Protan Vacuum Roofing System

Design and Application Guide

Kinozentrum, Klagenfurth - Austria

Supplement to TS (Technical Services)
Info No. 38

PROTAN
Roofing and Waterproofing Membranes

Drammen, December 2008
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General

Differences in pressure occur when a building is exposed to wind. Negative pressure forms over the roof, whereas positive pressure is exerted against the facades and can penetrate into the building and up into the roof structure from below. In a strong wind and over large surfaces, this results in high forces, which the roof structure and the roofing membrane must be dimensioned to withstand, and the loads are transferred to the supporting structure. The following methods are applied in principle for anchoring the roofing membrane and insulation to the substrate:

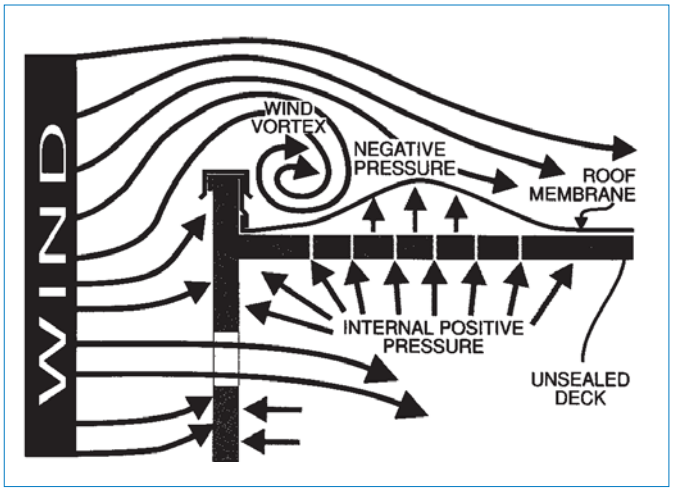
Ballasting
This method was once in very widespread use for flat roofs, although it is rarely specified on new buildings. Modern structures are often optimized in respect of loads, and upgrading to enable them to support gravel or some other form of ballast is thus relatively costly. A ballast layer also makes the roofing membrane inaccessible for inspection and difficult to replace.

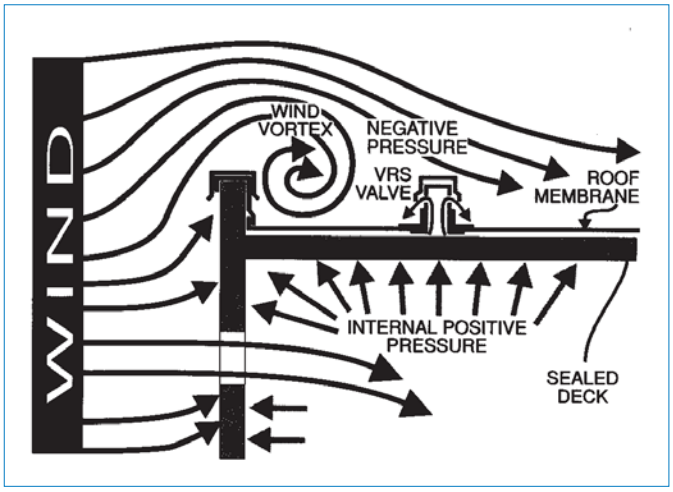
Adhesion
The dependence on the weather makes this an unreliable method in a Nordic climate, although welding to the underlay is carried out to some extent in conjunction with renovation with an asphalt membrane. The method is used to a greater extent in warmer parts of Europe. Compact, adhered constructions depend upon the interaction between the materials in the build-up layer, if delamination is to be prevented from occurring.

Mechanical fixing
This is the predominant method used today, and it has been in continuous development since the middle of the seventies. Calculation models and dimensioning bases have been developed, which permit secure and effective installation regardless of the weather and wind. The method is labour-intensive, however, especially on a concrete substrates which requires pre-drilling. This also causes puncturing of the vapour barrier, which can be a disadvantage if the indoor climate is associated with the risk of condensation in the insulating layer.

Vacuum
A roofing membrane in contact with a completely airtight and load-bearing underlay will, when subjected to a wind load, transmit the forces involved to the underlay as suction and without movement. Extensive experiences and documentation of the method are available from the USA, and since the first test trial in Norway in 1985, thousands of square meters Protan vacuum roofs have been installed in Europe. In association with the Norwegian «Statsbygg» and SINTEF Byggforsk, Protan has developed and adapted the method to Nordic climatic conditions - ref. SINTEF Technical Approval No. 2281.

In the case of substrates, which are suitable for vacuum installation, the method forms the basis for the most optimal roofing membrane system in terms of both technical and economic considerations.





Principle

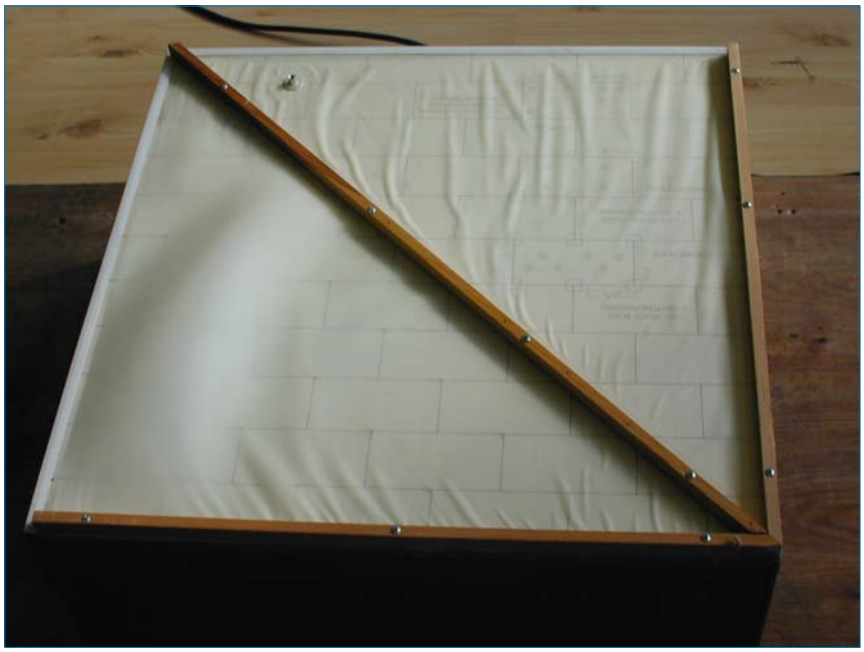
When the airflow causes negative pressure to form over the roof, the air volume between the roofing membrane and the airtight underlay expands, and it expands most where the negative pressure is greatest, i.e. in corner and edge zones. In order to «drain» out this positive pressure and any losses from leaks, so-called vacuum vents are installed where the negative pressure is expected to be greatest. We have acquired detailed knowledge from our experience of and studies into the aerodynamic flow conditions around building structures. This knowledge provides the basis for determining the frequency and positioning of the vents. The vents have valves, which let the air out, but not in.
Wind comes over the roof in relation to rapid changes in its intensity and the local direction. These sudden gusts of wind can be seen as «rippling» in the roofing membrane, similar to the effect over a stretch of water. It takes a few seconds for the pressure to be equalized. However, large movements over time indicate a faulty function. A correctly designed and installed vacuum roof «sucks» itself firmly to the substrate.

A condition for establishing negative pressure in the intermediate layer is that both the substrate and the attachment of the roofing membrane to it are airtight, or sufficiently airtight in relation to the vent capacity. In practice 100% airtightness is sought, and the vent system then acts as a form of security in the case of any leaks.

The manner in which load transmission takes place is for the negative pressure to be transferred down into the airtight layer or substrate, which in turn transmits the forces onwards into the supporting structure. The underlay can be a reroofing underlay or a surface of fibre board or concrete, for example. The procedure is based on the fact that this underlay is both sufficiently airtight and sufficiently strong to transmit the wind suction forces from the roof. It is also possible for positive pressure to occur in individual buildings, which presses up against the roof from inside. The roof construction must be dimensioned to withstand these loadings, and this is an important condition for vacuum roofs.

Insulation between the roofing membrane and the airtight underlay has no significance for the vacuum effect andfunction.

Protan vacuum-roofing systems can be used both for new roofing and for reroofing. The system requires a airtight layer in the substrate. This makes it particularly well suited for reroofing projects where the existing roofing membrane is still considered to be sufficiently intact and with sufficient anchoring to the supporting system. Old bitumen-membranes, with open blisters and overlaps and with questionable adhesion to the underlay, are an example of an unsuitable underlay.



Model trials which illustrate the difference between a vacuum roof and a roofing membrane without fixing under wind load.

Airsealing

General
The principle is that the underlay and the attachments of the roofing membrane to it must be as airtight as possible and sufficiently airtight by a good margin in relation to the vent capacity. This is a fundamental requirement. In order to assess the suitability of a particular building, it must be inspected and evaluated beforehand by a Protan technical representative or a person approved by Protan.

Sealing by making joints along edges and around penetrations is achieved by clamping the Protan roofing membrane to the underlay in an airtight fashion. This is done with a Protan steel bar and with a Protan airsealing band between the underlay and the Protan roofing membrane. As an alternative to the airsealing band, it is possible to use a sealant approved by Protan. The steel bar is secured to the substrate with bolts or screws with a minimum fixing distance of 150 mm. The bars are installed consistently with a spacing of 2 -10 mm (expansion requirement), and the airsealing band/sealant is laid continuously. Do also remember continuity when using secret fix pocket. In this way the roofing membrane is sealed both externally and internally to the flat area of the roof. It is important to ensure that all components around penetrations, including gullies, soil and vents are included. Examples are shown in drawings in NTG No. 2281.

It is important both for those who are involved in planning and for those who install the roofing membrane to think about airtightness during the entire process. This is new and unfamiliar to most people, yet it is a far more inspiring and motivating task due to speed of application.

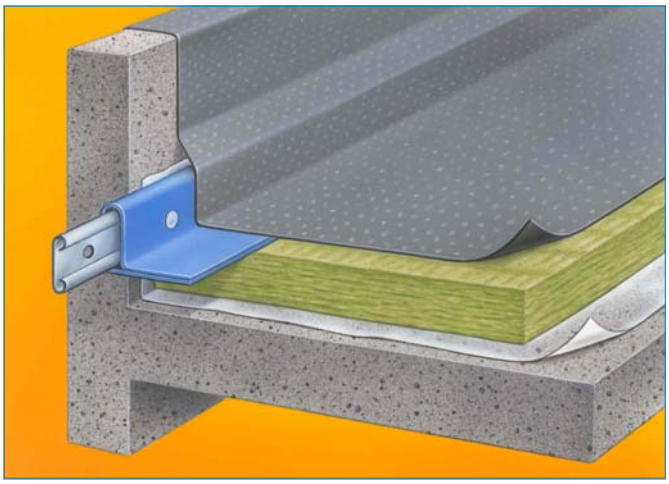
New roofing
Concrete underlay is inherently airtight, apart from at joints and grooves. These must be sealed, or as an alternative the Protan roofing membrane in these areas must be sealed.

The same applies to underlay made of fibreboard. Open sheet joints are not normally sufficiently airtight, and special sealing must be provided here.

On metal deck (corrugated sheets without sealing) the construction must include a separate airtight layer with load-bearing capacity. For example, a mechanically fixed Protan vapour barrier with 50 mm of insulation beneath it, will be an ideal underlay, ref. the “Protan 2X concept”, SINTEF Byggforsk TA no. 2415. Further insulation can then be placed on top before the final roofing membrane is applied. The Protan roofing membrane and the vapour barrier must be sealed by clamping them together at all the joints and penetrations. Sealing is performed as described above, but with the sealing medium in between the layers.
The transfer of pressure will now take place between the vapour barrier and the roofing membrane.

NB! Have a look at TS-info 38/rev. 08 for correct positioning and application of the air and vapour barrier.

Reroofing
A building intended for reroofing which already has an existing bitumen roofing membrane, often provides an ideal underlay, with or without supplementary insulation. However, the old roofing membrane must be carefully inspected for its airtightness and load-transfer capacity. A certain number of bubbles and cracks can be accepted provided that they are levelled and sealed. Allways consult a Protan technical representative.



Principle of edge connection

Vent locations

General
All vacuum-installed Protan roofing membranes must be designed by Protan's TS (Technical Services) Department. Guidelines for the calculation principles and the associated basis for TA No. 2281 are regulated in a separate agreement between SINTEF and Protan AS.

Many factors have an influence on the vent positions:
– topography around the building, adjacent building mass
– the form and height of the building
– form of the roof
– form, height and projection by the perimeter
– inset storeys and installations inside the flat area of the roof

On an «ordinary» flat roof, two vents are installed at each corner, both at the internal and external corners and at a distance of every 15m along the free perimeter. No vents are normally required along higher, adjacent buildings. The loading is different on pitched roofs and curved roofs and in these cases vents are also installed on either side of the roof ridge.
Exiting roofs with different forms must be evaluated in every individual case to establish whether they are suitable for vacuum installation.

New roofing
In the case of new buildings and roofs where the Protan vapour barrier constitutes the vacuum-sealing layer, this must be designed and mechanically fixed as appropriate for an exposed roofing membrane. The vapour barrier can then also serve as a temporary roofing membrane during the construction period or for a longer period if it is anchored against being blown off by the wind. The rest of the insulation and the final vacuum roofing membrane can be laid at a later stage, ref. "Protan 2X".

Reroofing
The wind load capacity of a vacuum-installed roof can never be greater than the capacity of the existing waterproofing. In reroofing, it is important to examine the load-transfer capacity of the old roofing membrane. This is in practice an equivalent evaluation to that for the adhesion or welding of a new roofing membrane to the old roofing membrane. The fundamental requirement is considered to be an intact bitumen membrane of inorganic origin either mechanically fixed or fully adhered to the insulation and concrete underlay or lightweight concrete substrate. The examination of an existing mechanically installed roofing membrane dating from before 1985 should also take into account possible corrosion of the fasteners.

Provided that the roofing membrane and fixings are still intact, a roof that has been in place for 15 years or more will normally be sufficiently securely attached. If upgrading of the fixing is required in relation to today's wind load standard, this can be done by increasing the fixing density and sealing the penetrations in the original roofing membrane. This question may arise for buildings in areas that are particularly exposed to the wind.

Vacuum vents in perimeter zone

Vacuum vents in the corner zone

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Application

General
Protan vacuum-roofing system should only be installed by applicators approved by Protan, who have received special project training and are regulary updated with information about the system.

All vacuum installed roofing membranes must also be inspected by a Protan appointed field technician during installation. Installation is documented in a report with a description, drawings and illustrations, and these are archived by Protan's TS (Technical Services) Department.

The Protan SE membrane is very simple to install. The membrane is unrolled in 2 m wide sheets or is laid as large prefabricated sheets. In this way, large areas can be covered in the course of a working day, which must be secured at the end of the day. The edge connections are usually installed before a start is made on the flat area of the roof, and the Protan membrane can then be welded continuously to these connections along the side edges. The exposed edge of the membrane can be sealed temporarily to the underlay either with mechanical fixings, by fully adhering or with ballast. Ballasting can be done by filling tubular pouches with water (Protan's Ventiflex tube), which can also be used out on the flat area of the roof - simple and easy, the water is drained out after use!

In valley linings with falls of 1 :40 or steeper, Protan's steel bar is always installed to lock the membrane to the underlay. This is especially important when using tapered insulation. The air passage to the vacuum vents must not be blocked when bars are fitted in the field area of the roof. This is achieved by installing the bars with 0.5 m spacing (opening) every 2.0 m, or by installing vacuum vents on both sides of the valley lining.

Roof insulation is laid loosely in layers with a minimum board thickness of 50 mm. The upper panel shall always be of mineral wool, for reroofing objects it is recommended to use only mineral wool throughout the whole sandwich, not EPS at all. This among other factors due to equalisation of air pressure. If other design is requested, this has to be approved especially by the TS-dept.
Protan EXG is used for roofing membrane on EPS insulation.

A «box formed gutter», if necessary with a longitudinal counter-fall, is recommended where it is necessary to build up a counter-fall of insulation in gutters. A counter-fall in two directions is an unnecessary complication. A single gutter is more cost-effective in terms of materials and assembly, and is easier to maintain. When limited to a smaller area, the gutter can also be incorporated in a prefabricated parapet restraint, if necessary with increased membrane thickness in this critical and ex-posed area of the roof. When pursuing the 2X-roofing concept, horizontal gutters can preferably be used, ref. TA no.2415.

The vacuum vents are installed progressively as the flat area of the roof is sealed.

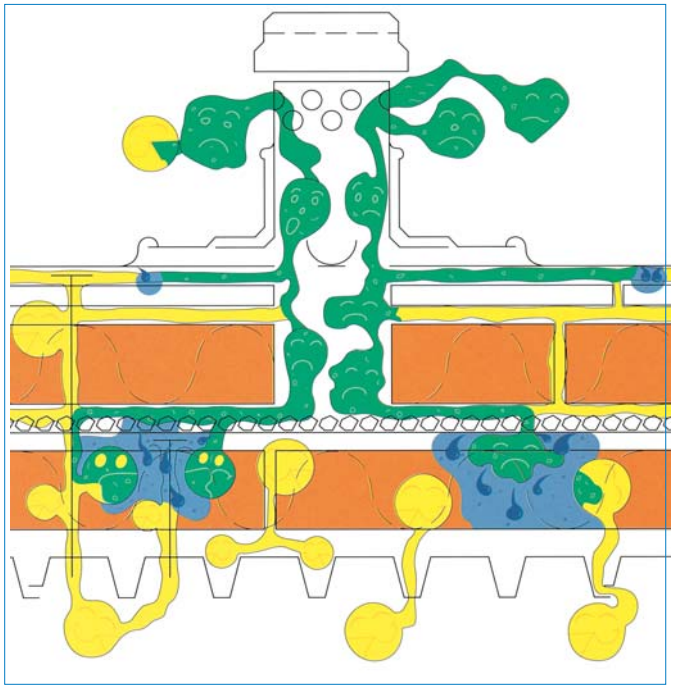
At all terminations where a secret fix pocket is not used, welding cords are used to lock the membrane to the fixing bar. This also applies around outlets.
In the case of outlets, it is important to have a separate vacuum seal with the underlying airtight layer. Otherwise air leaks can occur between the new outlet and the old drain, which is especially important in conjunction with the use of inset outlets.
Drawings of assembly details are shown in TA no. 2281.

When the time comes to replace the roofing membrane at the end of its service life, and it needs to be removed, it can be easily loosened and rolled up ready for its return to Protan or some other point for recycling.

Special points when reroofing
Old roofs consisting of old bitumen roofing membrane must be sealed. Blisters and open cracks must be repaired, which is achieved by cutting away the loose roofing membrane and welding a new bitumen roofing membrane in place over it. In the same way, a seal must be effected over any places where the roofing membrane may have been opened to permit inspection of the existing attachment.
When reroofing without supplementary insulation, Protan EX (fleece backed) or Protan FP with loose fleece are used. By using separate fleece the fleece must then be fixed to the underlay either by point adhesion or by mechanical fixings.

Humidity

A vacuum installed roofing system is based on an airtight underlay, and negative pressure over the flat area of the roof which will accordingly not suck up warm and humid indoor air into the cold part of the roof structure. The vacuum vents will help any humidity trapped in or over the subjacent airtight layer to dry out more rapidly and without weakening the fixing function (corrosion). This is an added benefit compared to other systems. Humidity trapped in roof structures can be an “environmental bomb” if fungus and mould growth occur. Especially in Nordic climates, it is almost an impossibility to operate an all-year-round roofing business without trapping in some water and humidity. The vacuum system, used in combined with a roofing membrane material that is open to diffusion, is a more secure way of avoiding this problem, and this is justifiably described as «the most ventilated roofing system».



Monitoring/ Inspection

Protan requires all roofs to be examined and inspected once a year as a minimum, and in the case of vacuum installated membranes a separate check list has been drawn up for monitoring and inspection. The manager of the building can opt to carry out the work himself, or a roofing contractor approved by Protan can perform this task annually.

Important factors which must be taken into account in the agreement:

– No changes must be made to the roofing membrane, the connections or the underlay without Protan or the roofing contractor being notified and approving the work in writing. No changes of a kind which can render the vacuum effect function invalid may be made.
– Cleaning of gutters and outlets, checking of drain function.
– Examination of vacuum vents.
– General inspection, checking of the roofing membrane in respect of any damage and deformations.
– Examination of metal work and terminations.
– Assessment of the need, if any, for corrective measures, responsibility for initiating their specification and implementation. The roofing contractor must be contacted in the case of doubt and in those cases in which the manager of the building himself takes responsibility for the work.

A vacuum installed roofing membrane, which moves in the wind is indicative of a faulty function. This can occur for a variety of reasons, and it is essential for Protan’s TS (Technical Services) Department to be notified without delay.
Unforeseen wind effect is likely to be the most probable cause, and repairs can be carried out in conjunction with the installation of additional vents. A faulty function will rarely occur, however, if the above-mentioned guidelines are followed.

Perforations or damage caused to the roofing membrane will not be detrimental to the vacuum effect. These can be repaired in the customary manner used with other Protan roofing systems.

Experiences gained from hurricanes in the USA indicate that vacuum installed roofing membranes are at least as secure as those fixed in some other way, a fact which is explained by the extensive quality assurance procedures during planning and execution. These same experiences provide the basis for the commercial introduction of the vacuum system by Protan in Europe.

Protan’s Vacuum Roofing System provides the client with an economic high performance solution and in addition makes the applicators job more comfortable and inspiring.

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