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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
Address:	3M Center, 235-3D-02	Author:	William Stegeman
City, State, Zip:	St. Paul, MN 55144	Report Number:	ESP017051P-AG/SW
		Client Purchase Order Number:	USMMMNY51T

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## INTRODUCTION

This report presents the results of abrasion resistance, peel and puncture tests conducted on samples 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 abrasion resistance (done at another Element Lab), tear, peel and puncture tests on the samples submitted and reporting the results.

## OBJECTIVE

Determine physical properties of the window films.

## SAMPLE IDENTIFICATION

The sample was identified as follows;

3M™ Safety and Security Film Anti-Graffiti and Security Window Film Series: AG4, AG6, SWF4, and SWF7.

## 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 D1044	Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion	Wheels: CS10F Weight: 500 g Cycles: 100
ASTM D3330	Standard Test Method for Peel Adhesion of Pressure-Sensitive Tape	Method A
ASTM D4830	Standard Test Methods for Characterizing Thermoplastic Fabrics Used in Roofing and Waterproofing"	Section 7

## 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

Byk Gardner Haze-Gard Plus, PT-173-021, Calibration Due: Per Use

Haze standard, ID PT-173-022 - Calibration Due: 10/10/2014

Fisher Scientific Digital Thermometer, ID PT-173-026 - Calibration Due: 9/4/2014, calibrated 8/5/14, due 8/5/15

Tabor Abrader, ID PT-173-024 - Calibration Due: 02/05/2015

Temp/Humidity PT-172-074 – Calibration Due: 1/31/2015

## TEST RESULTS

### Abrasion

Sample #	Haze %: Original	Haze %: Abraded	Change in Haze (% ABRASION)
AG6-1	3.16	3.91	0.75
AG6-2	4.82	6.72	1.90
AG6-3	2.49	3.34	0.82
Average	<b>3.49</b>	<b>4.66</b>	<b>1.16</b>
Std. Dev.	<b>1.20</b>	<b>1.81</b>	<b>0.64</b>
SWF4-1	2.95	7.50	4.10
SWF4-2	2.98	6.91	3.93
SWF4-3	3.50	6.99	3.49
Average	<b>3.14</b>	<b>7.13</b>	<b>3.84</b>
Std. Dev.	<b>0.31</b>	<b>0.32</b>	<b>0.31</b>

**TEST RESULTS Continued**
**Peel**

Sample Identification	Specimen	Width, in	Peak Load, lbs	Scatter Peel, lbs/in	Peel Strength, lbs/in
AG4	1	2.223	2.78	0.04	1.16
	2	2.256	3.34	0.03	1.26
	3	2.249	2.33	0.08	0.91
	4	2.238	3.71	0.09	1.29
	5	2.223	1.86	0.07	0.71
Average		<b>2.238</b>	<b>2.81</b>	<b>0.06</b>	<b>1.06</b>
Standard Deviation		<b>0.015</b>	<b>0.74</b>	<b>0.02</b>	<b>0.25</b>
AG6	1	2.244	1.04	0.01	0.33
	2	2.276	0.75	0.02	0.28
	3	2.262	0.82	0.01	0.34
	4	2.264	0.77	0.03	0.29
	5	2.273	0.84	0.01	0.33
Average		<b>2.264</b>	<b>0.84</b>	<b>0.02</b>	<b>0.31</b>
Standard Deviation		<b>0.013</b>	<b>0.11</b>	<b>0.01</b>	<b>0.03</b>
SWF4	1	2.287	0.96	0.02	0.38
	2	2.250	1.31	0.02	0.53
	3	2.130	0.90	0.02	0.40
	4	2.225	0.98	0.02	0.41
	5	2.272	1.16	0.03	0.38
Average		<b>2.233</b>	<b>1.06</b>	<b>0.02</b>	<b>0.42</b>
Standard Deviation		<b>0.062</b>	<b>0.17</b>	<b>0.00</b>	<b>0.06</b>
SWF7	1	2.278	1.17	0.02	0.47
	2	2.259	1.24	0.03	0.44
	3	2.239	1.18	0.02	0.46
	4	2.258	1.17	0.01	0.49
	5	2.149	1.03	0.01	0.46
Average		<b>2.237</b>	<b>1.16</b>	<b>0.02</b>	<b>0.46</b>
Standard Deviation		<b>0.051</b>	<b>0.08</b>	<b>0.01</b>	<b>0.02</b>

**TEST RESULTS Continued****Puncture**

Sample Id	Specimen	Peak Load, N
AG6	1	591.563
	2	537.167
	3	544.092
	4	544.250
	5	565.490
Average		<b>556.512</b>
Standard Deviation		<b>22.294</b>
SWF4	1	402.968
	2	405.170
	3	412.590
	4	389.9300
	5	406.348
Average		<b>403.401</b>
Standard Deviation		<b>8.335</b>

Respectfully submitted,



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