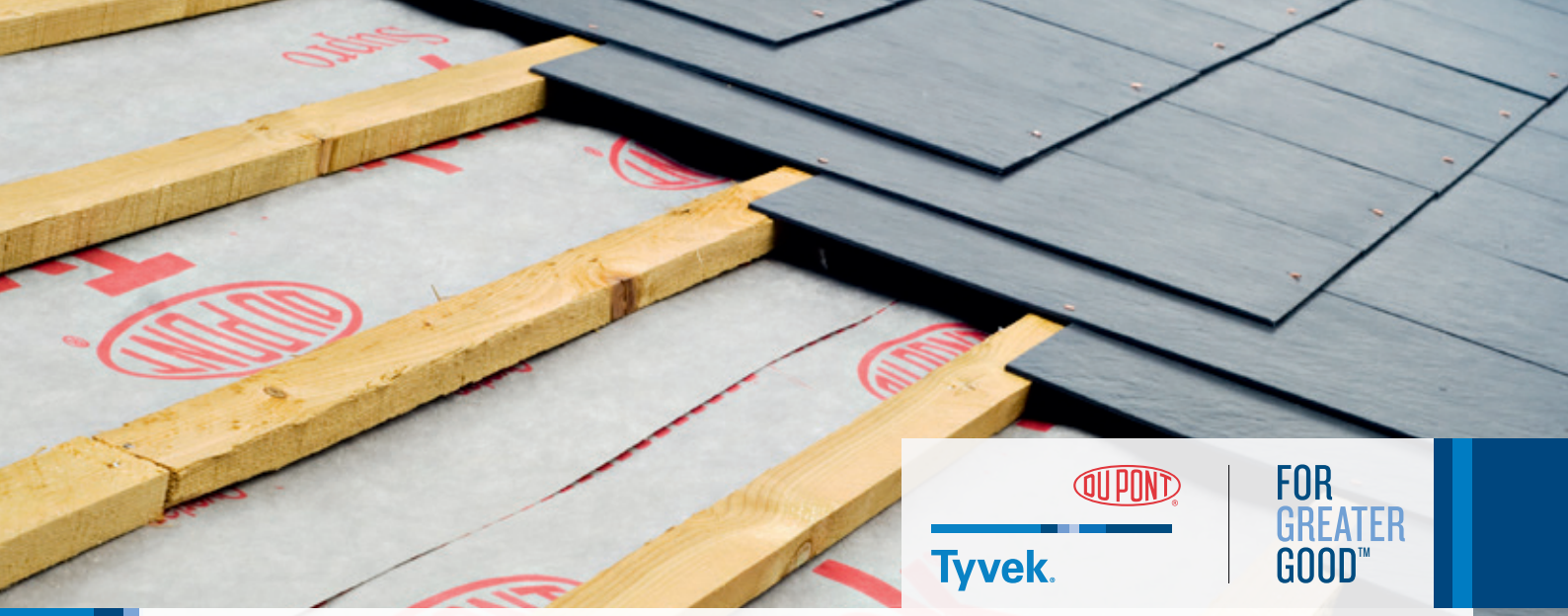
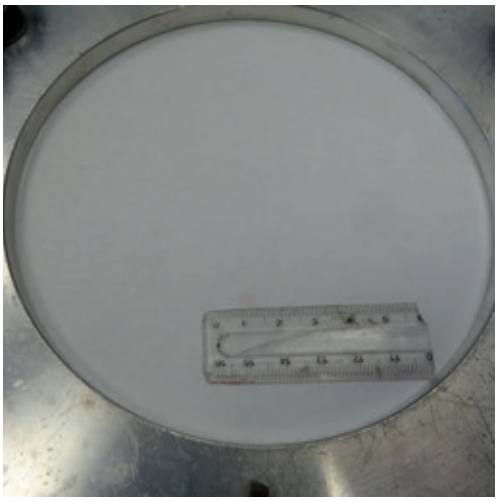
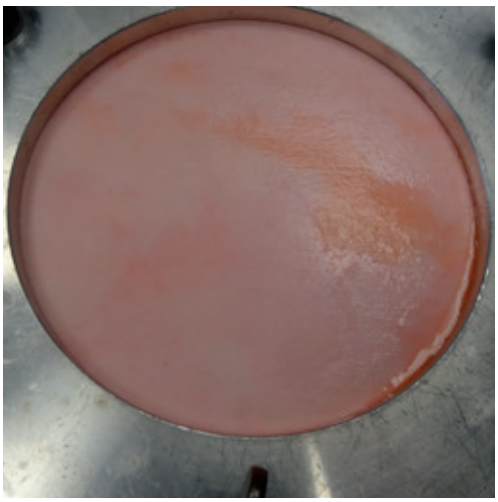


DuPont Tyvek. FOR GREATER GOOD™

DuPont™ Tyvek®
REPORT ON UNDERLAY FUNCTIONALITY OF 30 ROOFS





Brief Summary:

- The primary function for a roofing underlay is water tightness and its quality in terms of longevity presents the most risk for property, energy consumption, insurance - and reputations.
- Independent experts opened up 30 roofs to undertake rigorous water tightness tests on 'real world' aged roofing underlays
- 17 Roofs installed with Tyvek® over 20 years ago and 13 roofs with multi-layer or coated roofing underlays installed between 5 and 10 years ago were investigated
- DuPont was not involved in the selection of the roofs or the samples to be tested, nor has filtered or edited any of the results
- The independent test reporting went beyond the limitations of current standards to check the reality and precise scale of performance
- Results show troubling failures in water tightness in most alternative roofing underlays tested
- The industry's reputation and home owner's investments are at risk with a false sense of security - several products that do meet current standards have failed the tests after less than 10 years under the roof.

1. Do underlays in the market fulfil their role?

Water infiltration can be very expensive if it causes damage and/or reduces the efficiency of insulation. A home owner should expect that no water infiltration will occur over the lifetime of the roof. Under normal circumstances this function is performed by the roof covering. The underlay has a "secondary water shedding" role to avoid wind driven snow and rain from impacting the insulation. It does the 'back up' over the years by safely draining water should any roof covering problems or failures occur. If we focus too much on relying on mechanical properties to assess the functionality of underlays we actually deviate from the real problem, being the long term water tightness of the underlay.

• Long term water tightness is the crucial property for an underlay

In 2011 the CEN Technical Committee for flexible sheets for waterproofing voted for a Resolution to revise the EN13859-1&2 ageing test method in order to make it more representative for actual stress in underlay applications. National regulation and classification efforts concentrate mostly on the mechanical integrity of underlays at new. There is a lack of in-depth study and education in terms of 'real world' longevity and especially water tightness.

Over the last few years an increasing number of failed underlays have been observed and serious questions about longevity are increasingly causing controversy in the market, to the point that the reputation of an entire category of diffusion open underlays may be adversely affected.

For all these reasons DuPont decided in 2015 to instigate further testing beyond the confines of the laboratory to include field tests from 30 real home roofs with following objectives:

- To analyse the functionality of the Tyvek® diffusion open underlays in a minimum of 15 roofs that were older than 20 years.
- To analyse the functionality of multi-layer based diffusion open underlays in roofs between 5 and 10 years old. Roofs with microporous film and coated products were discovered and tested. This offers a more general overview, showing both cheaper and premium products used by installers.

The challenge for Tyvek® in the above test plan was more than double the real life aging time than alternatives. This was decided based on a 2010 laboratory study done by the SP Technical Research Institute in Sweden that showed Tyvek® keeping its water tightness for much longer than other membranes after UV and heating tests. (1)

2. Study Methodology

Martin Peifer from Steildach-Technik (Sachverständiger für das Dachdeckerhandwerk Fachbereich Steildachkonstruktionen) was nominated by DuPont to take the lead in this study. He has over 30 years' experience in pitched roof underlay application in Germany and at European level. All roofs were handled under the same criteria as in standard official investigations into building projects. The role of the expert was therefore agreed as below:

- Identification of the roofs and the home-owners who agreed to participate in the study and allow their roofs to be opened under the same universally applied conditions
- Two samples to be taken from the identified roofs, which were then repaired according to the German code
- Evaluation of the water tightness of the 30 samples (60 specimen) undertaken at an independent and certified laboratory (Kiwa GmbH TBU performed these measurements)
- Creating an expert opinion report (Gutachten) per roof including an assessment on the functionality of the specific underlays
- Creating an overall summary report

Important elements in view of neutrality and credibility are:

- DuPont was not involved in the selection of the roofs
- DuPont was not present for the sample taking (except in two cases for filming)
- DuPont has not filtered the full report or its results in anyway, neither for Tyvek® nor for the non-Tyvek® samples. 30 roofs were opened and all the 30 results are shown.

3. Description of the laboratory test methods used for this study

One of the key questions was to decide which test standard to apply in order to assess the long term functionality of the 30 underlays. The decision was made to use:

- EN13859-1&2 water tightness classification W1 (EN1928 & deviations described in EN13859) to make an assessment based on the official water tightness class within CE-conformity (picture 2)
- EN20811 (Textile: determination of resistance to water penetration), a test method allowing a graduation of the water hold property compared to new material (picture 3)

Picture 2: EN13859 W1 class (test equipment)

Picture 3: EN20811 (test equipment)

EN13859 basically represents a steady water column of 0.2 m applying pressure to the specimen. To pass W1, no water penetration shall occur within the 2-hour test duration.

For the EN20811 test, the specimen is stressed by a water column increasing at 60 cm/min. During the entire test duration, the surface is observed for water drops (leakage). When a third drop appears, the clock is stopped and this time measurement corresponds to the water column result at which the specimen has leaked.

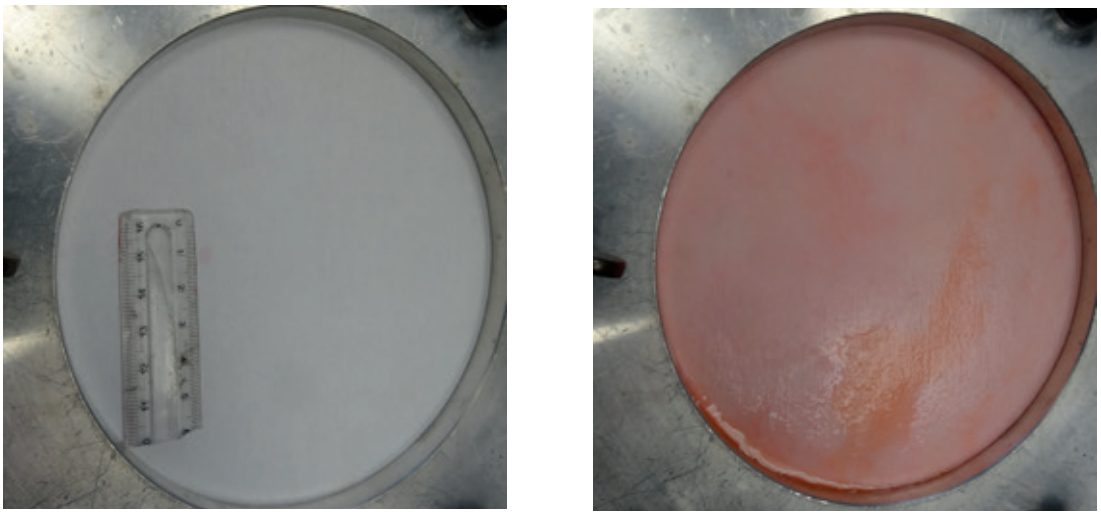
4. Results of EN13859 W1 classification of all 30 roofs

Table 1 shows all 17 Tyvek® and all 13 non Tyvek® products with the result of either a W1 pass or fail. For each roof, two different specimens were analysed for W1. No single roof had a result that differed between the two specimens, so in other words, both specimens were a pass or both were a fail.

Age (years)	Product description	Weigth gr/m²	W1 pass/fail
5	coated material	120	fail
5	coated material	120	fail
7	coated material	190	pass
8	coated material	160	fail
8	coated material	200	pass
8	multi-layer (microporous film)	145	fail
9	multi-layer (microporous film)	150	fail
9	multi-layer (microporous film)	125	fail
9	multi-layer (microporous film)	145	fail
9	coated material	140	fail
9	coated material	140	fail
9	multi-layer (microporous film)	145	fail
9	multi-layer (microporous film)	125	fail
21	Tyvek®	60	fail
21	Tyvek®	137	fail
21	Tyvek®	137	pass
21	Tyvek®	137	pass
21	Tyvek®	137	pass
22	Tyvek®	137	pass
22	Tyvek®	137	pass
22	Tyvek®	60	fail
22	Tyvek®	137	pass
23	Tyvek®	60	pass
23	Tyvek®	137	pass
23	Tyvek®	137	pass
23	Tyvek®	60	pass
23	Tyvek®	60	fail
23	Tyvek®	137	pass
23	Tyvek®	137	pass
24	Tyvek®	137	pass

***Table 1**: all 30 results of EN13859 W1-class (pass/fail)*

If there is a W1 pass, the claim is absolute. However, if there is a W1 fail there is zero possibility of differentiating the level of failure. Furthermore, a specimen that shows only the smallest leak in one spot suffers from a result equal to a specimen which fails completely even before achieving a water column of 20 cm (see picture 4).

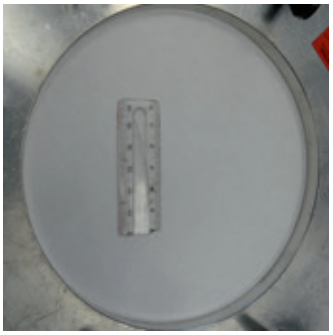


Picture 4: *On the left a small leak has appeared after 2 hours. On the right a complete failure prior to achieving the water column of 20 cm is observed. Both have failed a simple W1 classification.*

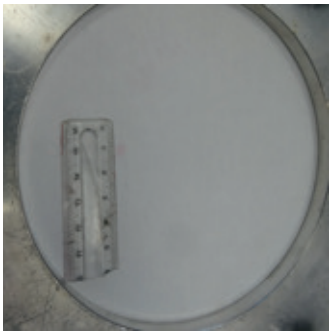
In order to allow a differentiation between the W1-failed specimens, in agreement with Steildach-Technik and with KIWA GmbH TBU, a "graduation" system was applied to this study. In picture 5 the graduation system is explained. The graduation scale begins at 10 with a W1 pass and ends at 1, being completely saturated during the process of filling in the water.

The expert's opinion is that the water tightness functionality of an underlay in application requires a W1 grade of minimum 6 and EN20811 water column of at least 50 cm

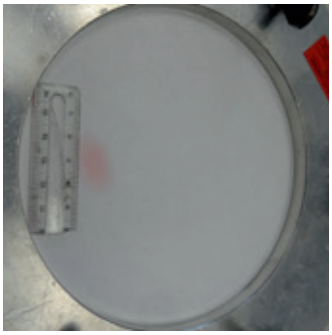
Picture 5: *W1 grading from 10 to 1*



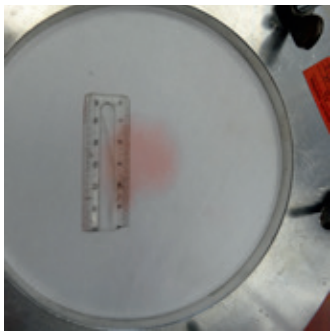
Grade 10: no leakage after 2 hrs (20 cm H_2O)



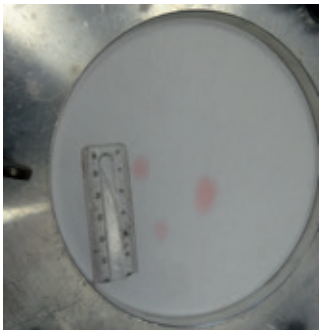
Grade 9: one leakage after 2 hrs (20 cm H_2O) of <1 cm



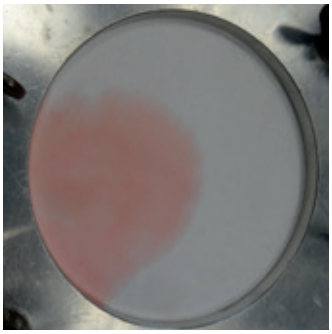
Grade 8: one leakage after 2 hrs (20 cm H_2O) between 1 and 3 cm



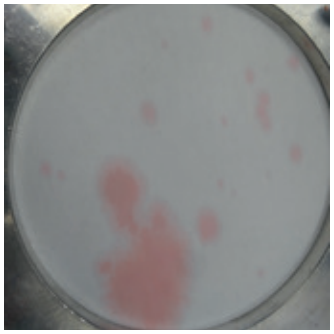
Grade 7: one leakage after 2 hrs (20 cm H_2O) of < 6cm



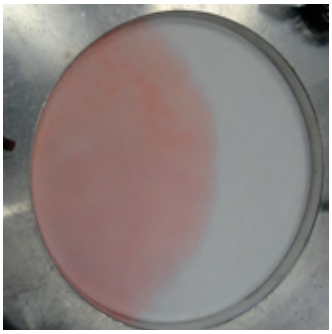
Grade 7: max 3 leakages after 2 hrs (20 cm H_2O) of each <2 cm



Grade 6: one leakage after 2 hrs (20 cm H_2O) on ca. 1/3 of surface

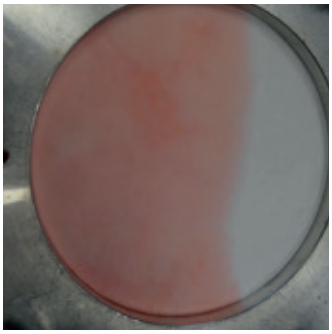


Grade 6: several leakages after 2 hrs (20 cm H_2O) on max 33% of surface

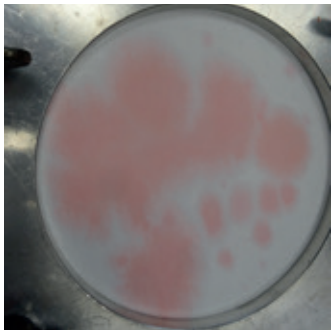


Grade 5: one leakage after 2 hrs (20 cm H_2O) on ca. 50% of surface

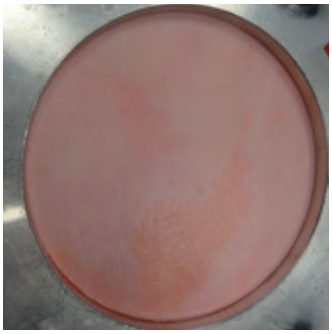
Grade 5: several leakages after 2 hrs (20 cm H_2O) on max 50% of surface



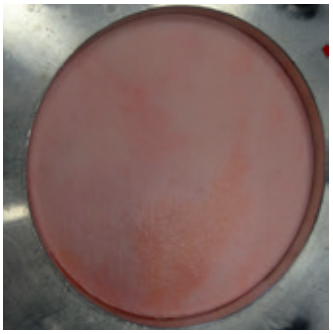
Grade 4: one leakage after 2 hrs (20 cm H_2O) on ca 66% of surface



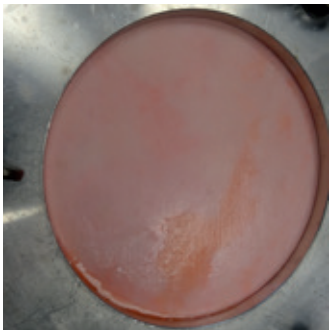
Grade 4: several leakages after 2 hrs (20 cm H_2O) on max 66% of surface



Grade 3: whole surface wet after 2 hrs (20 cm H_2O)



Grade 2: whole surface wet in <1 hour (20 cm H_2O)



Grade 1: whole surface wet already during filling in H_2O, so prior start of measurement

Table 2: below shows the W1 result by applying the W1 grading system in picture 5.

Age (years)	Product description	Weigth gr/m²	W1 grade 1st specimen	W1 grade 2nd specimen
5	coated material	120	2	1
5	coated material	120	1	2
7	coated material	190	10	10
8	coated material	160	6	9
8	coated material	200	10	10
8	multi-layer (microporous film)	145	1	1
9	multi-layer (microporous film)	150	1	1
9	multi-layer (microporous film)	125	1	1
9	multi-layer (microporous film)	145	1	1
9	coated material	140	2	2
9	coated material	140	6	6
9	multi-layer (microporous film)	145	1	1
9	multi-layer (microporous film)	125	1	1
21	Tyvek®	60	7	7
21	Tyvek®	137	6	6
21	Tyvek®	137	10	10
21	Tyvek®	137	10	10
21	Tyvek®	137	10	10
22	Tyvek®	137	10	10
22	Tyvek®	137	10	10
22	Tyvek®	60	6	7
22	Tyvek®	137	10	10
23	Tyvek®	60	10	10
23	Tyvek®	137	10	10
23	Tyvek®	137	10	10
23	Tyvek®	60	10	10
23	Tyvek®	60	9	8
23	Tyvek®	137	10	10
23	Tyvek®	137	10	10
24	Tyvek®	137	10	10

5. Results of EN20811 water column in underlay specimens from all 30 roofs

A distinct benefit of EN20811 is the additional information to quantify the impact of ageing upon the watertight properties of each underlay.

***Table 3**: below shows all water columns measured for all specimens from the 30 'real life' roofs.*

Age (years)	Product description	Weigth gr/m²	EN20811 (cm) specimen 1	EN20811 (cm) specimen 2
5	coated material	120	27	9
5	coated material	120	22	25
7	coated material	190	>540	>540
8	coated material	160	200	141
8	coated material	200	>540	>540
8	multi-layer (microporous film)	145	17	7
9	multi-layer (microporous film)	150	25	24
9	multi-layer (microporous film)	125	18	17
9	multi-layer (microporous film)	145	25	24
9	coated material	140	29	16
9	coated material	140	58	50
9	multi-layer (microporous film)	145	6	12
9	multi-layer (microporous film)	125	13	18
21	Tyvek®	60	111	120
21	Tyvek®	137	28	39
21	Tyvek®	137	123	141
21	Tyvek®	137	171	185
21	Tyvek®	137	147	171
22	Tyvek®	137	162	161
22	Tyvek®	137	155	160
22	Tyvek®	60	61	98
22	Tyvek®	137	156	170
23	Tyvek®	60	143	137
23	Tyvek®	137	145	170
23	Tyvek®	137	153	165
23	Tyvek®	60	111	125
23	Tyvek®	60	72	78
23	Tyvek®	137	152	153
23	Tyvek®	137	176	176
24	Tyvek®	137	178	148

Only one Tyvek® product out of 17 is below the limit set by the expert of a 50 cm EN20811 water column. After more than 20 years, the majority of Tyvek® products maintain >75% of EN20811 water column compared to when they were new.

6. Overall conclusion of the findings

Even if we take a very simplistic approach and we only take into account a straightforward W1 pass or fail, 13 of the 17 Tyvek® specimens achieved a W1-pass after more than 20 years in actual application stress.

For multilayer microporous film based products the result is dramatic with none of 6 samples achieving a W1-pass. For the coated products only 2 of 7 have a W1-pass. For these two product categories all the underlays had been in application for between 5 and 9 years only.

Based on the acceptance level explained before, the expert's conclusion was:

- 16/17 of Tyvek® products can be declared functional in water tightness after > 20 years
- 0/6 of multilayer microporous film based products can be declared functional after <10 years
- 4/7 of coated products can be declared functional after <10 years

Even when ignoring the difference in age of the underlays, Tyvek® is statistically the **significantly superior product** in this 30 roof study.

DuPont take these results into account to continue improving its products and encourages more players in the construction industry to consider 'real roof life' in their choices when producing and installing roof underlays.

(1) Click here to see more about the 2010 laboratory test results

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