PROTOTYPE PRODUCT ASSESSMENT

PPA No 08/P002

DUPONT CLIMATE SYSTEM

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Holder **DuPont de Nemours (Luxembourg) S.à r.l.**

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This document is intended to assist specifiers, regulators, contractors and others considering the use of prototype products[1], and their use in construction systems. In this regard, this document is a precursor to full Agrément approval, which may be granted following experience in use and surveillance of full factory production control procedures.

Generic type of construction product and use

The DuPont Climate System is for use as a complete membrane system for normal housing structures, contributing to wind and weather resistance, improved insulation levels, reduced risk of condensation and will enable the building envelope to breathe. The system comprises:

(1) Tyvek Enercor Roof — a vapour-open roof tile underlay with a metallised, low-emissivity surface placed on the cold side of traditional insulation to reflect heat in summer and reduce heat loss in winter. The underlay consists of Tyvek membrane 60 gm^{-2} coated with an aluminium lacquer on an EVA bonded fleece 72 gm^{-2}

(2) DuPont AirGuard — a 100% airtight vapour control layer with a metallised surface and low emissivity. It is placed on the warm side of the insulation at roof, wall and floor level with the metallised surface facing the interior of the building

(3) Tyvek Reflex — is a vapour open wall underlay with a metallised low emissivity surface which reflects heat in summer and reduces heat loss in winter. The underlay consists of Tyvek 80 gm^{-2} coated with an aluminium lacquer (also subject of BBA Certificate No 90/2548, Product Sheet 3).

Tyvek Enercor roof is ideally used as a roof underlay in combination with a VCL, like Dupont Airguard. Combining an LR underlay with a VCL installed on the warm side of the thermal insulation is the best solution to ensure a good airtightness and reduce the risk of interstitial condensation.

Accessories used with the DuPont Climate System (roofs) are:

- Tyvek Metallised Tape — to close laps between Tyvek Enercor Roof and Airguard membranes to make the building fabric airtight
- Tyvek Butyl Tape — used to connect the Tyvek Enercor Roof and Airguard membranes to wood or masonry.

Tyvek Reflex is ideally used in timber-frame wall construction in combination with a VCL, like Dupont Airguard. Combining an LR underlay with a VCL installed on the warm side of the thermal insulation is the best solution to ensure a good airtightness and reduce the risk of interstitial condensation.

Accessories used with DuPont Climate System (walls) are:

- Tyvek Metallised Tape to close laps between Tyvek Reflex layers to make the building fabric airtight
- Tyvek Butyl Tape can be used to connect the membrane to timber or masonry.

Tyvek Enercor Roof, Tyvek Reflex and Dupont Airguard are part of the DuPont Climate System to improve the thermal efficiency of Buildings, and reduce the risk of interstitial condensation.

Basis of this assessment

This document covers:

- factors relating to UK Building Regulations compliance
- performance data in support of functional capability
- FMEA/FMECA[2] and risk assessment based upon them
- application benefits
- limitations in use
- maintenance
- production control.

(1) In the context of this assessment, a prototype product is one developed fully at the laboratory stage but needs feedback from site experience to complete the development and complete the manufacturing process.

(2) Failure Modes Effects Analysis (FMEA) and Failure Modes Effects and Criticality (FMECA) were developed in the aeronautics, space, nuclear, chemical and automobile industries to assess residual risks. They can be adapted for making similar judgements about construction and building products (see 'Talon A' entry in the *Bibliography*).

In the opinion of the British Board of Agrément, the DuPont Climate System is fit for its intended use provided it is installed, used and maintained as set out in this Prototype Product Assessment. PPA No 08/P002 is accordingly awarded to DuPont de Nemours (Luxembourg) S.à r.l.

On behalf of the British Board of Agrément

Head of Approvals — Materials

Chief Executive

Regulatory compliance

Building Regulations

This assessment has taken regard of the relevant regulated requirements as expressed below and overleaf using data available at the date of issue. The DuPont Climate System can be used to contribute to meeting the relevant requirements of the national Building Regulations and home warranty providers with respect to:

The Building Regulations 2000 (as amended) (England and Wales)

Requirement:	C2(b)	Resistance to moisture – Precipitation and wind driven spray
Requirement:	C2(c)	Resistance to moisture – Condensation
Requirement:	L1(a)(i)	Conservation of fuel and power
Requirement:	Regulation 7	Materials and workmanship

The Building (Scotland) Regulations 2004 (as amended)

Regulation:	**8(1)(2)**	**Fitness and durability of materials and workmanship**
Regulation:	**9**	**Building standards – construction**
Standard:	3.10	Precipitation
Standard:	3.15	Condensation
Standard:	6.1(b)	Carbon dioxide emissions
Standard:	6.2	Building insulation envelope
Regulation:	**12**	**Building standards – conversions**

The Building Regulations (Northern Ireland) 2000 (as amended)

Regulation:	B2	Fitness of materials and workmanship
Regulation:	B3(2)	Suitability of certain materials
Regulation:	C4(b)	Resistance to ground moisture and weather
Regulation:	C5	Condensation
Regulation:	F2(a)(i)	Conservation measures
Regulation:	F3(2)	Target carbon dioxide emission rate

NHBC Standards

Chapter:	7.2	*Pitched roofs*
Chapter:	6.2	*External timber framed walls*

Zurich Building Guarantee Technical Manual

Section:	4	*Superstructure,* Sub-sections – *Pitched roofs, External walls – timber frame*

Key performance data

The data in Table 1 form part of DuPont de Nemours (Luxembourg) S.à r.l.'s declaration of conformity for Tyvek Enercor Roof (Tyvek 2507M) under EN 13859-1: 2005 and EN 13859-2 : 2004, by notified body number 1686.

The data in Table 2 form part of DuPont de Nemours (Luxembourg) S.à r.l.'s declaration of conformity for DuPont Airguard (5814X) under BS EN 13984 : 2004, by notified body number 1686.

The data in Table 3 are taken from the BBA's assessment of Tyvek Reflex Insulating Breather Membrane resulting in the issue of BBA Certificate No 90/2548, Product Sheet 3.

Table 1 Enercor Roof — properties

Property (units)	Nominal (mean value)	Tolerance		Method[1]
		Minimum	Maximum	
Length (m) (%)	Customer related	0	—	EN 1848-2
Width (mm) (%)	Customer related	–0.5	+1.5	EN 1848-2
Straightness (mm)	—	—	30	EN 1848-2
Mass per unit area (gm^{-2})	148	134	162	EN 1849-2
Reaction to fire (Class)	E-d2	—	—	EN ISO 11925-2
Watertightness (Class)	W1	—	—	EN 1928 (method A)
Water vapour transmission (m)	0.015	0.005	0.04	EN ISO 12572
Maximum tensile force (MD) (N per 50 mm)	250	200	350	EN 12311-1
Elongation at maximum tensile force (MD) (%)	15	5	30	EN 12311-1
Maximum tensile force (XD) (N per 50 mm)	220	180	310	EN 12311-1
Elongation at maximum tensile force (XD) (%)	27	14	40	EN 12311-1
Resistance to tearing (MD) (nail shank) (N)	180	125	235	EN 12310-1
Resistance to tearing (XD) (nail shank) (N)	190	120	260	EN 12310-1
Resistance to penetration of air m^3 (m^2 per hour. 50 Pa)$^{-1}$	—	—	0.25	BS EN 12114
Dimensional stability (MD and XD) (%)	—	—	1	EN 1107-2
Flexibility at low temperature (°C)	—	—	–40	EN 1109
Artificial ageing by UV and heat (residual value)	aged/new material			EN 1297 and EN 1296
Maximum tensile force in MD (%)	90	—	—	EN 12311-1
MD elongation at maximum tensile force (%)	90	—	—	EN 12311-1
Maximum tensile force in XD (%)	90	—	—	EN 12311-1
XD elongation at maximum tensile force (%)	90	—	—	EN 12311-1
Watertightness (Class)	W1	—	—	EN 1928 (method A)
Additional properties				
Temperature resistance (°C)	—	–40	+100	—
UV resistance (months)	—	—	4	—
Water column (m)	2	—	—	EN 20811
Wind tight	yes	—	—	—
Emissivity	0.15	—	—	DuPont method
Effective R-value of air cavity with Tyvek Enercor roof				BS EN ISO 6946
horizontal flow (m^2KW^{-1})	0.5	—	—	
vertical flow (m^2KW^{-1})	0.4	—	—	

(1) The test documents are detailed in the *Bibliography*. Numbers in the table refer to the sections/parts of the document.

Table 2 DuPont Airguard — properties

Property (units)	Nominal (mean value)	Tolerance		Method[1]
		Minimum	Maximum	
Length (m) (%)	Customer related	0	—	EN 1848-2
Width (mm) (%)	Customer related	–0.5	+1.5	EN 1848-2
Straightness (mm)	—	—	75	EN 1848-2
Mass per unit area (gm^{-2})	118	110	126	EN 1849-2
Thickness (mm)	0.4	0.3	0.8	EN 1849-2
Watertightness (pass/no pass)	pass	—	—	EN 1928 (method A)
Water vapour transmission (sd-value) (m)	700	200	—	EN 1931
Density of water vapour flow rate (g) ($kgm^{-2}s^{-1}$)	5.873 E-10	—	20.1 E-10	EN 1931
Maximum tensile force (MD) (N per 50 mm)	560	450	—	EN 12311-1
Elongation at maximum tensile force (MD) (%)	15	10	—	EN 12311-1
Maximum tensile force (XD) (N per 50 mm)	185	120	—	EN 12311-1
Elongation at maximum tensile force (XD) (%)	13	8	—	EN 12311-1
Resistance to tearing (MD) (nail shank) (N)	230	150	—	EN 12310-1
Resistance to tearing (XD) (nail shank) (N)	230	150	—	EN 12310-1
Resistance to impact (mm)	NPD[2]	—	—	EN 12691
Reaction to fire (Class)	E	Installed on mineral wool		EN ISO 11925-2
Joint strength (N per 50 mm)	—	120	—	EN 12317-2
Durability (exposure to artificial ageing)				
water vapour transmission properties (pass/no pass)	pass	—	—	EN 1931
Durability against alkali				
elongation at maximum tensile force (MD) (pass/no pass)	pass	—	—	EN 12311-1
elongation at maximum tensile force (XD) (pass/no pass)	pass	—	—	EN 12311-1
Additional properties				
Temperature resistance (°C)	—	–40	+80	—
Bendtsen air permeability (ml per min)	0	—	—	ISO 5636/3
Gurly air permeability (s)	—	>2000	infinity	ISO 5636/5
Emissivity	0.08	—	—	DIN EN 673
Effective R-value of air cavity with DuPont Airguard				BS EN ISO 6946
horizontal flow (m^2KW^{-1})	0.6	—	—	calculated
vertical flow (m^2KW^{-1})	0.42	—	—	calculated

(1) The test documents are detailed in Bibliography. Numbers in the table refer to the sections/parts of the document.

(2) No Performance Determined.

Table 3 Tyvek Reflex — properties

Property (units)	Nominal (mean value)	Tolerance		Method[1]
		Minimum	Maximum	
Length (m) (%)	Customer related	0	—	EN 1848-2
Width (mm) (%)	Customer related	–0.5	+1.5	EN 1848-2
Straightness (mm)	—	—	30	EN 1848-2
Mass per unit area (gm^{-2})	83	74	92	EN 1849-2
Reaction to fire (Class)	E-d2	tested on mineral wool and wood		EN 11925-2
Watertightness (Class)	W1	—	—	EN 1928 (method A)
Water vapour transmission (sd-value) (m)	0.08	0.02	0.15	EN ISO 12572
Maximum tensile force (MD) (N per 50 mm)	250	200	300	EN 12311-1
Elongation at maximum tensile force (MD) (%)	10	6	14	EN 12311-1
Maximum tensile force (XD) (N per 50 mm)	210	160	260	EN 12311-1
Elongation at maximum tensile force (XD) (%)	15	10	20	EN 12311-1
Resistance to tearing (MD) (nail shank) (N)	90	60	120	EN 12310-1
Resistance to tearing (XD) (nail shank) (N)	85	60	110	EN 12310-1
Resistance to penetration of air ($m^3[m^2h\ (50\ Pa)]^{-1}$)	—	—	0.03	EN 12114
Dimensional stability (MD and XD) (%)	—	—	1	EN 1107-2
Flexibility at low temperature (°C)	—	—	–40	EN 1109
Artificial ageing by UV and heat (residual value)	aged/new material			EN 1297 and EN 1296
maximum tensile force in MD (%)	90	—	—	EN 12311-1
MD elongation at max tensile force (%)	90	—	—	EN12311-1
Maximum tensile force in XD (%)	90	—	—	EN 12311-1
XD elongation at max tensile force (%)	85	—	—	EN 12311-1
watertightness (Class)	W1	—	—	EN 1928 (A)
Water vapour permeability ($gm^{-2}day^{-1}$)	284	—	—	BS 3177 (25°C/75% RH)
Vapour resistance (dry cup) ($MNsg^{-1}$)	0.72	—	—	BS 3177 (25°C/75% RH)
Vapour resistance (wet cup) ($MNsg^{-1}$)	0.58	—	—	BS 7374, Test 3 (23°C/95%–50% RH)
Mullen Burst strength (kNm^{-2})	870	—	—	BS 3137
1 metre head of water	pass	—	—	MOAT 27 : 5.1.4.2
Resistance to water penetration (Eosin test)	pass	—	—	BS 4016
Thermal resistance (m^2KW^{-1})	0.540	—	—	BRE[2][3]
Additional properties				
Temperature resistance (°C)	—	–40	+100	—
Bendtsen air permeability (ml per min)	0	—	—	ISO 5636/3
UV resistance (months)	—	—	4	—
Water column (m)	2	—	—	EN 20811
Windtight	yes	—	—	—
Emissivity	0.15	—	—	DuPont method
Effective R-value of air cavity with 348M horizontal flow (m^2KW^{-1})	0.5	—	—	BS EN 6946 calculated

(1) The test documents are detailed in *Bibliography*. Numbers in the table refer to the sections/parts of the document.

(2) Building Research Establishment.

(3) When tested by BRE, the TYVEK Reflex Insulating Breather Membrane, when incorporated into the cavity of a conventional construction comprising 12.5 mm plasterboard, 250 μm polyethylene vapour control layer, 89 mm studs (10.4% timber) and 100 mm mineral wool insulation [compressed to 89 mm ($\lambda = 0.037\ Wm^{-1}K^{-1}$)], 12 mm OSB sheathing, TYVEK Reflex Insulating Breather Membrane within a 50 mm cavity with 102.5 mm brick leaf.

Thermal resistance

For thermal resistance values of air cavities adjacent to the Tyvek Enercor Roof and DuPont AirGuard products, condensation risk calculations for roofs containing products in warm and cold, non-ventilated roof constructions are as follows:

Overview: When the Tyvek Enercor Roof and Dupont AirGuard vapour control products are installed with care to ensure an airtight construction in a cold-roof, the risk of interstitial condensation is minimal, and there is no need to provide ventilation openings at eave or ridge level.

When the products are installed in a warm roof, there is minimal risk of condensation when DuPont AirGuard vapour control layer is installed on the warm side of the construction.

In Scottish applications, where the metallised surface of the product are placed directly onto the sarking boards, the thermal resistance properties will be significantly reduced.

Tyvek Enercor Roof and the DuPont AirGuard products have a metallised surface and have an emissivity value of 0.15 and 0.08 respectively. These low emissivities, if used adjacent to an airspace can lower the overall resistance of the airspace (see Table 4).

Table 4 Airspace resistance values adjacent to low emissivity surface

Construction	Resistance of air layer (m^2KW^{-1})	
	Tyvek Enercor Roof ($\epsilon = 0.15$)	DuPont AirGuard ($\epsilon = 0.08$)
10 mm air cavity	0.316 (vertical heat flow)	0.363 (horizontal heat flow) 0.363 (vertical heat flow)
25 mm air cavity	0.383 (vertical heat flow)	0.664 (horizontal heat flow) 0.453 (vertical heat flow)

Cold roof calculations

Roofcond calculations

A traditional high-resistance underlay has been compared to Tyvek Enercor Roof breathable underlay using the Roofcond software package to calculate the maximum accumulation of condensate in the membrane in the north facing roof for a whole year.

The following considerations and roof construction were taken into account:

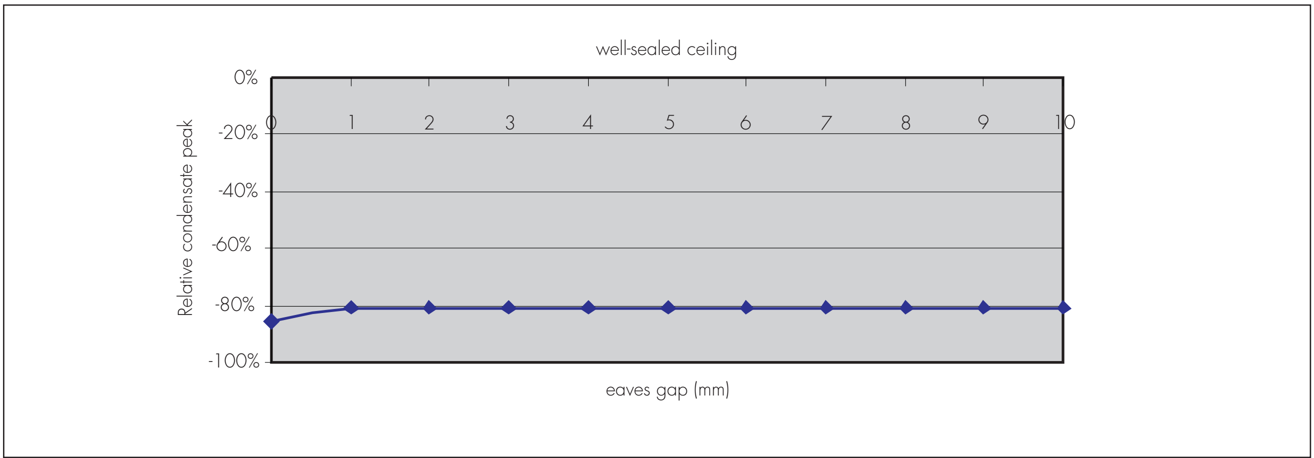
- roof slope: 30°
- ceiling length: 8.7 m
- ceiling width: 5.8 m
- no counter battens
- ceiling vapour resistance (DuPont AirGuard vapour control layer): 7500 $MNsg^{-1}$
- ceiling insulation vapour resistance (200 mm mineral wool): 2 $MNsg^{-1}$
- vapour resistance for the traditional underlay: 200 $MNsg^{-1}$
- vapour resistance of Tyvek Enercor Roof: 0.1863 $MNsg^{-1}$
- Tyvek Enercor Roof membrane air permeability (100 mm laps not taped): 0.5
- traditional underlay air permeability (100 mm laps): 1.0
- ceiling air permeability (normal gaps in ceiling): 1.0 ('normal' ceiling) or 0.2 ('well-sealed' ceiling with a vapour control layer)
- tiles' vapour resistance (concrete tiles): 3 $MNsg^{-1}$
- tiles are considered to be 'air open' with a tile permeability value of 1
- the batten space is not ventilated, the effect of ventilating the batten space was not analysed.
- the hourly climate data has been taken from Kew, which is likely to be experienced by most housing in England.
- an internal relative humidity corresponding to class 'High' (BS 5250 : 2002) was considered
- the house is assumed to be of rectangular shape with a simple duo pitch roof, with gable walls at either end and the ridge running east-west. The roof therefore has one north facing and one south facing slope. There is assumed to be a horizontal insulated ceiling with a triangular loft space above.
- data taken from C H Sanders, *Roofcond: A software package to carry out sensitivity analysis of the factors that effect condensation in domestic cold pitched roof* (Revised Manual, 26 March 2004).

For cases where Tyvek Enercor is used without a VCL, it is the designer's decision to verify the risk of condensation according to BS 5250 : 2002.

An analysis was carried out to compare Tyvek Enercor Roof in a ceiling with an air permeability of 0.2 (well-sealed ceiling with a vapour control layer) to a traditional underlay with a 10 mm gap at the eaves and a ceiling air permeability of 1 (normal ceiling), with all other parameters being equal. The results (see Figure 1) indicate that Tyvek Enercor Roof without ventilation at the eaves and used in a ceiling with an air permeability of 0.2 (well-sealed ceiling with a vapour control layer) achieves at least the same condensation risk as a traditional underlay with 10 mm eaves gaps in a normal ceiling.

It should be noted that an unventilated or sealed loft is by no means hermetically sealed (Pil project report) so there is always fortuitous ventilation equivalent to about at least 1.25 mm. Subsequently, there is no need for ventilators at the eaves as the fortuitous equivalent ventilation will be sufficient.

Figure 1 Relative condensate peak versus eaves gap – well-sealed ceiling



Conclusions

When Tyvek Enercor Roof and DuPont AirGuard vapour control layer are used with 'normal' and 'well-sealed' ceilings, in a cold non-ventilated roof construction, the construction achieves the same condensation risk as a traditional underlay with 10 mm of ventilation at the eaves.

It is important to note that a traditional underlay used in a well-sealed ceiling roof construction would not need the traditional 10 mm eaves ventilation, instead about 5 mm would suffice. This is still too high to be considered fortuitous in a non-ventilated roof.

Further analysis

Parameters other than ceiling air permeability can be analysed using the same approach, to see how their change affects the amount of condensation in a traditional underlay and in a roof construction using Tyvek Enercor Roof breathable membrane.

These parameters could be:

- roof slope
- dimensions of the ceiling
- counter battens
- vapour resistance of ceiling and insulation
- tiles' vapour resistance and air permeability
- ventilation of batten space
- internal humidity.

Also, Roofcond enables the calculation of the condensation in the tiles.

Warm roof calculations

An interstitial condensation risk assessment was conducted on the construction given below:

- internal surface: R = 0.04 m^2KW^{-1} (BR 443)
- 5 mm slates: $\lambda = 2.2$ $Wm^{-1}K^{-1}$, $\mu = 400$
- 25 mm battens/ventilated air space: $\lambda = 0.309$ $Wm^{-1}K^{-1}$, $\mu = 1$
- 0.52 mm Tyvek Enercor Roof: water vapour resistance = 0.1863 $MNsg^{-1}$ (tested by BBA)

- 115 mm timber rafters/PIR insulation at $\lambda = 0.023\ Wm^{-1}K^{-1}$
- 0.39 mm DuPont AirGuard vapour control layer: water vapour resistance = 7500 $MNsg^{-1}$,
  12.5 mm gypsum plasterboard: $\lambda = 0.25\ Wm^{-1}K^{-1}$ at $\rho = 900\ kgm^{-3}$, water vapour resistance factor, $\mu = 10$ (BS EN 12524 : 2000)
- internal surface: R = 0.10 m^2KW^{-1} (BR 443).

Roofs: Interstitial condensation risk calculations were made according to EN ISO 13788 : 2001 for external climate data corresponding to Turnhouse (Edinburgh) (Annex D, BS 5250 : 2002) and internal humidity class 4 (Dwellings with high occupancy).

In the above case, there is no risk of interstitial condensation as the DuPont AirGuard vapour control layer is located on the warm side of the construction.

In general, the product has a very high vapour resistance and, if located on the warm side of the construction, it can act as a vapour control layer.

Thermal resistance of air spaces

The values given in Table 4 have been calculated to BS EN ISO 6946 : 1997, using DuPont de Nemours (Luxembourg) S.à r.l's supplied emissivity values.

Key factors assessed

Thermal Insulation – Tyvek Enercor Roof and DuPont AirGuard used as part of the DuPont Climate System can contribute to limiting heat loss through a roof.

Risk of condensation — Tyvek Enercor Roof can be regarded as a low water vapour resistance (Type LR) underlay and can be used as part of a non-ventilated warm and ventilated cold, roof system.

Thermal performance — Factors for consideration for Agrément Certificate Approval

1 Calculations of the thermal transmittance (U value) of specific external wall constructions should be carried out in accordance with BS EN ISO 6946 : 1997 and BRE report (BR 443 : 2006). *Conventions for U-value calculations*, using an emissivity value of 0.15 for Tyvek Enercor Roof, 0.15 Tyvek Reflex and 0.08 for DuPont AirGuard.

2 The products can contribute to maintaining continuity of thermal insulation at junctions between the external wall and the other building elements. Guidance in this respect, and on limiting heat loss by air infiltration, can be found in:

England and Wales — *Limiting thermal bridging and air leakage: Robust construction details for dwellings and similar buildings* TSO 2002 and the Accredited Construction Details (version 1.0)

Scotland — Accredited Construction Details (Scotland)

Northern Ireland — Accredited Construction Details (version 1.0).

Risk of condensation – Factors for consideration for Agrément Certificate Approval

Roofs

1 For design purposes, Tyvek Enercor Roof's water vapour resistance may be taken as not more than 0.25 $MNsg^{-1}$ and for roofs designed in accordance with BS 5534 : 2003 or BS 5250 : 2002, Section 8.4, it may be regarded as a Type LR membrane (assuming a 2 mm gap between sarking boards when used in traditional Scottish applications).

2 In common with all roofs, care must be taken in the overall design and installation to minimise the risk of water vapour coming into contact with cold parts of the construction. Factors to be considered and minimised include: moisture diffusion through the ceiling, infiltration through unsealed openings/penetrations in the ceiling and services evaporating or venting moisture into cold spaces.

3 The risk of condensation is highest in new-build construction during the first heating period, where there is high moisture loading due to wet trades, such as in-situ cast concrete slabs or plaster. The risk of condensation diminishes as the building naturally dries out. See BBA Information Bulletin No 1 *Roof Tile Underlays in Cold Roofs during the Drying-out Period.*

Ceiling and insulation inclined (warm roof)

4 For roofs with an insulated inclined ceiling, ventilation above or below the underlay will not be required provided that the passage of moisture by diffusion and by convection is controlled, eg by a vapour control layer or a continuous envelope of insulation with a high vapour resistance.

Ceiling and insulation horizontal (cold roof)

5 For roofs with an insulated horizontal ceiling, ventilation above or below the underlay will not be required provided that the passage of moisture by diffusion and by convection is controlled, eg by a vapour control layer or a continuous envelope of insulation with a high vapour resistance.

Ceiling and insulation partially inclined (warm roof and cold roof)

6 For roofs with a combination of insulated horizontal ceiling and insulated inclined ceiling. ventilation above or below the underlay will not be required provided that the passage of moisture by diffusion and by convection is controlled, eg by a vapour control layer or a continuous envelope or insulation with a high vapour resistance.

Walls

For factors relating to wall constructions refer to the Tyvek Reflex Agrément Certificate No 90/2548, Product Sheet 3, Third issue.

FMEA/FMECA assessment

To make a judgement of any residual risk associated with this and other prototype products, FMEA and FMECA principles were applied. Two components (Tyvek Enercor Roof and DuPont AirGuard vapour control layer) plus Tyvek Reflex (subject of BBA Certificate No 90/2548, Product Sheet 3) of the DuPont Climate System were considered with two accessory items and the associated interfaces.

Residual risk judgement

Tyvek Enercor Roof and DuPont Airguard, as part of the DuPont Climate System as an innovative prototype product, have been assessed using FMEA and FMECA techniques to judge any residual risk associated with the product.

In the opinion of the BBA, Tyvek Enercor Roof, DuPont Airguard and Tyvek Reflex together comprise the DuPont Climate System and may be used according to the manufacturer's recommendations. The system's benefits can exceed the risks reported in this analysis.

As a prototype product it may be subject to improvement resulting from experience in use. Such changes should not reduce the product's ability to perform its function, and may be subject to reassessment.

Benefits in use

- The DuPont Climate System provides increased thermal insulation performance due to the low moisture content within the building envelope and the presence of low emissivity membranes.
- In summer, radiant heat is reflected outside the building.
- In winter, the risk of condensation is minimised and improvements in levels of traditional types of insulation occur due to airtightness and emissivity of the membranes.

Limitations in use

The DuPont Climate System contributes to making buildings airtight, so passive or mechanical ventilation systems may need to be installed to maintain good air quality inside the building. The presence of fresh air is important to health and comfort and ventilation plays a key role in removing by-products such as carbon dioxide, moisture, smoke and cooking smells generated by building occupants.

Maintenance

The elements of the DuPont Climate Control System (Tyvek Enercor Roof, DuPont Airguard and Tyvek Reflex) are confined within the building's structure and so are not accessible for maintenance.

Production control

DuPont de Nemours (Luxembourg) S.à r.l. has developed a production process for this product and has a Quality Manual and Quality Assurance Programme underwriting production of Tyvek Enercor Roof, DuPont Airguard and Tyvek Reflex. The objective of the programme is to supply products of reliable quality in compliance with the product performance claims on a consistent basis. The programme indicates procurement specifications of raw materials and components, production control, storage and packaging.

Bibliography

BS 3137 : 1972 *Methods for determining the bursting strength of paper and board*

BS 3177 : 1959 *Method for determining the permeability to water vapour of flexible sheet materials used for packaging*

BS 4016 : 1997 *Specification for flexible building membranes (breather type)*

BS 5250 : 2002 *Code of practice for control of condensation in buildings*

BS 5534 : 2003 *Code of practice for slating and tiling (including shingles)*

BS 7374 : 1990 *Methods of test for water vapour transmission resistance of board materials used in buildings*

BS EN 12114 : 2000 *Thermal performance of buildings — Air permeability of building components and building elements — Laboratory test method*

BS EN 12524 : 2000 *Building materials and products — Hygrothermal properties — Tabulated design values*

BS EN 13984 : 2004 *Flexible sheets for waterproofing — Plastic and rubber vapour control layers — Definitions and characteristics*

BS EN ISO 6946 : 1997 *Building components and building elements — Thermal resistance and thermal transmittance — Calculation method*

DIN EN 673 : 2003 *Glass in building — Determination of thermal transmittance (U value) — Calculation method*

EN 1107-2 : 2001 *Flexible sheets for waterproofing — Determination of dimensional stability — Plastic and rubber sheet for roof waterproofing*

EN 1109 : 1999 *Flexible sheets for waterproofing — Bitumen sheets for roof waterproofing — Determination of flexibility at low temperature*

EN 1296 : 2000 *Flexible sheets for waterproofing— Bitumen, plastic and rubber sheets for roofing—Method of artificial ageing by long term exposure to elevated temperature*

EN 1297 : 2004 *Flexible sheets for waterproofing—Bitumen, plastic and rubber sheets for roof waterproofing—Method of artificial ageing by long term exposure to the combination of UV radiation, elevated temperature and water*

EN 1848-2 : 2001 *Flexible sheets for water-proofing — Determination of length, width, straightness and flatness — Plastic and rubber sheets for roof waterproofing*

EN 1849-2 : 2001 *Flexible sheets for waterproofing— Determination of thickness and mass per unit area — Plastic and rubber sheets for roof waterproofing*

EN 1928 : 2000 *Flexible sheets for waterproofing — Bitumen, plastic and rubber sheets for roof waterproofing — Determination of watertightness*

EN 1931 : 2000 *Flexible sheets for waterproofing — Bitumen, plastic and rubber sheets for roof waterproofing — Determination of water vapour transmission properties*

EN 12310-1 : 1999 *Flexible sheets for waterproofing — Bitumen sheets for roof waterproofing — Determination of resistance to tearing (nail shank)*

EN 12311-1 : 2000 *Flexible sheets for waterproofing — Determination of tensile properties — Part 1 — Bitumen sheets for roof waterproofing*

EN 12317-2 : 2000 *Flexible sheets for waterproofing — Determination of shear resistance of joints — Plastic and rubber sheets for roof waterproofing*

EN 12691 : 2001 *Flexible sheets for waterproofing — Bitumen, plastic and rubber sheets for roof waterproofing — Determination of resistance to impact*

EN 13859-1 : 2005 *Flexible sheets for waterproofing — Definitions and characteristics of underlays — Part 1 Underlays for discontinuous roofing*

EN 13859-2 : 2004 *Flexible sheets for waterproofing — Definitions and characteristics of underlays — Underlays for walls*

EN 20811 : 1992 *Textiles. Determination of resistance to water penetration. Hydrostatic pressure test*

EN ISO 11925-2 : 2002 *Reaction to fire tests — Ignitability of building products subjected to direct impingement of flame — Single-flame source test*

EN ISO 12572 : 2001 *Hygrothermal performance of building materials and products — Determination of water vapour transmission properties*

EN ISO 13788 : 2001 *Hygrothermal performance of building components and building elements—Internal surface temperature to avoid critical surface humidity and interstitial condensation — Calculation methods*

ISO 5636-3 : 1992 *Paper and board — Determination of air permeance and air resistance (medium range) — Bendtsen method*
ISO 5636-5 : 2003 *Paper and board — Determination of air permeance and air resistance (medium range) — Gurley method*

MOAT No 27 : 1983 *General Directive for the Assessment of Roof Waterproofing Systems*

Talon A, Hans J, Chevalier J-L '*State of the Art Report' on FMEA and FMECA*. Research for and application to building domain CIB 80/RILEM 175 SLM : *Service Life Methodologies Prediction of Service Life for Building and Component*, 2005.

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