Dow Building Solutions

Insulating inverted flat roofs with XENERGY™ SL: basic principles

Introduction

XENERGY™ SL
Dow Building Solutions' XENERGY™ products include XENERGY™ SL materials for roofing applications. XENERGY™ products use carbon dioxide as the main blowing agent - the Ozone Depletion Potential (ODP) is zero and the Global Warming Potential (GWP) is less than five.

XENERGY™ SL is the solution Solution for insulating inverted roofs. The boards are unaffected by the conditions encountered on flat roofs, including wide fluctuations in temperature and repeated freeze/thaw cycles.

XENERGY™ SL insulation is intended for use on heavyweight decks (e.g. reinforced concrete) with a ballast layer of gravel or concrete slabs. It can also be used in the XENERGY™ MK system a unique development from Dow Building Solutions which brings together XENERGY™ SL and a vapour-permeable separation layer.

The rainwater cooling effect (caused by rainwater flowing between the insulation and waterproofing membrane) requires an increase in insulation thickness in order to meet BS EN ISO 6946. However, this increase can be substantially reduced by using the XENERGY™ MK system, which helps to minimise the heat loss due to rainwater cooling and therefore the amount of insulation required. Its rot resistance also makes it ideal for insulating green roofs.

XENERGY™ LG - an insulation board with an integral 10mm thick mortar topping - is ideally suited for parapet and upstand insulation.

Insulating inverted roofs

Basic principles

The performance and longevity of flat roofs depends upon many factors, including the position of the insulation within the construction.

If insulation is placed below the structural deck (cold roof construction) the structure remains cold and there is a considerable risk of condensation; for that reason cold deck roofs are seldom used.

Insulation placed above the structural deck and beneath the waterproof layer (warm roof construction) reduces the risk of condensation but, because the waterproof layer is thermally isolated from the rest of the roof construction, it is exposed to wide temperature fluctuations with consequent increased risk of premature failure **(Figure 1)**.

The inverted roof concept overcomes the problem by placing thermal insulation above the waterproof layer, maintaining it at an even temperature close to that of the building interior and protecting it from the damaging effects of UV radiation and from mechanical damage.

The insulation protects the waterproof covering from:
- wide temperature variations +80 to -20°C
- degradation from weathering
- mechanical damage during construction, use and maintenance

The waterproof layer acts as a total vapour control layer and, being on the warm side of the insulation, is maintained above dew point temperature so the risk of condensation is eliminated.

The inverted roof concept has other benefits.
The insulation can be:
- installed in any weather
- added to, without stripping the waterproof layer
- easily lifted and replaced/re-used if the building is altered

The insulation for an inverted roof must:
- **resist water absorption**
- **be unaffected by freeze/thaw cycles**
- **withstand surface traffic**
- **protect the waterproof layer long term**
- **be ballasted to prevent flotation**
- **be protected from UV and mechanical damage.**

General recommendations on the design of flat roofs are contained in BS 6229.

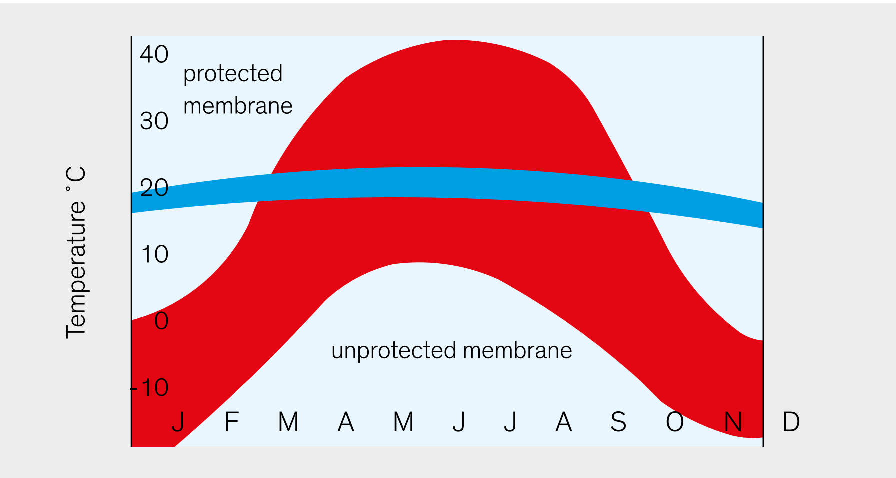

Figure 1: Temperature fluctuations in an unprotected roof covering compared with those in one protected by XENERGY™

Construction of the inverted roof

In the inverted roof system, insulation is laid over the waterproofing layer and suitably loaded to restrain it against flotation and wind uplift and to protect it against damage.

Inverted roof constructions can be categorised as heavyweight or lightweight by reference to the form of building construction involved. If the structure incorporates a concrete slab it will normally be cost effective to design the slab to support the load of 80-120 kg/m^2 imposed by a ballasted inverted roof system **(Figures 2)**.

The inverted roof concept is ideally suited to green roofs where the roof is covered with a plant bearing layer **(Figure 3)**. Green roofs may be used to:

- reduce a building's environmental impact
- provide a garden area for projects where space is at a premium
- contribute to a building's appearance
- attenuate the discharge of rain water from the roof

Roof loadings

The basic roof structure may be of concrete, metal or timber: it must be strong enough to withstand the maximum predicted loads with a suitable factor of safety.

Inverted roofs are subject to three main loads:

- dead loads: the self-weight of all the materials used: for calculation advice see BS 6399: Part 1
- wind loads: the positive and negative pressures acting on the roof should be calculated using either the standard or directional method given in BS 6399: Part 2. To calculate the weight of ballast required to resist wind uplift refer to BRE Digest 295. The stability of the ballast selected can be assessed using BRE Digest 311
- imposed loads: see BS 6399: Part 3.

Thermal performance

Table 1 shows the thickness of insulation required to achieve a range of U-values. In an inverted roof construction some rainwater will run off beneath the insulation boards and in doing so may draw heat from the deck.

This 'rainwater cooling effect' requires an increase in insulation thickness in order to meet BS EN ISO 6946. However, this increase can be substantially reduced by using the XENERGY™ MK system, which helps to minimise the heat loss due to rainwater cooling and therefore the amount of insulation required.

Figure 2: Inverted roof with paving ballast and inverted roof with aggregate ballast

Figure3: Inverted green roof

Condensation

The inverted roof construction can greatly reduce the risk of condensation in an existing building by keeping the roof structure and the waterproof layer above the dew point temperature.

Where the building is likely to have a high level of humidity, as in the case of swimming pools or commercial kitchens, a condensation risk assessment should be undertaken by a suitably qualified professional. A method for calculating the risk of interstitial condensation is given in BS EN ISO 13788.

Roofs with high thermal capacity - such as concrete at least 150mm thick - do not undergo rapid cooling by rainwater run-off.

Fire

Inverted roofs ballasted with incombustible material, such as aggregate or paving slabs, readily achieve an external fire rating of FAA when tested to BS 476: Part 3: 1958.

U-value	0.18	0.16	0.15	0.14	0.12	0.10
XENERGY™ SL	180	200	205	220*	260*	320*

Table 1: Required XENERGY™ SL thickness (mm) to meet U-values W/m²K using the XENERGY™ MK System

Roof build-up:

Ballast (aggregate/pavers)	Geotextile separation layer (if required)
XENERGY™ MK	Hot melt waterproofing 7.5 mm
XENERGY™ SL	Reinforced concrete deck 200 mm

Rainwater cooling penalty calculated to BS EN ISO 6946 Annex D4, p=3mm/day

* 2 layers of insulation required

They offer adequate resistance to the external spread of fire as required by Building Regulation B4 (Regulation 19 in Scotland). For further information on the fire performance of XENERGY™ SL boards see BS 6203.

Roof falls and drainage

Good drainage is vital to the long-term performance of a flat roof. As with any building element, when designing a flat roof, it is good design practice to follow and adopt relevant design guidance. The most referred to guidance is that of BS 6229:2003 – flat roofs with continuously supported coverings which recommends an appropriate fall be accommodated within the roof design, including inverted flat roofs.

It is also vital that the roof is adequately drained to prevent ponding. The location, size and number of rainwater outlets should be designed in accordance with BS EN 12056-3:2000. The roof deck should also be without deflections or depressions in which water may pond. To perform effectively, XENERGY™ boards should not be totally or permanently submerged in water during the product's lifetime on a roof.

If the roof is regarded as 'zero pitch', then particular attention must be given to the provision of roof drainage to prevent ponding, as outlined in the BBA Information Bulletin No 4. The location, number and size of the drainage outlets need to be designed to facilitate acceptable removal of rainwater (and water from other precipitation) to avoid the thermal insulation boards within the inverted roof construction being either totally or permanently immersed in water. If significant areas of ponding as a result of back falls are identified, an appropriate design strategy must be adopted to ensure their removal prior to the insulation being installed. Specify rainwater outlets which will accept run-off from both the top of the insulation and the surface of the waterproofing.

Further guidance and information can be found in ETAG 031, Guideline for European Technical Approval of Inverted Roof Insulation Kits Part 1.

Roof waterproofing

The inverted roof concept can be used with a wide range of waterproofing materials, including mastic asphalt, high performance built-up bitumen felt, hot melt modified bitumen, PU based systems and single ply polymeric membranes. Seek advice on compatibility with waterproofing materials from suppliers.

Separating layers

The recommendations for the use of separating layers in inverted roof construction are as follows:

- between waterproof layer and insulation:
  - mastic asphalt: BS 8218 requires a loose-laid nonwoven polyester fleece 130 - 140g/m^2 lapped 200 - 300mm
  - bituminous felts: separating layer not normally required
  - single ply polymeric membranes: a looselaid nonwoven polyester fleece is normally
  - recommended for pPVC membranes - consult the membrane supplier
  - PU based systems - consult supplier.
- between insulation and ballast:
  - to prevent fines from being washed under the insulation where they could damage the waterproof membrane use a loose-laid filter fabric, e.g. XENERGY™ MK
  - to reduce the depth of ballast required to counter board flotation to 50 mm washed 20/40 aggregate, irrespective of the insulation thickness, use a loose-laid non-woven geotextile e.g. XENERGY™ MK lapped 300 mm.


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Recommendations

STYROFOAM™ products include FLOORMATE™, and PERIMATE™.

XENERGY™ products contain a flame retardant additive to inhibit accidental ignition from a small fire source. XENERGY™ is however, combustible and if exposed to an intensive fire may burn rapidly.

During shipment, storage, installation and use XENERGY™ products should not be exposed to flames or other ignition sources.
Fire classification is based on small scale tests, which may not reflect the reaction of the products in its end use state under actual fire conditions. XENERGY™ products should, when installed, be adequately protected from direct exposure to fire.

Recommendations about the methods, use of materials and construction details are given as a service to designers and contractors. These are based on the experience of Dow with the use of XENERGY™ products. Any drawings offered by Dow are meant only to illustrate various possible applications and should not be taken as a basis for design.
Since Dow is a materials supplier and exercises no control over the installation of XENERGY™ products, no responsibility is accepted for such drawings and recommendations.

In particular, no responsibility is accepted by Dow for the systems in which XENERGY™ products are used or the method of application by which they are installed. The legal obligations of Dow in respect of any sale of XENERGY™ products shall be determined solely by the terms of the respective sales contract.

Visit **www.dowxenergy.co.uk** for further information on XENERGY™ SL insulation products as well as adhesives and sealants from Dow Building Solutions. For technical enquiries email FKLTECH@dow.com.

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