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Physical Properties of Window Films

Name	3M Renewable Energy	Date:	July 3, 20104
Attn:	Paul Neumann	Revision Date:	September 18, 2014
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City, State, Zip:	St. Paul, MN 55144	Report Number:	ESP017051P-600/800
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INTRODUCTION

This report presents the results of tensile/elongation and tear tests conducted on sample of window films. The testing was authorized by Paul Neumann of 3M Renewable Energy on June 12, 2014. The testing and data analysis were completed on September 18, 2014.

The scope of our work was limited to conducting tensile/elongation and tear tests on the sample submitted and reporting the results.

OBJECTIVE

Determine physical properties of the window films.

SAMPLE IDENTIFICATION

3M™ Scotchshield™ Safety and Security Film Ultra 600, and Ultra 800 base films (no coating).

TEST METHOD

The specimens were allowed to condition at standard laboratory conditions of $72 \pm 4^{\circ}\text{F}$ and $50 \pm 5\%$ relative humidity for at least 40 hours prior to testing. Testing was done according to ASTM Standards detailed below, with notes of parameters and/or deviations.

Test Method	Test Method Title	Parameters and/or Deviations from Method
ASTM D882	Standard Test Method for Tensile Properties of Thin Plastic Sheeting	Test Speed 2 in./min.
ASTM D1004	Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting	Grip separation 1 in. Test speed 2 in./min.

CALIBRATED TEST EQUIPMENT

Honeywell Temp/RH Chart Recorder, S/N 7852 243000007, ID MM190-024 calibrated 8/7/13 calibrated 8/5/14,
due 8/5/15

MTS Universal Test Machine, Mdl Qtest / 50LP, System #1532, ID MM210-009.3 & 6 calibrated 4/8/14 due 4/8/15

MTS Load Cell, 2250lbf Capacity, S/N 205974, ID MM210-009.1 calibrated 4/8/14 due 4/8/15

Interface Load Cell, 225 lbf capacity, S/N 677238, ID PT-163-042 calibrated 4/8/14, due 4/8/15

Mitutoyo Digimatic 8" Calipers, S/N 0006565, ID MM160-068 calibrated 8/8/13, calibrated 8/5/14, due 8/5/15

Mitutoyo Digimatic Indicator, Model C1012CMX, S/N 09040960, ID PT163-021 calibrated 8/8/13, calibrated
8/5/14, due 8/5/15

TEST RESULTS

Tensile

Specimen	Width, in	Thickness, in	Peak Load, lbs	Stress at Yield, psi	Stress at Break, psi	Elongation at Yield, %	Elongation at Break, %	Modulus, ksi
600 MD 1	0.990	0.006	88.4	14877	14353	7.21	13.27	621.3
2	1.018	0.006	136.0	14078	20556	6.92	58.58	575.1
3	0.951	0.006	93.2	14037	15079	7.47	21.72	584.0
4	0.992	0.006	133.0	14016	20629	9.10	62.77	565.5
5	0.996	0.006	121.3	14611	20290	7.24	54.51	593.1
Average	0.989	0.006	114.4	14324	18181	7.59	42.17	587.8
Standard Deviation	0.024	0.000	22.3	396	3176	0.87	22.91	21.3
600 TD 1	1.022	0.006	150.2	****	22975	****	55.86	637.1
2	0.974	0.006	145.5	****	24073	****	58.55	658.4
3	1.004	0.006	148.6	****	23854	****	60.07	659.9
4	0.963	0.006	150.1	****	24346	****	66.21	640.5
5	1.018	0.006	155.1	****	24177	****	65.20	637.0
Average	0.996	0.006	149.9		23885		61.18	646.6
Standard Deviation	0.026	0.000	3.5		539		4.41	11.6

TEST RESULTS Continued
Tensile Continued

Specimen	Width, in	Thickness, in	Peak Load, lbs	Stress at Yield, psi	Stress at Break, psi	Elongation at Yield, %	Elongation at Break, %	Modulus, ksi
800 MD 1	0.986	0.008	177.9	14308	21740	7.06	71.83	579.0
2	1.002	0.008	173.4	13910	20365	7.30	67.07	550.9
3	0.976	0.008	179.2	13454	21601	7.16	80.71	534.5
4	1.006	0.008	184.7	14002	21606	7.05	77.50	549.0
5	0.960	0.008	174.0	14235	22097	7.15	75.48	578.4
Average	0.986	0.008	177.8	13982	21482	7.14	74.52	558.4
Standard Deviation	0.019	0.000	4.6	337	656	0.10	5.26	19.6
800 TD 1	1.044	0.008	196.2	****	22375	****	58.85	637.5
2	0.996	0.008	187.1	****	22370	****	55.36	655.2
3	0.985	0.008	198.4	****	23982	****	76.99	599.2
4	0.984	0.008	199.5	****	23864	****	75.53	605.0
5	1.016	0.008	198.9	****	23188	****	73.56	630.6
Average	1.005	0.008	196.0		23156		68.06	625.5
Standard Deviation	0.025	0.000	5.2		777		10.15	23.2

TEST RESULTS Continued
Tear

Specimen	PeakLoad (lbf)	Extension (in)	TotalEnergy (in*lbf)	Grave Tear (lbf %)
600 MD - 1	17.57	0.56	8.05	805
2	19.60	0.53	7.77	777
3	15.17	0.54	6.67	667
4	14.74	0.43	4.54	454
5	21.84	0.69	11.60	1160
6	15.12	0.52	6.05	605
7	18.66	0.48	6.76	676
8	15.26	0.47	5.76	576
9	16.14	0.46	5.85	585
10	14.60	0.48	6.46	646
Average	16.87	0.52	6.95	695.09
Standard Deviation	2.46	0.07	1.92	191.76
600 TD - 1	16.33	0.51	6.69	669
2	13.88	0.68	6.97	697
3	13.19	0.45	4.91	491
4	14.00	0.46	5.47	547
5	14.19	0.38	3.70	370
6	18.74	0.44	5.32	532
7	14.06	0.41	3.82	382
8	17.42	0.55	7.16	716
9	14.65	0.65	7.46	746
10	16.42	0.48	6.16	616
Average	15.29	0.50	5.77	576.53
Standard Deviation	1.83	0.10	1.35	134.66

TEST RESULTS Continued
Tear

Specimen #	Peak Load (lbf)	Extension (in)	Total Energy (in*lbf)	Grave Tear (lbf %)
MD - 1	25.95	0.65	13.32	1332
2	19.82	0.60	10.31	1031
3	19.41	0.48	7.78	778
4	21.48	0.56	10.67	1067
5	27.65	0.70	15.36	1536
6	20.32	0.54	9.36	936
7	19.12	0.44	5.97	597
8	22.79	0.47	8.26	826
9	19.54	0.39	5.23	523
10	19.32	0.37	4.65	465
Average	21.54	0.52	9.09	908.90
Standard Deviation	3.02	0.11	3.46	346.47
TD - 1	18.80	0.47	6.77	677
2	17.31	0.34	3.66	366
3	20.81	0.55	9.23	923
4	18.41	0.41	5.05	505
5	19.10	0.54	7.86	786
6	20.61	0.57	10.05	1005
7	26.47	0.65	13.37	1337
8	18.79	0.38	4.57	457
9	17.66	0.35	3.99	399
10	18.38	0.51	7.67	767
Average	19.63	0.48	7.22	722.09
Standard Deviation	2.65	0.10	3.08	308.26

Respectfully submitted,



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