to rafters or truss top chords 90 x 45 mm or larger, or

(d) to collector support rails as described in section iii. below.

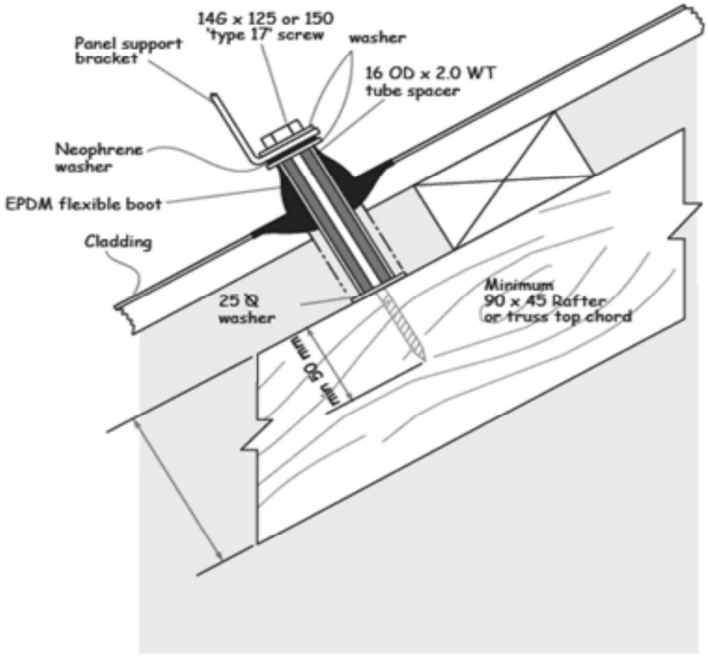

Figure 7: Screw fixing

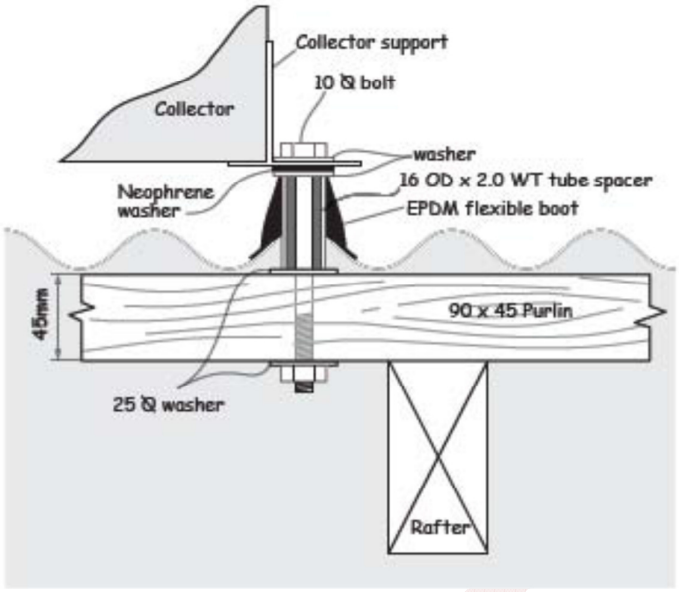

Figure 8: *Bolt fixing*

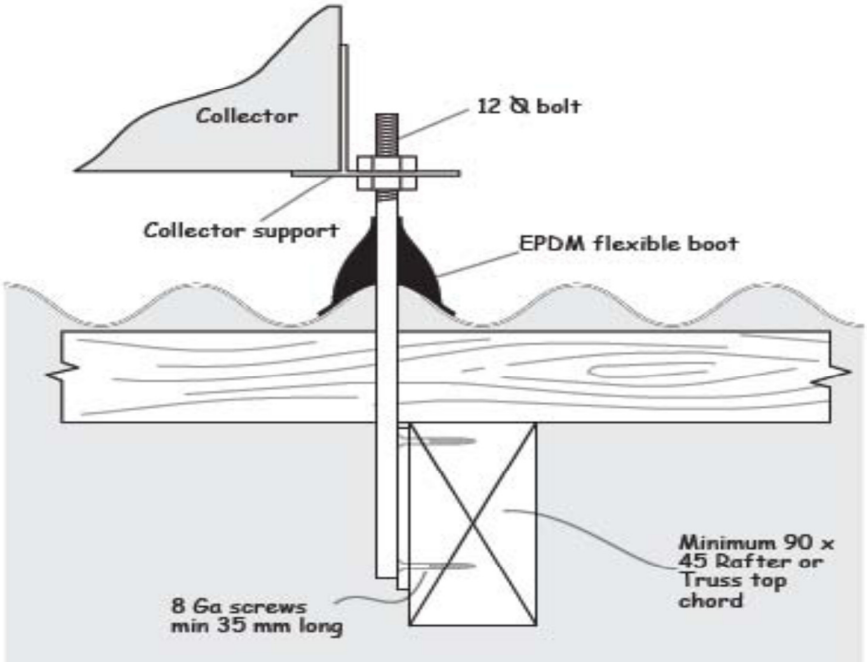

Figure 9(a): *Stud fixing*

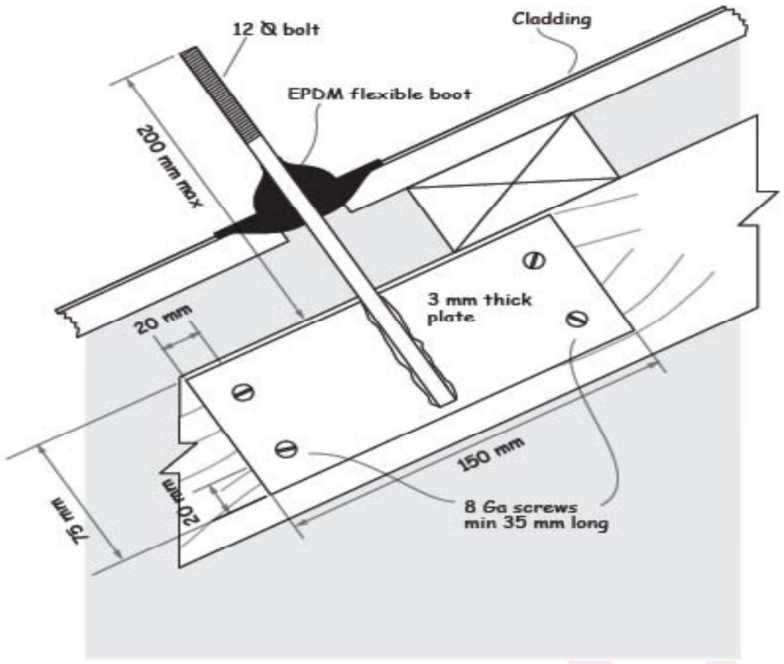

Figure 9 (b): *Stud fixing*

iii. Collector support rails (elevated)

Collector support rails should be in one piece and may be mild steel angles with dimensions determined by either Table 3 or Table 4 (as appropriate), or other material with equivalent strength and stiffness.

Collector support rails running horizontally across the slope of the roof, as shown in Figure 10, should span the outermost rafters or trusses that support the solar collector.

Collector support rails running horizontally across the roof slope, as shown in Figure 10, should be fixed to either:

(a) each rafter or truss top chord that they cross using the details given in Figures 7 or 9, or

(b) purlins at not more than 1500 mm centres and within 300 mm of each end of the collector support rails using the connection details shown in Figures 7 or 8. The purlins must be a minimum size of 90 x 45 mm on their flat and span a maximum of 900 mm.

Collector support rails running vertically up the slope of the roof, as shown in Figure 11, should span the outermost purlins that support the solar collector.

Collector support rails running vertically up the slope of the roof should be supported as shown in Figure 11 by either:

(a) rafters or truss top chords at not more than 1500 mm centres and within 300 mm of each end of the collector support rails using the connection details shown in Figure7 or 9, or

(b) each purlin crossed, using details shown in Figures 7 or 8. The purlins must be a minimum size of 90 x 45 mm on their flat and span a maximum of 900 mm.

Table 3: Support angle rails for panel collectors at a different pitch to roof cladding — up to 2.0 m slope length supported by rafters

Rafter or top chord spacing (m)	**ULS design wind speed** (m/s)	**Number of support Rafter or points per rail**		**Support rail steel angle** (mm)	**Stud fixing detail**	**Roof slope limits**
		For up to 4 m²	**For each added 2 m²**			
Up to 0.9	50	4 4	2 2	40 x 40 x 3 40 x 40 x 3	Fig 9 Fig 14	15° to 45° 0° to 15°
	44	2 4	1 2	30 x 30 x 3 40 x 40 x 3	Fig 9 Fig 9	30° to 45° 0° to 30°
	37	2 4	1 2	30 x 30 x 3 30 x 30 x 3	Fig 9 Fig 9	20° to 45° 0° to 20°
	32	2	1	30 x 30 x 3	Fig 9	0° to 45°
0.9 to 1.2	50	4 4	2 2	40 x 40 x 5 40 x 40 x 5	Fig 9 Fig 14	15° to 45° 0° to 15
	44	2 4	1 2	30 x 30 x 3 40 x 40 x 3	Fig 9 Fig 9	30° to 45° 0° to 30°
	37	2 4	1 2	30 x 30 x 3 40 x 40 x 3	Fig 9 Fig 9	20° to 45° 0° to 20°
	32	2	1	30 x 30 x 3	Fig 9	0° to 45°

Notes:

1. ULS: ultimate load strength

2. The strut attachment to the rails for 4 m^2 solar collectors should be:

- at the mid-point of the outer rail spans for four support points; or
- at the support connections to the rail for two support points.

Table 4: Support angle rails for evacuated tube solar collectors at a different pitch to roof cladding — up to 2.0 m slope length supported by rafters

Rafter or top chord spacing (mm)	**ULS design wind speed** (m/s)	**Number of support Rafter or top points per rail**		**Support rail steel angle** (mm)	**fixing detail**	**Roof slope limits**
		For up to 5 m_2	**For each added 2.5 m_2**			
up to 1200	up to 50	2	1	30 x 30 x 3	Fig. 9	0° to 45°

Notes:

1. This table applies only to evacuated tube solar collectors that have free air flow
between the tubes i.e. no reflector or other infill behind the tubes. 2. The strut attachment to the rails should be at the support connections to the rail.

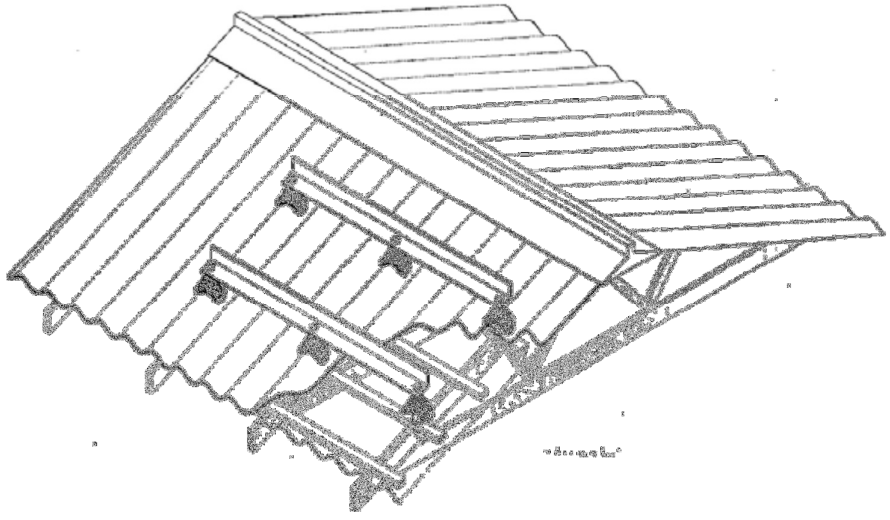

Fig 10: *Collector support rails across roof slope*

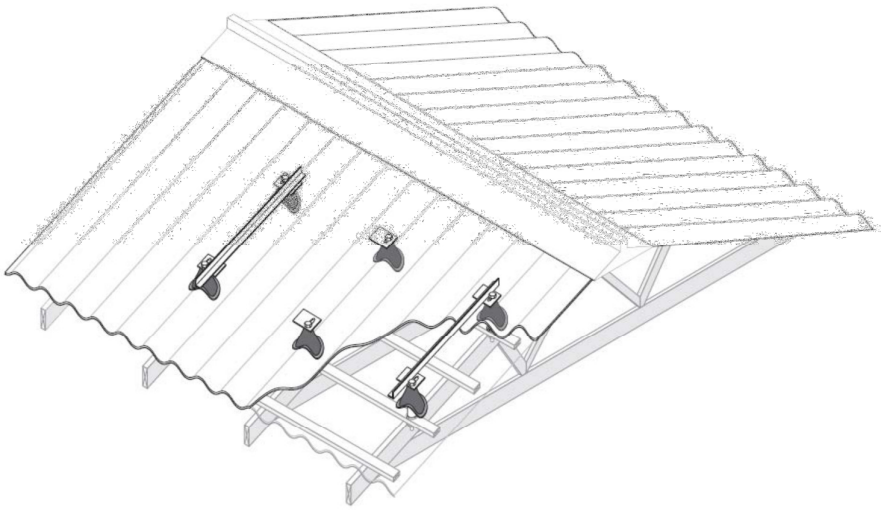

Fig 11: Collector frame up of roof

iv. Mounting collectors at a different pitch to the roof cladding (using horizontal support rails)

- Solar collectors installed at a different pitch to the pitch of the roof and supported by horizontal rails running across the roof slope should be connected to rafters or truss top chords as specified in either Table 3 or Table 4, as appropriate.
- Rails should be mild steel angles with dimensions determined by either Table 3 or Table 4 (as appropriate), or other material of equivalent strength and stiffness.
- Rails should be separated by a distance up the roof slope of at least the slope length of the solar collector, see Figure 13.
- The struts supporting the top edge of the solar collector and the diagonal brace should be mild steel angle complying with Table 5 or other material of equivalent strength and stiffness.

Strut and diagonal brace size (mm)	**Maximum length** (mm)
25 x 25 x 3	1200
30 x 30 x 3	1500
40 x 40 x 3	2400

Table 5: *Dimensions of struts and diagonal braces*

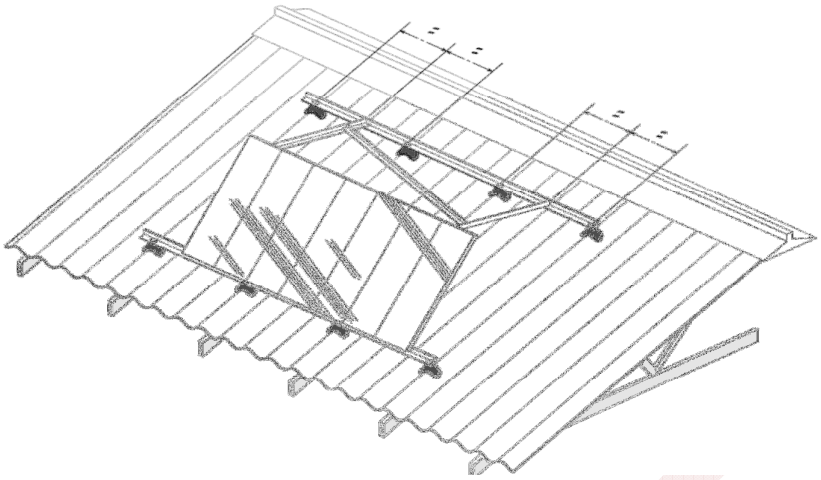

Fig 12: *Collector at different pitch to roof*

- The struts should be connected by a diagonal brace connected within 50 mm of the top of one strut and within 50 mm of the bottom of the adjacent strut.
- Connections between: struts and the diagonal brace; struts and support rails; support rails and the solar collector; and struts and the solar collector should use M8 class 4.6 bolts, nut and washers or another connection of equivalent strength.
- Flat plate solar collectors (and evacuated tube solar collectors with a reflector that prevents air flow between the tubes) with a slope length no longer than 2 m, should be installed in accordance with Table 3 and Figure 9 or 14.
- Evacuated tube solar collectors that allow air flow between the tubes, and have a slope length no longer than 2 m, should be installed in accordance with Table 4 and Figure 9.

v. Mounting collectors at a different pitch to the roof cladding (using frames)

Frames and diagonal braces should be specifically designed for the purpose.

- The frame should be fixed to purlins by 14 gauge (6.3 mm) Type 17 screws.
- The fixings of the frames to the purlins should be separated by a distance up the roof slope of at least the slope length of the solar collector (not the distance between the top edge of the collector and the roof cladding). See Figure 13.

- The frames (in a line across the slope of the roof) should be separated by at least the distance between the rafters or truss top chords (see Figure 15).

For flat plate solar collectors:

- The slope length should not exceed 1600 mm.
- Frames are required at each end of the solar collector and at centres in between no further apart than 1200 mm.
- Where the slope length is up to 800 mm frames should be fixed in accordance with Table 7 and Figure 16.
- Where the slope length is between 800 mm and 1600 mm, frames should be fixed in accordance with Table 6 and Figure 16.

Where the frame support requires three fixings (refer to Table 6 and Figures 15 and 16):

(a) Two of the fixings should be: at the higher end of the frame; fixed to purlins by a channel or top hat section running across the slope of the roof above a purlin; and

(b) The two top fixings should be spaced a minimum of 300 mm apart; and.

(c) Each supporting purlin should be fixed to the adjacent rafters or truss top chord with either 3 x 5mm diameter "Z" nails or a 25 x 1 mm steel strap and two 30 x 3.15 mm nails at each end.

For evacuated tube solar collectors:

- The slope length of evacuated tube solar collector should not exceed 2 m (see Figure 16).
- Frames are required at each end of the solar collector and at centres in between no further apart than 1600 mm
- Frame should be fixed in accordance with Table 8 and Figure 16.

Where alternative fixings are proposed these should distribute the load of the solar collectors over at least the number of fixing points required for the same size (and type) of solar collector following Table 3, 4, 6 or 7, as appropriate.

ULS design wind speed (m/s)	**Minimum purlin size**	**Maximum purlin span** (mm)	**Minimum number of fixings per frame**
50	100 x 50, 90 x 45 75 x 50, 70 x 45	1200 600	3 3
44	100 x 50, 90 x 45 75 x 50, 70 x 45	1200 900	3 3
37	100 x 50, 90 x 45 75 x 50, 70 x 45	1200 900	2 2
32	100 x 50, 90 x 45, 75 x 50, 70 x 45	1200	2

Table 6: *Support channel rails for solar collectors at a different pitch to roof cladding – up to 1600 m slope length supported by purlins*

ULS design wind speed (m/s)	**Minimum purlin size**	**Maximum purlin span** (mm)	**Minimum number of fixings per frame**
32 to 50	100 x 50, 90 x 45, 75 x 50, 70 x 45	1200	2

Table 7: *Support channel rails for solar collectors at a different pitch to roof cladding – up to 800 mm slope length supported by purlins*

ULS design wind speed (m/s)	**Minimum purlin size**	**Maximum purlin span** (mm)	**Minimum number of fixings per frame**
32 to 50	100 x 50, 90 x 45, 75 x 50, 70 x 45	1200	2

Table 8: *Support channel rails for evacuated tube solar collectors at a different pitch to roof cladding – up to 2.0 m slope length supported by purlins*

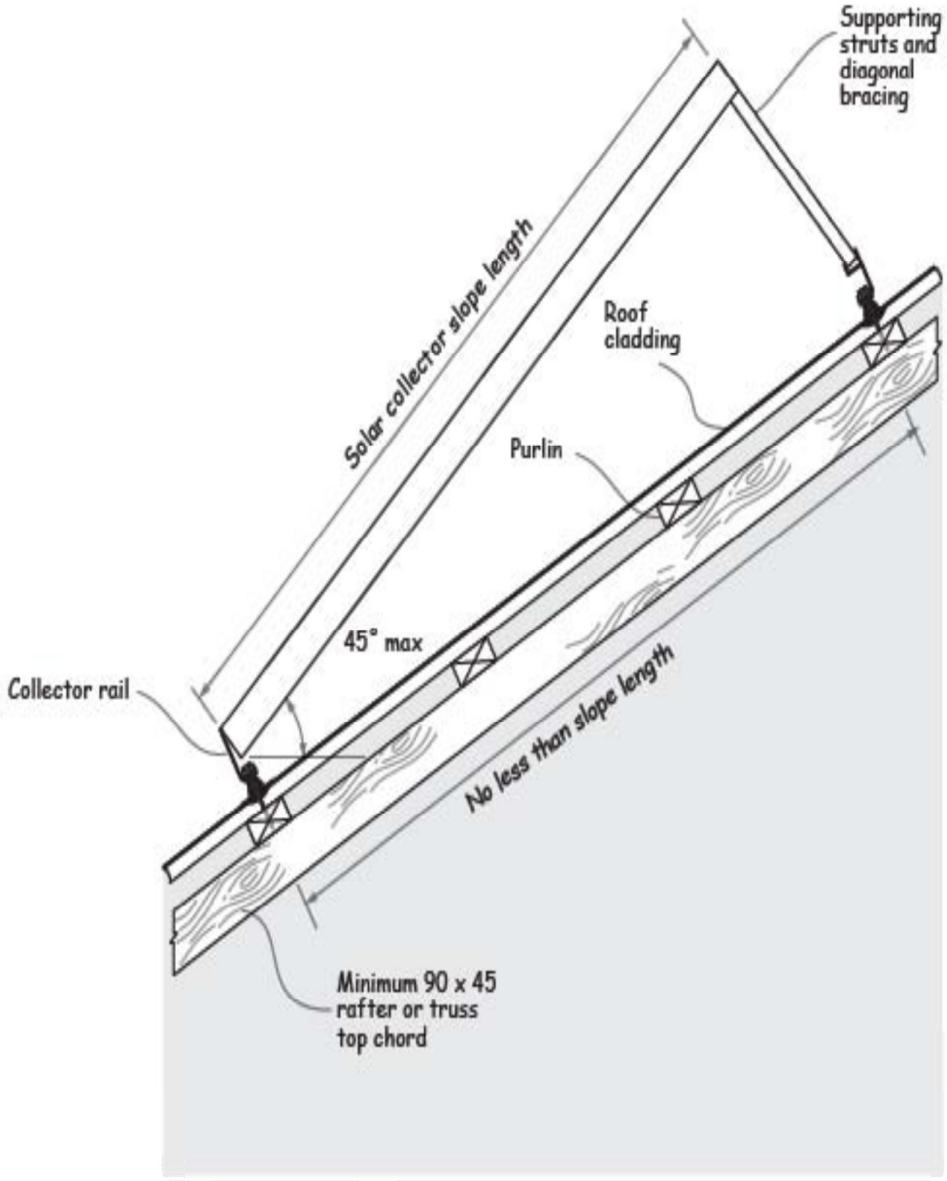

Figure 13: *Collector at different pitch to roof*

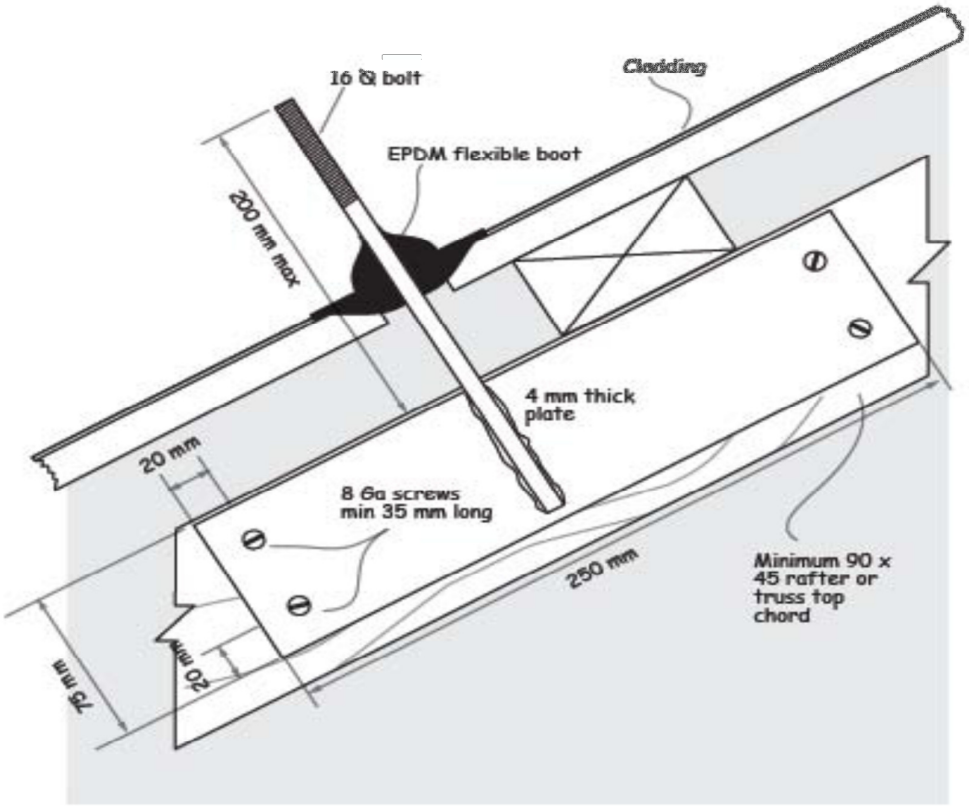

Figure 14: *Stud fixing for panels at different pitch*

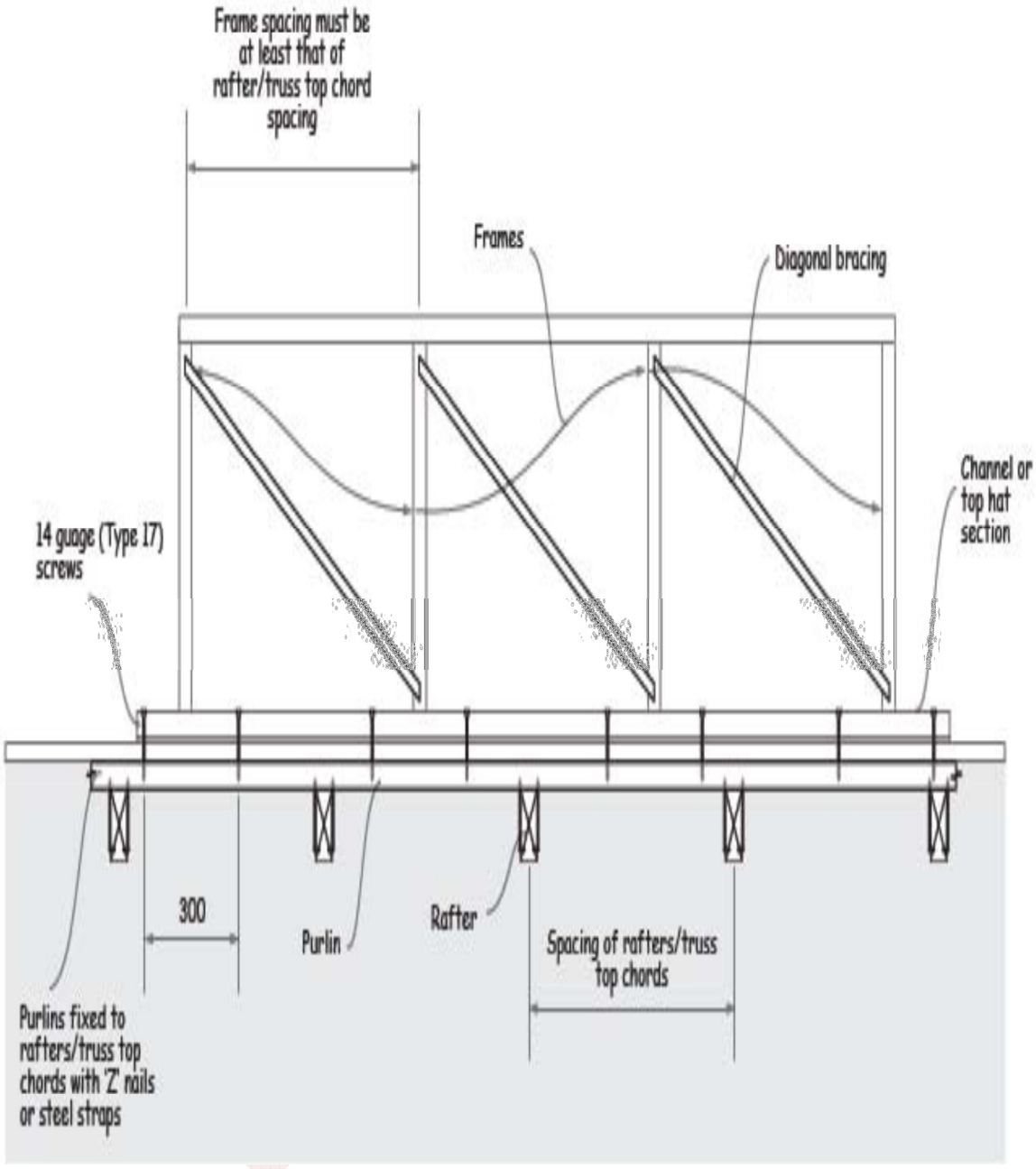

Figure 15: *Solar collectors at a different pitch to the roof, supported using frames (elevation view)*

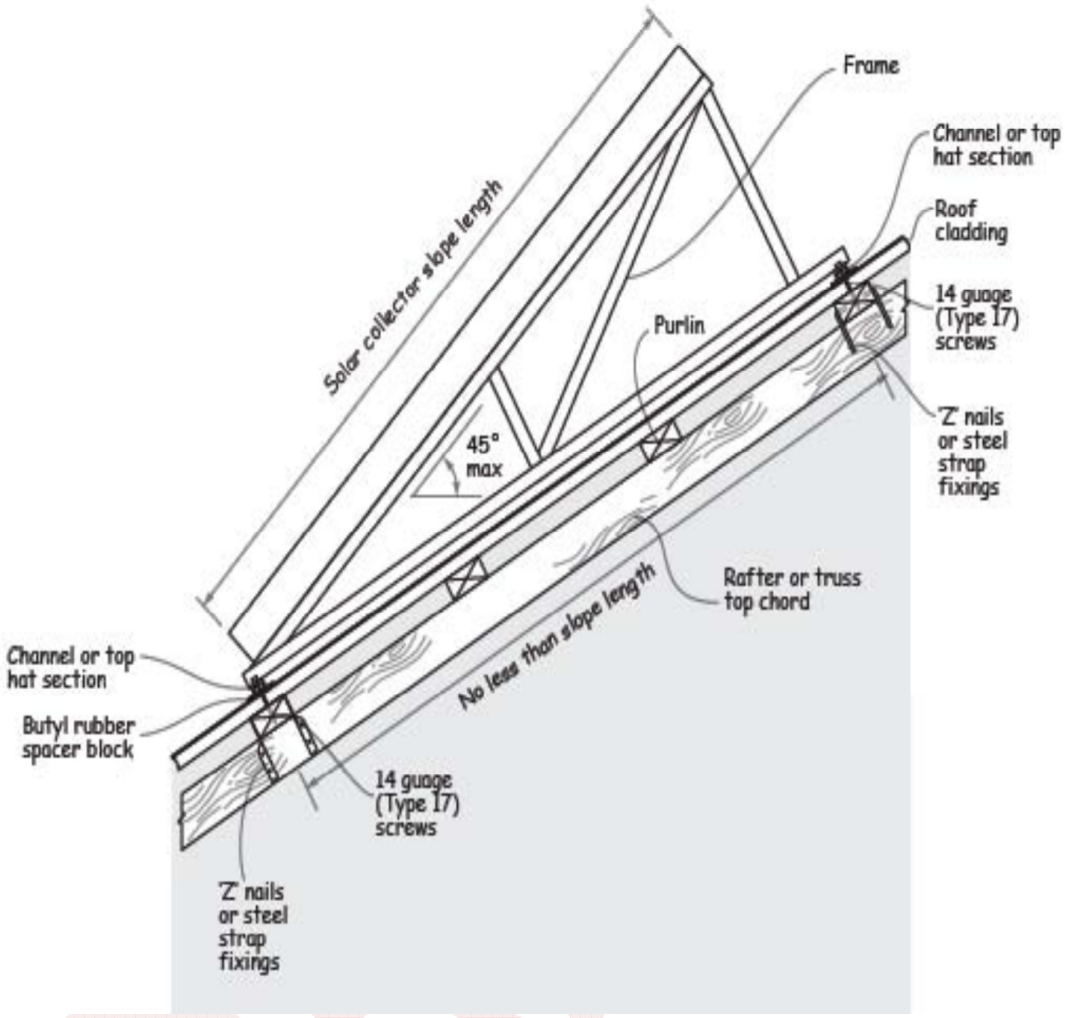

Figure 16: *Solar collectors at a different pitch to the roof supported using frames (section view)*

F) Installations beyond the scope of these guidelines

Solar water heater installations that include the installation of a hot water tank on the roof of a building add a significant additional load to the roof structure. In these cases it is expected that the roof structure will need to be strengthened to support the additional load.

3. 2. DURABILITY

a) Background

The size and strength of the solar water heaters frames and supports is usually determined based on mild steel physical properties (which are usually required to be hot dip galvanized to achieve adequate durability). However, they are other materials that are made of lighter material, which still achieves the strength and stiffness requirements to meet the durability performance requirement in the building standards.

b) Principle

The objective of durability in these guidelines is to ensure that a building, throughout its life, will continue to satisfy the other objectives of the building standards

Solar water heaters are easy to access, moderately difficult to replace and failure to comply with the building standards is unlikely to be detected during normal use. Therefore, some parts of the solar water heater may need to be replaced before the determined time. If that is the case, these parts should be able to be replaced without removal of more durable parts of the solar water heater

c) Guidance

There are many ways to achieve the Building standards performance requirements for durability.

- One way, is to use hot dip galvanized mild steel, however, other materials that meet the National Building standards durability requirement and have equivalent stiffness and strength can also be used. These other materials are often lighter, resulting in reduced additional load on the building structure.
- Designers will need to demonstrate how their proposed solution meets the durability requirements according to the Building Standards.

- Building consent Authorities should be receptive to alternative solutions proposals that comply with the Building standards performance criteria because they often result in a better solution for the supplier and the customer.

3. 3. EXTERNAL MOISTURE

a) Background

Penetrations in roofs for the installation of solar water heaters are adequately described in these guidelines to achieve the Building standard performance criteria for external moisture.

b) Principle

The objective of this external moisture clause is to protect people from illness or injury caused by external moisture entering the building

c) Guidance

Solar water heaters should be not installed on a roof with a lower pitch than that provided under these guidelines (Ref. Table 3) and /or relevant national building standards.

3. 4. HAZARDOUS SUBSTANCES AND PROCESSES

a) Background

There are no known concerns with solar water heater installations achieving the hazardous building materials requirements. However the mitigation measures should be provided.

b) Principle

The objective of this Hazardous substances and processes clause is to safeguard people from injury and illness caused by exposure to hazardous building materials.

c) Guidance

For solar water heaters, the most practical way to achieve the building standard performance criteria is to ensure that, it is unlikely for people to come into contact with any broken glass (or other brittle material).This can be achieved by installing the solar collector on the roof of a building and the installers should avoid installing evacuated tube or other glass solar collectors over an unprotected area such as a pergola, etc...

3. 5. ELECTRICITY

a) Background

There are no known concerns with solar water heater installations achieving the electrical installation requirements of the Building standards. However the mitigation measures should be provided.

b) Principle

The objective of this electricity clause is to protect people from fire and injury caused by electrical installations.

c) Guidance

New electrical work associated with installing a solar water heater must be certified that is, a Certificate of Compliance (CoC).The CoC is required in accordance with the provisions of the Electricity installation guidelines.

3. 6. WATER SUPPLIES SYSTEM REQUIREMENTS

a) Background

These guidelines want to avoid the unnecessary retesting of products that have already been satisfactorily tested to a relevant international Standard, where the installation of these products achieves the performance requirements of the Building standards.

The international standards require solar water heaters to have a minimum of 50 liters of hot water storage per square meter of collector area. This is a prescriptive way to demonstrate that the relevant performance criteria are achieved.

b) Principles

The objective of this clause is to protect people from illness or injuries caused by water flow systems and protect people from loss of amenity caused by failure of water flow systems.

c) Guidance

Solar water heating systems should comply with an appropriate product Standard to ensure that the system is safe.

However, for the product Standards that do not include system tests, further information may be required to demonstrate that the Building standard performance criteria are met. For example the relationship

between solar collector area and hot water storage will need to be verified and the solar water heating system should also have fail-safe mechanisms to deal with excessive temperatures and pressures. As an alternative to having a minimum of 50 litres of hot water storage per square metre of collector area, systems could be tested to meet the required building standards performance criteria. The regulator may consider that national relevant standards are enforced.

3. 7. ENERGY EFFICIENCY - ORIENTATION AND INCLINATION

a) Issue

The inclination requirements in these guidelines cannot be achieved when solar collectors are installed parallel to the roof cladding on low pitched roofs. The cost of changing the inclination may outweigh the benefits of increased performance from the solar water heater in some cases.

b) Principle

The objective of this clause is to facilitate the efficient use of energy. Solar energy used in solar water heaters, does not come from a network utility operator and is not a depletable energy resource. This clause includes no performance criteria related to the energy efficient use of renewable solar energy used in solar water heaters, but any supplementary heating from a network utility operator is covered by the Building standards.

The performance requirements that are related to hot water systems state that they must:

- limit the energy lost in the heating process, and
- be constructed to limit heat loss from hot water tanks and hot water pipes.

c) Guidance

The solar collector should be reasonably well orientated and solar water heater system should be isolated. To achieve to this; hot water pipes should be isolated otherwise the solar energy from the solar water heater will exceed any additional heat loss that may occur from a solar hot water storage tank which may not limit the heat loss from the tank to the same extent as other water heaters.