

File R21
Project 06CA22812

September 6, 2006

REPORT

on

PREPARED ROOF COVERING MATERIALS
ASPHALT SHINGLE WIND RESISTANCE

Under The

CLASSIFICATION PROGRAM

GAF Building Materials
Wayne, NJ 07470

Copyright © 2006 Underwriters Laboratories Inc.

Underwriters Laboratories Inc. authorizes the above named company to reproduce this Report provided it is reproduced in its entirety.



GENERAL

The Standard ANSI/UL2390, "Test Method for Wind Resistant Asphalt Shingles with Sealed Tabs" (ASTM D7158, "Standard Test Method for Wind Resistance of Sealed Asphalt Shingles (Uplift Force/Uplift Resistance Method)") is an evaluation procedure to determine a wind uplift coefficient based on airflow perpendicular to and across the shingle surface. The wind uplift coefficient is calculated by measuring pressures above and below the shingle surface at the windward and leeward sides of the sealant. The uplift force (lbf) acting on the sealant is then calculated to correspond to the wind speed Classification desired. Once this force (lbf) is identified, the next step is to determine the resistance force (lbf) capability of the tab sealant as determined by mechanical test. This capability is determined by the "Standard Test Method for Measurement of Asphalt Shingle Tab Mechanical Uplift Resistance, ASTM D6381 (ASTM D7158).

INVESTIGATION

The subject of this investigation is the evaluation of the wind resistance capability of laminated design asphalt shingles when sealed at the lead edge to the course below. The shingles evaluated in this project are shown in Table No. 1.

TABLE NO. 1

<u>Location</u>	<u>Shingle</u>	<u>Location</u>	<u>Shingle</u>
Baltimore, MD	Timberline 30 Timberline Select 40 Timberline Ultra	Millis, MA	Timberline 30
Dallas, TX	Timberline 30 Timberline Ultra	Minneapolis, MN	Sentinel Timberline 30 Timberline Canadian 40 Timberline Select 40 Royal Sovereign Timberline Ultra Marquis WeatherMax
Dudley, NC	Timberline 30 Royal Sovereign Timberline Select 40 Timberline Ultra	Mobile, AL	Timberline 30 Royal Sovereign
Erie, PA	Royal Sovereign Marquis WeatherMax	Mt. Vernon, IN	Royal Sovereign Grand Timberline Jumbo Royal Sovereign Country Estates Camelot Slateline Grand SLATE Country Mansion
Fontana, CA	Timberline 30 Timberline Select 40 Timberline Ultra Royal Sovereign Sentinel Grand Sequoia Grand Canyon	Tampa, FL	Timberline 30 Timberline Ultra Timberline Select 40
Michigan City, IN	Timberline 30 Timberline Select 40 Timberline Ultra		

The evaluation process included three integral test procedures involving Section 1: The determination of the "Shingle Rigidity" for both single and laminated layers, Section 2: the determination of wind uplift coefficients (DCp's) to calculate the potential uplift force (lbf) on the sealant at the desired wind speed Classification, Section 3: the determination of the resistance force (lbf) capability of the sealant by mechanical test, ASTM D6381 (ASTM D7158), and Section 4: the determination of the total resistance force (lbf) capability of the sealant.

For Section 1, the determination of the "Shingle Rigidity", the shingles were separated into groups based on the shingle design and product specifications. The Timberline Ultra, Camelot, Slateline, Country Estates, Grand SLATE, Timberline 30, Grand Timberline, Grand Sequoia, Grand Canyon, and Royal Sovereign shingles were chosen to be representative of all the shingles in Table No. 1.

For Section 2, the determination of the wind uplift coefficients, the shingles were separated into groups based on the shingle design and product specifications. The Country Estates shingles produced in Mt. Vernon were chosen to be representative of the Country Mansion shingles produced in Mt. Vernon. The Timberline 30 shingles produced in Dallas and Tampa and the Timberline Ultra shingles produced in Dallas, Tampa, Minneapolis, Baltimore, and Fontana were chosen to be representative of the shingles shown in Table 1 based on existing test data and the product specifications.

TABLE 1

<u>Timberline 30</u>	<u>Timberline Canadian 40</u>	<u>Timberline Select 40</u>	<u>Timberline Ultra</u>
Baltimore, MD Dudley, NC Fontana, CA Michigan City, IN Millis, MA Minneapolis, MN Mobile, AL	Minneapolis, MN	Baltimore, MD Dudley, NC Fontana, CA Michigan City, IN Minneapolis, MN Tampa, FL	Dudley, NC Michigan City, IN

The Royal Sovereign shingles produced in Erie, Minneapolis, and Mt. Vernon were chosen to be representative of the Royal Sovereign and Sentinel shingles shown in Table 2, based on existing test data and the product specifications.

TABLE 2

<u>Royal Sovereign</u>	<u>Sentinel</u>
Dudley, NC Mobile, AL Fontana, CA	Fontana, CA Minneapolis, MN

For Section 3, the determination of the resistance force, the shingles were separated into groups based on the shingle design and product specifications. The Country Estates shingles produced in Mt. Vernon were chosen to be representative of the Country Mansion shingles produced in Mt. Vernon.

The Timberline 30 shingles produced in Dallas and Tampa and the Timberline Ultra shingles produced in Dallas, Tampa, Minneapolis, Baltimore, and Fontana were chosen to be representative of the shingles shown in Table 3 based on existing test data and the product specifications.

TABLE 3

<u>Timberline 30</u>	<u>Timberline Canadian 40</u>	<u>Timberline Select 40</u>	<u>Timberline Ultra</u>
Baltimore, MD Dudley, NC Fontana, CA Michigan City, IN Millis, MA Minneapolis, MN Mobile, AL	Minneapolis, MN	Baltimore, MD Dudley, NC Fontana, CA Michigan City, IN Minneapolis, MN Tampa, FL	Dudley, NC Michigan City, IN

The Royal Sovereign shingles produced in Erie, Minneapolis, and Mt. Vernon were chosen to be representative of the Royal Sovereign and Sentinel shingles shown in Table 4, based on existing test data and the product specifications.

TABLE 4

<u>Royal Sovereign</u>	<u>Sentinel</u>
Dudley, NC Mobile, AL Fontana, CA	Fontana, CA Minneapolis, MN

DESCRIPTION

PRODUCT COVERED

The products covered by this Report are asphalt glass mat shingles identified as Sentinel, Timberline 30, Timberline Canadian 40, Timberline Ultra, Timberline Select 40, Royal Sovereign, Marquis WeatherMax, Jumbo Royal Sovereign, Country Estates, Country Mansion, Camelot, Slateline, Grand SLATE, Grand Sequoia, and Grand Canyon.

The products in this Report are currently Listed under the product category, Prepared Roof Covering Materials (TFWZ).

USE:

The products are intended for use as building materials as permitted by authorities having jurisdiction.

TEST RECORD NO.1

EXAMINATION OF MATERIALS:

The materials used in this investigation were produced under the observation of a representative and the Listing Program of Underwriters Laboratories Inc., in a ready-to-use form and as evidenced by the Listing Marking on the products. The composition of the finished materials is of a proprietary nature. Data on the composition is on file at the laboratories for use in the Follow-Up Service Program.

Various physical and chemical tests were conducted on the components and finished products. The results developed from these tests were employed in establishing specifications for use in the factory Follow-Up Service Program.

Test results relate only to the items tested.

SECTION 1: SHINGLE RIGIDITY

TEST SPECIMENS

The tests were conducted in accordance with Section 3 "Shingle Rigidity" of the ANSI/UL 2390 Standard (Section 11.1 "Determination of Shingle Uplift Rigidity" of the ASTM D7158 Standard). The test specimens consisted of 3-3/4-in by 4-in sections of the "Royal Sovereign," "Grand Sequoia," "Grand Canyon," "Slateline," "Grand SLATE," and "Country Estates" shingles that were representative of the shingle's windward edge. Sets of specimens of "Grand Timberline," "Camelot," "Timberline Ultra," and "Timberline 30" were prepared for both the single layer and for the laminated (double) layer.

TEST METHOD

The tests were conducted in accordance with Section 3 "Shingle Rigidity" of the ANSI/UL2390 Standard.

RESULTS

$$EI = [(\Delta F / \Delta \delta) \times L^3] / 3$$

Where:

EI = Shingle Rigidity

ΔF = Load (lbf) at 0.5-in deflection minus load (lbf) at 0.2-in deflection.

$\Delta \delta$ = 0.3-in, amount of deflection.

L = The distance from the exposed end of the specimen to the front edge of the clamp holding the specimen in place on the fixture.

"Country Estates":

Specimen	F@0.2inch (lbf)	F@0.5inch (lbf)	ΔF (lbf)	L (inch)	EI
1	3.20	6.80	3.60	2.62	
2	3.80	7.80	4.00	2.60	
3	4.10	7.90	3.80	2.45	
4	4.00	7.60	3.60	2.52	
5	4.00	8.40	4.40	2.53	
6	3.60	7.40	3.80	2.61	
7	2.90	6.80	3.90	2.61	
8	3.90	7.50	3.60	2.59	
9	3.20	7.10	3.90	2.58	
10	3.40	6.50	3.10	2.53	
AVG.	3.61	7.38	3.77	2.56	70.61

"Camelot" (Single layer):

Specimen	F@0.2inch (lbf)	F@0.5inch (lbf)	ΔF (lbf)	L (inch)	EI
1	0.75	1.35	0.60	2.47	
2	0.90	1.55	0.65	2.53	
3	0.70	1.20	0.50	2.45	
4	0.45	1.00	0.55	2.63	
5	0.70	1.30	0.60	2.56	
6	0.45	1.00	0.55	2.51	
7	0.50	0.95	0.45	2.51	
8	0.75	1.40	0.65	2.38	
9	0.65	1.25	0.60	2.54	
10	0.45	0.85	0.40	2.55	
AVG.	0.63	1.19	0.56	2.51	9.79

"Camelot" (Double layer):

Specimen	F@0.2inch (lbf)	F@0.5inch (lbf)	ΔF (lbf)	L (inch)	EI
1	5.20	11.80	6.60	2.53	
2	3.80	8.00	4.20	2.72	
3	2.00	6.00	4.00	2.67	
4	2.00	7.10	5.10	2.54	
5	4.00	7.50	3.50	2.57	
6	4.00	7.40	3.40	2.60	
7	2.30	4.40	2.10	2.57	
8	3.00	5.30	2.30	2.53	
9	4.00	7.60	3.60	2.53	
10	4.50	8.60	4.10	2.59	
AVG.	3.48	7.37	3.89	2.59	74.66

"Slateline":

Specimen	F@0.2inch (lbf)	F@0.5inch (lbf)	ΔF (lbf)	L (inch)	EI
1	0.45	0.85	0.40	2.64	
2	0.31	0.59	0.28	2.61	
3	0.41	0.58	0.17	2.61	
4	0.36	0.68	0.32	2.58	
5	0.38	0.71	0.33	2.58	
6	0.40	0.77	0.37	2.60	
7	0.45	0.77	0.32	2.50	
8	0.32	0.60	0.28	2.55	
9	0.35	0.68	0.33	2.61	
10	0.31	0.62	0.31	2.69	
AVG.	0.37	0.69	0.31	2.60	6.05

"Grand SLATE":

Specimen	F@0.2inch (lbf)	F@0.5inch (lbf)	ΔF (lbf)	L (inch)	EI
1	4.00	7.40	3.40	2.65	
2	3.50	7.50	4.00	2.56	
3	3.60	7.00	3.40	2.59	
4	4.10	8.60	4.50	2.48	
5	3.80	7.60	3.80	2.60	
6	3.00	9.50	6.50	2.51	
7	4.70	8.80	4.10	2.52	
8	4.50	6.50	2.00	2.65	
9	3.80	7.50	3.70	2.59	
10	4.00	7.60	3.60	2.62	
AVG.	3.90	7.80	3.90	2.58	74.16

"Grand Sequoia":

Specimen	F@0.2inch (lbf)	F@0.5inch (lbf)	ΔF (lbf)	L (inch)	EI
1	2.50	6.40	3.90	2.79	
2	2.20	7.30	5.10	2.71	
3	2.80	8.50	5.70	2.77	
4	3.00	10.00	7.00	2.50	
5	2.40	7.00	4.60	2.80	
6	2.55	8.50	5.95	2.63	
7	2.30	6.30	4.00	2.79	
8	2.55	8.00	5.45	2.62	
9	2.00	6.90	4.90	2.70	
10	2.60	10.00	7.40	2.65	
AVG.	2.49	7.89	5.40	2.70	117.57

"Grand Canyon":

Specimen	F@0.2inch (lbf)	F@0.5inch (lbf)	ΔF (lbf)	L (inch)	EI
1	3.00	7.50	4.50	2.73	
2	3.00	9.00	6.00	2.74	
3	4.00	10.00	6.00	2.66	
4	3.00	8.00	5.00	2.78	
5	4.50	10.50	6.00	2.74	
6	4.00	10.10	6.10	2.65	
7	5.00	10.00	5.00	2.60	
8	6.00	11.50	5.50	2.64	
9	4.00	11.00	7.00	2.67	
10	3.00	9.50	6.50	2.71	
AVG.	3.95	9.71	5.76	2.69	124.85

"Timberline 30" (Single):

Specimen	F@0.2inch (lbf)	F@0.5inch (lbf)	ΔF (lbf)	L (inch)	EI
1	0.19	0.34	0.15	2.69	
2	0.23	0.38	0.15	2.67	
3	0.23	0.40	0.17	2.67	
4	0.32	0.55	0.23	2.56	
5	0.20	0.37	0.17	2.62	
6	0.20	0.35	0.15	2.71	
7	0.21	0.40	0.19	2.61	
8	0.20	0.37	0.17	2.67	
9	0.22	0.40	0.18	2.59	
10	0.21	0.39	0.18	2.62	
AVG.	0.22	0.40	0.17	2.64	3.56

"Timberline 30" (Double):

Specimen	F@0.2inch (lbf)	F@0.5inch (lbf)	ΔF (lbf)	L (inch)	EI
1	0.90	1.50	0.60	2.51	
2	0.85	1.50	0.65	2.59	
3	1.05	1.80	0.75	2.61	
4	1.05	1.75	0.70	2.57	
5	0.95	1.70	0.75	2.63	
6	0.90	1.60	0.70	2.56	
7	0.95	1.55	0.60	2.60	
8	0.80	1.50	0.70	2.61	
9	1.00	1.80	0.80	2.56	
10	0.65	1.55	0.90	2.65	
AVG.	0.91	1.63	0.72	2.59	13.79

"Timberline Ultra" (Single):

Specimen	F@0.2inch (lbf)	F@0.5inch (lbf)	ΔF (lbf)	L (inch)	EI
1	0.60	1.15	0.55	2.62	
2	0.60	1.15	0.55	2.57	
3	0.65	1.30	0.65	2.51	
4	0.65	1.20	0.55	2.48	
5	0.70	1.25	0.55	2.59	
6	0.47	0.78	0.31	2.63	
7	0.50	0.95	0.45	2.57	
8	0.60	1.00	0.40	2.57	
9	0.60	1.15	0.55	2.59	
10	0.65	1.20	0.55	2.54	
AVG.	0.60	1.11	0.51	2.57	9.60

"Timberline Ultra" (Double):

Specimen	F@0.2inch (lbf)	F@0.5inch (lbf)	ΔF (lbf)	L (inch)	EI
1	2.70	4.50	1.80	2.52	
2	2.70	4.90	2.20	2.56	
3	2.80	4.70	1.90	2.57	
4	2.70	4.50	1.80	2.50	
5	2.60	4.50	1.90	2.56	
6	2.60	4.70	2.10	2.56	
7	2.90	4.70	1.80	2.56	
8	2.60	4.50	1.90	2.54	
9	2.60	4.30	1.70	2.54	
10	2.30	4.80	2.50	2.51	
AVG.	2.65	4.61	1.96	2.54	35.77

"Grand Timberline" (single):

Specimen	F@0.2inch (lbf)	F@0.5inch (lbf)	ΔF (lbf)	L (inch)	EI
1	0.30	0.54	0.24	2.66	
2	0.29	0.62	0.33	2.66	
3	0.23	0.54	0.31	2.62	
4	0.30	0.65	0.35	2.60	
5	0.35	0.68	0.33	2.63	
6	0.40	0.80	0.40	2.60	
7	0.45	0.80	0.35	2.60	
8	0.30	0.62	0.32	2.70	
9	0.34	0.63	0.29	2.64	
10	0.45	0.85	0.40	2.46	
AVG.	0.34	0.67	0.33	2.62	6.61

"Grand Timberline" (double):

Specimen	F@0.2inch (lbf)	F@0.5inch (lbf)	ΔF (lbf)	L (inch)	EI
1	2.90	5.80	2.90	2.58	
2	2.00	5.90	3.90	2.69	
3	3.20	6.40	3.20	2.64	
4	2.50	5.20	2.70	2.70	
5	2.30	5.40	3.10	2.55	
6	2.30	5.50	3.20	2.57	
7	2.20	5.60	3.40	2.61	
8	2.70	5.60	2.90	2.73	
9	2.80	6.20	3.40	2.65	
10	3.10	6.00	2.90	2.59	
AVG.	2.60	5.76	3.16	2.63	63.95

"Royal Sovereign":

Specimen	F@0.2inch (lbf)	F@0.5inch (lbf)	ΔF (lbf)	L (inch)	EI
1	0.29	0.52	0.23	2.73	
2	0.32	0.60	0.28	2.58	
3	0.31	0.58	0.27	2.66	
4	0.32	0.60	0.28	2.63	
5	0.31	0.58	0.27	2.57	
6	0.39	0.68	0.29	2.55	
7	0.31	0.58	0.27	2.61	
8	0.38	0.66	0.28	2.59	
9	0.40	0.66	0.26	2.60	
10	0.35	0.61	0.26	2.64	
AVG.	0.34	0.61	0.27	2.62	5.35

SECTION 2: WIND UPLIFT COEFFICIENT

PREPARATION OF TEST PANELS

The shingles were applied to four test panels in accordance with the manufacturer's instructions. The "measurement area" was located in accordance with Section 4.5 of the ANSI/UL 2390 Standard (Section 8.2.1.5 of the ASTM D7158 Standard). The pressure taps were installed in accordance with Section 6, Figure 6.2 of the Standard for the "Royal Sovereign," "Marquis WeatherMax," "Slateline," and "Grand SLATE" shingles. Due to the irregular pattern of the following laminated shingles, pressures tap locations on the top of the shingle and beneath the shingle varied within the "measurement area" to represent the exposure to the wind in relationship to the shingle course below:

Shingle	No. of Pressure Tap Locations Top of the Shingle	No. of Pressure Tap Locations Beneath of the Shingle
"Timberline 30"	6	6
"Country Estate"	6	6
"Camelot"	12	12
"Grand Sequoia"	8	8
"Grand Canyon"	8	8
"Timberline Ultra"	8	8
"Grand Timberline"	24	24
"Jumbo Royal Sovereign"	12	12

The pressure taps were located at the windward and at the leeward side of the sealant strip.

The panels with shingles were placed in the temperature treatment cell while maintained at a one in six incline and at a temperature of 57 - 60°C (135 - 140°F) for a continuous period of 16 hours. After treatment, the test panels were allowed to cool to room temperature while maintained at a one in six incline.

TEST METHOD

The tests were conducted in accordance with Section 7 "Uplift Coefficient Test Procedure" of the ANSI/UL2390 Standard (Section 11.2 "Determination of the Shingle Wind Uplift Coefficient (DCp)" of the ASTM D7158 Standard).

As outlined in Section 7.1.2, with the test panel in position and without shims in place, the air-flow test apparatus was started and adjusted to produce an air velocity of 35 ± 3 mph as measured at a reference velocity position 1-in above and the center of the measurement area. The mean pressures of each pressure tap location were recorded at 1-second intervals for 30 seconds.

Shingle lift coefficients, DC_p 's were calculated from the measured data at each pressure tap above and below the shingle. The formula for DC_p is:

$$DC_p = (P_{top} - P_{bottom}) / (1/2\rho U_{ref}^2)$$

Where:

P_{top} = is measured time-averaged pressure on the top of the shingle
 P_{bottom} = is measured time average pressure on the top of the bottom shingle
 U_{ref} = is mean air velocity
 ρ = air density

In order to simulate the shingle deflection at higher wind speeds, subsequent tests were conducted with uplift shims having a minimum thickness of 0.04 inch, positioned in accordance with Section 7.2.2. The deflection represented by the shim height was compared to the deflection calculated in accordance with Section 7.2.4, using shingle Rigidity (EI) from, Section 1. Where the calculated deflection was greater than the shim height the test was repeated using thicker shims. The process was continued until the calculated deflection was equal to the shim height.

The maximum uplift coefficients (DC_p) from the windward and leeward side from four test panels were averaged together to determine the final value DC_p . The wind uplift coefficient measured at the windward side of the sealant pattern is to be identified as DC_{p1} . The wind coefficient measured at the leeward side of the sealant pattern is to be identified as DC_{p2} .

The wind coefficients values DC_{p1} and DC_{p2} are used to determine the total uplift force, F_T , defined as pounds force (lbf) per 3.75 in. length of shingle windward edge, was calculated in accordance with Section 7.3 (refer to the formula below). The Wind Speed Classification was based on 150 mph, (Class H).

$$F_T = V^2 \times DC_{p1} \times L1 \times K_a \times K_b + V^2 \times DC_{p2} \times L2/2 \times K_a \times K_b$$

Where:

L = The clear distance measured from the windward edge of the lowermost sealant pattern to the windward edge of the affixed shingle as installed on the roof.

L1 = The distance measured from the centerline of the sealant pattern of the windward edge of the affixed shingle as installed on the roof.

L2 = The distance measured from the centerline of the sealant pattern of the affixed shingle to the windward edge of the shingle directly above as installed on the roof.

Ka = 1 for standard residential structure

Kb = 0.000285

V = 150 mph

The magnitude of the force on the windward side of the sealant (F_F) is calculated using the formula below:

$$F_F = V^2 \times DC_{p1} \times L1 \times K_a \times K_b$$

The magnitude of the force on the leeward side of the sealant (F_B) is calculated using the formula below:

$$F_B = V^2 \times DC_{p2} \times (L2/2) \times K_a \times K_b$$

The magnitude of the total uplift force may also be calculated using the formula below:

$$F_T = F_F + F_B$$

For shingle designs with two parallel sealant patterns, the value of F is the greater force calculated using the following equations:

$$F_1 = V^2 \times DC_{p1} \times L1 \times K_a \times K_b + V^2 \times DC_{p3} \times L3/2 \times K_a \times K_b$$

$$F_2 = V^2 \times DC_{p2} \times L2/2 \times K_a \times K_b + V^2 \times DC_{p3} \times L3/2 \times K_a \times K_b$$

RESULTS

"Country Estate" (Mt. Vernon, IN)

Where:

L = 0.8125 in.

L1 = 1.125 in.

L2 = 4.875 in.

L3 = 1.500 in.

Maximum shim thickness = 0.04 in.

Test No.	Windward Side			Leeward Side			In-between Sealant Pattern		
	P _{top} - P _{bottom} (psf)	V (mph)	DCp1	P _{top} - P _{bottom} (psf)	V (mph)	DCp2	P _{top} - P _{bottom} (psf)	V (mph)	DCp3
1	2.08	35	0.65	0.60	35	0.19	1.03	35	0.32
2	1.84	33	0.67	0.16	33	0.06	0.58	33	0.21
3	2.41	34	0.81	0.26	34	0.09	0.81	34	0.27
4	2.62	34	0.90	0.10	34	0.03	0.58	34	0.20
Average			0.76			0.09			0.25

Calculated uplift force (F₁) on the sealant strip: **6.7** lbfCalculated uplift force (F₂) on the sealant strip: 2.6 lbf"Camelot" (Mt. Vernon, IN)

Where:

L = 1.00 in.

L1 = 1.25 in.

L2 = 3.875 in.

L3 = 1.500 in.

Maximum shim thickness = 0.04 in.

Test No.	Windward Side			Leeward Side			In-between Sealant Pattern		
	P _{top} - P _{bottom} (psf)	V (mph)	DCp1	P _{top} - P _{bottom} (psf)	V (mph)	DCp2	P _{top} - P _{bottom} (psf)	V (mph)	DCp3
1	2.35	36	0.73	0.55	32	0.21	0.89	32	0.34
2	2.60	36	0.77	0.77	36	0.36	1.2	36	0.36
3	1.96	35	0.64	0.39	35	0.13	0.72	35	0.24
4	2.15	32	0.80	0.56	32	0.22	0.81	32	0.31
Average			0.74			0.20			0.31

Calculated uplift force (F₁) on the sealant strip: **7.4** lbfCalculated uplift force (F₂) on the sealant strip: 4.5 lbf

"Slateline" (Mt. Vernon, IN)

Where:

L = 1.00 in.

L1 = 1.25 in.

L2 = 3.875 in.

L3 = 1.500 in.

Maximum shim thickness = 0.04 in.

Test No.	Windward Side			Leeward Side			In-between Sealant Pattern		
	P _{top} - P _{bottom} (psf)	V (mph)	DCp1	P _{top} - P _{bottom} (psf)	V (mph)	DCp2	P _{top} - P _{bottom} (psf)	V (mph)	DCp3
1	1.91	35	0.61	0.31	35	0.10	1.17	35	0.38
2	2.39	35	0.76	0.19	35	0.06	0.64	35	0.20
3	1.81	35	0.59	0.42	35	0.14	1.11	35	0.37
4	2.00	35	0.63	0.34	35	0.11	1.00	35	0.32
Average			0.65			0.10			0.32

Calculated uplift force (F₁) on the sealant strip: **3.6** lbfCalculated uplift force (F₂) on the sealant strip: 3.3 lbf"Grand SLATE" (Mt. Vernon, IN)

Where:

L = 0.625 in.

L1 = 1.00 in.

L2 = 5.00 in.

L3 = 1.500 in.

Maximum shim thickness = 0.04 in.

Test No.	Windward Side			Leeward Side			In-between Sealant Pattern		
	P _{top} - P _{bottom} (psf)	V (mph)	DCp1	P _{top} - P _{bottom} (psf)	V (mph)	DCp2	P _{top} - P _{bottom} (psf)	V (mph)	DCp3
1	2.83	33	1.04	0.13	33	0.05	0.45	33	0.16
2	2.88	34	0.99	0.12	34	0.04	0.50	34	0.17
3	3.18	32	1.22	0.14	32	0.05	0.31	32	0.12
4	2.98	34	1.03	0.08	34	0.03	0.64	34	0.22
Average			1.07			0.04			0.17

Calculated uplift force (F₁) on the sealant strip: **7.6** lbfCalculated uplift force (F₂) on the sealant strip: 1.5 lbf

"Grand Sequioia" (Fontana, CA)

Where:

L = 0.50 in.

L1 = 0.75 in.

L2 = 0.75 in.

L3 = 3.375 in.

Maximum shim thickness = 0.04 in.

Test No.	Windward Side			Leeward Side			In-between Sealant Pattern		
	P _{top} - P _{bottom} (psf)	V (mph)	DCp1	P _{top} - P _{bottom} (psf)	V (mph)	DCp2	P _{top} - P _{bottom} (psf)	V (mph)	DCp3
1	3.59	36	1.09	0.08	36	0.03	0.21	36	0.06
2	2.41	36	0.72	0.53	36	0.16	0.15	36	0.05
3	3.06	36	0.92	0.85	36	0.26	0.30	36	0.09
4	2.05	35	0.64	0.47	35	0.15	0.34	35	0.11
Average			0.84			0.15			0.08

Calculated uplift force (F₁) on the sealant strip: **4.9** lbfCalculated uplift force (F₂) on the sealant strip: 1.3 lbf"Grand Canyon" (Fontana, CA)

Where:

L = 0.625 in.

L1 = 0.875 in.

L2 = 1.00 in.

L3 = 3.375 in.

Maximum shim thickness = 0.04 in.

Test No.	Windward Side			Leeward Side			In-between Sealant Pattern		
	P _{top} - P _{bottom} (psf)	V (mph)	DCp1	P _{top} - P _{bottom} (psf)	V (mph)	DCp2	P _{top} - P _{bottom} (psf)	V (mph)	DCp3
1	1.59	33	0.58	0.29	33	0.10	0.18	33	0.06
2	2.25	32	0.84	0.34	32	0.12	0.25	32	0.09
3	1.81	32	0.67	0.40	33	0.15	0.14	33	0.05
4	1.87	34	0.61	0.20	34	0.07	0.18	34	0.06
Average			0.68			0.11			0.07

Calculated uplift force (F₁) on the sealant strip: **4.5** lbfCalculated uplift force (F₂) on the sealant strip: 1.0 lbf

"Timberline 30" (Dallas, TX)

Where:

L = 0.875 in.

L1 = 1.125 in.

L2 = 4.375 in.

Maximum shim thickness = .04 in.

Test No.	Windward Side			Leeward Side		
	$P_{top} - P_{bottom}$ (psf)	V (mph)	DCp1	$P_{top} - P_{bottom}$ (psf)	V (mph)	DCp2
1	1.93	32	0.72	0.09	32	0.03
2	1.75	34	0.58	0.19	35	0.06
3	2.25	35	0.71	0.06	35	0.02
4	2.34	35	0.76	0.13	34	0.04
Average			0.69			0.04

Calculated uplift force (F_T) on the sealant strip: **5.5 lbf**Calculated uplift force (F_F) on the sealant strip: **5.0 lbf**Calculated uplift force (F_B) on the sealant strip: **0.5 lbf**"Timberline 30" (Tampa, FL)

Where:

L = 0.625 in.

L1 = 0.812 in.

L2 = 4.687 in.

Maximum shim thickness = .04 in.

Test No.	Windward Side			Leeward Side		
	$P_{top} - P_{bottom}$ (psf)	V (mph)	DCp1	$P_{top} - P_{bottom}$ (psf)	V (mph)	DCp2
1	2.81	35	0.87	0.56	35	0.18
2	2.75	35	0.86	0.50	35	0.16
3	2.61	34	0.87	0.61	34	0.20
4	3.05	34	1.02	0.83	34	0.28
Average						

Calculated uplift force (F_T) on the sealant strip: **8.0 lbf**Calculated uplift force (F_F) on the sealant strip: **4.7 lbf**Calculated uplift force (F_B) on the sealant strip: **3.2 lbf**

"Timberline Ultra" (Dallas, TX)

Where:

L = 1.0 in.

L1 = 1.25 in.

L2 = 4.25 in.

Maximum shim thickness = .04 in.

Test No.	Windward Side			Leeward Side		
	P _{top} - P _{bottom} (psf)	V (mph)	DCp1	P _{top} - P _{bottom} (psf)	V (mph)	DCp2
1	1.88	32	0.72	0.28	32	0.11
2	1.85	33	0.65	0.65	34	0.22
Average			0.69			0.17

Calculated uplift force (F_T) on the sealant strip: **7.8 lbf**Calculated uplift force (F_F) on the sealant strip: **5.5 lbf**Calculated uplift force (F_B) on the sealant strip: **2.3 lbf**"Timberline Ultra" (Tampa, FL)

Where:

L = 0.750 in.

L1 = 0.875 in.

L2 = 4.875 in.

Maximum shim thickness = .04 in.

Test No.	Windward Side			Leeward Side		
	P _{top} - P _{bottom} (psf)	V (mph)	DCp1	P _{top} - P _{bottom} (psf)	V (mph)	DCp2
1	2.84	32	1.06	0.76	32	0.28
2	2.41	32	0.93	0.90	32	0.35
Average			1.00			0.32

Calculated uplift force (F_T) on the sealant strip: **10.4 lbf**Calculated uplift force (F_F) on the sealant strip: **5.6 lbf**Calculated uplift force (F_B) on the sealant strip: **4.8 lbf**

"Timberline Ultra" (Minneapolis, MN)**Where:**

L = 0.50 in.

L1 = 0.75 in.

L2 = 4.875 in.

Maximum shim thickness = 0.04 in.

Test No.	Windward Side			Leeward Side		
	P _{top} - P _{bottom} (psf)	V (mph)	DCp1	P _{top} - P _{bottom} (psf)	V (mph)	DCp2
1	2.69	34	0.91	0.35	34	0.12
2	2.98	35	0.94	0.63	35	0.20
3	2.72	34	0.90	0.34	34	0.12
4	3.13	35	1.01	0.27	35	0.09
Average			0.94			0.13

Calculated uplift force (F_T) on the sealant strip: **6.6 lbf**Calculated uplift force (F_F) on the sealant strip: **4.5 lbf**Calculated uplift force (F_B) on the sealant strip: **2.1 lbf**"Timberline Ultra" (Baltimore, MD)**Where:**

L = 1.75 in.

L1 = 2.00 in.

L2 = 3.00 in.

Maximum shim thickness = 0.208 in.

Test No.	Windward Side			Leeward Side		
	P _{top} - P _{bottom} (psf)	V (mph)	DCp1	P _{top} - P _{bottom} (psf)	V (mph)	DCp2
1	1.61	33	0.59	0.66	36	0.20
2	1.46	32	0.57	0.88	32	0.34
3	1.49	33	0.54	0.60	33	0.22
4	1.50	34	0.51	0.73	34	0.25
Average			0.55			0.25

Calculated uplift force (F_T) on the sealant strip: **9.3 lbf**Calculated uplift force (F_F) on the sealant strip: **6.9 lbf**Calculated uplift force (F_B) on the sealant strip: **2.3 lbf**

"Timberline Ultra" (Fontana, CA)**Where:**

L = 1.25 in.

L1 = 1.4375 in.

L2 = 4.25 in.

Maximum shim thickness = 0.06 in.

Test No.	Windward Side			Leeward Side		
	$P_{top} - P_{bottom}$ (psf)	V (mph)	DCp1	$P_{top} - P_{bottom}$ (psf)	V (mph)	DCp2
1	2.07	34	0.72	0.62	33	0.22
2	2.07	34	0.69	0.65	35	0.21
3	1.88	34	0.63	0.50	34	0.17
4	2.16	35	0.69	0.71	34	0.23
Average			0.68			0.21

Calculated uplift force (F_T) on the sealant strip: **8.8 lbf**Calculated uplift force (F_F) on the sealant strip: **6.0 lbf**Calculated uplift force (F_B) on the sealant strip: **2.8 lbf**"Grand Timberline" (Mt. Vernon, IN)**Where:**

L = 0.625 in.

L1 = 1.00 in.

L2 = 5.00 in.

L3 = 1.50 in.

Maximum shim thickness = 0.06 in.

Test No.	Windward Side			Leeward Side			In-between Sealant Pattern		
	$P_{top} - P_{bottom}$ (psf)	V (mph)	DCp1	$P_{top} - P_{bottom}$ (psf)	V (mph)	DCp2	$P_{top} - P_{bottom}$ (psf)	V (mph)	DCp3
1	3.34	36	1.02	0.27	36	0.08	0.65	35	0.21
2	3.12	33	1.15	0.34	33	0.12	0.93	33	0.34
3	3.42	34	1.14	0.59	34	0.20	1.22	34	0.42
4	3.17	34	1.09	0.04	34	0.01	0.63	34	0.22
Average			1.10			0.10			0.30

Calculated uplift force (F_1) on the sealant strip: **8.5 lbf**Calculated uplift force (F_2) on the sealant strip: 3.1 lbf

"Jumbo Royal Sovereign" (Mt. Vernon, IN)

Where:

L = 0.75 in.

L1 = 1.00 in.

L2 = 5.00 in.

L3 = 1.50 in.

Maximum shim thickness = 0.04 in.

Test No.	Windward Side			Leeward Side			In-between Sealant Pattern		
	P _{top} - P _{bottom} (psf)	V (mph)	DCp1	P _{top} - P _{bottom} (psf)	V (mph)	DCp2	P _{top} - P _{bottom} (psf)	V (mph)	DCp3
1	2.25	35	0.73	0.37	35	0.12	1.14	35	0.37
2	1.86	34	0.61	0.81	34	0.27	1.10	34	0.36
3	1.82	34	0.61	0.57	36	0.17	1.17	37	0.34
4	1.76	33	0.62	0.34	35	0.11	0.99	33	0.35
Average			0.64			0.17			0.36

Calculated uplift force (F₁) on the sealant strip: **5.8 lbf**Calculated uplift force (F₂) on the sealant strip: 4.4 lbf"Royal Sovereign" (Erie, PA)

Where:

L = 1.00 in.

L1 = 1.25 in.

L2 = 3.75 in.

Maximum shim thickness = 0.04 in.

Test No.	Windward Side			Leeward Side		
	P _{top} - P _{bottom} (psf)	V (mph)	DCp1	P _{top} - P _{bottom} (psf)	V (mph)	DCp2
1	1.41	35	0.45	0.51	35	0.17
2	1.27	34	0.42	0.75	34	0.25
3	1.42	35	0.45	0.33	35	0.11
4	1.61	35	0.51	0.50	35	0.16
Average						

Calculated uplift force (F_T) on the sealant strip: **5.7 lbf**Calculated uplift force (F_F) on the sealant strip: **3.7 lbf**Calculated uplift force (F_B) on the sealant strip: **2.1 lbf**

"Royal Sovereign" (Minneapolis, MN)**Where:**

L = 1.00 in.

L1 = 1.25 in.

L2 = 3.75 in.

Maximum shim thickness = 0.04 in.

Test No.	Windward Side			Leeward Side		
	$P_{top} - P_{bottom}$ (psf)	V (mph)	DCp1	$P_{top} - P_{bottom}$ (psf)	V (mph)	DCp2
1	1.29	35	0.41	0.12	35	0.04
2	1.41	34	0.46	0.17	34	0.06
3	1.39	34	0.47	0.12	34	0.04
4	1.34	35	0.43	0.16	35	0.05
Average			0.44			0.05

Calculated uplift force (F_T) on the sealant strip: **4.1 lbf**Calculated uplift force (F_F) on the sealant strip: **3.5 lbf**Calculated uplift force (F_B) on the sealant strip: **0.6 lbf**"Royal Sovereign" (Mt. Vernon, IN)**Where:**

L = 1.00 in.

L1 = 1.25 in.

L2 = 3.75 in.

Maximum shim thickness = 0.04 in.

Test No.	Windward Side			Leeward Side		
	$P_{top} - P_{bottom}$ (psf)	V (mph)	DCp1	$P_{top} - P_{bottom}$ (psf)	V (mph)	DCp2
1	1.48	35	0.48	0.80	35	0.25
2	1.43	34	0.49	0.28	34	0.09
3	1.73	35	0.54	0.70	35	0.22
4	1.76	36	0.53	0.94	35	0.29
Average			0.51			0.21

Calculated uplift force (F_T) on the sealant strip: **6.6 lbf**Calculated uplift force (F_F) on the sealant strip: **4.1 lbf**Calculated uplift force (F_B) on the sealant strip: **2.6 lbf**

"Marquis Weather Max" (Minneapolis, MN)**Where:**

L = 1.00 in.

L1 = 1.25 in.

L2 = 3.75 in.

Maximum shim thickness = 0.04 in.

Test No.	Windward Side			Leeward Side		
	P _{top} - P _{bottom} (psf)	V (mph)	DCp1	P _{top} - P _{bottom} (psf)	V (mph)	DCp2
1	1.83	36	0.55	0.11	36	0.03
2	1.64	37	0.48	0.30	36	0.09
3	1.52	35	0.48	0.12	35	0.04
4	1.25	35	0.41	0.17	35	0.05
Average			0.48			0.05

Calculated uplift force (F_T) on the sealant strip: **4.5 lbf**Calculated uplift force (F_F) on the sealant strip: **3.8 lbf**Calculated uplift force (F_B) on the sealant strip: **0.6 lbf**"Marquis Weather Max" (Erie, PA)**Where:**

L = 1.00 in.

L1 = 1.25 in.

L2 = 3.75 in.

Maximum shim thickness = 0.04 in.

Test No.	Windward Side			Leeward Side		
	P _{top} - P _{bottom} (psf)	V (mph)	DCp1	P _{top} - P _{bottom} (psf)	V (mph)	DCp2
1	1.62	35	0.52	0.11	35	0.04
2	1.55	35	0.48	0.13	36	0.04
3	1.50	35	0.49	0.16	35	0.05
4	1.53	35	0.49	0.12	35	0.04
Average			0.50			0.04

Calculated uplift force (F_T) on the sealant strip: **4.5 lbf**Calculated uplift force (F_F) on the sealant strip: **4.0 lbf**Calculated uplift force (F_B) on the sealant strip: **0.5 lbf**

SECTION 3: MECHANICAL TEST

TEST METHOD

The tests were conducted in accordance with ASTM D6381 (ASTM D7158). The test specimens are constructed from pieces of shingles, overlaid and sealed prior to testing. All specimens are conditioned for 16 hours at 135-140 degrees Fahrenheit and allowed to cool to room temperature before they are tested. Specimens are tested in accordance with Procedure A, (R_A), by lifting the exposed edge and recording the uplift force required to break the seal, and in Procedure B, (R_B), by recording the perpendicular force to break the seal. The apparatus used to conduct the tests was an Instron 5565, with a crosshead speed of 5 in./min.

TEST SPECIMENS

In Procedure A, the test specimens consisted of a 3-3/4-in. by 7-in. bottom piece and a 3-3/4 in. by 4-1/2 in. top piece cut from the same shingle. The top piece was then laid over the bottom piece overlapping the adhesive strip in the manner representative of the actual alignment as specified by the manufacturers installation instructions.

In Procedure B, the test specimen consisted of a bottom piece 4 by 6 in. and a top piece 1-1/2 by 3-3/4 in. both cut from one shingle. The top piece centered over the bottom piece such that the sealant material is centered on the long axis of the rectangular piece.

RESULTS

"Country Estates" Shingle manufactured at Mt. Vernon, IN plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R_A), Max. Load (lbf)	16.8	35.3	29.8	22.2	25.7	20.8	30.0	22.5	21.1	31.0	25.5

"Camelot" Shingle manufactured at Mt. Vernon, IN plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R_A), Max. Load (lbf)	15.2	17.5	10.6	16.1	19.9	20.2	18.5	4.6	19.4	20.3	16.2
Procedure B, (R_B), Max. Load (lbf)	29.4	31.1	37.5	34.7	24.4	11.7	13.0	31.2	26.5	25.3	26.5

"Slateline" Shingle manufactured at Mt. Vernon, IN plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R_A), Max. Load (lbf)	15.8	16.5	24.9	19.7	13.0	17.1	14.6	18.8	15.1	20.7	17.6

"Grand SLATE" Shingle manufactured at Mt. Vernon, IN plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R_A), Max. Load (lbf)	18.9	12.6	15.5	15.2	21.7	14.7	14.3	14.7	9.3	14.6	15.1

"Grand Sequoia" Shingle manufactured at Fontana, CA plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R_A), Max. Load (lbf)	10.9	13.8	6.9	10.5	18.4	23.8	17.3	11.8	4.8	5.5	12.4

"Grand Canyon" Shingle manufactured at Fontana, CA plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R_A), Max. Load (lbf)	12.5	22.1	8.8	20.6	26.5	15.2	31.8	30.5	20.1	17.5	20.6

"Timberline 30" Shingle manufactured at Dallas, TX plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R_A), Max. Load (lbf)	35.9	9.6	28.0	41.2	25.3	23.3	12.6	33.7	30.8	26.9	26.7
Procedure B, (R_B), Max. Load (lbf)	35.0	37.0	36.5	31.2	30.4	35.0	32.8	34.5	35.7	26.0	33.4

"Timberline 30" Shingle manufactured at Tampa, FL plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R_A), Max. Load (lbf)	22.7	11.3	23.4	19.0	12.7	19.6	17.0	11.2	13.7	20.3	17.1
Procedure B, (R_B), Max. Load (lbf)	30.0	28.4	22.0	22.3	27.1	26.3	21.6	33.1	27.5	26.9	26.5

"Timberline Ultra" Shingle manufactured at Dallas, TX plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R _A), Max. Load (lbf)	5.7	10.0	12.8	18.2	11.8	14.7	17.6	5.3	16.9	11.3	12.4

"Timberline Ultra" Shingle manufactured at Tampa, FL plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R _A), Max. Load (lbf)	29.2	20.0	19.6	28.4	9.1	23.3	14.8	7.3	12.6	15.1	17.9

"Timberline Ultra" Shingle manufactured at Minneapolis, MN plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R _A), Max. Load (lbf)	18.0	11.2	22.6	8.3	22.3	19.3	14.8	15.8	24.9	23.0	18.0

"Timberline Ultra" Shingle manufactured at Baltimore, MD plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R _A), Max. Load (lbf)	3.8	3.6	7.5	13.5	7.1	13.1	7.6	11.1	6.8	6.6	8.1
Procedure B, (R _B), Max. Load (lbf)	11.7	15.6	24.7	18.8	13.6	31.5	8.1	16.7	31.6	32.6	20.5

"Timberline Ultra" Shingle manufactured at Fontana, CA plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R _A), Max. Load (lbf)	7.4	12.4	10.6	9.9	11.5	8.1	5.5	8.9	5.5	13.8	9.4

"Grand Timberline" Shingle manufactured at Mt. Vernon, IN plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R _A), Max. Load (lbf)	15.9	18.4	18.2	11.5	11.4	14.6	12.4	21.0	13.1	13.5	15.0

"Jumbo Royal Sovereign" Shingle manufactured at Mt. Vernon, IN plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R_A), Max. Load (lbf)	21.2	13.9	24.6	26.6	23.1	22.4	17.8	18.9	22.3	15.1	20.6

"Royal Sovereign" Shingle manufactured at Erie, PA plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R_A), Max. Load (lbf)	17.7	16.6	10.6	15.4	19.4	17.3	17.9	19.2	22.6	15.6	17.2

"Royal Sovereign" Shingle manufactured at Minneapolis, MN plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R_A), Max. Load (lbf)	7.7	9.9	6.8	10.1	13.2	10.8	17.6	8.6	9.9	9.4	10.4

"Royal Sovereign" Shingle manufactured at Mt. Vernon, IN plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R_A), Max. Load (lbf)	17.3	18.5	13.5	15.3	14.6	17.7	17.1	20.1	15.0	4.4	15.4

"Marquis WeatherMax" Shingle manufactured at Minneapolis, MN plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R_A), Max. Load (lbf)	16.0	14.1	11.4	17.0	11.2	18.0	14.8	21.0	15.9	14.1	15.4

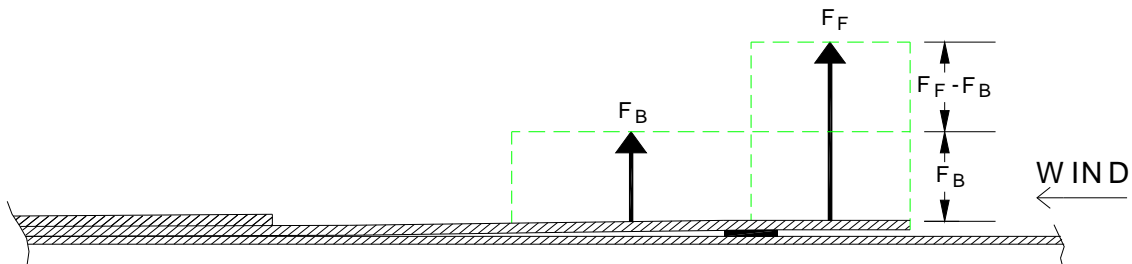
"Marquis WeatherMax" Shingle manufactured at Erie, PA plant:

Test No.	1	2	3	4	5	6	7	8	9	10	Average
Procedure A, (R_A), Max. Load (lbf)	0.8	13.1	16.1	22.3	20.6	16.8	7.3	12.0	21.5	14.5	14.5

SECTION 4: UPLIFT RESISTANCE DETERMINATION

Wind applied to a shingle results in both a peeling force on the shingle in the area in front of the sealant and a perpendicular force on the shingle at the sealant. ASTM D6381 (ASTM D7158) includes two procedures to evaluate these different force applications. Procedure A measures the uplift force required to break the seal by lifting the exposed edge of the shingle with a peeling action. Procedure A results in the resistance R_A . Procedure B measures the perpendicular force with balanced components in front of and behind the sealant is applied to the shingle, over the sealant location. Performing Procedure B results in resistance R_B . Based on the wind load distributions shown below, (Case 1 and Case 2), the forces generated from Procedure A and B, (R_A and R_B) cannot simply be summed together. The means of apportioning the two resistances is detailed below.

CASE 1: Wind Load Distribution, when $F_F > F_B$



WIND LOAD DISTRIBUTION ON SHINGLE

The apportionment of the peeling and perpendicular resistances, R_A and R_B , is dictated by the mechanisms within the two test methods. Procedure B applies an uplift force equally to the shingle on both sides of the sealant. Therefore, the F_B component is considered to be applied equally to both sides of the sealant. For the purposes of apportioning the resistance value, R_A , the F_F component is reduced by the magnitude of F_B that is assigned to be in front of the sealant. Applying this force distribution, the following equation is generated:

$$R_T = \left[\frac{(F_F - F_B)}{F_T} \right] \times R_A + \left[\frac{(2F_B)}{F_T} \right] \times R_B$$

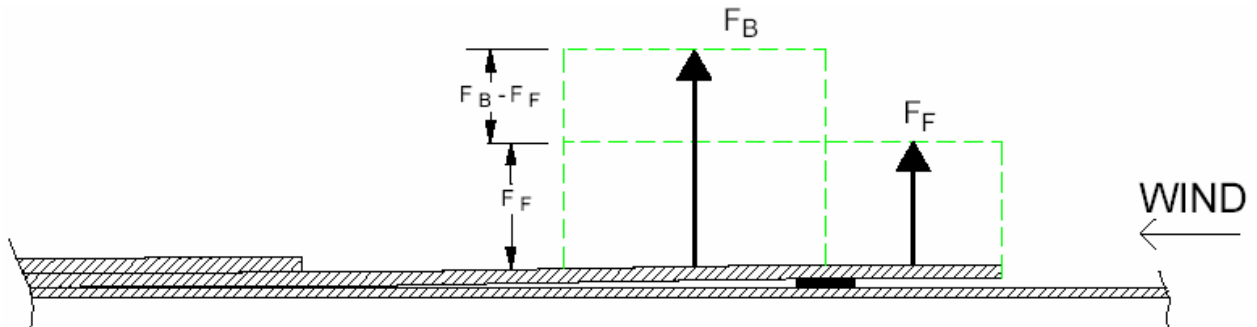
With the constraint that R_T shall not exceed $3R_A$.

If $R_A \geq F_T$ or $R_T \geq F_T$, then shingle passes.

Note: Resistance values determined by Procedure B are always greater than those derived from Procedure A. The constraint that R_T shall not exceed $3R_A$ represents a conservative approach so that results from Procedure B should not be allowed to overwhelm those from Procedure A.

CASE 2: Wind Load Distribution, when $F_F < F_B$

As in Case 1, the apportionment of the peeling and perpendicular resistance is dictated by the mechanisms within the test methods. Procedure B applies an uplift force distributed equally to the shingle on both sides of the sealant. The F_F component is applied to both sides of the sealant, and the F_B component is reduced by the magnitude of F_F that is applied behind the sealant to balance the F_F applied in front of the sealant. Applying this force distribution, the following equation is generated:



WIND LOAD DISTRIBUTION ON SHINGLE

"Peeling"

"Perpendicular"

$$R_T = [(F_B - F_F) / F_T] \times R_A + [(2F_F) / F_T] \times R_B$$

With the constraint that R_T shall not exceed $3R_A$.

If $R_A \geq F_T$ or $R_T \geq F_T$, then shingle passes.

Note: Resistance values determined by Procedure B are always greater than those derived from Procedure A. The constraint that R_T shall not exceed $3R_A$ represents a conservative approach so that results from Procedure B should not be allowed to overwhelm those from Procedure A.

RESULTS

Shingle	Wind Speed Classification Class H = 150 mph	F _F (lbf)	F _B (lbf)	F _T (lbf)	R _A (lbf)	R _B (lbf)	R _T (lbf)	Results
Country Estates (Mt. Vernon, IN)	Class H	-	-	6.7	25.5	-	-	R _A > F _T
Camelot (Mt. Vernon, IN)	Class H	-	-	7.4	16.2	26.5	-	R _A > F _T
Slateline (Mt. Vernon, IN)	Class H	-	-	3.6	17.6	-	-	R _A > F _T
Grand SLATE (Mt. Vernon, IN)	Class H	-	-	7.6	15.1	-	-	R _A > F _T
Grand Sequoia (Fontana, CA)	Class H	-	-	4.9	12.4	-	-	R _A > F _T
Grand Canyon (Fontana, CA)	Class H	-	-	4.5	20.6	-	-	R _A > F _T
Timberline 30 (Dallas, TX)	Class H	5.0	0.5	5.5	26.7	33.4	28.0	R _T > F _T
Timberline 30 (Tampa, FL)	Class H	4.7	3.2	8.0	17.1	26.5	24.8	R _T > F _T
Timberline Ultra (Dallas, TX)	Class H	5.5	2.3	7.8	12.4	-	-	R _A > F _T
Timberline Ultra (Tampa, FL)	Class H	5.6	4.8	10.4	17.9	-	-	R _A > F _T
Timberline Ultra (Minneapolis, MN)	Class H	4.5	2.1	6.6	18.0	-	-	R _A > F _T
Timberline Ultra (Baltimore, MD)	Class H	6.9	2.3	9.3	8.1	20.5	14.3	R _T > F _T
Timberline Ultra (Fontana, CA)	Class H	6.0	2.8	8.8	9.4	-	-	R _A > F _T
Grand Timberline (Mt. Vernon, IN)	Class H	-	-	8.5	15.0	-	-	R _A > F _T
Jumbo Royal Sovereign (Mt. Vernon, IN)	Class H	-	-	5.8	20.6	-	-	R _A > F _T
Royal Sovereign (Erie, PA)	Class H	3.7	2.1	5.7	17.2	-	-	R _A > F _T
Royal Sovereign (Minneapolis, MN)	Class H	3.5	0.6	4.1	10.4	-	-	R _A > F _T
Royal Sovereign (Mt. Vernon, IN)	Class H	4.1	2.6	6.6	15.4	-	-	R _A > F _T
Marquis WeatherMax (Minneapolis, MN)	Class H	3.8	0.6	4.5	15.4	-	-	R _A > F _T
Marquis WeatherMax (Erie, PA)	Class H	4.0	0.5	4.5	14.5	-	-	R _A > F _T

Since in all cases $R_A > F_T$ or $R_T > F_T$, all the above shingles comply with UL 2390 (ASTM D7158) and wind speed Classification, Class H.

PRACTICABILITY:

The materials used in the test assemblies can be readily installed by qualified workmen with tools and methods commonly used for construction work of a similar nature.

The materials and installation procedures described in this Report are judged to be significant factors in the uplift resistance of the construction.

The magnitude of the wind velocity across roof decks and assemblies and the resulting uplift pressures are dependent upon many factors such as wind gusts, the shape of the roof deck and assembly, edge configuration and the landscape surrounding the roof installation. A method to calculate the File uplift pressures on roof decks and assemblies is contained in ASCE 7, "Minimum Design Loads for Buildings and Other Structures".

CONCLUSION

The following conclusions represent the judgment of Underwriters Laboratories Inc. based upon the results of the examination, tests and data analysis presented in this Report, as they relate to established principles and previously recorded data.

The products covered by this Report are judged to be eligible for Classification and Follow-Up Service. The manufacturer is authorized to use the Laboratories' Classification Markings as shown below on such products which comply with the Follow-Up Procedure and any other applicable requirements of Underwriters Laboratories Inc. Only those products which properly bear the Laboratories' Classification Markings are considered as Classified by Underwriters Laboratories Inc.

CLASSIFICATION MARKING

The Classification Marking to be used with the shingles in the table below is illustrated below. The Classification Mark for these products includes the Listing Mark for Prepared Roof Covering Materials (TFWZ) and the statement:

ALSO CLASSIFIED IN ACCORDANCE WITH UL 2390/ASTM D6381
AS TO UPLIFT RESISTANCE
CLASS H

and / or

ALSO CLASSIFIED IN ACCORDANCE WITH ASTM D7158
AS TO UPLIFT RESISTANCE
CLASS H

<u>Location</u>	<u>Shingle</u>	<u>Location</u>	<u>Shingle</u>
Baltimore, MD	Timberline 30 Timberline Select 40 Timberline Ultra	Millis, MA	Timberline 30
Dallas, TX	Timberline 30 Timberline Ultra	Minneapolis, MN	Sentinel Timberline 30 Timberline Canadian 40 Timberline Select 40 Royal Sovereign Timberline Ultra Marquis WeatherMax
Dudley, NC	Timberline 30 Royal Sovereign Timberline Select 40 Timberline Ultra	Mobile, AL	Timberline 30 Royal Sovereign
Erie, PA	Royal Sovereign Marquis WeatherMax	Mt. Vernon, IN	Royal Sovereign Grand Timberline Jumbo Royal Sovereign Country Estates Camelot Slateline Grand SLATE Country Mansion
Fontana, CA	Timberline 30 Timberline Select 40 Timberline Ultra Royal Sovereign Sentinel Grand Sequoia Grand Canyon	Tampa, FL	Timberline 30 Timberline Ultra Timberline Select 40
Michigan City, IN	Timberline 30 Timberline Select 40 Timberline Ultra		

Report by:

KIMBERLY A. LAMKE
Associate Project Engineer

Reviewed by:

ALPESH PATEL
Senior Project Engineer