PROTAN

INSTALLATION MANUAL

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1 Introduction

Protan is one of the largest producers of thermoplastic roofing membrane (PVC) in Europe. Our business concept is to protect assets against the effects of wind and weather. We supply both roofing systems, membranes, terraces, wet rooms for new builds and renovation projects as well as radon protection. Our world-leading solutions are developed and produced in Norway pursuant to the highest quality standards. They are tested and approved by a number of civil engineering institutions throughout Europe and in Norway.

Protan roofing membrane can be used on all types of roof structure, for both new buildings and renovation, on flat roofs, with and without ballast, and pitched and arched designs. Our roofing membranes are particularly suitable for roofs with complicated shapes, such as feature/designer roofs.

Protan's membranes are used in many different areas such as terraces, bath/wet rooms, turf roofs, parking canopies and tunnels.

A roof depends not only on the quality of the roofing membrane. It is just as important for the roofing membrane to be installed according to the manufacturer's instructions and current national requirements. To ensure a high quality and correct installation, Protan has established a network of authorised roofing contractors throughout Europe.

Being an Authorised Protan Roofing Contractor carries obligations and as such the contractor must follow Protan's guidelines, including ensuring that the roofing personnel have the necessary training and knowledge to lay Protan roofing membranes.

Protan provides our authorised roofers basic mandatory training in installing Protan Single Ply roofing membranes. The training gives roofers expert practical and theoretical knowledge of the products and roofing systems.

Protan's installation manual is a useful reference for roofers and project managers on the correct use of Protan's various types of roofing membrane and roofing methods.

Protan is a company characterised by innovation, development and adaptation to the ever-changing market conditions and requirements. The installation manual demonstrates current technical solutions. New technical solutions and any new product versions are presented at Protan's website, www.protan.com, and takes precedence over the installation manual.

The information in the installation manual should cover most information needs. However, if you cannot find an answer to your question, please contact Protan.

2 Materials Science for Plastic-based Roofing Membranes

Plastic-based roofing membranes are primarily made of plasticized PVC. There is also a small market for TPO-based roofing membranes. A common feature of both these types is that they are reinforced with a textile made of polyester or glass.

PVC

PVC (polyvinyl chloride) is probably the most versatile plastic material available on the market today and accounts for 25% of plastic production in Europe. PVC is used in many different industries such as building/construction, medicine, automotive, sport/leisure and clothing/textiles. Building and construction represents the biggest market for PVC. The dominant products here are pipes, window sections, roofing membranes and flooring/wallpaper.

The reason why PVC has so many applications is that the properties of the material can be varied greatly. PVC can be rigid and strong in a pipe but soft and flexible in a roofing membrane. This variation in properties is achieved by adding various materials to PVC such as plasticizers, fillers, stabilisers and functional pigments. Roofing membranes contain a significant proportion of plasticizers to ensure adequate flexibility and low-temperature softness.

PVC is a thermoplastic. This means that the material melts/hardens at a high temperature. This is very beneficial in industrial production as the material can thus be extruded, calendered, blow-moulded and processed at a process temperature in the range 150-200°C. PVC can also be welded with a number of welding methods such as hot air, hot wedge and high-frequency. PVC can also be bonded.

Most plastic types have carbon and hydrogen as their most important components and are produced 100% from fossil fuel such as oil. PVC is different in that it contains chlorine in addition to carbon and hydrogen. So less than half of the material (only around 43%) comes from non-renewable fossil resources. The content of chlorine (57%) comes from common salt, of which there is an unlimited supply in the world.

PVC is very resistant to wind and weather as well as chemicals and contaminants. This means that PVC products have a long life. The content of chlorine results in PVC being a more fire-resistant material than most other plastic materials.

TPO/FPO

TPO (thermoplastic polyolefin) and FPO (Flexible polyolefin) are a small group of materials based on rubber-modified polyethylene or polypropylene. The added rubber makes the product flexible but not as much as plasticized PVC. A TPO/FPO is also a thermoplastic like PVC. Therefore, the material will melt/harden at a high temperature and can thus be processed and welded with the same methods as PVC (but not with the high-frequency method). A TPO/FPO has fillers, stabilisers and functional pigments added to achieve the properties required. It is more difficult to make this material fire stable than PVC.

Textiles

Plastic-based roofing membranes are reinforced with a textile to meet requirements for strength, dimensional stability and durability, among other things. The textiles are based on either polyester or glass.

A polyester textile is woven, knitted or bonded. A common feature of these textiles is that there is load-bearing polyester yarn on both the warp and the weft. Polyester textiles are always used in roofing membranes that are to be fixed mechanically and be exposed.

A glass fibre textile is a fleece consisting of thin sliced glass fibres that are bonded together with a binder. Such a glass fleece is particularly suitable for giving a roofing membrane dimensional stability and is thus used in roofing membranes that are to be under ballast or are embedded under concrete footing, etc.

For special applications there also textiles that consist of both polyester and glass.

Protan PVC single ply roofing membranes

Protan's PVC roofing membranes are, in principle, textile reinforcement coated with plasticized PVC on both sides.

The products can be divided into 2 main groups.
One group contains polyester-reinforced roofing membranes for mechanical fixing and vacuum fixing.
The other contains glass fibre-reinforced membranes for membrane structures, ballasted coverings and terrace solutions.
All of Protan's PVC products can be welded to each other.

Main group 1
Protan SE, EX, EX-A, SE Titanium +, BP, BPX & T

Polyester-reinforced PVC coverings for mechanically fixed, adhered and vacuum fixed roofs.

Protan SE:
- a top layer of PVC that is chemically stabilised for resistance to UV, fire and temperature
- a core (reinforcement) of polyester
- a dark underside of PVC
- available in thicknesses of 1.2 mm to 2.0 mm in a wide range of colours

Protan EX:
- Protan SE with polyester fleece laminated to the back
- available in thicknesses of 1.2 mm to 1.8 mm in a wide range of colours

Protan EX-A:
- Protan SE with an extra strong laminated polyester fleece on the reverse.
- thickness of 1.5 mm

Protan SE Titanium +:
- Protan SE with biocides and laqcuered surface.
- thickness of 1.6 mm

Protan BP:
- a robust membrane with extra strong polyester reinforcement.

Protan BPX:
- Protan BP with polyester fleece laminated to the back

Protan T:
- A Protan SE-variant in thickness 2,0 mm

Areas of use

Protan SE – for mechanically fixed coverings and vacuum roofs.
Protan EX – a special product for reroofing, mechanically fixed or vacuum fixed.
Protan turf roof membrane – a special version of Protan EX. This is fixed mechanically as the base for turf.

Protan EX-A - for adhered roofs
Protan SE Titanium + - for extensive green roofs.
Protan BP - for Protan BlueProof roofs
Protan BPX - for Protan BlueProof roofs when reroofing on old bitumen.
Protan T - for exposed terraces and balconies

NOTE: The Protan SE versions must not be used/installed:
- loose (apart from vacuum roofs)
- with gravel ballast
- as membranes (for example terraces and bathrooms)
- for roofing details where the covering has to be overstretched

Main group 2 - Protan G, GG, and GT

Glass fibre-reinforced PVC coverings for membrane structures, loose and ballasted coverings.

In general, the coverings have:
- a top layer of PVC that is chemically stabilised for the intended area of use
- a core (reinforcement) of glass fleece
- a dark underside of PVC

The Protan G type of products are available in thicknesses of 1.5 mm to 2.4 mm in a wide range of colours.

Areas of use
Protan G 1.5 mm is used:
- on roofs with gravel ballast
- as a membrane in bathrooms
- as a membrane on terraces
- for roofing details

Protan GG 2.0 mm is used:
- for heavy membrane structures (parking decks and similar)
- on planted roofs

Both Protan G and GG can be used as membranes in tunnels and culverts.

Protan GT 2.4 mm is used as exposed covering on terraces with pedestrian traffic. This is preferably installed mechanically on a dimensionally stable substrate.

Other products

Second-Protan Roofing Membrane is a polyester reinforced thermoplastic waterproofing membrane with high tensile and tear strength. Second-Protan Roofing Membrane is down-graded varieties of Protan polyester reinforced roof membrane. They can vary in thickenss from 0,8 mm- 2,0 mm.
The downgrade is related to small errors in relation to product properties or appearance that do not affect the tightness of the product. The membrane has good properties at both high and low temperatures, is added with fire retardants and has good resistance to UV radiation and contamination. The membrane is marked with yellow paint in the roll edge, to ensure visible identification of the second membrane also after installation.
Second-Protan Roofing Membrane with polyester reinforcement is used as a moisture barrier, temporary coating or underlay etc. The moisture barrier can be laid loosely or fixed mechanically to supporting substrates. Areas of use include as a roof vapour barrier, as an underroof, as radon protection, as a sill covering membrane, as a temporarily exposed covering with limited UV resistance or as a sealing layer where there is a need for a light membrane that is strong and flexible.

Chemical resistance for Protan SE and G versions

Generally speaking, the chemical resistance of Protan PVC roofing membranes depends on concentration, duration of contamination and temperature. The table below indicates the resistance to a number of different common substances at normal temperature.

Material	Suitable	Conditionally suitable	Unsuitable
Water	x		
Seawater	x		
Salt	x		
Road salt	x		
Detergents	x		
Herbicides	x		
Urine	x		
Chemicals		x	
Paint		x	
Lacquer		x	
Glue		x	
Grouting / sealant		x	
Emissions from industry		x	
Emissions from agriculture		x	
Bitumen			x
Asphalt			x
Tar			x
Oil			x
Petrol			x
Diesel			x
Fat			x
Solvents			x

3 Roof Structures and Vapour Control Layers

Functional requirements:

The most important functional requirements of a roof are:

- Water must not penetrate into the structure through the roofing membrane.
- Rain and water from melting snow must be drained away properly.
- Snow must be able to lie on the roof or slide off at no risk to the roof or the surroundings.
- Water vapour and damp indoor air must be prevented from penetrating into the roof structure.
- Noise reduction.
- Materials used must withstand the impact of sunlight and the wind and mechanical impacts.

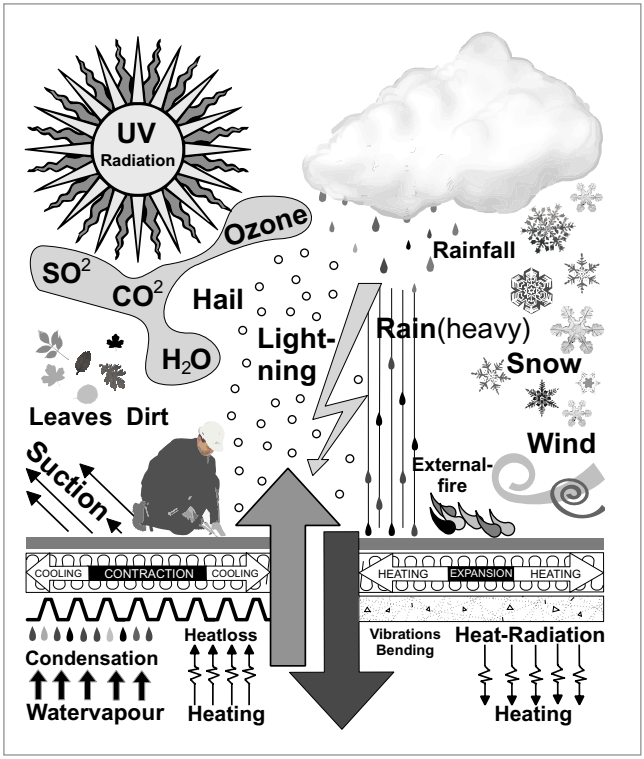


Fig. 1

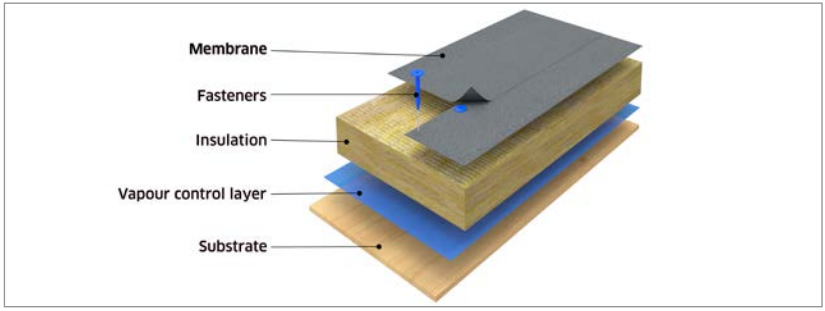
Pitch:

We primarily distinguish between two roof pitches:

- Flat roofs: Roof angle < 10 degrees
- Sloping roofs: Roof angle ≥ 10 degrees
- Always follow national guidelines regarding roof angles.

Compact/Warm roofs:

In compact/warm roofs, the various material layers lie directly on top of each other with no form of air gap or ventilated layer. In such roofs, the roofing membrane will be able to function as part of the air seal. There are often leaks in connection with, for example, parapets/rafters so that the vapour control layer becomes the sealing layer on which airtightness depends.
Compact/warm roofs will have two vapour-tight layers, the vapour barrier and the roofing membrane. The use of wood-based materials between two vapour-tight layers must be avoided because any moisture can cause rot.



Ventilated roofs/Cold roofs:

Ventilated roof structures (cold roofs) are roof structures in which there is an air layer to allow outdoor air to flow through between the insulation and the outer roof. This avoids condensation against the cold underside of the outer roof. A correctly installed ventilated/cold roof will prevent snow/ice on the surface from melting. Good drying conditions are an important property of ventilated roof structures.

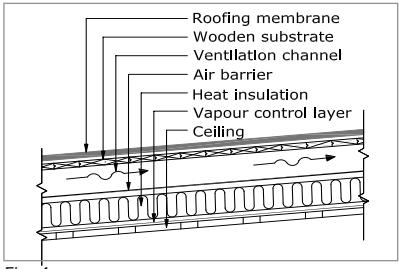


Fig. 4

Building moisture:

Building materials such as concrete and wood have an excess of moisture in a new building. This needs to dry out to achieve equilibrium with the air humidity in the building. Such a drying process can take a long time and cause many practical problems. Therefore, it is important to keep this moisture under control. Organic materials should be avoided as far as possible in the roof structure.

Compact/warm roofs with heavy mineral wool on a concrete supporting deck and with a covering of single ply or roofing felt contain no organic materials that can be damaged by moisture. The concrete may contain a lot of moisture that may gradually move up into the insulation and reduce the thermal insulation capacity. This solution can easily be protected against moisture by placing a vapour-tight layer on the concrete supporting deck before the insulation and covering. This prevents the moisture from moving (diffusing) upwards through the structure and condensing. The moisture later has the opportunity to dry out downwards over a long period of time.

Therefore, installation of the vapour control layer is very important to the moisture protection of the building. The roof being able to dry out well is almost as important as the roofing membrane being watertight.

Vapour control layer – function:

The vapour control layer in a building is designed to prevent moisture from penetrating from inside the building out into the walls and roof by means of diffusion and via air leaks (convection). It is also designed to prevent the occurrence of troublesome draughts and heat loss via air leaks.

In order for the vapour control layer to function properly, including as an airtight layer, it is necessary for it to be installed with tight joints and tight finishes against lead-throughs and at connections to the vapour barrier layer in the walls.

In compact/warm roofs, it will normally be enough to have polyethylene (PE-foil) as the vapour control layer.
Consult the client if there is any doubt about the function/quality of the vapour control layer.

Roofs of cold stores, in which the internal temperature is lower than the outdoor temperature all year round, must have maximum vapour tightness in the covering. An internal vapour control layer is not necessary on cold stores. To achieve sufficient vapour tightness and air tightness when roofing cold stores with Protan, a layer of polyethylene must be laid on the top layer of insulation before the roofing membrane. In practice, the joints and lead-throughs determine the airtightness.

Polyethylene (PE):
Polyethylene is used widely today as a material for vapour barriers. It is produced in thicknesses up to 0.20 mm and in several different widths and lengths. The European standard, EN 13984 : 2013 - Flexible sheets for waterproofing. Plastic and rubber vapour control layers. Definitions and characteristics, specifies the characteristics of flexible sheets of plastic or rubber intended for use as water vapour control layers for buildings and applies to both reinforced and unreinforced products.

In compact/warm roofs, it may be necessary to use vapour control layers made of other materials. The most common are polymeric sheets of PVC or TPO, bitumen roofing membranes with a core of glass or polyester fleece or rubber made of butyl.

All joints must be installed precisely to achieve an airtight layer. They may be overlap joints, taped joints, mastic (bonded) joints or welded joints. Welded joints are the best fully airtight joints.

Protan Vapour Control Layer:
The Protan Vapour Control Layer, of minimum 0.8 mm thick PVC roofing membrane, meets the requirements for diffusion tightness specified in the Norwegian Standard. The material is weldable with hot air and can, therefore, produce a fully airtight solution. This is particularly important around details such as parapets and lead-throughs.

The Protan Vapour Control Layer is used in buildings with a high level of moisture. In extreme cases such as indoor swimming pools, the roof moisture barrier is supplemented with a layer of polyethylene with a 200 mm overlap joint to achieve additional diffusion resistance. A fully covered moisture barrier will create a tight basin on the roof. To prevent any leaks that may arise via the roofing membrane from remaining in the structure, the moisture barrier can be drained with separate drains. The drainage can be conducted downwards so that any leaks can be discovered at an early stage.

Protan EasyBond VCL
Protan EasyBond is a vapour control layer made of cross-laminated PE film with an aluminium foil inside. The vapour control layer's underside is self-adhesive. It can be used as a vapour control layer where that is need for extra high vapour resistance (Sd>1500 m). It has high strength and durability and can withstand foot-traffic during the construction period. It can be stepped onto directing even when the substrate is profiled steel sheets.

Vapour control layer and covering during construction:
The Protan 2X roof system uses a polymer-modified asphalt based covering with a core of polyester or a roofing membrane with polyester

reinforcement as a combined vapour control layer and covering during construction. This is done if it is necessary to use the roof as a temporary work platform during the construction period.

This layer is often installed directly on the supporting deck but it may be useful to insulate it a little, for example on a supporting roof deck of corrugated steel before the initial construction membrane is laid.

The fall, rainwater outlet and drains are arranged as required and as practical as possible.. Drains from the construction membrane should be provisional and sealed after they have been replaced with permanent drains.

Vapour and air sealing of details:
Finishes to parapets and lead-throughs must be made as tight as possible. Along the parapets, the vapour control layer is folded up the parapet (height dependent on substrate type) and clamped behind the linear parapet fixing from the roofing membrane. PVC roofing membranes are particularly suitable products for achieving tight seals around details as a result of their flexibility and the large range of finished details.

When roofing in rain or snow, it is important not to trap any moisture in the layer between the vapour control layer and the membrane. The choice of vapour control layer is made during project planning and is based on calculations of the building's internal and external moisture loads and temperature and its structure. The total of these factors places the building in various risk classes which, in turn, set specific requirements for the type of vapour barrier that must be used (see the table. ***Important!*** These are Norwegian guidelines. Please make sure you follow local guidelines for your market.).

Risk class	Total load points	Requirements for vapour barrier
R1	$0<\Sigma P<12$	0.2 mm polyethylene laid with 200 mm loose overlaps
R2	$12\leq\Sigma P<22$	0.2 mm PE foil laid with 200 mm clamped overlaps and installed with tight connections (clamping ring, taping, joint filler)
R3	$22\leq\Sigma P<32$	a) Roof moisture barrier of bitumen roofing membrane of minimum class U2 NS3530 laid with welded joints and tight connections b) Roof moisture barrier of 0.8 mm PVC membrane laid with welded joints and tight connections
R4	$\Sigma P\geq32$	a) Roof moisture barrier of bitumen roofing membrane of minimum class U2 NS3530 laid with welded joints and connections b) Roof moisture barrier of, for example, 0.8 mm PVC membrane laid with welded joints and tight connections with 0.15 mm polyethylene loosely laid out with loose overlaps in addition to having adequate vapour resistance NOTE: For EC > 32 mechanical fixing of the roofing membrane itself is not recommended.

Source: TPF no. 7

Requirements for substrate:
It is important for the substrate not to have sharp edges (stone) or objects (screws) that may damage the vapour control layer. The roofer is responsible for notifying the client if the substrate is not satisfactory.

4 Roofing Tools and Equipment

Handheld welding equipment

A handheld welding device of type Leister, Steinel or Sievert is used to weld details and to join roofing membranes. The suppliers have special cases containing all welding equipment, for example Leister Triac S with accessories such as nozzles, rollers, scissors, etc.

Automatic welding machines

Automatic welding machines are used to weld Protan roofing membranes. Whether narrow sheets or large sheets are used for roofing on sloping surfaces or flat roofs, hot air welding machines are normally used. Be careful with the settings of the welding machine before the welding operation starts. The quality of an automat welding is a function of correct combination of settings between the welding temperature and welding speed. The settings must also be adjusted to the outdoors conditions (temperature, moisture etc.) and the material thickness. Always remember proper "melt-out" of the PVC along the welding seam during the welding operation.
NOTE: Automatic welding machines must be used on 2 m wide sheets.

There are several types of welding machine on the market. Some of the most widely used ones are mentioned here.

Leister Varimat V2

Fig. 6 Leister Varimat V2

The Leister Varimat V2 is very suitable for welding of PVC roofing membranes. The automatic machine weighs 35kg and is good for use on large roof surfaces. Extra weight can be added over the pressure wheel of the welding machine. Height and angle of the ergonomic guide bar can be easily adjusted. For stable welding process, the patented spherical pressure roller compensates unevenness of surface. Depending on the material, its thickness and the welding conditions (moisture and air temperature) a potential operating speed is up to 5m/min. The maximum weld width is 40 mm. The machine has user-friendly display with "e-Drive" (press and turn control) to adjust temperature, air flow and speed. A voltmeter on the instrument panel displays how much voltage is being fed to the machine. In case of too high undervoltage the machine cuts out to maintain the process reliability. By pressing the Drive key on the panel, the menu displays all operating times and the distance which the device has travelled since being switched on. The machine is well suited for loose membranes as it does not pull the membrane with it during welding.

Leister Uniroof AT

Fig. 7 Leister Uniroof AT

The Uniroof AT is a compact welding machine that is well suited for welding of Protan PVC roofing membranes on smaller flat or pitched roof surfaces. Thanks to its slim design and construction, as well as the movable transport axle, the machine can be used in narrow circumstances. Functional control panel with display makes it easy to set and follow the welding parameters (set point and actual figures during runtime as well as voltage for better control). The Uniroof AT has a maximum weld width of 40mm and a recommended top speed of 2m/min.

Machine welding

Read the instruction manual for the welding machine. Ensure that the machine is maintained daily (dried and lubricated) and stored in a dry place when not in use. Take the welding machine out of the transport box and store it indoors at weekends. To achieve a good weld, it is important for all moving parts of the machine to function properly and for the nozzle to be in the correct position. If a fold occurs in the roofing membrane along the weld, this is probably due to deficiencies and/or faults in the nozzle, pressure rollers and/or lock belt wheels.

NOTE: Peel tests must be carried out at the start of machine welding and at intervals of 200 lm to ensure a proper welding quality.

5 Insulation

The current U-value (heat transmission coefficient) required for homes in Norway is 0.13 W/m²K (indoor temperature over 20°C), which means that at least 280 mm of EPS or mineral wool insulation must be laid on the roof. Old roofs that are reroofed often need to have additional insulation added.

Insulation materials

The most important requirements of insulation materials for use on roofs and membrane structures are:

- Thermal insulation capacity
- Fire resistance
- Compressive strength

The most widely used insulation materials are:

- EPS (expanded polystyrene)
- XPS (extruded polystyrene)
- Mineral wool (rock wool/glass wool)
- PIR / PUR (Polyisocyanurate / Polyurethane)

EPS is widely used for insulation of roofs in Norway. EPS contains small cells with thin walls. The pores between these walls contain stationary air. EPS is available with different compressive strengths and is available with content of graphite to improve thermal performance.

XPS is widely used for insulation in connection with covered membrane systems due to its high compressive strength. XPS insulation has a closed cell structure and on account of its low water absorption, it can be used on top of membranes in inverted systems.

EPS and XPS boards can be supplied with rebated sides so that, after installation, there are no openings between the boards (thermal bridges). Alternatively, it is possible to lay two layers of boards without rebates with staggered joints. For mineral wool, it is important for the panels to push against the neighbouring board/structure.

NOTE: A layer of glass fleece (migration/fire barrier) or a 30mm layer of mineral wool must always be laid out over polystyrene insulation (EPS and XPS) before laying Protan PVC roofing membranes.

Mineral wool is a general name for glass and rock wool. Rock wool consists of a large number of thin fibres of molten rock to which a binder is added and which are then pressed together. The quantity of material per cubic metre determines the material's compressive strength. Mineral wool is a non-combustible material that is used alone or in combination with EPS, for example.

Polyisocyanurate and polyurethane insulation consists of rigid foam boards which mainly are used on exposed warm roofs. The foam panels are produced by a chemical reaction during which a blowing agent is added. The rigidity of the panels allows for infrequent light traffic. The boards are typically faced with aluminium foil or glass tissue and have a significantly better thermal performance than EPS or mineral wool.

Prolonged spot loading of any insulation (walking on it over an extended period of time, for example) may result in the insulation losing its strength and thermal performance. So, take the necessary precautions such as laying out pressure relief plates such as higher strength boards, steel plates, plywood, XPS or walkway sheets in zones in which there will be permanent traffic.

Note: Insulation must not become wet as water in the insulation reduces the insulation capacity dramatically. Insulation stored at a construction site must be covered with a tarpaulin or similar waterproofing material.

Mechanically installed roofs

Insulation boards must never lie loose under the membrane. There must be a minimum of 1 fixing point in small insulation boards and 2 fixing points in large insulation boards. PIR/PUR boards often need significantly higher number of fasteners installed independently of the roofing membrane. This is particularly important on roofs covered with 2m SE. Follow the insulation supplier’s installation instructions. The requirements may vary with different products, wind loads and regulations in different countries.”

6 Separation Layers, Migration Barriers, Sliding Layers and Protection Layers

In practice, migration refers to the migration of plasticizer. Protan roofing membranes contain a number of chemical compounds, including plasticizers . Plasticized PVC membrane has the property that when in direct contact with bitumen roofing membranes or polystyrene (insulation), for example, a chemical reaction will occur over a period of time that may result in the gradual reduction of the plasticizer in the PVC membrane. This may cause the membrane to become more rigid over time and lose some of its beneficial properties. To avoid this, it is necessary to lay out a barrier layer, a migration layer.

A separation layer must be functional under all conceivable conditions to which the roofing membrane/membrane is exposed during its expected life.

- A **migration barrier** is laid between two layers to prevent chemical interaction between them.
- A **sliding layer** is laid between two layers to prevent excessive friction between them.
- An **Leveling layer** is laid between two layers to hide irregularities in the substrate.
- A **protection layer** is normally laid over the membrane to protect it against mechanical impacts and the like (Protan recommends a layer of 1.2-2.0 mm PVC membrane, or a minimum 300 g/m^2 polypropylene fleece).
- A **fire protection layer** is laid between two layers to prevent burning objects from melting down into flammable insulation material.

A layer of glass fleece (weight min. 50 g/m^2) is laid as a migration barrier on all polystyrene insulation (EPS and XPS). The glass fleece is laid out loose with an overlap of approximately 120 mm.

Underlaying deck	**Protan PVC-membrane**	
Old bitumen roofs	**Protan EX** Protan EX has a migration barrier laminated on the reverse side.	**Protan SE, G & GG** Protan SE requires a separate migration barrier installed on top of the bitumen surface to avoid migration. Protan recommends: Fibertex F2B, 140 g/m^2 polypropylene, supplied by Protan AS.
EPS/XPS-insulation		SE, G & GG requires a separate migration barrier installed on top of the bitumen surface to avoid migration. Protan recommends: Glass fleece 120 g/m^2 supplied by Protan AS.
Substrates of smooth concrete or light weight concrete	**Protan SE, G & GG** Protan SE, G & GG requires a sliding/levelling layer installed on top of the concrete deck. Protan recommends: Fibertex F4M 300 g/m^2 PP, supplied by Protan AS.	
Timber, rubber, such as underlaying blocks, mats, packing, etc.	As for old bitumen roofs.	
Old mechanically fastened polymeric membrane	As for old bitumen roofs (140 g/m^2 polypropylene fleece/geo-textile). Existing membrane to be slit at perimeters, change of angle, fixing lins etc to alleviate any stress/tension transfer to new fasteners and to assist in the drying out of any trapped moisture.	
Old gravel ballasted polymeric membrane	Where possible the existing membrane should be removed, if this is not feasible, the existing membrane should be slit at perimeters, change of angle, fixing points etc to alleviate any stress/tension transfer to new fasteners and to assist in the drying out of any trapped moisture.	
Liquid plastic roofs	Roofs should be evaluated, please contact Protan Technical Services.	

7 Wind load calculations

There are national wind load standards for calculating the local wind load to which a building is exposed. National wind load standards must always be used as the basis for the installation of a mechanically fixed or ballasted roofing membrane. Protan design guide is based on work from SINTEF Building and Infractructure and the Norwegian Roof Producers' Research Group, TPF. It is tailored to meet the specific requirement of EN 1991.1.4:2001 NA. Wind actions, which will be the model standard in all countries which are members of the European Standards Organisation (CEN).

Roofing systems:

Protan's roofing membranes can be installed in four different ways. As a rule of thumb, the polyester-reinforced products are used for mechanically fixed roofs, while glass fibre-reinforced products are used for ballasting.

Mechanical fixing	– Protan SE, EX, SE Titanium + and BP
Ballasting	– Protan G and GG
Bonding (Adhered)	– Protan EX-A
Vacuum	– Protan SE, EX and BP

Wind load calculation:

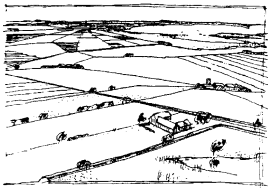
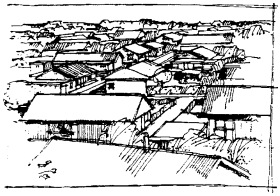
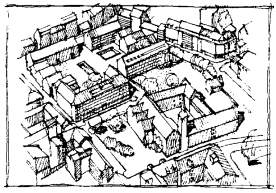
A wind load calculation must be performed for all roofing projects, both refurbishments and new builds. The information required to perform a wind load calculation for a building is as follows:

- Location
- Reference wind speed
- Height above sea level
- Height of the building
- Roof type
- Terrain category
- Topography

When the location in which the building is located is known, the reference wind speed can be determined from national tables in the wind load standard. When the address is known, the height above sea level can also be determined as the ground level of the building. The roof type and the height, length and width of the building are also important information for the calculation and the division of roof zones and their size for the roof area.

Terrain category:

The wind speed is very much affected by features of topography. EN 1991-1-4 has defined two major aspects of influence; roughness factor related to terrain category and topography factor related to hills, cliffs etc.There are five classes of terrain category. These vary from open sea to towns and dense spruce forests. The terrain can also be described as the degree of roughness and describes how the wind is affected by obstacles on the terrain. Low roughness results in the wind being reduced less by the terrain. See the table on the next page.

Terrain category 0	Sea, coastal area exposed to the open sea.
Terrain category I 	Coastal, rough sea. Open country and beach zones.
Terrain category II 	Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights.
Terrain category III 	Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest).
Terrain category IV 	Area in which at least 15 % of the surface is covered with buildings and their average height exceeds 15 m.

If, within 10 km of the building, the terrain has a lower roughness than where the building is located, i.e. more open terrain exposed to wind, the open terrain category for this terrain must be used in the wind load calculation.

Topography:
It can be complicated to determine the building's situation in relation to the terrain. It has therefore been simplified to five alternatives in which only two dimensions in the topography are taken into account. The building's location in relation to the top of the terrain and the height of the top are the important factors. This is a simplification of the standard and produces a somewhat stricter calculation than the precise three-dimensional calculation on which the standard is based.

1) The building is located on flat terrain (no topographical impact)
2) The building is located behind the top of a slope
3) The building is located in front of the top of a slope
4) The building is located on a ridge
5) The building is located on the leeward side of steep terrain

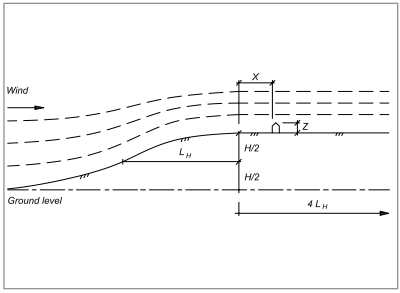


Fig. 10 2) The building is located behind the top of a slope

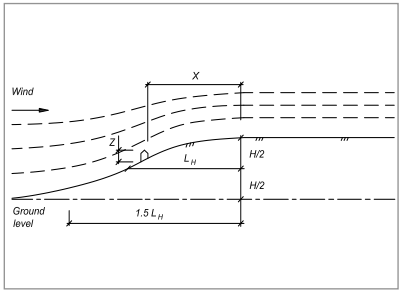


Fig. 11 3) The building is located in front of the top of a slope

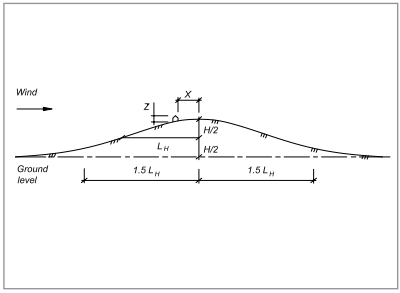


Fig. 12 4) The building is located on a ridge

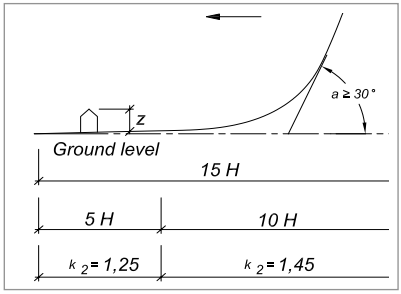


Fig. 13. 5) The building is located on the leeward side of steep terrain

The forces of the wind on the roof surface:

The principles of how wind affects buildings are well known. In simplified terms, it can be said that the roof surface is divided into three zones, the corner, edge and field zones, for most roof types. The impact of the wind is always greatest in the corner zone, a little lower in the perimeter zone and lowest in the field zone. This explains why it is necessary to fix the roof tighter in the corner and perimeter zones than in the field zone.

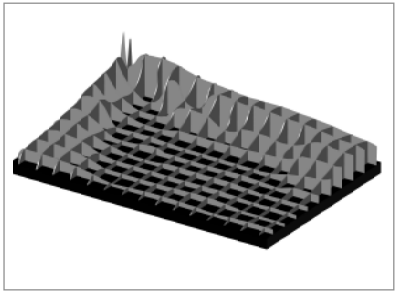


Fig. 14

To determine the size of the corner, edge and field zones, respectively, the roof must first be defined as a high or low building. For this determination, the highest value of b, the dominant wind façade, must be determined. In principle, this always means the widest side of a building from which the wind can come.

- A building is defined as a low building if it is wider than twice its height (b > 2h)
- A building is defined as a high building if its width is less than or equal to twice its height (b < 2h)

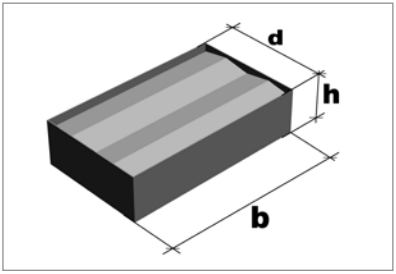


Fig. 15a Low building b > 2h

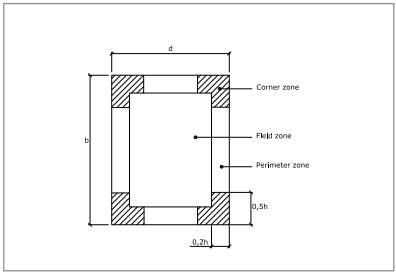


Fig. 15b

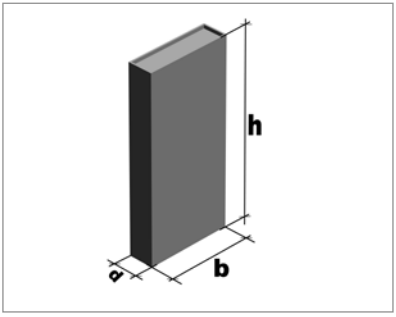


Fig. 16a High building b ≤ 2h

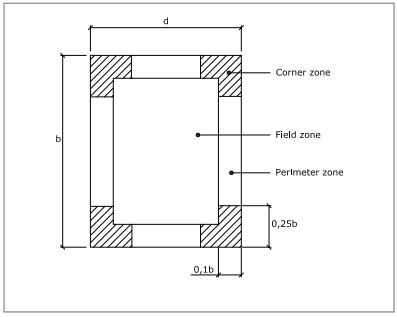


Fig. 16b

Calculation form

Project name/number: Street and street number: Postcode/post town: Municipality:	
Construction site's height above sea level: Largest width facing wind - b: Building depth - d: Other dimensions:	
Roof type:	Flat roof Monopitched roof Duopitched roof Arched roof/dome
Terrain category	**0 Open, rough sea** I Coastal, rough sea. Open country and beach zones II Agricultural area, area with scattered small buildings or trees III Continuous small houses, industrial area or forest area IV Urban areas in which at least 15% of the area is covered by buildings and their average height exceeds 15 metres. Spruce forest areas
Topography	The building is located on flat terrain The building is located behind the top of a slope The building is located in front of the top of a slope The building is located on a ridge The building is located on the leeward side of steep terrain
New building/reroofing: **External load:** Permeable/non-permeable substructure: Tight building/building with openings:	
Internal load: **Vapour barrier, (type):** **Permeable/non-permeable substructure:**	
Roof's supporting structure/quality: **Steel plates:** Thickness: Profile centre distance:	
Insulation (type, thickness)	
Fixings: In the roofing (tubes/washers): In the supporting structure (screws/nails):	
Pull-out value:	

Mechanical fixing with polyester-reinforced products:

The purpose of mechanical fastener is to fasten the roofing membrane to the load-bearing structure to ensure that the roofing membrane withstands the wind forces to which it will be exposed in its expected life. The roofing membrane is laid out loose, straightened up and tightened before the fasteners are installed. A correct wind load calculation provides the wind's dimensioning load for the different roof zones. The dimensioning load is used to calculate the distance between the fasteners in the roofing membrane.

The fasteners are washers or tubes made of plastic or metal in combination with suitable screws, plugs or nails, depending on the type and quality of the supporting substrate. To be able to absorb and transfer the wind forces between the fixing and the roofing membrane, a roofing membrane with a reinforcement of strong polyester is used.

To ensure that well documented fasteners are used, fasteners with SINTEF Approval or equivalent must be used. The tube/washer must be tested for wind load according to the applicable standards in combination with the type of Protan roofing membrane to which it is to be anchored in the supporting substrate.
Standardised wind load tests form the basis of documented values of the fixing's pull-out strength (capacity) in the roofing membrane and the supporting substrate.

When calculating the mechanical fastener, it is necessary to assess what is the weakest link in the structure. Breakage can occur in:

- Screw/nail to the substrate
- The tube/washer with the screw/nail
- Design
- Tube/washer in the membrane

The lowest of these break values is used in the calculation and is called the calculation capacity.

Important rules for mechanical fixing/wind load calculation

- Always follow the calculation form. Check that the form matches the local conditions and the products delivered.
- The distance between fixings at the edge of the sheet must never be less (except in certain markets) than 200 mm or more than 1000 mm. When using 2.0 m sheet widths, the fixing interval must never exceed 530 mm.
- 2.0 m wide sheets must only be used in the field area of the roof and on roofs exposed to moderate wind (dimensioning load maximum 3,75 kN/m^2).

- 2.0 m wide sheets require that the substrate be reasonably air tight in the form of an air tight supporting structure or with an additional vapour control layer.
- 2.0 m wide sheets must always be used with washers/tubes with teeth/barbs or with a high design capacity. Alternatively, it is possible to use Protan EX and washers/tubes without teeth/barbs because the fleece on the back of Protan EX contributes to a higher pull-out strength.
- 2.0 m wide sheets must not be used on a supporting structure of steel-decks when it is thinner than 0.7 mm. In general, it is recommended not to use steel decks thinner than 0.7 mm.
- The parapet must be fixed mechanically with a Protan Grip Steel Bar in the substrate of the roof.
- Rectangular washers must always be fitted so that the longest side is parallel to the edge of the sheet.
- The fixing interval along the parapet/skylight/raised structure must never exceed 0.5 m and the fixing must normally be just as tight as in the corner area.
- The sheets should be installed across concrete/lightweight concrete elements, across the corrugation of steel decks and across wooden boards.
- The installation of insulation and the roofing membrane should be planned so that the mechanical fixing of the roofing membrane also ensures that the insulation boards are fixed. There is a requirement forat least one fixing per insulation board and this is done best by installing the roofing membrane across the panels. Alternatively, the insulation boards must be fixed separately. Be particularly careful when roofing with 2 m wide sheets.
- When fixing in concrete elements, the fixings must never be placed closer than 50 mm from the element edge on concrete and 100 mm on light-weight concrete.
- The fixing must never be installed closer than 30 mm from the membrane sheet's edge. Follow the fastener lines on the membrane. The entire washer must be within the edge of the sheet.

	Design windload	
	$q_d \leq 3750$ N/m^2	$q_d > 3750$ N/m^2
Min. number of fixing pts. – per insulation panel *) – per m^2	 1 1	 1 2
Max. distance between rows of fixing pts. – corner- and perim. zone – field zone	 1.0 m no. req	 0.6 m 1.0 m
Max. distance between fixing pts. in one row – corner- and perim. zone – field zone	 1.0 m no. req.	 0.6 m 1.0 m
Minimum distance between rows of fixing pts.	0.2 m	0.2 m

**) Minimum 1 or in accordance with suppliers specifications or local branch recommendations*

Ballasting

Ballasted roofs are roofs in which the roofing membrane is covered with a ballast such as concrete, concrete tiles, gravel (crushed stone or natural gravel) or soil as the basis for planting (green roofs). If the ballast consists of crushed stone with sharp edges, the roofing membrane must be protected with polyester fleece or similar with a minimum weight of 300 g/ m^2

The advantage of ballasting a roof may be aesthetic effects and the opportunity to use the roof area for other purposes. The supporting structure in ballasted roofs must be designed to withstand the weight of the ballast. Ballasting is, therefore, mostly used on concrete decks.

The main purpose of the ballast is to prevent the wind from affecting the roofing membrane. The critical factor in this respect is not just the total weight of the ballast but also the type of ballasting material used.
For example, fine-grained gravel can be blown off a roof surface more easily than concrete slabs.

If the underlying structure is to be defined as airtight, a 50 mm layer of round-grained natural gravel with a minimum grading of 16-23 mm provides adequate protection against evenly distributed wind suction; dimensioning load (q_d) < 3,75 kN/m^2 (in the corner zone, that is usually most exposed).

A grading of 16-32 mm is considered able to resist a wind speed of 80 m/s in a wind vortex before there is movement in the gravel. The speed in a wind vortex is calculated on the basis of the roof's dimensioning wind speed/load, which is calculated using the applicable wind load standard for the building in question.

50 mm concrete tiles are considered adequate protection against constant suction on the roof, q_d < 5 kN/m^2.

The following rules of thumb can be used for minimum protection:
- Low building, places not exposed to wind; gravel
- High building, places not exposed to wind; gravel plus concrete tiles in the corners
- Low building, places exposed to wind; gravel plus concrete tiles in corners and perimeter zones
- High building, places exposed to wind; gravel plus reinforced integral cast in corners and perimeter zones.

For additional safety when ballasting, it is necessary to use linear fixing along the parapet.

Bonding

In the Nordic countries, it is not common practice to bond entire roof surfaces and details. This is primarily because bonding is a very weather-dependent process. However, on some occasions, it may still be a good solution, given the right weather conditions.
All types of bonding that are to be used for Protan roofing membranes must be tested and approved for this purpose.

Adhering roof surfaces

Bonding entire roof surfaces is more common in more southerly parts of Europe than in the Nordic countries. The most common bonding method is full-surface bonding, using polyurethane adhesive on a load-bearing substrate. However, both water-based adhesive types and Protan contact adhesive can also be used under specific conditions. It is important to be aware that bonding is a very weather-dependent form of installation. For additional safety when bonding, it is necessary to use linear fixing along the parapet. Other conditions are that the substrate is suitable for bonding, i.e. dry and clean, there are good weather conditions and the temperature is not below 5 °C during installation. The supplier's instructions for use of the adhesive must be followed.

Bonded roof systems are particularly suitable for buildings with concrete decks, hollow decks, thin concrete elements, lightweight concrete and wooden substrates where mechanical fixing may be difficult for various reasons. Reroofing with additional insulation is another alternative.

A fully-bonded system with Protan roofing membrane will, for example, consist of a supporting structure, vapour control layer, thermal insulation and Protan EX-A. It is important that these layers are bonded to each other well to transfer the wind forces from the surface through these layers down to the supporting structure without them delaminating.

It is, therefore, important to ensure that the thermal insulation is adequately fixed to the substrate. If it is adhered with bitumen-based bonding, it will achieve adhesion of around 2.5 kN/m^2 while correctly fully-bonded membrane will achieve adhesion of around 10 kN/m^2. In areas exposed to wind, the insulation panels must, therefore, also be fixed mechanically to achieve sufficient fixing strength to the substrate to resist the wind load. The number of fixings is determined on the basis of the wind load calculation.

Bonding parapets and details

Bonding is also used to a certain extent to fix to raised edges such as higher walls, skylights, etc. Protan contact adhesive is used against vertical surfaces. Protan recommends always considering whether mechanical fixing can be used instead of bonding as it is more secure.
NOTE: Always use adhesives that are approved by Protan.

Vacuum Installation

Protan's Vacuum System means that the roofing membrane is laid completely loosely over an airtight, load-bearing substrate and is just anchored and made airtight to the parapet and penetrations.

A membrane that is in contact with a fully air tight, load-bearing substrate will transfer wind forces to the substrate as suction without movement. When the air flow over the roof surface creates negative pressure, the air volume within the roof system expands. The air volume increases most where the negative pressure in the greatest, i.e. in the corner and perimeter zones. To "drain out" this pressure and any air leaks, vacuum vents are installed where the negative pressure is expected to be greatest. The vacuum vents have valves that let air out but not in.Knowledge about the wind flows in and around a building form the basis of the design and positioning of the vents, which are carried out in consultation with Protan Technical Service. The air volume increases most where the vacuum is greatest, i.e. in the corner and perimeter zones. To drain out this overpressure and any air leaks from non-tight places, vacuum vents are installed where the vacuum is expected to be greatest. The vacuum vents have flaps that let air out but not in. Knowledge about the wind flows in and around a building form the basis of the dimensioning and positioning of the vents, which are done in consultation with Protan Technical Service.

All penetrations and connections to the parapet must be made airtight with linear load distributors (Protan Steel bar) and air seal tape.

8 Mechanical Installation of Protan Single Ply Roofing Membranes

Only Protan roofing membranes with polyester reinforcement are designed for mechanical fixing to exposed surfaces. In principle, this means all versions of Protan SE.

Fasteners

There are various types of fasteners on the market that are approved for use with Protan roofing membranes. The combination of fasteners (screws/ tubes) must be selected on the basis of their suitability for the supporting substrate, as well as the insulation layer, the thickness of the insulation layer and the type of roofing membrane. The fastening system must have SINTEF Building and Infrastructure Technical Approval or equivalent. This guarantees that the product is well documented and tested.
NOTE: Always follow the supplier's instructions for installation of the fasteners.

The figures show examples of fasteners for concrete roofs and steel roofs with plugs and self-drilling screws, respectively. Screws can be used on wooden roofs. They may be self-drilling.

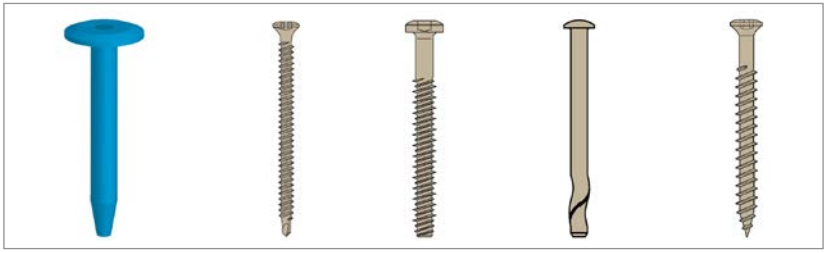


Fig. 17

Corrosion protection, use groups
The corrosion protection of the mechanical fasteners must be documented and assessed in relation to the assumed impacts on the roof. Corrosion protection is divided into four use groups:

K – for buildings with little added moisture
– normally not recommended

KL – for buildings with a risk of extended periods of condensation moisture on the fastener caused by high relative humidity in the air between the membrane and the tight substrate
– can be used where the conditions are normally considered to be unproblematic.

KLA – for buildings with a high risk of extended periods of condensation moisture on the fastener on account of high relative humidity in the air between the membrane and the tight substrate. Also used where there may be aggressive substances in the insulation or for reroofing where there is little opportunity for drying
– recommended for use in most cases

KLAM – for the same type of building as KLA but with an additional risk of wear and damage of any corrosion protection during installation, for example via a shale-strewn bitumen membrane
– this is a new use group that is designed to cover cases in which the fastener is exposed to mechanical wear during installation and where the conditions are otherwise like use group KLA

Plastic tubes or aluminium washers are assumed to meet KLA requirements without testing.

Steel screws
There are three main types of steel screw on the market:
- screws with a standard tip for fixing in thin and medium-thin sheets
- self-drilling screws with a full drill tip for fixing in thick sheets or
- self-drilling screws with a reduced drill tip for fixing in thin or medium-thick sheets.

The screws are produced with various head shapes to meet the producer's or user's requirements. They are available in stainless steel or corrosion-protected in various ways to meet the requirements of the specific use groups. Steel deck thinner than 0.7 mm should not be used.

Protection against unscrewing:
The most important means of preventing screws from coming unscrewed is to use a washer with a long tube in combination with a short screw. This results in the movement in the membrane that is transferred to the washer being transferred to the steel screw to only a small extent. Systems of barbs or a special thread design will also prevent screws from coming unscrewed. Consult the fastener supplier to ensure you select the correct screw.

Concrete screws / nails / spikes
Concrete screws are most common fasteners for concrete deck. Nails and spikes are also available.

Concrete screws have an anti corrosion coating, nails and spikes are mostly made of stainless steel. A common feature of all fasteners for concrete is that they are installed in predrilled holes in the concrete.
Be careful to use the correct drill diameter and drill depth so that the producer's recommendations are followed.

Imprecise drill holes or drill holes with the incorrect diameter will not produce the intended protection against removal.
In concrete elements it is important to be aware of the following factors:

- Through drilling
- Any tension cables/reinforcement in the elements
- Never drill holes less than 50 mm from the edge of the element on account of the risk of flaking

When a deck is drilled through, pieces of concrete are usually knocked out on the lower side. This is usually only an aesthetic problem but problems may arise with the fixing if a lot of concrete is knocked out in relation to the anchor length of the concrete nail or screw. This is particularly relevant on DT elements. Protan recommends using screws to avoid the concrete flaking.

Lightweight concrete screws
Separate lightweight concrete screws are available or screws in combination with expanding tubes/plugs for fixing in lightweight concrete. The installation instructions must always be followed carefully. Be particularly careful to use the correct length of fastener and to ensure that it has an adequate fastening depth in the substrate. Use the correct drill diameter and special tools for installation. Be particularly aware that installation tools may vary with the length of the fastener. The fixing must not be less than 100 mm from the edge of elements on account of the risk of flaking.

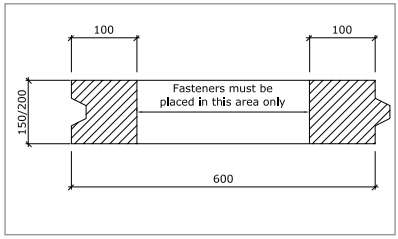


Fig. 18

Wood screws
Ensure that the screw is long enough to pass right through the substrate and that the screw is threaded right up to the head. The screw must be adapted to the washer used. Ensure that screws are not overtightened. Preferably use an electric screwdriver with adjustable torque.

Roof boards have many joints, cracks and knots. If the screws are inserted in them, it may lead to weak fixings. With mechanical attachment on roof boards, the membrane should be laid so that the fixing goes across the board direction. If the membrane has to be laid parallel to the roof boards, it is necessary to ensure that the fasteners are outside the joints.

Plastic tubes
There are a number of different plastic tubes on the market. They may have a round or rectangular washer part with or without barbs.

The tube produces a telescopic effect when using a compressible substrate of insulation such as mineral wool. The plastic tube does not conduct heat and therefore also prevents efficient heat transfer through the insulation layer. Plastic tubes are used in combination with different types of screw for fixing in profiled steel deck, for roof boards or together with different steel nails or special concrete screws for fixing in predrilled holes in concrete. There are also special washers and screws for installation in lightweight concrete.

Metal washers
Attachment with standard steel washers in longitudinal overlap joints can be used on solid substrates such as roof boards or concrete. The metal washers may be round or rectangular with or without punched spikes. On a substrate of insulation with a compressive strength of min. 80 kPa such as EPS or equivalent, some steel washers can be used but mostly plastic tubes are used.

Methods for mechanical attachment

At the edge of the sheet
Protan roofing membranes with polyester reinforcement are fixed mechanically by the rolls being rolled out, straightened up, tightened, fixed at both ends, welded together and fixed systematically along one longitudinal edge of the sheet with fasteners. The fasteners are installed with the edge of the screw/core 30 mm from the edge of the sheet. The next sheet is laid with a minimum of 120 mm overlap. 2 m wide sheets must have 130 mm overlap. The joints are normally done with a 40 mm welding nozzle (automatic welding machine).

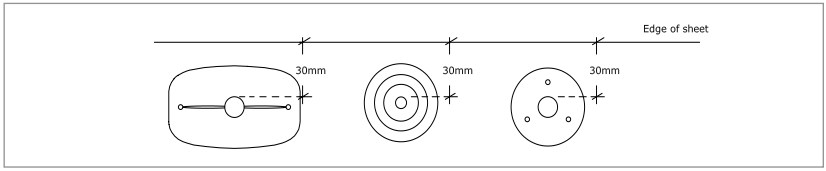


Fig.19

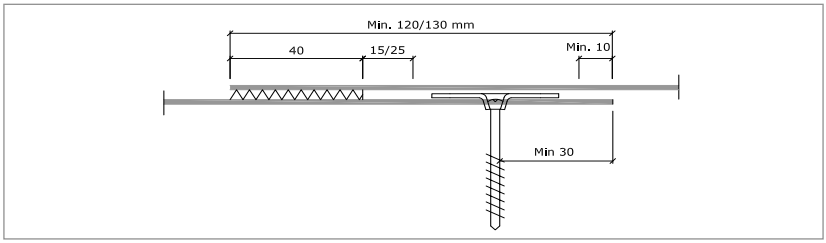


Fig. 20

The positioning of fixing points is geometrically linked to the width of the sheet in one direction. When the membrane is lifted up under wind load, the weld edge is exposed to tensile forces both vertically and horizontally. Therefore, it is important for the inner edge of the weld to be even approximately 15 mm from the edge of the fastener. In an uneven weld, the weld is subject to spot load, while an even weld distributes the wind forces linearly. An even weld is obtained best by using an automatic welding machine.

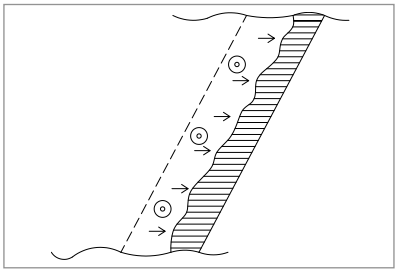


Fig. 21 Uneven weld

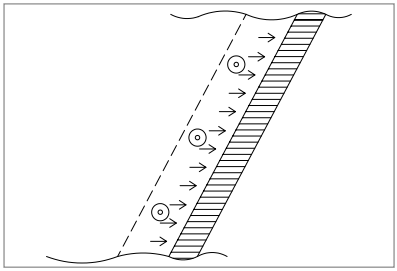


Fig 22 Even weld

The capacity (strength) of the fixing in the roofing membrane depends on the material from which the washer/ tube is made and its design. If the fastener is incorrectly installed, this may lead to poorer capacity in the roofing membrane than that specified.

Rectangular washers are fixed so that the long side is parallel to the longitudinal edge of the sheet. Any incorrect installation may affect the quality of the weld. This happens by the lock belt or pressure roller on the welding machine not functioning optimally when passing an incorrectly installed fastener and this resulting in poorer/uneven quality of the weld.

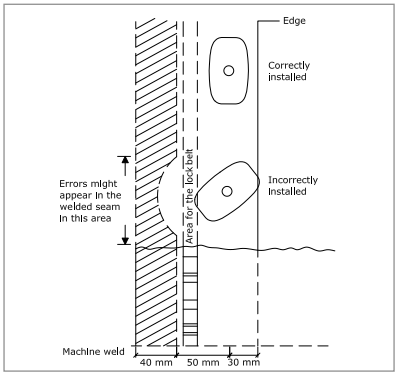


Fig. 23 Stress points in the welded seam caused by incorrect installation of fasteners

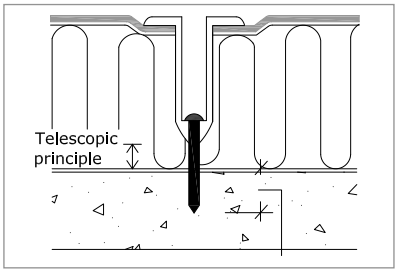


Fig. 24a This installation gives the proper telescopic principle

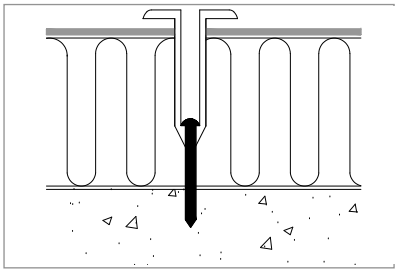


Fig. 24b Fastener installed too loose
- Screw spike or tube is too long
- Hole is not deep enough

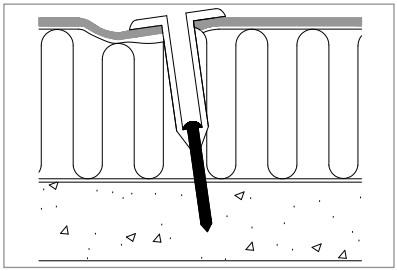


Fig. 24c Fastener installed at an angle to the substrate. After a long time this can cause the edge of the tube to wear through the overlapping membrane

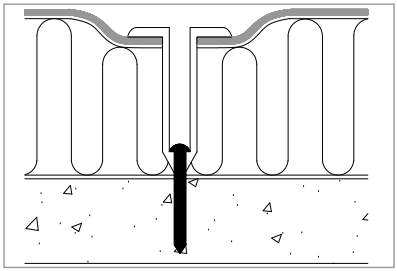


Fig. 24d Fastener installed too deep
- Screw/spike or tube is too short
- Hole is too deep

In the underlying secret strip - Protan secret fix strip sheets with longitudinal strips

The fastener is inserted in the secret strip that is welded to the underside of the roofing membrane. The fastener must be 30 mm from the secret strip edge and 15 mm from the pre-weld edge. The total width of the secret strip is approximately 120 mm, including the 40 mm weld.

The position of fixing points may be varied geometrically in both directions, depending on whether the secret strip is welded across the sheet or along the rear of large prefabricated sheets.

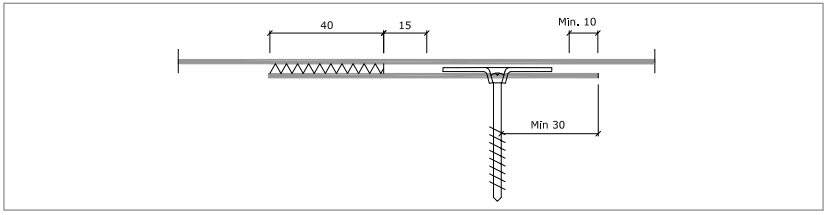


Fig.25

Through the sheet with cover
The fastener is installed through the membrane sheet outside of the overlap. The fixing points are covered with a 130 mm cover strip and 40 mm welds around the fasteners.

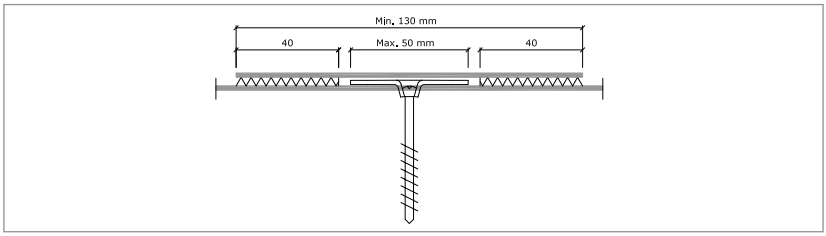


Fig. 26

Protan steel bar
In exposed roof systems Protan requires the membrane at the transition between the roof surface and the parapet to be fastened linearly.

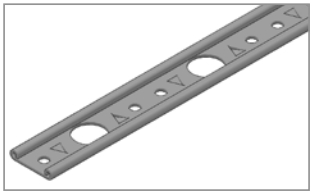


Fig. 27 Protan Grip Steel bar

Protan Steel Bar provides a good air seal and linear retention, as well as reducing the risk of point loading at the welds and fastenings. The strength and rigidity of the bar ensures that horizontal and vertical forces in the roofing are transferred to it as an evenly distributed load.

Protan steel bar comes in two variants, Protan Steel Bar and Protan Grip Steel Bar.

Protan Steel Bar has 20 mm diameter pre-drilled holes every 75 mm for insertion of fasteners in sleeves and between the 20 mm holes there are two 6,5 mm pre-drilled holes at a distance of 25 mm apart for screws without plastic selves. The Protan Steel Bar is primarily used in parapets with secret fix pocket placed in the change of angle.

Protan Grip Steel Bar has 20 mm diameter pre-drilled holes for insertion of fasteners in sleeves and between the 20 mm holes there are two 6,5 mm pre-drilled holes at a distance of for screws without plastic selves. On the reverse, the bar has "teeth" facing both directions for extra "grip" in the parapet secret strip. The Protan Grip Steel Bar is primarily used in parapets with secret fix stips placed in the change of angle.

9 Hot Air Welding

Protan roofing membranes are welded with hot air, either with handheld equipment or with an automatic welding machine. The welding is performed by the roofing membrane being rolled out with an overlap. Both sides of the overlap are heated to melting point (around 170°C) and pressed together with the pressure roller. Although it is a good practice to put the overlap in fall direction, this is not necessary to take into account when weldig Protan PVC roofing membrane. The PVC from both sides melts homogenously together in the joint. The advantage of hot air welding is that the method can easily be adapted to varying climatic conditions by finding the optimal relationship between heat, air flow rate and rate of progress. Welding under humid conditions creates no problems either as the hot air dries the welding surface before the roofing membrane is melted and pressed together.

Test welding is always necessary to find the correct settings for the welding machine.

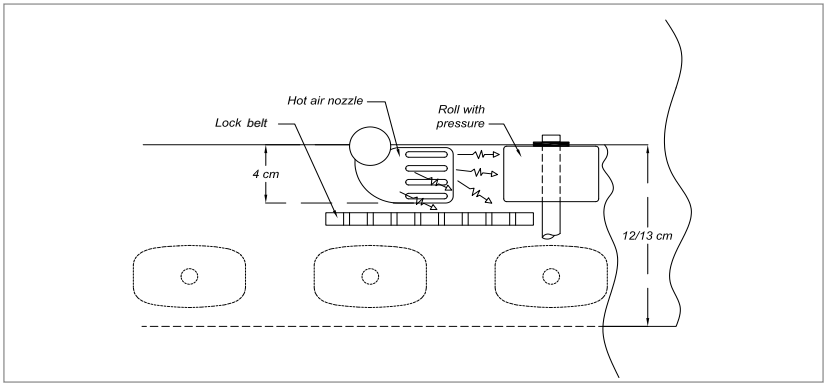


Fig. 28

Welding PVC
A correct weld is characterised by good PVC melt-out along the weld.

- If the heat is too high or the rate of progress too slow:
  – The roofing membrane is burned and charred.
- If the heat is too low or the rate of progress too fast:
  – No melt-out and the weld can easily be separated.

Note the separate procedure for welding "wet" roofing membranes.

During welding, there will always be some welding smoke. Make sure the temperature is set optimally on the handheld equipment and the automatic welding machine to minimise the welding smoke. When welding indoors or outside in stationary air, use a breathing mask, for example a half mask with an A2/P2 filter (3M 4255). Alternatively, establish ventilation.

Rule: one welding/peel test at the start and subsequently for every 200 linear metres of welding. For a tear/peel test, the width of an approved weld should be 40 mm.

Welding procedure for machine welding PVC
To avoid folds in the roofing membrane, the sheet must be stretched. The roofing membrane is then fixed at both ends before machine welding begins. The welding temperature and rate of progress must be adjusted according to the outdoor temperature, the thickness of the roofing membrane and any moisture in the welding area. The PVC must always melt out along the weld. Ensure that the power cable for the machine is the correct length. Please note that thicker roofing membranes and/or water-proofing membranes require a slower welding speed and extra weights on the welding machine, not necessarily a higher welding temperature. Remember to carry out peel tests of the welding at the start and subsequently for every 200 linear metres of welding. For a tear/peel test, the width of an approved weld should be 20 mm.
Where a welding sample has been taken, a round patch marked "Quality inspection" must be placed over the sample location. Quality inspection patches with text printed on them are supplied in standard colours. They are sent with the delivery in a quantity of 1 per 100 m^2 Protan roofing membrane. It is recommended that you stock a suitable quantity of quality inspection patches in relevant colours in case you need more.

T-joints
A welding machine can be used to make proper T-joints in roofing membranes in thicknesses up to 1.6 mm. To avoid an open channel (leakage) at the intersection, additional pressure is applied to the welding machine with the hands. Alternatively, use a pressure roller over the T-joint right after the machine has passed over. The thicker the roofing membrane, the more care the roofer must take when welding T-joints. There must always be reinforcements on T-joints when the roofing membrane is thicker than >1.6 mm. NOTE: Reinforcements must always be welded on over T-joints on membranes.

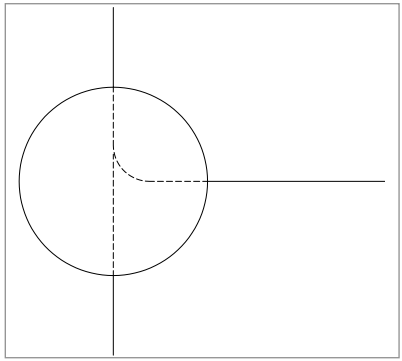


Fig. 29 T-joint with reinforcement

Transition from machine weld to hand weld
The transition between machine weld and hand weld must be made as shown in figure no. 30. Remember to tear back the weld to a "good weld" before hand-welding. If you are uncertain, you can weld a round 110 mm

reinforcement over the area. A clear transition can be achieved by using a steel plate (approximately 100 x 200 mm) in the overlap at the start and finish of machine welding.

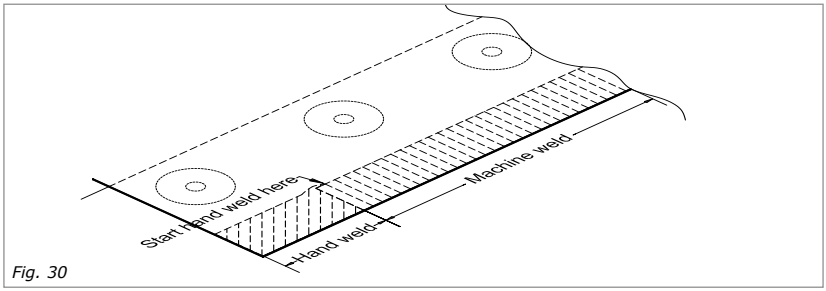


Fig. 30

Hand-welding PVC
Details are welded with a 20 mm nozzle and a narrow pressure roller. If you perform a longitudinal weld with handheld equipment (replacing a machine weld), you should use a 40 mm wide nozzle and a wide pressure roller. This is to achieve the correct width and strength of weld and to ensure a straight welding line. This is particularly important when hand-welding Protan SE on mechanically installed roofs.

Method:
Work out the correct welding temperature on a test piece of roofing membrane and perform a test weld. For a tear/peel test, the proper weld width should be minimum 20 mm.

NOTE: It is not regarded as necessary to perform welding tests for hand-welding as this is a very controlled process. Hand-welding always starts with a pre-weld.

NOTE: Spot welding is prohibited when welding roofing membranes.

The purpose of the pre-weld is to establish a barrier to prevent hot air from disappearing under the roofing membrane. The pre-weld contributes to a controlled welding process when the main weld is to be performed. The pre-weld also stabilises the roofing membrane so that the main weld can be performed without any movements in the roofing membrane. The pre-weld is performed by the nozzle being placed flat in between the two layers of roofing membrane at a distance of approximately 30 mm from the edge of the roofing membrane. The pressure roller is pressed parallel to the nozzle opening.

Main weld with handheld equipment
When the main weld is performed, hold the nozzle and the pressure roller

angled (approximately 45°) to the edge of the roofing membrane. Tilt the nozzle up a little at the front. We recommend a distance of approximately 10-20 mm from the nozzle opening to the pressure roller. Roll the pressure roller parallel to the nozzle opening and well over the weld joint so that an even melt out of PVC can be seen.
Make sure the temperature is set correctly on the handheld equipment to minimise the welding smoke.
NOTE: A correct weld is characterised by good melt out of PVC material.
If the membrane along the weld becomes brown, the heat is too high. It is then necessary to lower the heat and/or increase the rate of progress.
In the opposite case, if the roofing membrane separates on account of incomplete fusion, the heat must be increased and/or the rate of progress must be reduced. If you suspect that there is a weak welding area, always place a reinforcement over it. Uniform, round reinforcements must be used on the roof.

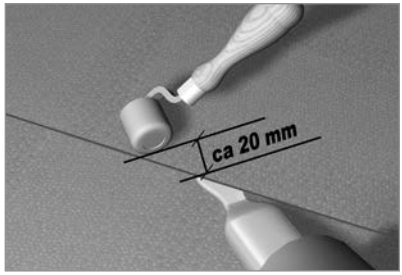


Fig. 31 Hand weld

TACK WELDING IS PROHIBITED!

It is often observed that roofers have the habit of spot-welding roofing membranes in place. Spot-welding means when the roofer uses the hand-held equipment and welds spots, for example every 500 mm in the overlap on the inside of the pre-weld. The roofer does this to hold the roofing membrane in place in the wind and/or to stretch it before machine-welding or hand-welding. These weld points are subject to the entire wind load. Protan roofing membranes are not designed to transfer wind forces in such spot welds. If you spot-weld Protan roofing membranes, holes (tears) can occur in the weld spots over time, with leaks and water damage as a result. It is therefore prohibited to spot-weld Protan roofing membranes.

Welding "wet" roofing and waterproofing membranes

Protan G products
Protan G and GG are subject to more moisture absorption than the SE membranes.

- In roof or membrane projects, where the membrane is stored for a long time, it is necessary to ensure that it is stored correctly, preferably under a roof or in a separate container.

NOTE: Important: rolls of membrane must not be used for temporary ballasting.

G membranes that have been placed outdoors for a while have sometimes been difficult to weld. If you have dried the membrane as described below and the welding samples are still not approved, the joint may be reinforced

with an approximately 200 mm wide strip of Protan SE 1.6 mm. This strip is welded over the membrane joint.

Protan SE products

- At a construction site, it is important for the rolls to be stored on a pallet (off the ground) and for them to be covered with a light tarpaulin. SE-L may trap moisture more than regular SE.
- Rolls of roofing membrane must not be placed on the roofing for the purpose of temporary ballasting.

We recommend that parapets and details be installed as the roof area is laid. At certain times of the year, moisture absorption can lead to welding problems if the parapet is welded long after the roof surface has been covered.

- It is important to store the parapet upstand restraint correctly. It must be stored dry and otherwise in the same way as the roofing membrane.

Remember to take welding samples.

Testing welding joints

Current test methods:

1. Manual test with the seam probe.
2. Tear/peel test.
3. Vacuum test.
4. Water pressure test (tests the entire surface).

Manual test with the Seam Probe

Place the point of the seam probe against the edge of the welded area. Pull the probe along the seam applying a little pressure. This will detect any areas that have not been welded correctly, when the probe penetrates the unwelded area. When a ”fish mouth” is discovered, pull the mebrane apart until it meets an area where the weld can no longer be separated. Then use the hand welder to reweld open area.

Fig. 32 Manual test with seam probe

Tear/peel test
Welding samples must be taken from all machine welds performed on the construction site. NOTE: A minimum of one sample must be taken at the start of welding and peel tests should be carried out at 200 lm intervals The weld must be tested in cooled condition. In a good weld, the material must not separate in the weld but in the weave. The proper weld width should be minimum 20 mm. If, for aesthetic reasons, it is not possible to cut out welding samples in the roof surface, test welding may be performed away from the roof surface.

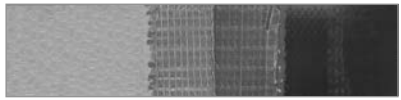


Fig. 33 Tear/peel test

NOTE: Only when roofing with a special colour or in cases in which quality inspection patches are not available is it possible to cut round reinforcements in the same size and use these as quality inspection patches. Circular welding patches with a diameter of 180mm may be used.

Vacuum test
Vacuum testing with a bell is a safe, flexible, non-destructive test method.

Fig. 34 Vacuum test

Exposed points such as T-joints may be tested pneumatically with a vacuum bell. Any weakness in the T-joint will appear as bubbles after 2 or 3 seconds when soapy liquid is applied to the joint and suction from the vacuum bell is established.

Equipment required:
- Vacuum pump with manometer and regulator
- Transparent vacuum bell
- Leak indicator liquid

Test procedure:
1. Spray indication liquid (soapy water or windscreen wiper fluid) onto the joint (test area).
2. Place the vacuum bell over the test area.
3. Establish a vacuum for 2 or 3 seconds (the roofing membrane is sucked up).
4. A leaky point will appear with bubbles.
5. Mark any weak points and weld reinforcements over them.

Water pressure test
Water testing is suitable as a test method only on membranes in which any leak will not cause damage (for example a structure of steel or concrete without fittings).
The method is not suitable and must not be performed for testing the tightness of roofs where the building is inhabited or houses an operational business.

The fall of the roof means that a high water level is required for a water test, which may provoke a leak that would not otherwise have occurred. The pipe system may not be able to withstand the powerful water pressure that a water test entails. No standard insurance covers damage caused by a water test. In addition, the insulation in the structure will be moistened by any water penetration. Wet insulation must be replaced. In other words, water testing is not suitable where the water may damage the underlying structure more than normal climatic impact.

Water testing must be used with care when there is a risk of temperatures approaching freezing point. Water testing must not be carried out at temperatures below freezing point.

Before water testing begins, the construction management must be notified and the weight of the water must be assessed against the load-bearing capacity of the structure. 100 mm water is equivalent to 100 kg/m^2. Always seek advice from the building's consultant. Instead of sealing the rainwater outlets to perform the test, it is possible to weld an "elevation ring" around the rainwater outlet. This avoids an unintentionally high water level.

For most structures, a test time within normal working hours will be sufficient. Water testing in accordance with the wet room standard is for 24 hours. A roof that is subject to pressure testing must not be left as, in the event of leaks, water penetration may occur that requires the roof to be emptied of water fast. Water must be drained carefully to avoid pressure build-up in the drain pipe. The pipe system is not normally dimensioned for this and, as mentioned earlier, the consequence may be major water damage. It may be expedient to use a few siphons (hoses) in addition when draining the water.

It is important to make clear agreements with the client in connection with a water test. The following must be clarified:

1. The area to be water-tested.
2. That the area is ready for testing (fully roofed and the pipe system is connected).
3. The time of water testing – start and finish.
4. Inspection of the roof during the water test.
5. Inspection during drainage.
6. Authorised signature that the water test has been performed.

NOTE: Do not have the water test carried out overnight or over a weekend.

We recommend always conducting a pressure-test or vacuum-test all membranes before covering and integral casting take place.

Important: get the signature of the construction manager stating that the membrane has been tested and approved. Protan has a separate form for water testing membranes.

10 Roofing Systems/Principles – Installation

It can be very profitable, in terms of the quantity of work, economy and ergonomics, to choose the right roofing system when a roof surface needs to be covered. Protan's roofing systems contain many product and system versions and it may be very beneficial to combine them.
Set aside time for thorough planning. This investment will be repaid in efficiency out on the roof!

Mechanically fixed roof surfaces – exposed roof surfaces

Exposed roof surfaces are roof structures in which the sealing/water-proofing layer is the top layer and is resistant to the impact of the wind and weather. This means that the roofing membrane must be watertight, resist UV radiation from sunlight, withstand local wind forces and be fire-resistant according to the applicable rules for spread of flames. These are functional requirements that are normally made for an exposed roof surface.

Protan SE and EX

Protan SE and EX have a core of polyester that provides good strength for mechanical fixing so that the wind forces on the roof surface are transferred to the supporting roof structure.
The fleece-coated versions of Protan SE make installation easier on structures for which a form of migration barrier is required as the migration barrier is laid in the same process as the roofing membrane. Protan EX is preferably used for reroofing old bitumen roofs. Laying a loose migration barrier with Protan SE is also an adequate solution but involves an additional operation on the roof.

Installation

Protan SE and EX must only be fixed mechanically (apart from vacuum roofs). At the start of the roofing process, the first sheet is rolled out, aligned, stretched up and fixed at both ends. Fasteners are then installed along both longitudinal sheet edges at the interval described in the wind load calculation for the roof. The next sheets are rolled out, stretched and fixed at both ends before being welded to the previous sheet. Fasteners are then installed along the loose longitudinal sheet edge. The line marked along the sheet shows where the overlap is to be (120 mm) and where the fasteners are to be placed (approximately 37 mm from the sheet edge). The roofing membrane is supplied in widths of 1.0 m and 2.0 m as standard. For 2 m sheet widths, the overlap is 130 mm.

Rule: welding first, then mechanical fixing! Remember to stretch (kick) the roofing membrane carefully out when you put the fastener in place to achieve good stretching and an even surface on the roofing membrane.

Installation of sheets - Protan SE and EX

1. Roll out the entire roofing membrane from A to B.
2. Adjust the roofing membrane so that it has a 120 mm overlap. Follow the marked line.
3. Place 2-3 fasteners at one end.
4. Stretch (kick) the roofing membrane carefully in the longitudinal direction.
5. Place 2-3 fixings at the other end.
6. Run the welding machine from A to B.
7. Place fasteners along the sheet edge. Follow the dimensioning table for correct fixing intervals and the marked line. Stretch/kick the roofing membrane carefully out sideways while installing the fasteners.

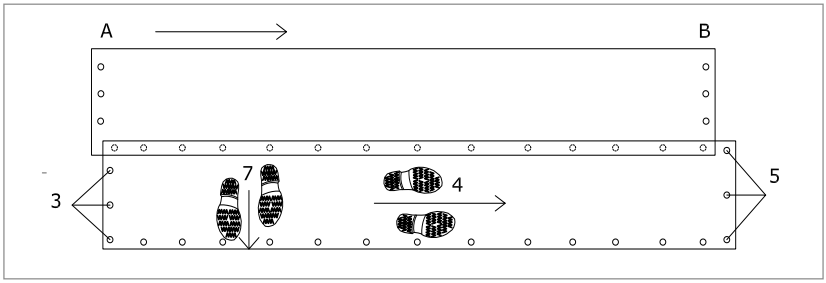


Fig. 35

Protan EX

This SE quality has been specially developed for reroofing old bitumen or synthetic single ply roofs. A polyester fleece (migration barrier) is laminated to the underside of the roofing membrane so that the migration barrier and the roofing membrane are laid out in one operation. On the underside of Protan EX one longitudinal sheet edge is without fleece so that it can be welded with an overlap to the next sheet. Protan EX is installed as described above but the end laps must be butt-jointed and cover stripped. When Protan EX is rolled out on old bitumen, the fleece may get stuck. This can be a challenge when the sheets are to be stretched. To make it easier to stretch, it is recommended to lay plastic foil temporarily between the old membrane and Protan EX. The plastic is removed before the overlap is welded.

Another alternative is to use a simple stretching device such as a manual winch.

Butt-jointing: The end joints on Protan EX have to be cover stripped. This is achieved by laying the end joints against each other and a cover strip of approximately 250 mm Protan SE being welded over them.

NOTE: If 2 m wide sheets are mechanically installed, with screws and flat washers, on wooden substrates (without additional insulation), it is necessary to use Protan EX. This is to utilise the additional strength in the sheet edge with fleece.

Cover stripping end joints
In order for end joints to be cover stripped as well and as efficiently as possible, it may be an advantage to plan the roofing so that the end joints are beside each other on the roof surface. Cover stripping across several sheets produces a better, more uniform appearance in the roof surface. For fleece-laminated products, it may be an advantage order special lengths to minimise joints.

Roofing systems

Protan roofing membranes, mechanically installed sheets

Local wind loads will always determine which roofing system can be used. In general, it is expedient to use rolls of 1 m width in the field zone as well as in the corner and perimeter zones on roofs moderately exposed to wind and roofs with many lead-throughs or designer roofs with and without profiles.
2 m wide sheets are normally used in the field zone on roofs not exposed to wind. 2 m wide sheets are not permitted for use on supporting structures of lightweight concrete or in the corner and perimeter zones of a roof.
A combination of 1 m wide sheets in the corner and perimeter zones and 2 m in the field zone is often used. In areas particularly exposed to wind, it is necessary to use sheets narrower than 1 m, or to use Protan secret fix strips in the corner and perimeter zones with a suitable secret strip distance. It is often preferable to use prefabricated systems instead of narrow sheets as they are normally less labour-intensive.

Stop and lock

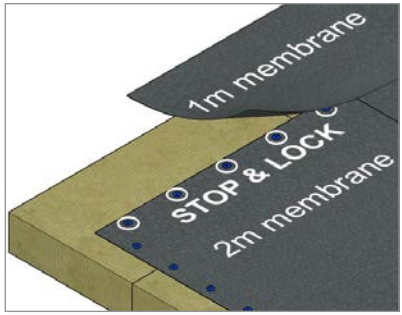


Fig. 36

For roofing with 2 m sheets, it is important to note the following: The material's initial shrinkage and the wind forces on the roof surface have a greater impact in a 2 m sheet than in a 1 m sheet. This is important to take into consideration when planning the roofing. In the transition between the field zone and perimeter zone, where the 2 m sheets finish ("stop") and, for example, it is necessary to use 1 m sheets in a transverse direction, the 2 m sheet must be fixed ("lock") along the short side. Otherwise, the forces in the 2 m sheet will be so large that it will pull the connecting roofing membrane with it. The sheet from the perimeter zone (secret fix strip, 1 m or narrower) is then welded over the end of the 2 m sheets. It is also important to take the forces in the 2 m sheet into account when changing the angle. The sheets must be "locked", if possible with a bar, to prevent the roofing membrane from rising in the buckling point.

Secret fix strips
(Protan SE quality only)

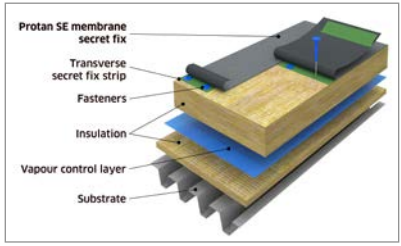


Fig.37a

Secret fix strips are Protan SE roofing membranes in a 2.0 m width with underlying secret strips, welded across the sheet direction. The secret strips are high-frequency welded to the back of the roofing membrane at a distance adapted to the wind load on the roof.

- The secret strip itself is 1.8 m long, which produces a 100 mm free weld edge on each side of the 2 m wide roll.
- The first two secret strips are installed the opposite way round to the others. The purpose of this is to align the sheets when laying them.
- The overlap must be approx. 100 mm.
- The secret strips are screwed to the supporting substrate and the fasteners must be placed as symmetrically as possible on the secret strip.
- The fasteners must be a minimum of 30 mm onto the secret strip and not closer than 90 mm to the end of the secret strips.

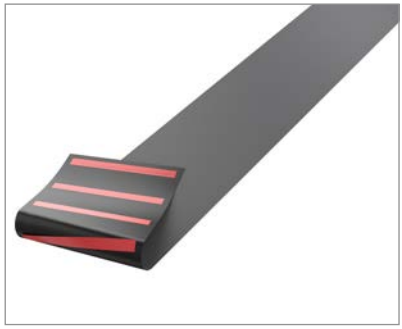


Fig.37b

- It is necessary to install a minimum of 3 and a maximum of 7 fixings in each secret strip.
- Only the secret strip must be used for fixing.
- It is recommended that fixings/tubes without barbs are used.
  On account of the strong textile in the secret strip itself, it is difficult to press the barbs through. As the secret strip is pressed down, the barbed tube will cause the membrane to gather/wrinkle during installation.

Number of attachments per stripnumber			3	4	5	6	7
Attachment distance in the strip mm			630	480	380	320	270
Number of attachments per square metre for:							
Strip distance (mm):	400	units/m^2	4	5,2	6,6	7,8	9,3
Strip distance (mm):	600	units/m^2	2,6	3,5	4,4	5,2	6,2
Strip distance (mm):	800	units/m^2	2	2,6	3,3	3,9	4,6
Strip distance (mm):	1000	units/m^2	1,6	2,1	2,6	3,1	3,7
Strip distance (mm):	1200	units/m^2	1,3	1,7	2,2	2,6	3,1

There are 2 systems for project planning and roofing with secret fix strips:

System 1:
- Equal secret strip distance and equally long rolls (for example rolls from stock).
- With equal secret strip distance, it is necessary to install a different number of fasteners in the different zones of the roof. The roofer must carefully follow the fixing plan.

System 2:
- Different secret strip distances and lengths for the rolls intended for the various zones on the roof (must be planned).
- With varying secret strip distances, you may achieve the advantage of installing the same number of fasteners in each secret strip, but the roofer must take care to use the right rolls in each zone.

At the start of roofing, it is important for the roofing membrane to be rolled straight. The next secret fix strip must be oriented parallel and with an overlap on the adjacent sheet. Deviations here will lead to too little or too much overlap. The secret fix strip cannot be stretched up in the same way as a 1 m or 2 m sheet.

a) If the secret strip is installed directly from the roll, there is little opportunity to stretch the roofing membrane.
b) It may, therefore, be expedient to fold the roll approximately 2 m back to make it easier to access the secret strips. We recommend doing this when roofing on soft insulation. The heavy roll sinks a little down into the insulation and creates an additional fold. If the roll is placed behind the secret strip installed last, this fold will be avoided. In addition, you will also have a little stretching of the roofing membrane.

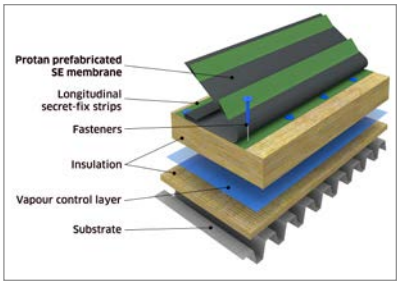
c) If the roofing membrane is rolled fully out and then folded back, you have the opportunity to stretch the roofing membrane a little.

The technique you choose to use depends on the substrate, weather conditions and your usual practice.

To increase progress, several sheets may be installed in parallel before the roofing membrane is welded. The overlap can be created the right way in relation to the fall direction to avoid water penetration.
A more detailed description of roofing with Protan secret fix strips is provided in a later chapter in the roofing manual.

Prefabricated sheets with longitudinal secret strips (Protan SE quality only)
Prefabricated sheets with longitudinal secret strips are sheets welded together on which secret strips are welded on the back in a longitudinal direction. The standard dimensions of the sheets are 3.96 m x 12.5 m, but in principle most dimensions required can be produced. The secret strips are welded to the back with a c/c distance adapted to the substrate and the local wind load. On the prefabricated sheets, the longitudinal secret strips are installed with the strips facing outwards from the centre. This is to make installation optimal.

1. The sheets are laid out and folded back to the middle secret strips.
2. The sheet is aligned and the secret strips are stretched up and then screwed to the structure.
3. The sheet is then folded out and installed strip by strip.



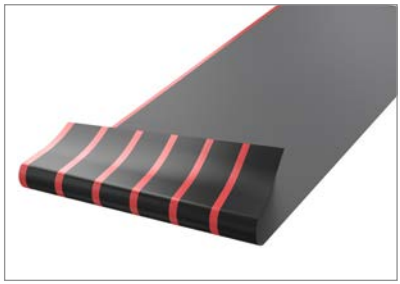


Fig. 38 Prefabricated sheet with standard secret strip location

The advantage of using prefabricated sheets is that they allow very fast installation as there is considerably less welding work on the construction site. The only welding work needed is to join the prefabricated sheets and the detail work. This produces fast, reliable progress. This is also an advantageous way of avoiding moisture in the roof structure.

Vacuum roofs – exposed roof surfaces

A roofing membrane that lies on a fully airtight, load-bearing substrate will transfer wind forces down to the substrate as suction without movement. For the substrates for which vacuum fixing is suitable, the method forms the basis for optimal roofing at an optimal cost. The roof's suitability for vacuum fixing must only be assessed in consultation with Protan.

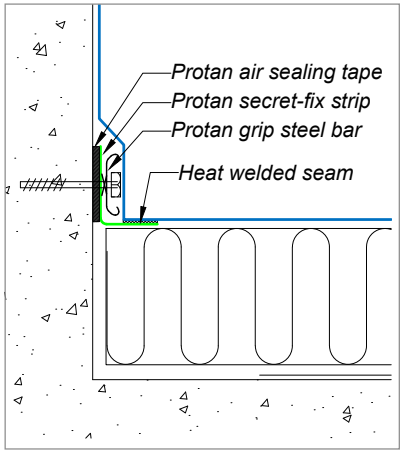


Fig. 39

2 m wide rolls over the entire roof surface or larger, prefabricated sheets are used to cover vacuum roofs. No mechanical attachment is required. However, the roofing must be made airtight around all lead-throughs, including rainwater outlets, and along the parapet. To achieve an airtight connection to the parapet and details, Protan air-sealing tape is used under a Protan steel bar to prevent air from penetrating through irregularities along the substrate.

When the air flow causes a vacuum to be created over the roof, the air volume between the membrane and the airtight substrate increases. The vacuum is greatest in the corner and perimeter zones. To drain out this overpressure and any air leaks from small non-tight places, vacuum vents are

Fig. 40 Vacuum vent

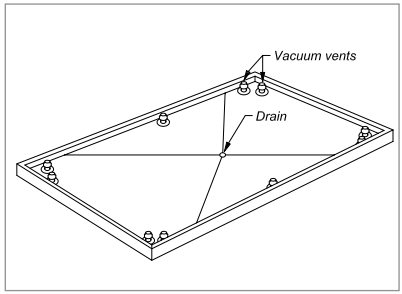


Fig. 41

installed where the vacuum is expected to be greatest. The vents have flaps that let air out but not in. In general it can be said that two vents must be placed in each corner of a roof, both internal and external corners, and per 15 linear metres along free roof edges. The location of the vents is determined in consultation with Protan.
Wind travels over the roof in gusts with rapid changes in intensity and local direction. These gusts may be reflected as "quivers" in the roofing in the same way as on the surface of water. It takes a few seconds for the pressure to be equalised and the roofing to cling to the roof. A correctly dimensioned and installed vacuum roof clings to the substrate.
The vacuum system is particularly suitable for reroofing, where existing roofing is considered to be sufficiently intact and to have adequate anchoring to the support system. New buildings in which the roof moisture barrier constitutes the airtight and load bearing layer are also well suited for vacuum roofs.

Bonded roof surfaces – Protan EX-A
It is most common to use bonded roof solutions in warmer parts of Europe. However, in some cases this roofing method may also be expedient in Nordic regions. Bonded roofing systems are particularly well suited for buildings with supporting structures that may make mechanical fixing difficult or labour-intensive such as concrete decks, concrete hollow decks, thin concrete elements, lightweight concrete and simple wooden substrates. Alternatively, bonded roofing solutions may be used for reroofing if an additional insulation layer is laid over existing roofing. However, here the insulation must also be fixed to the old roofing or down into the supporting substrate to enable it to absorb the wind forces.
Protan EX-A must be used when a roof surface is to be fully bonded.
A standard fully-bonded roof structure consists of:
- Supporting roof structure
- Vapour barrier
- Insulation
- Protan EX-A

The layers in this roof structure must be sufficiently well bonded to each other that the wind forces are transferred down to the load-bearing substrate.
The vapour barrier will normally be a bitumen felt that is solidly bonded to the substrate. The insulation must either be bonded to the vapour barrier or fixed mechanically in accordance with guidelines provided by the insulation supplier.
Protan EX-A is bonded to the insulation with a polyurethane adhesive approved by Protan for this purpose. When Protan EX-A is bonded to the substrate, the roofing membrane is

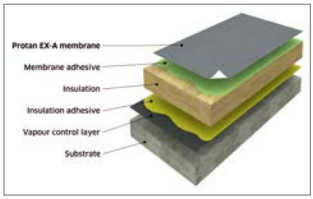


Fig. 42

welded together with standard overlap welding The ends are butt jointed and cover stripped. Any excess glue in the welding area must be removed. In addition to being bonded, Protan EX-A must be fixed mechanically to the parapet with a Protan steel bar, anchored mechanically along all lead-throughs and fixed in areas with large changes in angle. This must be done to avoid possible delamination in these areas that are most vulnerable to wind and tensile forces in the roofing membrane.

Roofing system selection

There are many factors to consider when selecting roofing systems for different roofs and it may make good financial sense to weigh them up against each other.

Each system has its own clear advantages/limitations that naturally affect the choice of roofing system. However, what is important is to consider the installation as a whole and perhaps spend a little extra time assessing the alternatives. On an optimally planned roof, there must be no more material waste than can easily be carried back down again.

A combination of systems is often the best solution. For example, secret fix strips in the corner and perimeter zones and standard 1 or 2 metre rolls in the field zone, or other expedient combinations. The tables below show a very simplified summary of the systems in which the various products must be used and where the various systems can be used most expediently on exposed roofs.

Roofing system Exposed roofs	Protan		
	SE	**EX**	**EX-A**
Mechanically fixed - standard overlap	✔	✔	
Mechanically fixed - Secret Fix Strip	✔		
Mechanically fixed - Prefabricated sheets (PFS)	✔		
Vacuum installed	✔	✔	
Bonded (fully)			✔

Roof Conditions	Standard 1m roll	Standard 2m roll	Secret fix	Prefabricated Sheets	Vacuum **	Fully Adhered
Large roof surfaces	!	✔	✔	✔	✔	✔
Small roof surface	✔	!	✔	!	!	✔
Pitched roof	✔	✔	✔	!	!	!
Many roof penetrations	✔	!	!	!	!	!
Rapid installation	!	✔	✔ / !	✔	✔	✔
Low capacity substrate	✔	✔ *	✔	✔	!	✔
High capacity substrate	!	✔	✔	✔	✔	✔
Difficult access	✔	!	!	!	!	!
Profiles	✔	!	✘	✘	✘	✔
High wind exposure	✔	!	✔	✔	✔	✘

✔ Very suitable
! Conditionally suitable
✘ Not so suitable
* Not suitable for aerated concrete
** Airtight substrate assumed

Parapet fixing - technical solutions

Protan requires the transition to the parapet generally always to be installed with linear fixing. Protan accepts several technical solutions for parapet fixing. However, a common feature of these is that Protan steel bars must be used.
Steel bars have the requisite suitability in respect of installation friendliness, strength and rigidity. To install Protan Steel Bar to the Parapet, use Protan secret fix pocket, and to install Protan Grip Steel Bar, use Protan parapet solution with secret-fix strip.

Note that the parapet substrate may be different from the roof construction. Suitable fasteners for the parapet subsstrate must be used.

Some pre-accepted solutions are shown here. Installation of the most widely used solutions are shown step by step later in the roofing manual. Any other solutions must always be approved by Protan.

Low parapet

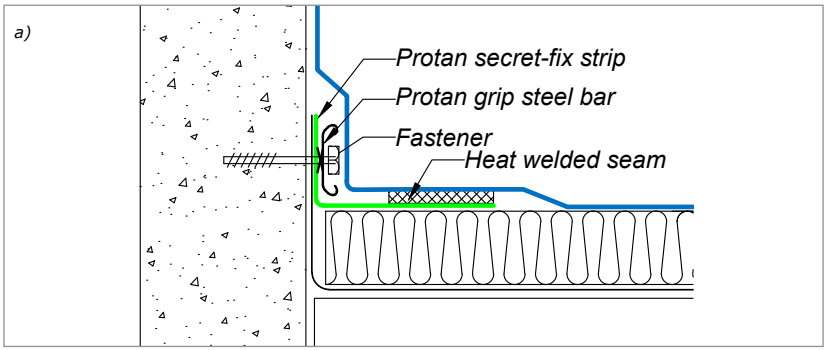


Fig. 43a Parapet skirt of Protan roofing membrane with a secret fix strip welded on for Protan grip steel bar fixed to the parapet.

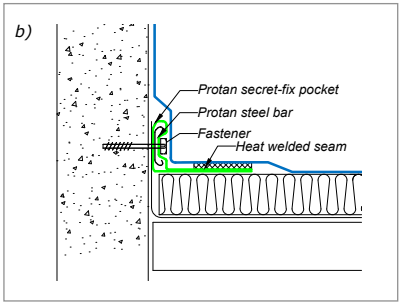


Fig. 43b Parapet skirt of Protan roofing membrane with secret pocket welded on fixed to the parapet with Protan steel bar.

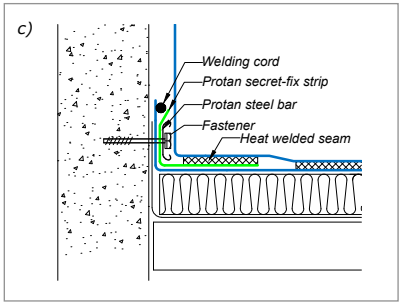


Fig. 43c Protan roofing membrane taken approximately 100 mm up on the parapet. Secret strip or pocket welded onto the parapet skirt, fixed mechanically to the parapet with a bar. Remember the welding cord between the roofing membrane and secret strip.

High Parapet, h ≥ 600 mm

It is necessary to weld an additional secret strip on the back of the roofing membrane to fix to parapets that are higher than 600 mm. The secret strip is usually placed at half the height of the parapet.
On very high parapets, more secret strips need to be fixed and the maximum distance between them must be 400 mm.

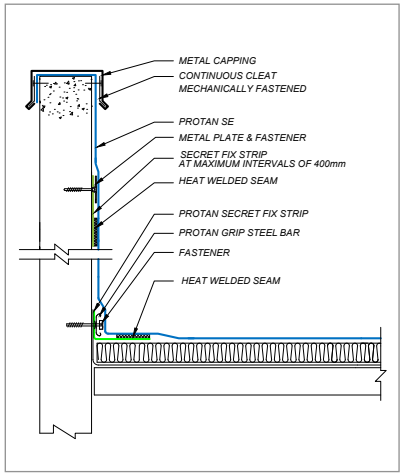


Fig. 44

Very low parapet or no parapet

1.
On fully horizontal roof edges that are finished with flashings/trims, the membrane must be passed under the flashing all the way out and over the roof edge. The flashing is screwed tight to fix both the flashing and the roofing membrane. A strip of roofing membrane is then welded to the roofing membrane and flashing.

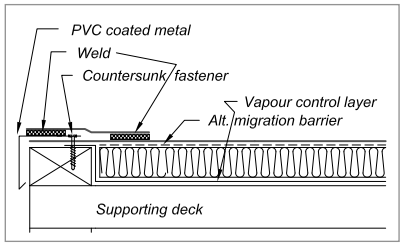


Fig. 45

2.
When finished against a low parapet, the roofing membrane is fixed in the buckling point using either a pocket or a secret strip with a Protan steel bar. The parapet skirt is passed over the roof edge and a flashing is fixed over the roof edge.

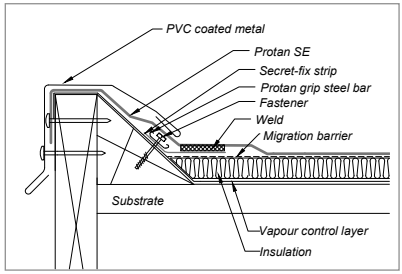


Fig. 46

Termination against an external roof edge – alternative method:
The roofing membrane from the roof surface is provisionally fixed along the roof edge. In a width of 400 mm, the roofing membrane is laid with the back up along the roof edge and is fixed by a flashing minimum 0.7 mm thick being laid over it and being screwed to the roof structure in accordance with the dimensioning of the roof. The roofing membrane that hangs down is pulled tightly back over the flashing and welded to the roofing membrane on the roof surface.

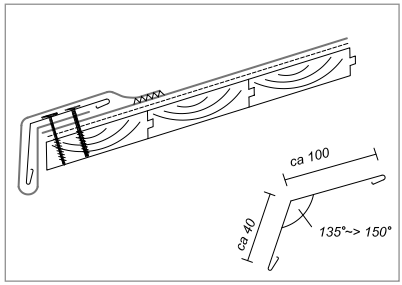


Fig. 47

Roofing gutters – valley gutters

Valley gutters in this context are longitudinal, V-shaped or rectangular gutters between two roof surfaces. The angle between these roof surfaces may vary. Valley gutters will always be the place on the roof where the roof water collects on its way to the drain. At the same time, a valley gutter is the place on the roof that will normally suffer the greatest impact from ice and snow. For this reason, it may be beneficial to select a thicker quality of roofing membrane for the gutters, for example Protan SE 1.6 mm. It is therefore important to pay this area particular attention and to plan the installation so that the roofing is installed in the best possible way. In general, cross joints should be avoided in valley gutters.

When choosing a solution for roofing the gutters, it is necessary to consider the following:

- The direction of the crowns with a substrate of profiled steel deck
- The distance from element edge to fastener with a substrate of concrete/lightweight concrete elements.

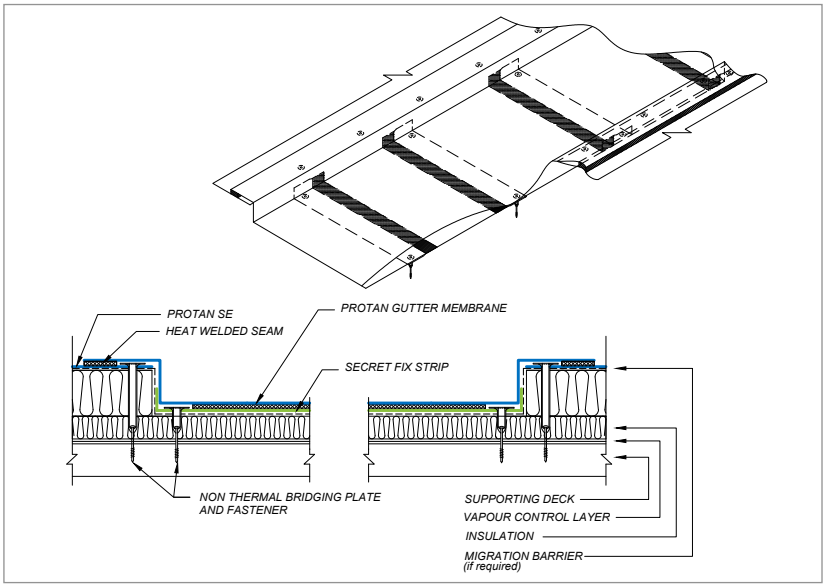


Fig. 48

Method 1 – Protan Gutter is a prefabricated roll made of Protan SE 1,6mm with transverse secret fix strips. It's dimension is 1,33 x 15m and the secret strips are centered at 700mm for mechanical fixing. The three first transveres strips are directed the opposite way for stretching up and aligning the gutter membrane sufficiently. Protan Gutter membrane is positioned and stretched before mechanically fixed to the supporting deck by minimum three fasteners each strip, one in each end and one in the middle. Then it is hot-air welded to the adjacent Protan membrane that covers the roof surface.

Method 2 – lowered gutter, horizontal or with fall – longitudinal secret fix pocket/secret strip.
The gutter is covered with a longitudinal sheet with longitudinal secret strips or secret fix pockets welded on, adapted to the point of change of angle in the gutter. A Protan steel bar is used for linear fixing in the secret fix pocket or secret strip. In areas with low wind exposure, the secret strip may be fixed with standard fixings.

Method 3 – V-shaped gutter – longitudinal secret strips

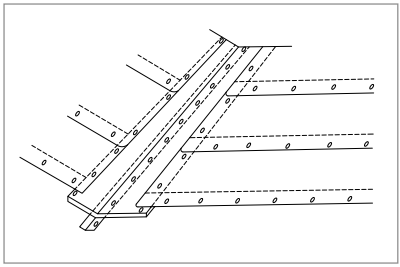


Fig. 52

The gutter is covered with a longitudinal sheet with one or more longitudinal secret strips welded onto it. One of the secret strips must be in the centre of the sheet for secure fixing in the low point. More secret strips may need to be placed as required or according to the wind load assessment. Like method 1, this method will be well suited for reroofing projects.

Method 4 – V-shaped gutter – strips in the change of angle

The roof is covered in the direction of fall with Protan roofing membrane and the sheets are taken down and finished as far down towards the change of angle as possible. When reroofing and if there is a risk of precipitation, it is necessary to postpone installation of the bottom fasteners until it is time to weld the longitudinal strip. The width of the strip must beadapted to each individual case, but must not exceed 0.5 m width. Ensure that the sheet edges are well fixed before the strip is installed in the change of angle.

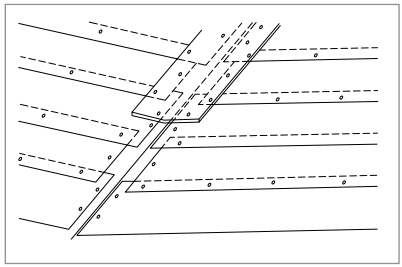


Fig. 53

Termination to walls

General

Check the height of lead-throughs, parapets, etc. so that the upstand is adapted to the roof. The upstand must be approximately 300 mm or minimum 150 mm above the highest point of the roof surface. Protan SE is fixed mechanically with, for example, an underlying secret strip or pocket. If the roof surface is covered with Protan EX, it is recommended to use Protan SE and a loose migration barrier on this upstand.

Protan G and GG can be bonded or a pocket or secret strip of SE quality can be welded to the back of the membrane for mechanical fixing in the change of angle.

Termination to walls with cladding or timber panelling

Protan roofing membrane is taken up and trapped behind the cladding. If possible, the membrane must be laid under the wall's wind barrier. For reroofing, the wall cladding must be loosened and the roofing membrane clamped in place behind it. It may be expedient to use a fillet installed under the existing cladding lath.

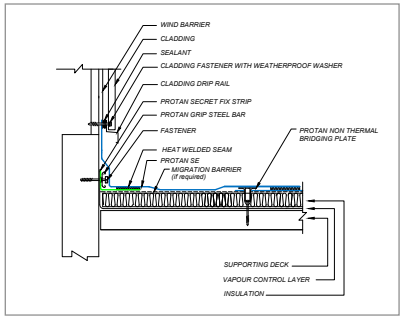


Fig. 54

For horizontal timber panelling, the 2-3 lowest boards can be loosened and the roofing membrane taken up behind the panel.

Termination to a concrete wall

Cut a slit in a concrete wall. The slit must be approximately 20 mm deep and preferably diagonally upwards. Protan roofing membrane is taken up to the slit. G products are bonded, while SE products are fixed mechanically with secret strips or pockets.
The roofing membrane is fixed to the wall ahead of the slit. Fit self-locking joint flashings and seal the joint with sealant.
NOTE: Mastic is also necessary in fitting joints/overlaps.

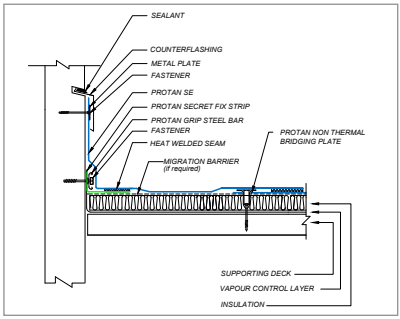


Fig. 55

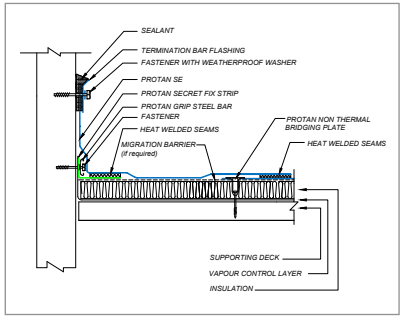


Fig. 56

Roof lights and other lead-throughs

On mechanically fixed membranes, the roofing membrane is fixed around skylights and lead-throughs with a c/c distance equivalent to that in the perimeter zone.
NOTE: It must never be fixed with a distance greater than 500 mm.

For roofing skylights and boxes, it may be expedient to take the roofing membrane from the roof surface and up approximately 100 mm on the vertical (this also prevents water penetration during roofing work). Then fix the skylight/box roofing either with a pocket/bar or with a secret strip/bar and welding cord. Use Protan SE for the roofing. This roofing method requires that the screws have a good grip in the change of angle.

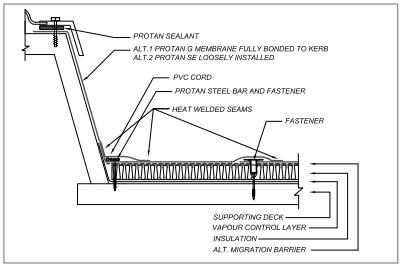


Fig. 57

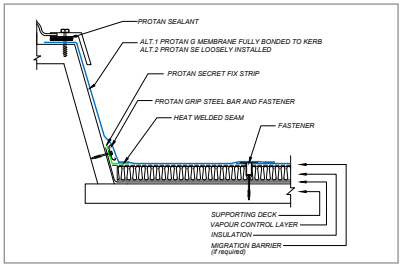


Fig. 58

Skylights and boxes that are not higher than 300 mm and that are 90 degrees to the roof can be roofed with prefabricated coverings. This requires precise measurement and is only possible on new roofs. Fixing points must be placed along the lead-through if prefabricated coverings are used. A bar in the vertical will add too much and make adaptation of the coverings difficult. Skylight coverings are supplied in Protan G with 4 corners welded on.

Round pipe details are roofed with Protan G. It is recommended that you use prefabricated roofing details. At least 4 fixing points must be placed around the lead-through.

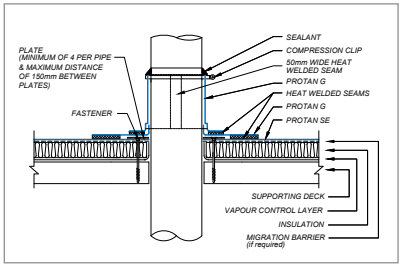


Fig. 59

Rainwater outlets

Water must always have free access to drains/rainwater outlets.
The rainwater outlets must be placed in the lowest areas of the roof and a roof must have a minimum of two drains. The dimensions of roof rainwater outlets should be min. 75 mm, preferably 110 mm.
REMEMBER: The rainwater outlets must always be fixed mechanically to the substrate.

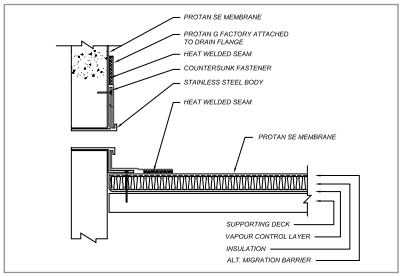


Fig. 60

Always ensure there is a local fall to the rainwater outlet, for example by cutting out a recess of approximately 10 -20 mm in the insulation or embedding the rainwater outlet flange in the roofing bitumen/roof boards. There must be non-flammable insulation around the rainwater outlet.

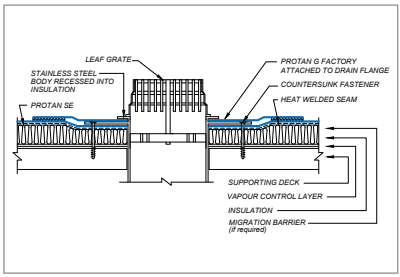


Fig. 61

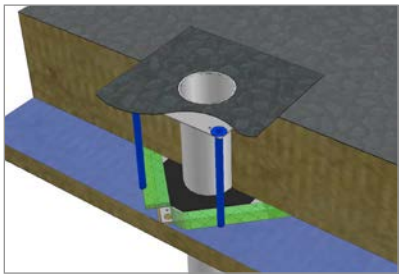


Fig. 62

Installing a Jual roof rainwater outlet

Cut out for local fall under the rainwater outlet flange. Make a circular hole in the roofing membrane and press the rainwater outlet pipe down. Fix the rainwater outlet mechanically to the substrate and weld the roofing membrane on the rainwater outlet flange to the roofing membrane.

Roofing rainwater outlets with a clamping ring

Protan G must always be used. It is heated, overstretched and passed under the clamping ring. This is particularly important when the rainwater outlet is strongly embedded in the insulation. On mechanically installed roofs, it is always necessary to place additional fasteners around the rainwater outlet when Protan G is welded to Protan SE.
This is particularly important when the rainwater outlet is in the middle of a membrane sheet and when 2m wide sheets are used.

Connection to old rainwater outlets

For reroofing, Protan roofing membranes must be protected against any bitumen on the rainwater outlet. This is done most easily by laying a layer of Polyethylene over and under the roofing membrane and sealing with sealant. Check that all screws in the clamping ring are well tightened.

Special measures for reroofing

Reroofing old single ply membrane – ballasted roofing
When reroofing old single ply membrane, if no additional insulation is used, it is necessary to take into account the migration of plasticizer from new to old membrane, movements and shrinkage in the old membrane and the accumulation of condensation in the intermediate layer. To avoid migration of plasticizer, it is necessary to lay 140 g/m^2 polypropylene fleece as a migration barrier. The old roofing membrane must either be removed or be left on the roof. If you choose not to remove the old roofing membrane, it must be cut up in change of angle against the parapet and around lead-throughs. In addition, it must be cut up every two metres (tension relief and condensation drying).

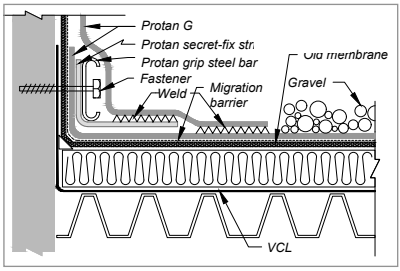


Fig. 63

Reroofing mechanically fixed single ply membrane
Old single ply membrane is cut up in the change of angle against the parapet and around lead-throughs and cut throughout between each row of fasteners. Alternatively, old membrane can be removed for recycling. 140g/m^2 polypropylene fleece must be laid between old and new membranes if the roof does not have additional insulation.
NOTE: When reroofing, it is important for the roof to be kept watertight while the work is in progress. To prevent water penetration overnight and at weekends, it is practical to weld the new roofing membrane temporarily to the old membrane if they are compatible. When the roofing is continued, the new roofing membrane must be cut up along the weld to release it from the old membrane. This is very important. Otherwise, any tension in the old membrane will be transferred to the new membrane. This welding area will also be subject to migration.

Partial reroofing/roofing
In some cases, just parts of a roof surface need to be reroofed as either a permanent or a temporary solution. Depending on how long a transitional solution is to last, there are several alternatives to choose from. Transition membrane is used between the Protan roofing membrane and an old bitumen roof.

Daily finishing/temporary finishing for roofing with PVC transition membrane

A temporary solution is designed to hold for a limited time, anything from overnight or for a weekend, where it is essential that the roof is tight, to a few years, pending the roofing of the rest of the roof surface. A transition membrane consisting of bitumen-resistant PVC on the top and weldable bitumen on the back must be used for this temporary transition.

NOTE: The temporary solution is not covered by any warranties.

Installation:

The transition membrane is supplied in full rolls. We recommend that it be divided into approximately 150 mm for use as a temporary transition to old bitumen.

When installing transition membrane, it is important to note that the bitumen side of the transition membrane and the old bitumen must be joined well enough to ensure watertightness. However, this join must not be exposed to forces from wind load or other movements/forces in the roofing membrane. It is therefore important to note the installation procedure.

1. Protan roofing membrane is finished with fixings (tension relief) on the side against the transition membrane.
2. The transition membrane is welded to the old membrane at the Protan roofing membrane finish.
   - Remove the protective plastic on the bitumen side.
   - Fully weld the bitumen membrane to the existing substrate with hot air or propane. The standard method for bitumen roofing must be carried out, including removal of granules.
3. A strip of roofing membrane is welded to the top of the transition membrane, overlaps the fixings and is welded to the new membrane.
4. A more permanent solution can be produced by, in addition to the above solution, welding a strip of bitumen between the top of the transition membrane and out onto the old bitumen deck.

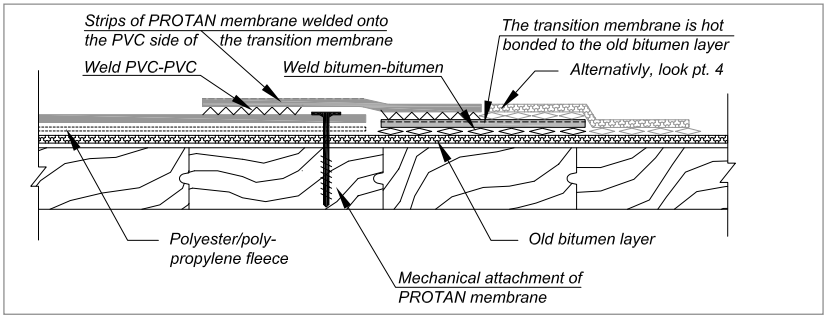


Fig. 65

Permanent finishes in connection with partial roofing
Permanent finishes/transitions between two different, incompatible roofing membranes should preferably be laid to the roof's high points. On flat roofs, it is necessary to build up a physical partition with, for example 2" x 4" planks which are covered from both sides. It is always necessary to ensure that drainage is possible from all roof sections. This solution is valid whatever the type of roofing membrane.

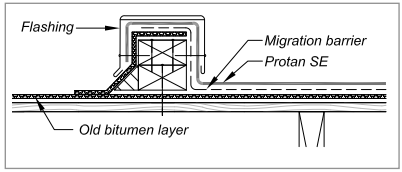


Fig. 66

Flashings

Flashings for PVC roofs
Flashings for use when roofing with PVC roofing membranes must be approved by Protan. The Protan approved metal makes it possible to hot-air weld directly to the flashings, for example to the roof base flashings.

Finishing at the base of the roof
1. Protan SE with polyester reinforcement and hot-air welded joints
2. Sliding layer of geotextile
3. Hot-air welding
4. Board edge flashings of Protan proven metal
5. Front edge board
6. Gutter
7. Snow stoppers, if necessary

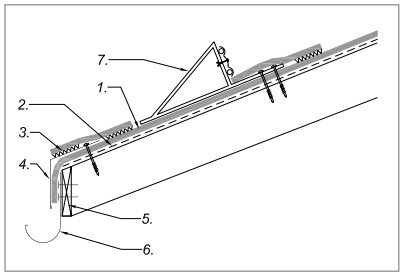


Fig. 67

Alternative solution to PVC-coated flashings
As an alternative to plastic-coated flashings, the solution outlined in the chapter on parapets may be used, see fig.47, page 63.

Terraces

Exposed terrace roofing – Protan GT

Protan GT terrace membrane is a durable floor covering in glass fibre-reinforced PVC to which plasticizer has been added and which has been UV-stabilised so that it is suitable for use outdoors. The finished result depends greatly on the substrate which is covered. Irregularities, counterfalls, etc. in the substrate will be visible but otherwise have no practical significance to the function of the membrane.

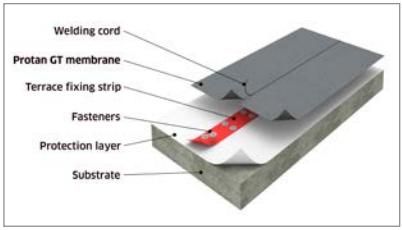


Fig. 68

Substrate:

Protan GT is dimensionally stable is therefore recommended only for use on "dead" substrates such as concrete. In "living" substrates, movements may occur on account of temperature and moisture that will cause wrinkles in the membrane.

The substrate must be clean and smooth. Irregularities in the substrate will affect the finished result. 300 g/m^2 polypropylene fleece must always be laid between the terrace membrane and the substrate. This will absorb any irregularities and hide the fixings used for installation. For substrates with moderate humidity and temperature movements, a 2.0 mm thick polyester-reinforced exposed terrace coating, Protan T, has been developed as a better alternative.

Installation:

Membranes with a thickness of 2.4 mm are always used on horizontal surfaces. Details and finishes are covered with a fully dyed 1.4 mm thick membrane. The membrane is cut to the correct lengths and it is also necessary to take account of symmetry and the direction of installation when laying it out. On account of the embossing of the surface, you should aim to lay the sheets consistently the same way on large terrace surfaces.

The terrace membrane must be fixed on all four sides. It is important for the membrane to be fixed at all finishes and angle changes. Take account of the wind conditions when choosing a fixing method.

To remove all stresses in the material, it is important for the terrace membrane to be rolled out and have the chance to "relax" for around half an hour before installation begins. At temperatures lower than +10°C, the membrane takes longer to relax. To avoid folds, etc., it is important for the terrace membrane to be tightened strongly during installation.

NOTE: We do not recommend installing it in cold weather. Consult Protan TS for further installation guidance.

Wall finishes are installed as the rest of the membrane installation, either behind plating or via slits into the wall with flashings on top. A Protan approved PVC-coated metal with a drip mould must be installed against external gutters. The terrace membrane may be welded directly to the metal with hot air.

Profile roofing

Profile roofing has been developed to give roofs an exciting, exclusive appearance. The roof's tightness requirements are met by the Protan roofing membrane and the profiles welded on help to create depth and life in the roof surface. A good result depends on, among other things, a smooth substrate. The profiles may be installed independently of the underlying roofing membrane but they should preferably be placed over the membrane joints. Precise measurement of the roof surface is important to ensure symmetry. Remember to take account of obstacles such as skylights in the roof surface. It is a good idea to start the profile 100 mm from the ridge and finish 100 mm before the roof edge. Profile roofing is marketed as Protan Feature Roofs.

NOTE: The c/c distance between the profiles must be determined with the client, contractor, architect or owner.

Omega profile

The Omega profile, Fig. 70, is a soft PVC profile with the same weldability as Protan roofing membrane. The profile is available in the same colours as Protan SE, in lengths of 4 metres and in bundles of 25 profiles. The joint pieces are supplied with the profiles.
An Omega profile can be installed manually (handheld equipment and pressure roller) or with a Leister Variant welding machine with Protan's accessories. The welding rate for an Omega profile is 2 to 3 metres per minute with a machine. If the profile is installed manually, with handheld equipment and a pressure roller, it is necessary to use a strong guide to ensure that the Omega profile is welded straight. During installation, place the lute against the profile. Protan stocks Omega profiles in light and dark grey.

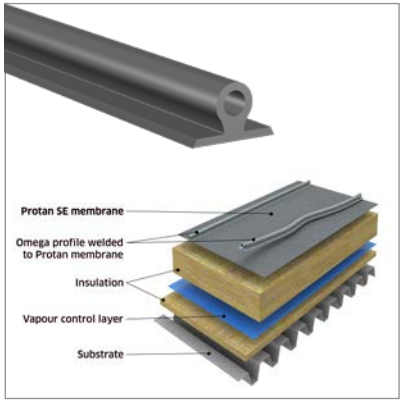


Fig. 70

For further details on installation, please contact Protan.

Walkway Sheets

All roofs are subject to some degree of pedestrian traffic and Protan roofing membranes tolerate this without problems. With their embossed surface, Protan roofing membranes also produce enhanced slip protection. However, we recommend laying separate walkway sheets for work/maintenance traffic or other pedestrian traffic on the roof. This applies particularly to ballasted roofs.

A walkway sheet must clearly mark where people can walk on the roof. In addition, a walkway sheet provides additional protection against mechanical damage and makes an aesthetic impression.

Protan Walkway Pad

The PROTAN WALKWAY PADs are UV-stabilized and have an anti-slip surface for good friction. They can be welded to all Protan PVC membranes. The heavy fish bone pattern on the upper side ensures good friction and on the underside there are channels for drainage of water. They are well suited as walkways and protection of exposed roofs in areas there are regular pedestrian traffic, work etc. In addition to good HSE related to slip resistance, Protan PVC Walkway Pads contribute to a good load distribution of pedestrian traffic on exposed roofs. When used, there will normally be no need for additional rigid layers to prevent damage / compression of the underlying structure.

Alternatively you can weld and extra layer of Protan roofing membrane in a colour that contrasts with the existing roofing membrane.

On exposed roof surfaces (mechanically fixed), the following alternatives may be used:

- Protan SE in most cases.
- Protan GT 2.4 for roofs with major work/maintenance traffic.
- Protan walkway sheet 2.2 mm. The same applies to this as to Protan GT 2.4 but the walkway sheet has a coarser surface texture.

On ballasted roof surfaces:

- A protective sheet of PVC or a min. 300 g/m^2 fleece is laid loosely on Protan G. Concrete tiles are laid over this on small XPS blocks or specially made support blocks made of plastic or neoprene.

Roofing systems for covered/ballasted solutions

Membranes that are covered with ballast are usually referred to as ballasted or protected roofs. The purpose of the ballast is normally to protect the membrane against wind and UV radiation and to protect the structure against fire. The membrane is also protected against external mechanical influence. The ballast protects against rapid temperature fluctuations and stores water/delays the runoff of water (green roofs) in the event of large quantities of precipitation.
Covered membranes must, among other things, meet strict requirements for dimensional stability and ageing and resist water pressure.
Membranes from the Protan G series are normally used. However, in special applications, Protan EX is also used.

The product is chosen on the basis of a total functional assessment. Protan's range of roofing membranes has been developed for use in various applications. Here is a list of a number of areas of use and the suitable roofing membrane for them.

System	Application area	Protan Turf roof membrane	Protan SE Titanium +	Protan G	Protan GG
Cover/ballasted membranes	Gravel ballasted			✔	
	Terraces with slabs, decking etc.			✔	✔
	Intensive green roof			✔	✔
	Extensive green roof		✔	✔	
	Turf roof	✔			
	Duo roof/Inverted roof			✔	✔
	Parking deck				✔
	Wet rooms			✔	

Gravel-ballasted roofs

Membranes ballasted with gravel give the roof a more aesthetic, natural surface. However, the gravel primarily ensures that the membrane is held in place. In addition, the gravel layer contributes to meeting current fire requirements and helps to produce a cooler indoor climate during hot periods in the summer.

The membrane, Protan G, is laid loose over the surface and is ballasted gradually. Standard rolls of 2 m width or special lengths are used. It is also possible to make prefabricated sheets to measure. The larger the units, the faster the roof surface can be covered and ballasted, provided that there are few lead-throughs.

NOTE: Gravel-ballasted membranes/ Protan G must be fixed mechanically to the parapet. This is done by welding a Protan SE secret strip or secret fix pocket to the back of the Protan G at the change of angle. The parapet is then installed as a standard mechanically fixed parapet. Remember: use a welding cord over the bar when using secret strips.

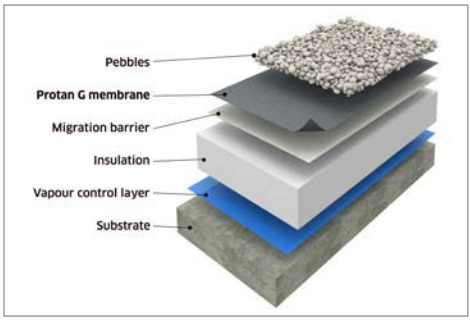


Fig. 72

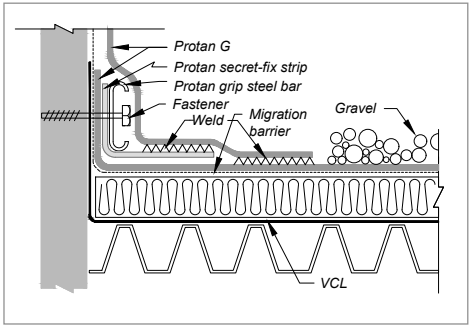


Fig. 73

Terraces

Membrane for covered terraces – Protan G
Protan G is used as the membrane for terraces that are to be covered. The covering may be wooden decking, tiles, artificial grass, integral cast or similar.

To prevent the membrane from being subject to mechanical damage or any chemical impact, it is necessary to lay a protective layer over the membrane. Protan G is UV-resistant. Therefore, it does not require details and vertical surfaces that are exposed to sunlight to be covered.

Protan G for use on terraces is laid loose on either uninsulated or insulated surfaces. The migration barrier or equalisation layer against the underlying structure is chosen according to the type of substrate. In insulated terrace solutions, the membrane may be laid either under the insulation, between two layers of insulation or over the insulation.

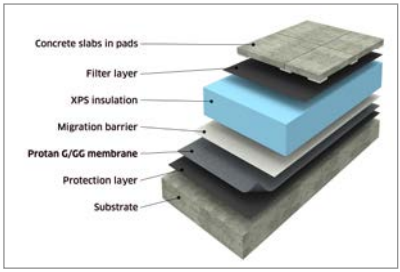


Fig. 74

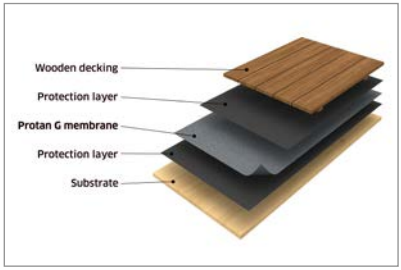


Fig. 75

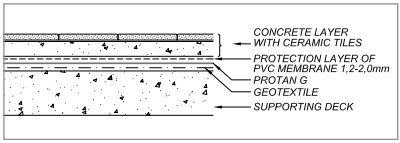


Fig. 76

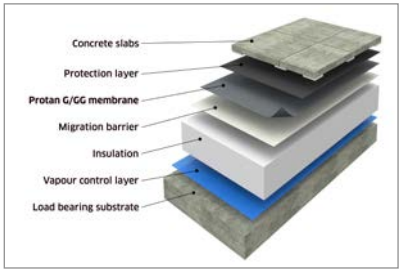


Fig. 77

Duo roofs/inverted roofs and membrane structures – Protan G

On insulated decks, the membrane may be laid either over, under or between two layers of insulation. It is important to use the correct migration barrier/equalisation layer for the structure. Where the insulation is on the "wet" side of the membrane, it is necessary to use non water-absorbent insulation, for example extruded polystyrene, XPS.

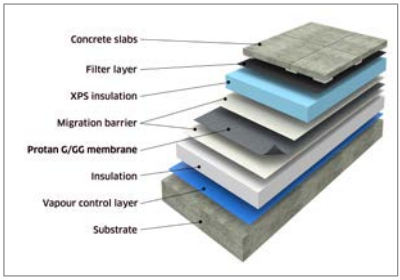


Fig. 78

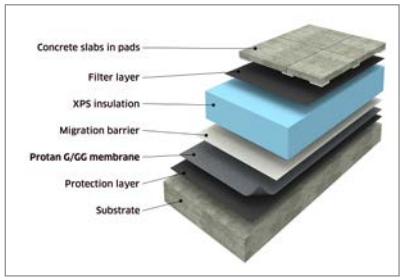


Fig. 79

Parking decks – Protan GG

Protan GG is used as the membrane on parking decks. Protan GG is a water pressure membrane for drivable decks and must always be covered. The installation of membranes requires great care during the construction phase by the roofer, other tradesmen and the owner. Protan GG has a light coloured surface, among other things to ensure that the melt-out in connection with welding the membranes is highly visible and thus easier to check.

Reinforcement patches must always be installed in T-joints on membranes and in the change of angle in connection with welds. Remember to take welding samples.

It is important to protect the membrane on both sides with a migration barrier and/or a sliding/equalisation layer. Over Protan GG, it is always necessary to ensure that the cover (bitumen/integral cast/flags) can move independently of the membrane. In such structures, the membrane often gets a labour-intensive, expensive cover. Therefore, it is essential that necessary measures be taken to ensure that the membrane is tight during the construction process until it is covered. When the welding work has been completed, it is necessary to check the membrane and welds carefully.

The check must include:
- a check of all welds
- that reinforcements are installed in all angles and T-joints
- that all details are correctly performed
- that there is no damage to the membrane

After the check, the roofer must always lay out the protection layer. Protan membranes can be checked for tightness as follows:

- water testing (if practically possible) or
- vacuum testing of the welds
- other approved methods

All verticals and details must be covered with Protan G or GG. Remember never to use fleece qualities as the sliding/protection layer between integral cast and Protan membrane. PVC sheets must mainly be used as the sliding/ protection layer. Alternatives are pressure-resistant insulation or 2-layer Polyethylene.

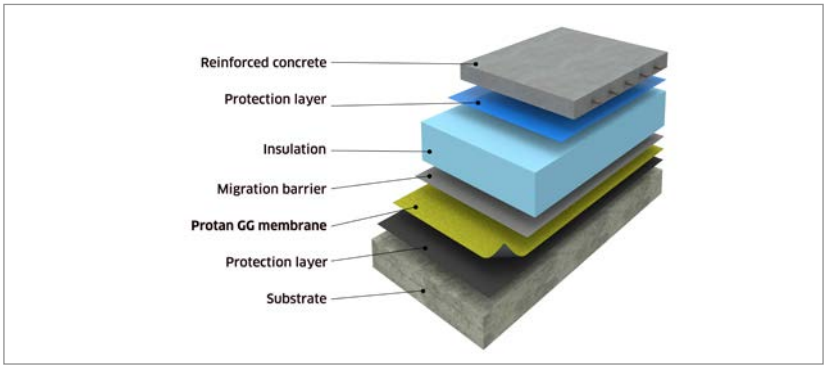


Fig. 80

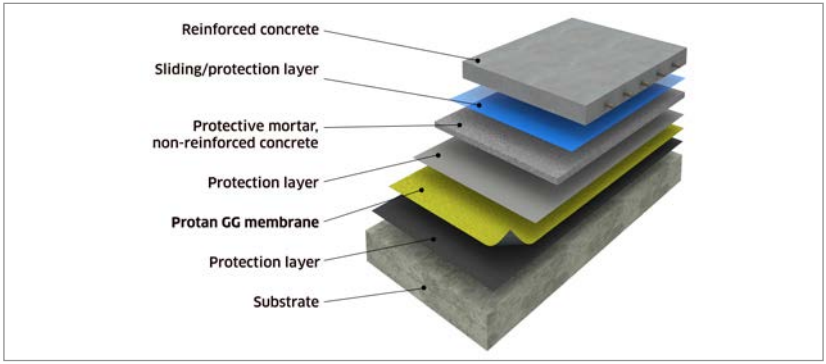


Fig. 81

Green roofs (planted roofs)

In general, it can be said that green roofs are a roof structure with a membrane as a sealing layer and a planted soil layer above it. Green roofs produce an aesthetically pleasing appearance and have environmental and energy-saving advantages. This may be particularly expedient in urban zones.

Green roofs, intensive

Intensive green roofs support various planting options including lawns, shrubs, coppices and trees. These are often designed as roof gardens with recreation areas or amenity spaces and require a deeper system build-up with soil or growing medium thickness of approximately 200mm and up. Due to the loadings of an intensive system, a structural engineer must be consulted.

We recommend Protan GG for intensive green roofs to withstand high water pressure and heavy loads of the system. The membrane is installed together with the necessary protection layers depending on a supporting deck, the migration barrier is used to avoid direct contact with EPS/XPS-insulation.

The green roof system must be able to drain freely so that the vegetation does not become ponded in water. It is also essential that the system can store enough water to survive drought conditions. Therefore, it is important that each individual roof is assessed, and suitable system components are specified.

The installed membrane and the welds must be carefully inspected before the membrane is covered. Reinforcement patches must be welded over all T-joints and welds in change of angle at the parapets, walls and penetrations.

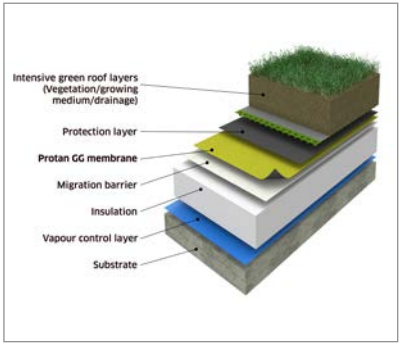


Fig. 82

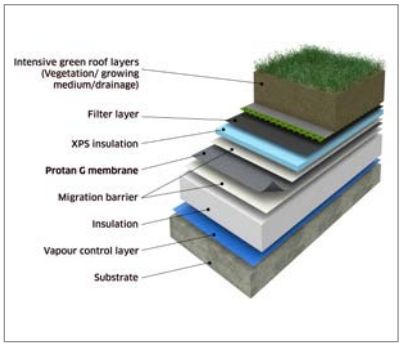


Fig. 83

Green roofs, extensive – Protan SE Titanium +

In extensive green roof structures, the soil may be up to 200 mm deep and the weight may be equivalent to a standard gravel-ballasted roof. This type of roof is mostly used for its environmental benefits.
In low-rise green roofs, precultivated mats with plants, for example Sedum, are often used. These mats have to meet the wind load requirements and the roof structure must tolerate the additional weight moistened planting entails.

Protan SE Titanium + is well suited for extensive roofs and can be installed without mechanical anchorage to the roof surface. Protan SE Titanium + is a fire classified and load bearing roofing membrane, which allows the building to be used even before the sedum is installed.

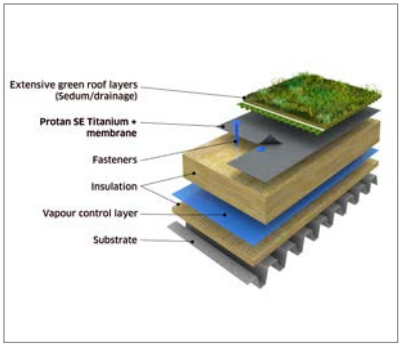


Fig. 84

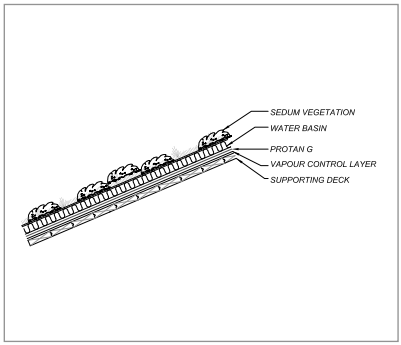


Fig. 85

Turf roofs – Protan turf roof membrane – EX 1.6 mm

Protan turf roof membrane or Protan EX 1.6 mm is used under turf. Turf roofs are a special version of green roofs and are used widely on sloping cabin roofs. Protan turf roof membrane is laid in sheets in the direction of fall of the roof. The sheets are laid from the base of the roof to the base of the roof over the ridge. The membrane is laid out and fixed mechanically to the substrate and can subsequently remain temporarily exposed without blowing off, even if the turf is not laid on top. The membrane must be fixed as standard roofing membrane in accordance with the direction rules in TPF no. 5, i.e. in accordance with the requirements for temporary structures. This means that the fixing must be dimensioned for a load of 65% of the dimensioning load at the location. It is also necessary to ensure mechanical fixing along the base of the roof, either in the form of turf retention boards or some other form of fixing. The turf can be laid directly on the membrane without using a drainage layer. All changes of angle on the roof must be anchored mechanically and details covered in accordance with the relevant roofing instructions.

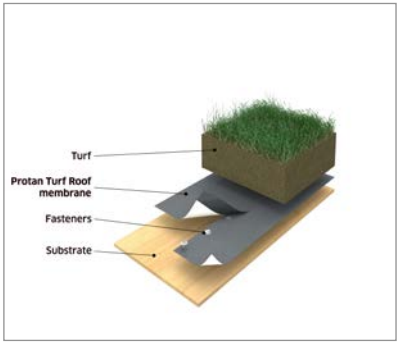


Fig. 86

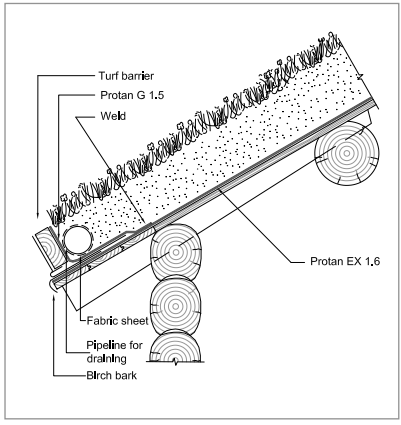


Fig. 87

Membranes for wet rooms – Protan wet room membranes – Protan G

Protan wet room membranes (Protan G 1.5 mm) can be used as the sealing layer on floors in wet rooms, either as a membrane laid right under tiling or as a membrane laid under an integral cast. The membrane can be laid on most solid substrates.

Before Protan G 1.5 mm is laid, the substrate must be clean and dry. Large scratches and major damage must be repaired in advance. Loose particles and any grease and oil must be removed from the substrate. Prefabricated details are used where possible for lead-throughs, corners and other details. Connections to walls must be performed in accordance with the approved principles in Byggforskserien (Byggforskserien's building details 541.805) from SINTEF Building and Infrastructure.

Membrane direct under tiling

When the membrane is laid right under tiling, it must be bonded to the substrate with CascoProff Ekstra. Before bonding, absorbent substrates must be primed. If there are heating cables in the floor, the moisture content of the concrete must not exceed 75% RH (relative humidity) before bonding. To bond tiles, use Keraquick tile bonding mixed with Latex Plus as a replacement for water.

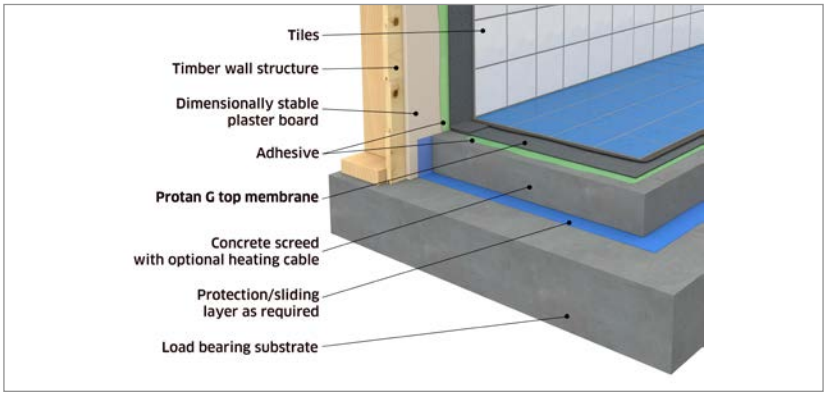


Fig. 88

Membrane under integral cast – protection layer/sliding layer

When the membrane is laid under an integral cast, it is necessary to use an all-over protection layer of plasticized PVC between the wet room membrane and the integral cast.

If the membrane is laid on a cement-based substrate, it is necessary to use a sliding and protection layer of plasticized PVC or polypropylene fleece (300 g/m²) between the floor and the membrane. For other cases, use an approved geotextile.

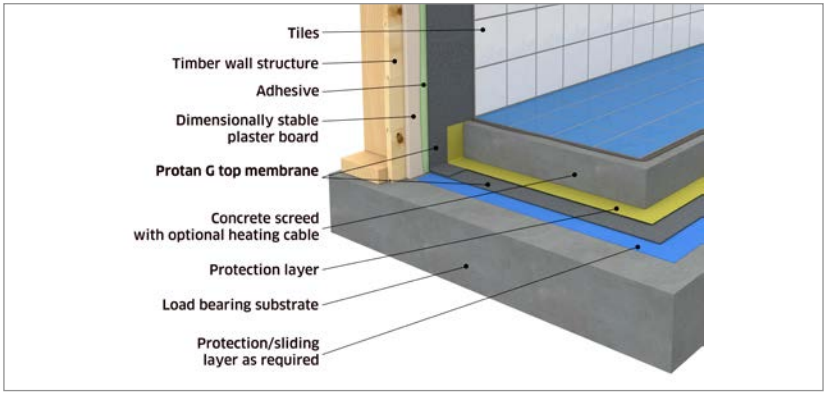


Fig. 89

Outlets in wet rooms

Outlets with clamping rings must always be used in wet rooms.
The clamping ring is removed before the membrane is laid over the outlet. A small hole is then cut out in the centre over the outlet. The membrane is heated with a hot-air device while being rolled/stretched down in the outlet to adapt the clamping ring. When the membranes have been sufficiently worked, cut out a large hole (approximately 2/3 of the diameter of the outlet) and press the clamping ring down and screw it into place. Finally, trim any membrane that sticks out from the clamping ring carefully.

NOTE: It is important for the clamping ring to be pressed right down before being screwed in place. If the clamping ring is too high, the result may be a long cut (hole) in the membrane when the screw presses the clamping ring down. This may result in a water leak if the outlet becomes clogged. Ensure that the seal is in place in the outlet before installing the clamping ring.

Expansion joints

On account of the roofing membranes' flexibility and good elongation at break, it is not necessary to take additional action when roofing over expansion joints.

Any fixings must, however, be placed at least 150 mm from an expansion joint so that movements can be absorbed and distributed in the membrane.

11 Methods of Roof Detail Installation

At Protan Roofing School the roofers are taught all methods of detail installation – this includes both by the use of the mechanically installed Protan SE and the Protan G membrane for fully bonding (Contact adhesive).

NOTE: In this guide we only show the detailing of the Protan SE membrane without paying attention to the mechanical fastening.

External corner/roof light penetration -
Method 1 – refurbishment and new roofing

Penetrations can be formed:

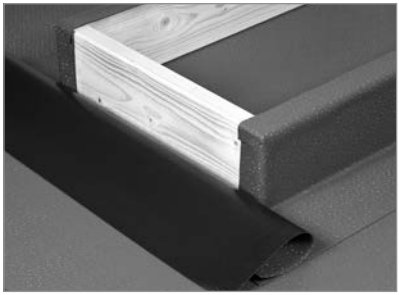
a) Mechanically with Protan SE
   Protan SE is mechanically fixed by the use of nails or screws in the materials overlap.
b) Fully adhered with Protan G
   Protan G is bonded by the use of Protan Contact Adhesive 95 by applying an even layer on the rear side of the membrane. The membrane is bonded to the detail wall when the adhesive is "partly dried" an shall be pressed in position with the wide pressure roller.

1.
Precise equal lengths of Protan membrane are placed on the two long sides.
NOTE: The lengths shall be added 2x130mm to the measure of the long side.
Mark the distance of 130mm around the detail to make it easier to get an equal width of the covering on the horizontal surface when installing.

2.
Cut from the corner and straight out in length direction of the detail.
Protan SE is nailed minimum 50mm around the corner and trimmed.
Using Protan G the membrane is bonded and trimmed in the same way.
NOTE: If the adhesive has dried out it can be activated by heating it with the hand held hot air tool.

3.
Cut the membrane which is turned around the corner into the corner by placing the knife on the top edge.
Do not cut too far!

4.
Cut a downward arc of approximately 30 mm with a rounded corner and weld into position.



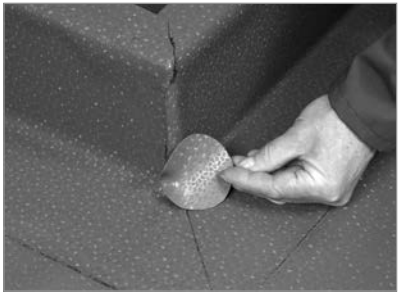
5.
Finish the long sides first and make sure the membrane is welded properly into each angle.
Then finish the short sides making sure the material is wide enough i.e. width of detail + 2x130 mm.

6.
Cut from top of the detail and downwards approximately 5 mm on the short side before the corner. Cut an "arc" the size of the top of your thumb in the lower part of the corner and continue cutting the mitre angle.

7.
The underlying overlap is removed by cutting it of at a distance 40 mm from the mitre angle.

8.
Pre-weld the vertical side into position (direction: from bottom and upwards) thereafter horizontal part from the inner corner and outwards. Then do the final welding.
NOTE: Make sure the membrane is placed thoroughly into position in the corner.

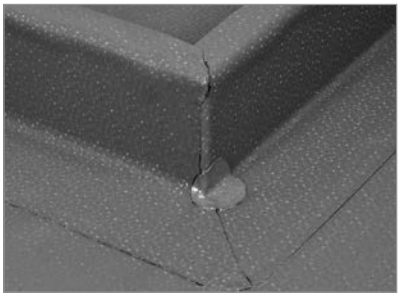
9.
Apply heat to the "arc" in the corner and to the membrane. Weld the two surfaces together applying pressure with your thumb or pressure roller.



10.
All four corners must always be reinforced by a piece of G membrane approximately 60 mm diameter. (alternatively use pre-fabricated details).
Warm, stretch and weld into place around the corner using the small detail roller. It's sufficient with 20 mm around the corner. The membrane patch is centered so that half of it goes up vertically and that it covers the previous welding.

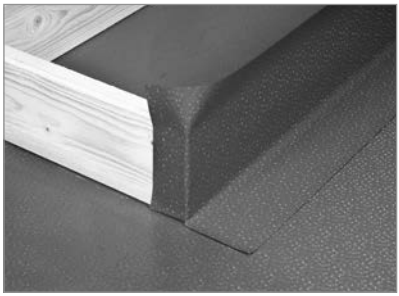
11.
Start the welding on the vertical and weld well passed the change of angle. Then weld the opposite vertical side on to the corner.

12.
The remaining part of the reinforcement patch is applied heat and then pressure with your thumb or the grip of the pressure roller.

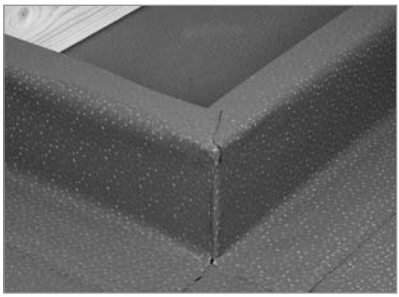


13.
The finished external corner.

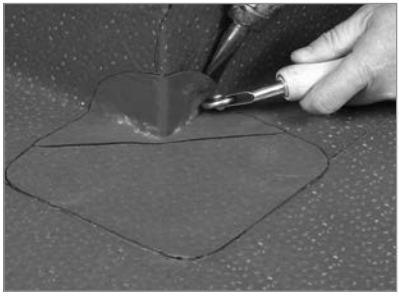
External corner/roof light penetration - method 2 - new roofing.



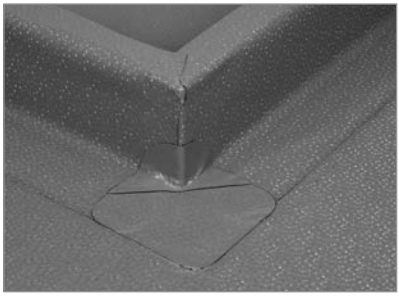
14.
Detailing of external corners by using pre-fabricated details on i.e. roof light penetrations is done as follows:
Start approximately 50 mm around one corner and pull the measured strip of membrane all around the rectangular box. While doing this the membrane is cut straight at all corners and jointed to the start of the membrane strip by hot air welding.
Tip: Before covering, measure overlap around the roof light. Align the strip to the marking.



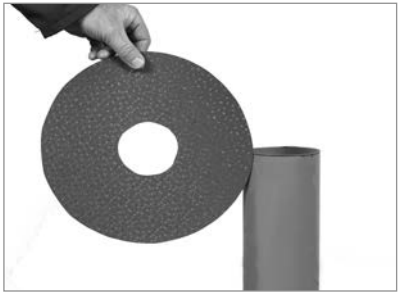
15.
Curve the membrane corners and weld the reinforcement to the roofing membrane. At the top of the detail cut the membrane 45° against the corner and weld.



16.
Install the pre-fabricated details in all corners. The welding is done with pre-weld and final weld starting from the changes of angle.



17.
Finished covering of a roof light penetration.
For certain standard measure details a prefabricated coverings can be manufactured for the whole penetration.



Pipe penetration

18.
Protan G membrane should be used to form pipe penetrations.
Cut a circle of membrane minimum 200mm larger than the diameter of the pipe. Cut a hole in the centre, 30 mm less in diameter than the pipe.

19.
Stretch the membrane slightly to allow it to slide down the pipe.

20.
Pre-weld and final weld the flange down onto the roof surface. Do not weld the flange all the way into the pipe.

21.
Measure the circumference of the pipe and allow an approx 100 mm longer and 25 mm wider piece of G membrane than required.
Wrap the membrane around the pipe and slide tow small scraps of material between the pipe and the membrane, to allow the flashing to slide easily back up the pipe.
Pre-weld and final weld the detail.

22.
Pull the flashing of the pipe. Cut approximately 30 mm off the flashing end until there is a proper welding seam. Then cut the lap at 45° from the inner layer of membrane at one end. This is the end which will be welded to the roof surface.

23.
Slide the flashing back onto the pipe with the end that is to be welded on the roof surface at the top. Heat approximately 20-30 mm all around the flashing.

24.
Stretch the heated area to obtain a flange to weld onto the roof surface.

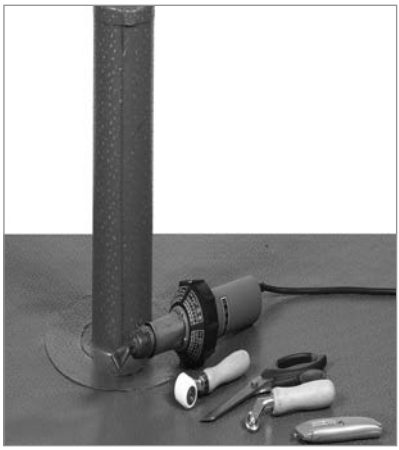
25.
Turn the flashing vertically and pull it back down. Weld the 20 mm flange by pre- and final weld to the roof surface, using a small pressure roller.
NOTE: It is recommended to do this welding in one operation, without stop. Start and stop the welding process at the overlap area.

26.
Cut an oval patch of G membrane minimum 60 mm and weld into position where there is a double thickness of material. This to reinforce the weld and stop any risk of capillary action. The patch should be on the horizontal surface. First weld against the pipe then the rest of the patch.

27.
Cut a piece of G membrane, long enough to wrap around the inside of the pipe with 30 mm overlap. Push the membrane inside the pipe with the rare facing out. Make sure that the membrane is touching all surfaces and tack weld the pieces together.
Please note this is a very rare exception of allowing tack welding.

28.
Pull out the tack welded piece of membrane back out of the pipe and weld the internal seam from both ends.

29.
Push the welded piece beck inside the pipe leaving approximately 30mm sticking up. Make sure that the weld on the membrane inside the pipe lines up with the vertical weld on the flashing. Apply heat all around the internal flashing and stretch it back over the external flashing to form the top hat.
To prevent the top hat from being blown off, tack weld at four points around the flashing.

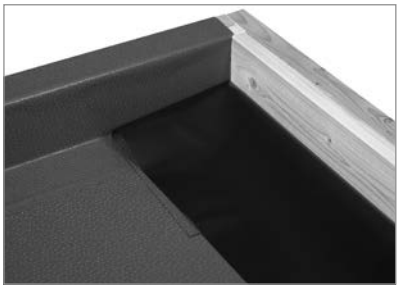


30.
Finished covered pipe

Internal corner
There are 2 methods of detailing internal corners:
- Folded corner – when the upstand is lower than 300 mm.
- Cut corner – when the upstand is higher than 300 mm

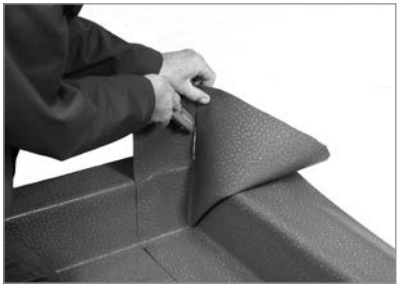
Folded corner

31.
Complete the first parapet flashing so it finishes tight into the corner. Pre weld and final weld the flashing onto the roof surface.

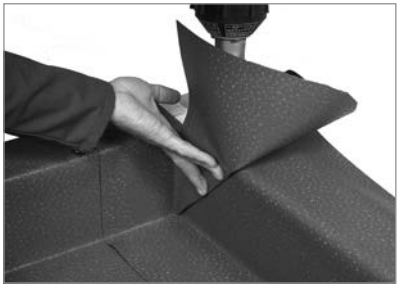


32.
Measure the second flashing allowing enough material to cover the first parapet. Terminate 50 mm up and over the parapet.

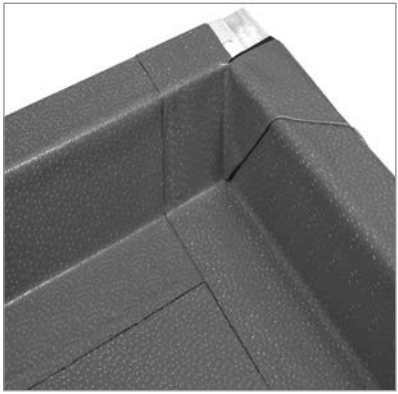
33.
Position the flashing into the corner. Make certain that the flashing lies flat and there is a smooth transition through the change of angle. Fold the flashing and pre-weld into position. Final weld the vertical and roof surface.



34.
Cut from the upper edge corner straight up.

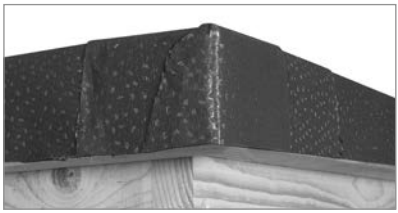


35.
Put the nozzle down to the bottom of the fold and weld together to create a sharp edge. Make sure the folded material goes into the corner. Weld the fold to the opposite side of the vertical weld.



36.
Weld the cut section to the parapet flashing.

37.
Cut a piece of Protan G allowing 30mm of membrane on each side, to be welded back onto the flashing. Allow the corner to overlap the flashing by approximately 10 mm and weld into position.



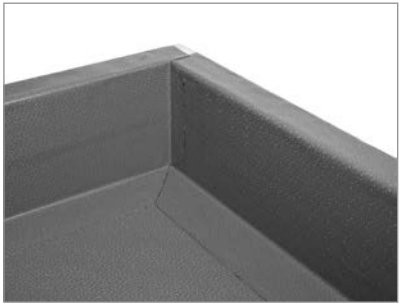
38.
Cut and weld the external side of the parapet.

39.
The finished folded corner with all the tools you need to complete the work.

Corner with prefabricated internal corner detail.

40.
Complete the first parapet flashing so it finishes tight into the corner. Pre weld and final weld the flashing onto the roof surface.

41.
Measure and cut the second flashing, allowing 100 mm extra on the length. Position the flashing into the corner and at the cross section of the roof surface cut the membrane into the corner (45°)

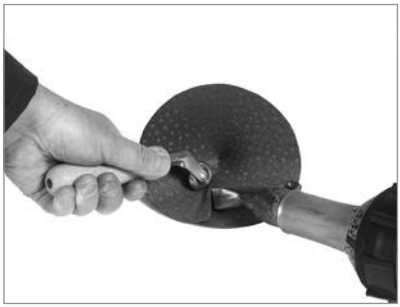


42.
Mark a straight vertical line, minimum 60mm wide, and cut away excess material. Ensure that the membrane is pushed fully into the corner.
Make a 45° cut at the bottom to allow for welding. Pre-weld and final weld all connections.

43.
Place the pre fabricated detail well into the corner and its angles.
NOTE: The pre fabricated detail can be warmed and stretched to fit/ be adjusted to the angles without wrinkles and cracks.

44.
Cut a circle of Protan SE or G - diameter approximately 180 mm. make a cut to the centre and fold the circle to form a small cone then position.

45.
Put the reinforcement into the corner and adjust it to fit into every angle.
Pre weld the piece of membrane when you are sure it fits.
Pull it back out and cut of the excess membrane leaving 30 mm overlap.



46.
Weld the seam both in front and back.

47.
Cut a small piece of G membrane – diameter approximately 20 mm, to be welded to the rear of the corner where the two seems meet at the point. Apply heat and weld the circle to the corner.
NOTE: It is easy to weld this detail if you find a steel plate to weld the detail on.

48.
Position the detail making sure it fits into every angle. Weld into position by pre weld and final weld.

12 Installation of Perimeter upstand restraint with Secret Fix Pocket

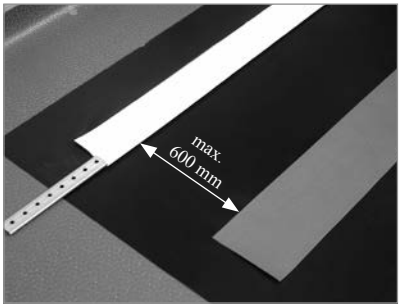
Protan can supply prefabricated membrane flashing with the secret fix pocket welded to the rear of the sheets. Alternatively the pocket can be measured and welded on site. The pocket is delivered in lengths of 19.80 m.

The first sheet in the perimeter zone should be allowed to return through the change of angle by 50-100 mm.
Advantages:
- Saves use of extra fasteners in the edge of the sheet
- The upstand material will be fixed together with the pocket
- prevents water from running into the construction before the upstand restraint is installed.

Slide the metal bar into the pocket with the flat side towards the upstand before welding the pocket to the membrane. Due to expansion remember to install the bars with a 10 mm gap.

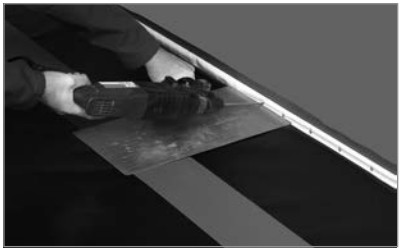
The pocket with the metal bar inside should be welded onto the rear of the membrane minimum 100 mm from the edge. This option MUST be carried out by the automatic welding machine.

NOTE: The speed of the automatic welding machine can be increased to prevent wrinkles in the parapet upstand restraint membrane when welding the pocket onto the membrane. The quality of the welding shall be tested by carefully peeling the end of the pocket.



49.
On upstands above 600 mm an extra strip must be welded on the back of the sheet. On high parapets the strips shall be installed at an internal distance of 400 mm. The strips must be prewelded onto the sheet.

50.
The pocket with the bar inside is mechanically fastened into the vertical face of the angle. Ensure that the bar is pushed fully into the change of angle. The pocket must be stretched sideways while fastened and start the installation of the pocket by fastening at least two screws in the bar.

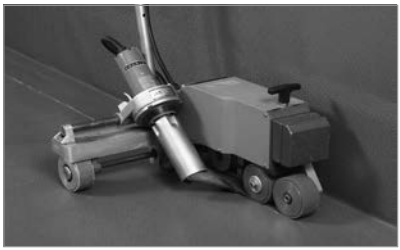


51.
When drilling in concrete while installing the pocket detail it is advisable to use a metal plate to avoid damage to the membrane.

52.
Remember to fix the metal bar according to the wind uplift calculation.
NOTE: At any changes in angle in the parapet, highest- / lowest point, a vertical seam restraint must be made.

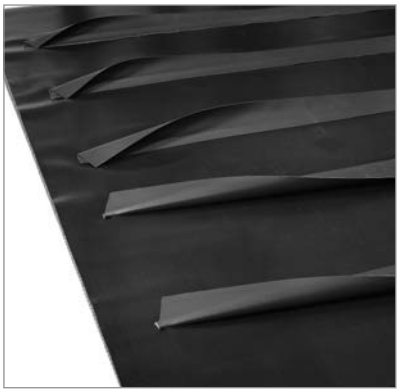
53
Where additional strips are required, sue spot ficing with relevant plates and fasteners. The fasteners shall be fixed according to the wind uplift calculation.

54.
The finished installation of a perimeter upstand restraint. (cut so show the secret pocket and strip)

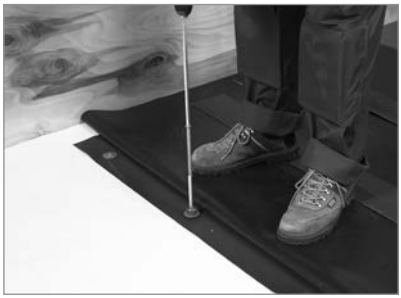


55.
The overlap between the flashing and the membrane from the parameter zone should be welded with the automatic welder.

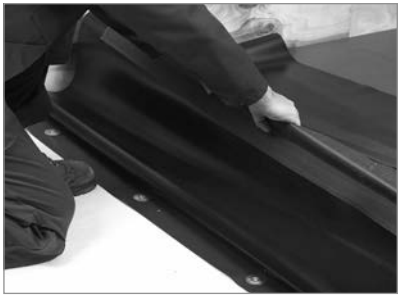
13 Installation of Protan membrane with Protan Secret Fix Strip (Protan SE)



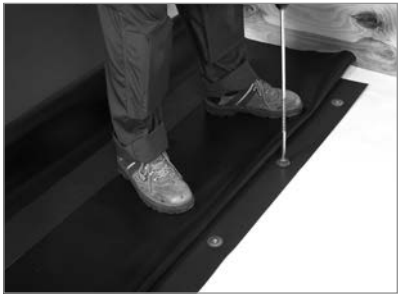
56.
Protan Secret Fix Rolls are prefabricated 2 m wide Protan SE rolls with strips welded to the rear of the membrane. Standard length of the rolls is 15 m. The strips appear as the roll is unrolled on site. The first strips, between 2 and 5 pieces, run in the opposite direction compared to the other strips. This is to enable correct alignment of the sheets. Protan Secret Fix Strip can be delivered with strip centers from 400 – 1200 mm. Each strip should have a minimum of 3 fasteners and a maximum of 7 fasteners.
Follow the wind uplift calculation.



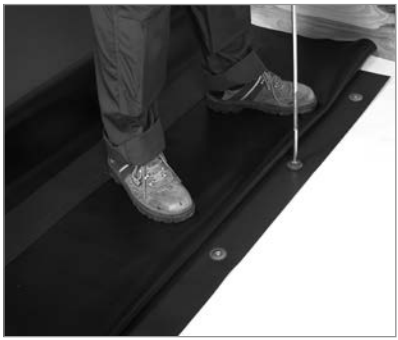
57.
Unroll the 2 m wide rolls by unrolling the strips that are welded in the opposite direction. Turn this part of the roll backwards and align the sheet.
Start fastening the strips mechanically when the membrane is placed in the correct position.
NOTE: To gain "stretch" in the material it is best to fix the fasteners form the middle and stretch towards the sides of the strip while continuing fastening.
The fasteners should be fixed as far in from the side of the strip as possible (minimum 90 mm) and not closer than 30 mm from the edge of the strip.



58.
Next strip is pulled out and fixed.



59.
When the strips running the opposite direction are installed, unroll the remaining strips one by one and install.
NOTE: When windy it might be wise to stand behind the roll while installing the strips.



60.
On soft insulation you should, to gain good stretch (the heavy roll compresses the soft insulation), leave the remainder of the roll behind the previous fixed strip. All stretching of the material should be done through the strip.

61.
All stretching of the material should be done through the strip.
NOTE: On cold winter days pay extra attention to the installation while pulling the material backwards and stretching the strip by "kicking" the material backwards to expose the strip. This may cause a sharp fold in the material which is undesirable. Stretching on cold days must only be done by hand force.

62.
Position the next sheet and align with the previous, overlapping with 80-100 mm.
Although there is no reason that finished seams cannot run against the fall of the roof, it is good roofing practice to try to keep them running with the fall on the roof.

The overlap is welded with the automatic welding machine.

THINK PERSONAL SECURITY -
it is ***your*** health
THE 12 RULES OF SAFETY

1. Always use safety equipment in perimeter areas on flat roofs!
2. Pay particular attention when working in perimeter areas and on pitched roofs!
3. Keep the building site orderly!
4. Be aware of any overhead cranege!
5. Ladders should be long enough to be secured against slipping, and in good condition!
6. Provide fire-fighting equipment when working with naked flames on roofs!
7. Remember: Helmet, safety shoes and respiratory equipment!
8. Follow instructions for working with hoists and other lifting equipment!
9. Ensure that all safety equipment is secure before leaving for the day!
10. Secure openings, skylights and corners!
11. Follow instructions for electrical tools and equipment!
12. Keep emergency exits and escape routes open!

YOUR PLACE OF WORK -
ENSURE YOUR SAFETY PRECAUTIONS
MEET THE MINIMUM STANDARDS LAID DOWN
BY THE RELEVANT AUTHORITY