Architectural Testing

PERFORMANCE TEST REPORT

Rendered to:

VELUX America, Inc.

PRODUCT: SUN TUNNEL™ Polycarbonate Dome

Report No: D3964.02-106-31
Report Date: 06/19/14
Test Record Retention Date: 06/03/18

130 Derry Court
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Architectural Testing

PERFORMANCE TEST REPORT

Rendered to:

VELUX America, Inc.
P.O. Box 5001
1418 Evans Pond Road
Greenwood, South Carolina 29648-5001

Report No:	D3964.02-106-31
Test Dates:	03/05/14
Through:	06/03/14
Report Date:	06/19/14
Test Record Retention Date:	06/03/18

Products: SUN TUNNEL™ Polycarbonate Dome

Project Summary: Architectural Testing, Inc. was contracted by VELUX America, Inc. to perform testing on the polycarbonate material used in the dome of their SUN TUNNEL™ system. The samples tested successfully met the performance requirements listed in the listed in the 2012 International Building Code (IBC) for light transmitting plastics for the properties listed below. Test specimens description and results are reported herein.

Test Methods: The test specimens were evaluated in accordance with the following methods.

ASTM D 1929-96(2001), *Standard Test Method for Determining Ignition Temperature of Plastics.*

ASTM D 2843-99(2004), *Standard Test Method for Density of Smoke from the Burning or Decomposition of Plastics.*

> ***Note**: The thickness of the specimens does not meet the specimen criterion as stated in the method, and was tested in the thickness intended for use in accordance with IBC.*

ASTM D 635-06, *Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.*

ASTM G 155-05a, *Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*

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Test Procedures and Test Results: Testing procedures and the results obtained from testing are reported as follows. All conditioning of test specimens and test conditions were at standard laboratory conditions.

ASTM D 1929 - Self-Ignition and Flash Ignition

Self-ignition temperature is the minimum temperature at which the self-heating properties of the specimen lead to ignition or ignition occurs of itself, under test conditions, in the absence of any additional flame ignition source. Flash ignition temperature is the minimum temperature at which, under specified test conditions, sufficient flammable gases are emitted to ignite momentarily upon application of a small external pilot flame. These temperatures were determined by observing the test specimen at a known temperature utilizing a self-ignition furnace (ICN 62156).

Caveat: *These test results relate only to the behavior of test specimens under the particular conditions of the test. They are not intended to be used, and shall not be used, to assess the potential fire hazards of a material in use.*

Self-Ignition

Specimen	Initial Mass (g)	Final Mass (g)	Mass Loss (g)	Initial Temperature (ºC)			Final Temperature (ºC)		
				Air	Furnace	Sample	Air	Furnace	Sample
1	3.1496	3.0870	0.0626	400	426	413	400	426	416
2	3.0779	2.3157	0.7622	440	468	454	447	468	459
3	3.1433	0.4129	2.7284	480	507	493	490	506	509
4	3.0885	0.5593	2.5292	500	529	513	515	528	531
5	3.1699	0.3982	2.7717	520	546	530	531	546	555
6	3.1927	0.2477	2.9450	540	560	553	551	560	575
7	3.0441	0	3.0441	560	589	585	566	589	584
8	3.1969	0.1050	3.0919	550	574	569	555	574	600

Specimen	Ignition (min:sec)	Combustion Type	Observations (min:sec)					
			Char	Melt	Bubble	Foam	Smoke	Soot
1	-	-	-	0:15	3:23	-	4:51	-
2	-	-	-	0:13	1:49	-	2:38	-
3	-	-	-	0:08	0:25	-	1:22	-
4	-	-	-	0:05	0:44	-	1:46	-
5	-	-	-	0:04	0:33	-	1.30	-
6	-	-	-	0:10	0:30	-	1:26	
7	1:27	Flame	-	0:05	0:17	-	1:00	1:27
8	2:05	Flame	-	0:05	0:26	-	1:19	2:05

Self-Ignition Temperature: **550 ºC**

Test Results: (Continued)

Flash Ignition

Specimen	Initial Mass (g)	Final Mass (g)	Mass Loss (g)	Initial Temperature (ºC)			Final Temperature (ºC)		
				Air	Furnace	Sample	Air	Furnace	Sample
1	3.1131	2.5797	0.5334	400	411	407	400	411	410
2	3.1959	2.9664	0.2295	440	453	447	442	453	452
3	3.1803	0.1830	2.9973	480	495	489	491	495	502
4	3.1754	-	3.1754	460	475	469	474	475	485
5	3.1456	0.8116	2.3340	450	461	456	455	461	468

Specimen	Ignition (min:sec)	Combustion Type	Observations (min:sec)					
			Char	Melt	Bubble	Foam	Smoke	Soot
1	-	-	-	0:15	4:03	-	7:53	-
2	-	-	-	0:14	2:49	-	4:15	-
3	2:45	Flame	-	0:10	1:26	-	2:02	2:45
4	3:08	Flame	-	0:05	1:05	-	1:37	3:08
5	3:00	Flame	-	0:10	1:30	-	2:15	3:00

Flash Ignition Temperature: **450 ºC**

Test Results: (Continued)

ASTM D 2843 - Smoke Density

A test specimen was exposed to a flame inside a Smoke Chamber (ICN 004388). Due to the dripping of the test specimen, a second flame was introduced into the chamber to keep the entire test specimen exposed to a flame for the duration of the test. The horizontal light absorption was measured across the light beam path of a photoelectric cell, and the condition of the smoke chamber was observed. The Light Absorption Curves are presented in Appendix A.

Caveat: *This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire-hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.*

Smoke Density

Specimen	Width (in)	Length (in)	Thickness (in)	Maximum Smoke Density (%)	Smoke Density Rating
1	1.022	1.000	0.254	88.92	58.4
2	1.028	1.018	0.252	91.36	66.8
3	1.010	1.024	0.254	77.80	56.5

Average Smoke Density Rating: **60.6**

Note: *During all smoke density tests, the letters on the exit sign were visible and readable through the smoke. The test specimens melted, flamed, and extinguished during the test.*

Test Results: (Continued)

ASTM D 635 - Rate of Burn

The test specimen was supported horizontally at one end and the free end exposed to a gas flame from a laboratory burner (ICN Y002875) for 30 seconds. After removal of the flame, the test specimen was observed for time and extent of burning.

Caveat: *This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions but does not by itself incorporate all factors required for fire hazards or fire risk assessment of materials, products, or assemblies under actual fire conditions.*

Rate of Burn

Specimen	Initial Burn	Sustained Burn Beyond 30 sec or 25 mm	Length Burned, L (mm)	Time, t (sec)	Linear Burn Rate, V (mm/min)	Comments
1	Y	N	-	-	-	Melting, Charring, Flaming drips
2	Y	N	-	-	-	
3	Y	N	-	-	-	
4	Y	N	-	-	-	
5	Y	N	-	-	-	
6	Y	N	-	-	-	
7	Y	N	-	-	-	
8	Y	N	-	-	-	
9	Y	N	-	-	-	
10	Y	N	-	-	-	

Note: *Lack of sustained burn corresponds to a Class CC1 product. The test specimens were an average of 5" (nominal x 127 mm) long by .5" (nominal x 12.7 mm) wide by .124" (nominal 3.15 mm) thick.*

Test Results: (Continued

ASTM D 638 - Tensile Tests

Test Procedure and Summary of Results: Test specimens were cut by ATI to the dimensions designated for a Type I specimen. Test specimens were conditioned in lab conditions forty eight hours prior to testing. Five control specimens at room temperature & five specimens weathered in accordance with ASTM G 155-13 at 2000 hrs. of exposure were tested. Tensile properties were determined by utilizing an Instron Model 3369 Universal Test Machine (005740) operating at a cross head speed of 0.2 in/min and a Class C extensometer.

Tensile Properties

Control Specimens				
Specimen	**Width (in)**	**Thickness (in)**	**Maximum Load (lbf)**	**Tensile Strength (psi)**
1	0.500	0.121	523	8,650
2	0.500	0.123	534	8,690
3	0.500	0.120	522	8,690
4	0.500	0.121	538	8,890
5	0.500	0.120	531	8,860
			Average	**8,760**

Weathered Specimens				
Specimen	**Width (in)**	**Thickness (in)**	**Maximum Load (lbf)**	**Tensile Strength (psi)**
1	0.500	0.121	347	5,740
2	0.500	0.123	531	8,630
3	0.500	0.120	546	9,090
4	0.505	0.121	530	8,670
5	0.502	0.123	541	8,770
			Average	**8,180**

Note: *These results represent a 7% decrease in tensile strength after weathering.*

Architectural Testing will service this report for the entire test record retention period. Test records that are retained such as detailed drawings, datasheets, representative samples of test specimens, or other pertinent project documentation will be retained by Architectural Testing, Inc. for the entire test record retention period.

Results obtained are tested values and were secured using the designated test methods. This report does not constitute certification of this product nor an opinion or endorsement by this laboratory. It is the exclusive property of the client so named herein and relates only to the specimens tested. This report may not be reproduced, except in full, without the written approval of Architectural Testing, Inc.

For ARCHITECTURAL TESTING, INC.:

Digitally Signed by: Rodney E. Holland

Rodney E. Holland - Technician I
Components / Materials Testing

Digitally Signed by: Gary Hartman

Gary Hartman, P.E. - Director
Components / Materials Testing

REH:reh/nlh

Attachments (pages) This report is complete only when all attachments listed are included.
Appendix A - Drawing (1)
Appendix B - Light Absorption Curves (4)

Revision Log

Rev. #	Date	Page(s)	Revision(s)
0	06/19/14	N/A	Original report issue.

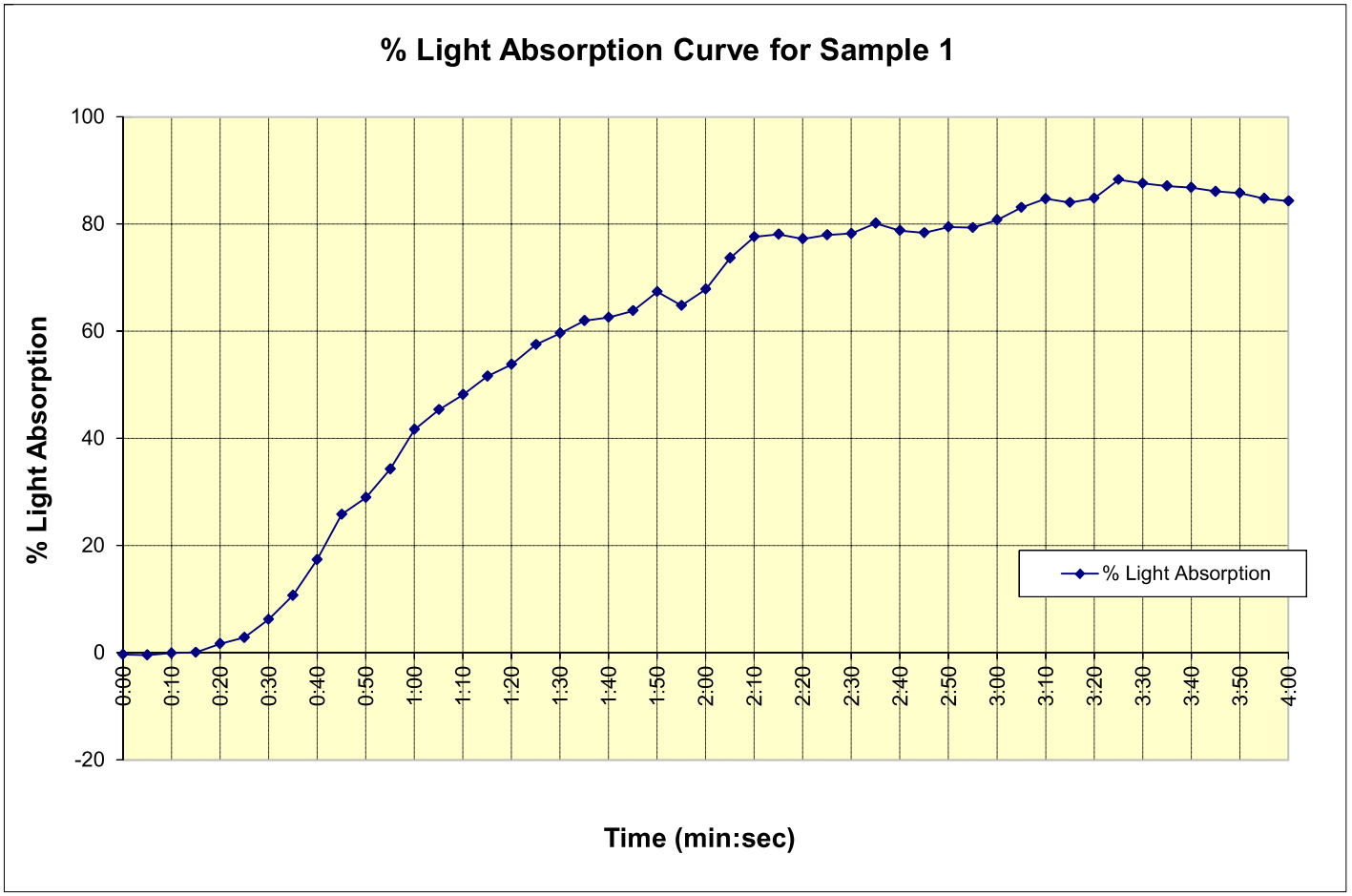
Smoke Density Testing per ASTM D 2843

Exit Sign Chamber

ATI No.: D3964.02-106-31
Test Date: 3/1/2014
Technician: DMC

Time (min:sec)	% Light	% Light Absorption
0:00	100.29	-0.29
0:05	100.41	-0.41
0:10	100.04	-0.04
0:15	99.91	0.09
0:20	98.31	1.69
0:25	97.12	2.88
0:30	93.76	6.24
0:35	89.27	10.73
0:40	82.59	17.41
0:45	74.16	25.84
0:50	70.98	29.02
0:55	65.69	34.31
1:00	58.28	41.72
1:05	54.63	45.37
1:10	51.78	48.22
1:15	48.38	51.62
1:20	46.15	53.85
1:25	42.46	57.54
1:30	40.35	59.65
1:35	38.01	61.99
1:40	37.38	62.62
1:45	36.17	63.83
1:50	32.59	67.41
1:55	35.19	64.81
2:00	32.15	67.85
2:05	26.32	73.68
2:10	22.34	77.66
2:15	21.88	78.12
2:20	22.73	77.27
2:25	21.99	78.01
2:30	21.74	78.26
2:35	19.81	80.19
2:40	21.21	78.79
2:45	21.62	78.38
2:50	20.50	79.50
2:55	20.65	79.35
3:00	19.20	80.80
3:05	16.86	83.14
3:10	15.24	84.76
3:15	15.97	84.03
3:20	15.17	84.83
3:25	11.70	88.30
3:30	12.39	87.61
3:35	12.88	87.12
3:40	13.18	86.82
3:45	13.88	86.12
3:50	14.19	85.81
3:55	15.22	84.78
4:00	15.67	84.33

Sample #	Manufacturer	Product Name	Material Type	Width (in)	Length (in)	Thickness (in)
1	Velux America Inc.	Dome	Polycarbonate	1.030	1.015	0.254



Calibration	Resistance (kΩ)
100% Light	2.368

Plot Area	240	Maximum Smoke Density	88.92 %
Area Under Curve	140.1	**Smoke Density Rating***	**58.4**

* Note: Miami-Dade County requires the Smoke Density Rating to be less than 75.

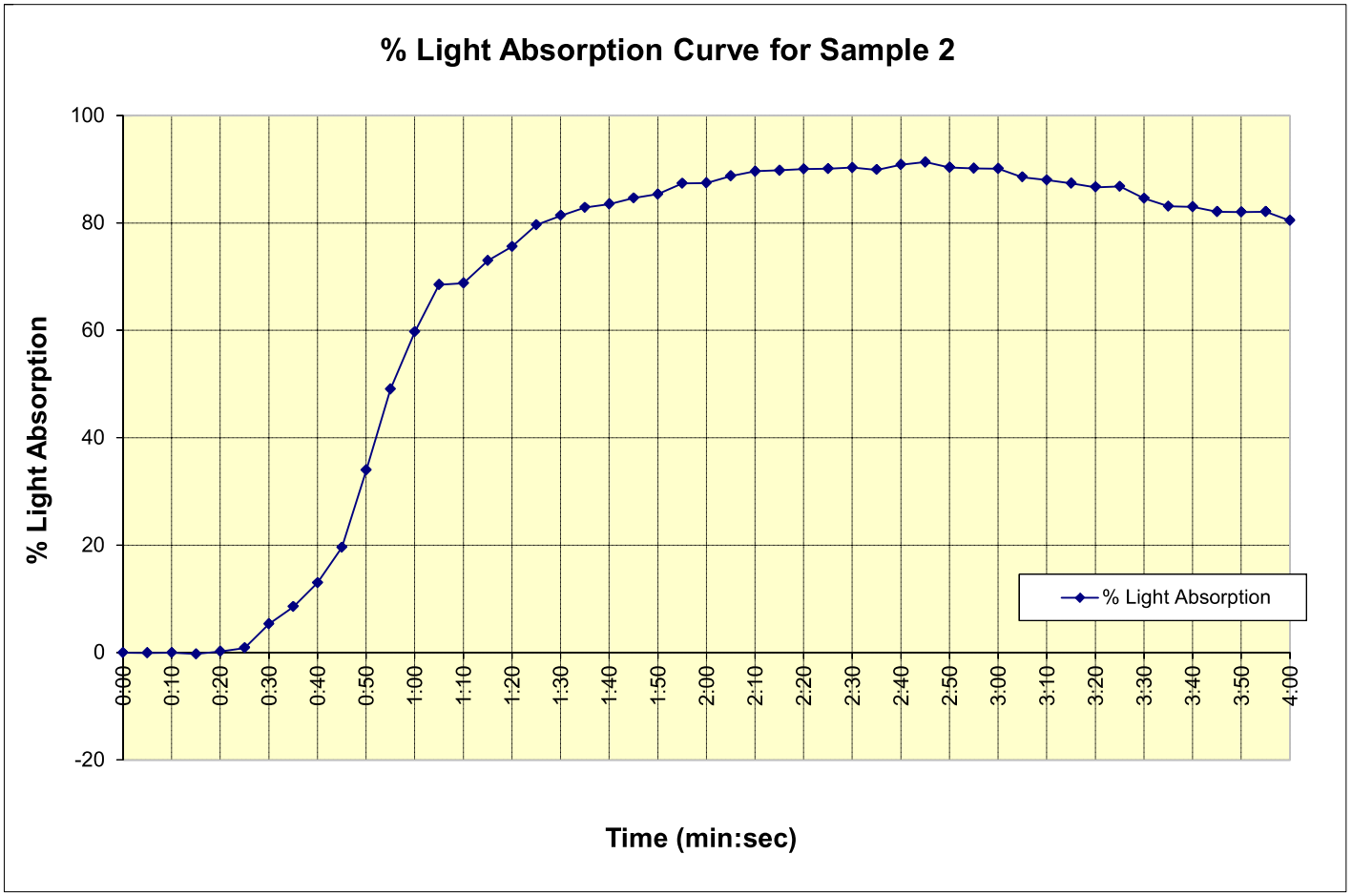
Smoke Density Testing per ASTM D 2843

Exit Sign Chamber

ATI No.: D3964.02-106-31
Test Date: 3/1/2014
Technician: DMC

Time (min:sec)	% Light	% Light Absorption
0:00	100.00	0.00
0:05	100.03	-0.03
0:10	100.02	-0.02
0:15	100.24	-0.24
0:20	99.75	0.25
0:25	99.12	0.88
0:30	94.64	5.36
0:35	91.45	8.55
0:40	86.99	13.01
0:45	80.40	19.60
0:50	66.00	34.00
0:55	50.93	49.07
1:00	40.25	59.75
1:05	31.48	68.52
1:10	31.18	68.82
1:15	26.99	73.01
1:20	24.39	75.61
1:25	20.34	79.66
1:30	18.61	81.39
1:35	17.11	82.89
1:40	16.48	83.52
1:45	15.35	84.65
1:50	14.62	85.38
1:55	12.63	87.37
2:00	12.55	87.45
2:05	11.22	88.78
2:10	10.36	89.64
2:15	10.19	89.81
2:20	9.94	90.06
2:25	9.89	90.11
2:30	9.68	90.32
2:35	10.09	89.91
2:40	9.13	90.87
2:45	8.64	91.36
2:50	9.65	90.35
2:55	9.82	90.18
3:00	9.87	90.13
3:05	11.44	88.56
3:10	11.99	88.01
3:15	12.59	87.41
3:20	13.33	86.67
3:25	13.18	86.82
3:30	15.38	84.62
3:35	16.87	83.13
3:40	16.97	83.03
3:45	17.88	82.12
3:50	17.94	82.06
3:55	17.88	82.12
4:00	19.55	80.45

Sample #	Manufacturer	Product Name	Material Type	Width (in)	Length (in)	Thickness (in)
2	Velux America Inc.	Dome	Polycarbonate	1.028	1.018	0.252



Calibration	Resistance (kΩ)
100% Light	2.402

Plot Area	240	Maximum Smoke Density	91.36 %
Area Under Curve	160.4	**Smoke Density Rating***	**66.8**

* Note: Miami-Dade County requires the Smoke Density Rating to be less than 75.

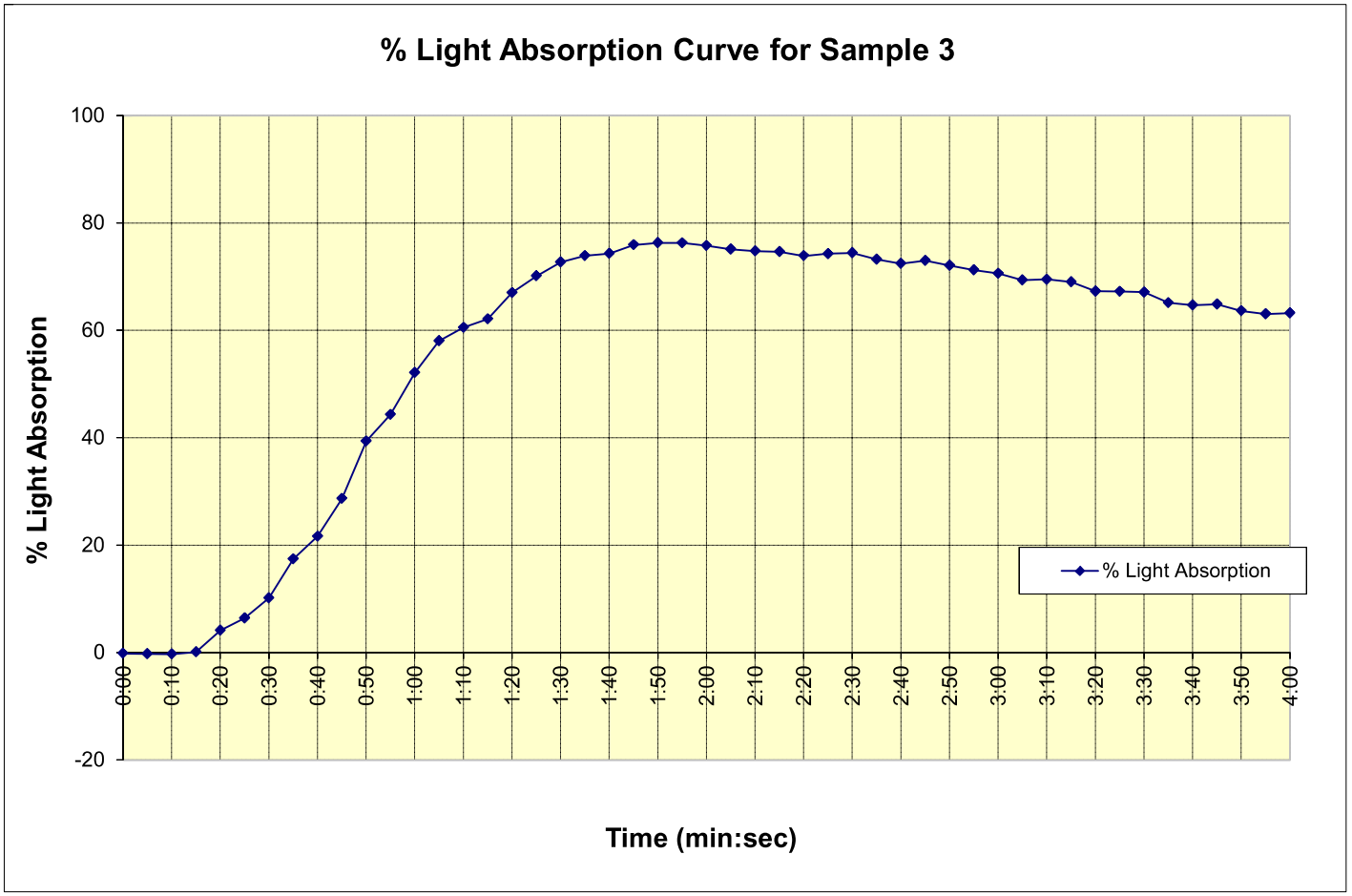
Smoke Density Testing per ASTM D 2843

Exit Sign Chamber

ATI No.: D3964.02-106-31
Test Date: 3/1/2014
Technician: DMC

Time (min:sec)	% Light	% Light Absorption
0:00	100.15	-0.15
0:05	100.22	-0.22
0:10	100.26	-0.26
0:15	99.86	0.14
0:20	95.83	4.17
0:25	93.57	6.43
0:30	89.80	10.20
0:35	82.56	17.44
0:40	78.35	21.65
0:45	71.32	28.68
0:50	60.58	39.42
0:55	55.64	44.36
1:00	47.84	52.16
1:05	41.92	58.08
1:10	39.44	60.56
1:15	37.86	62.14
1:20	32.96	67.04
1:25	29.87	70.13
1:30	27.25	72.75
1:35	26.09	73.91
1:40	25.67	74.33
1:45	24.08	75.92
1:50	23.69	76.31
1:55	23.71	76.29
2:00	24.21	75.79
2:05	24.88	75.12
2:10	25.21	74.79
2:15	25.33	74.67
2:20	26.12	73.88
2:25	25.71	74.29
2:30	25.56	74.44
2:35	26.76	73.24
2:40	27.55	72.45
2:45	27.01	72.99
2:50	27.88	72.12
2:55	28.76	71.24
3:00	29.41	70.59
3:05	30.61	69.39
3:10	30.47	69.53
3:15	30.97	69.03
3:20	32.70	67.30
3:25	32.74	67.26
3:30	32.88	67.12
3:35	34.83	65.17
3:40	35.28	64.72
3:45	35.12	64.88
3:50	36.34	63.66
3:55	36.95	63.05
4:00	36.78	63.22

Sample #	Manufacturer	Product Name	Material Type	Width (in)	Length (in)	Thickness (in)
3	Velux America Inc.	Dome	Polycarbonate	1.010	1.024	0.254



Calibration	Resistance (kΩ)
100% Light	2.394

Plot Area	240	Maximum Smoke Density	77.80 %
Area Under Curve	135.6	**Smoke Density Rating***	**56.5**

* Note: Miami-Dade County requires the Smoke Density Rating to be less than 75.

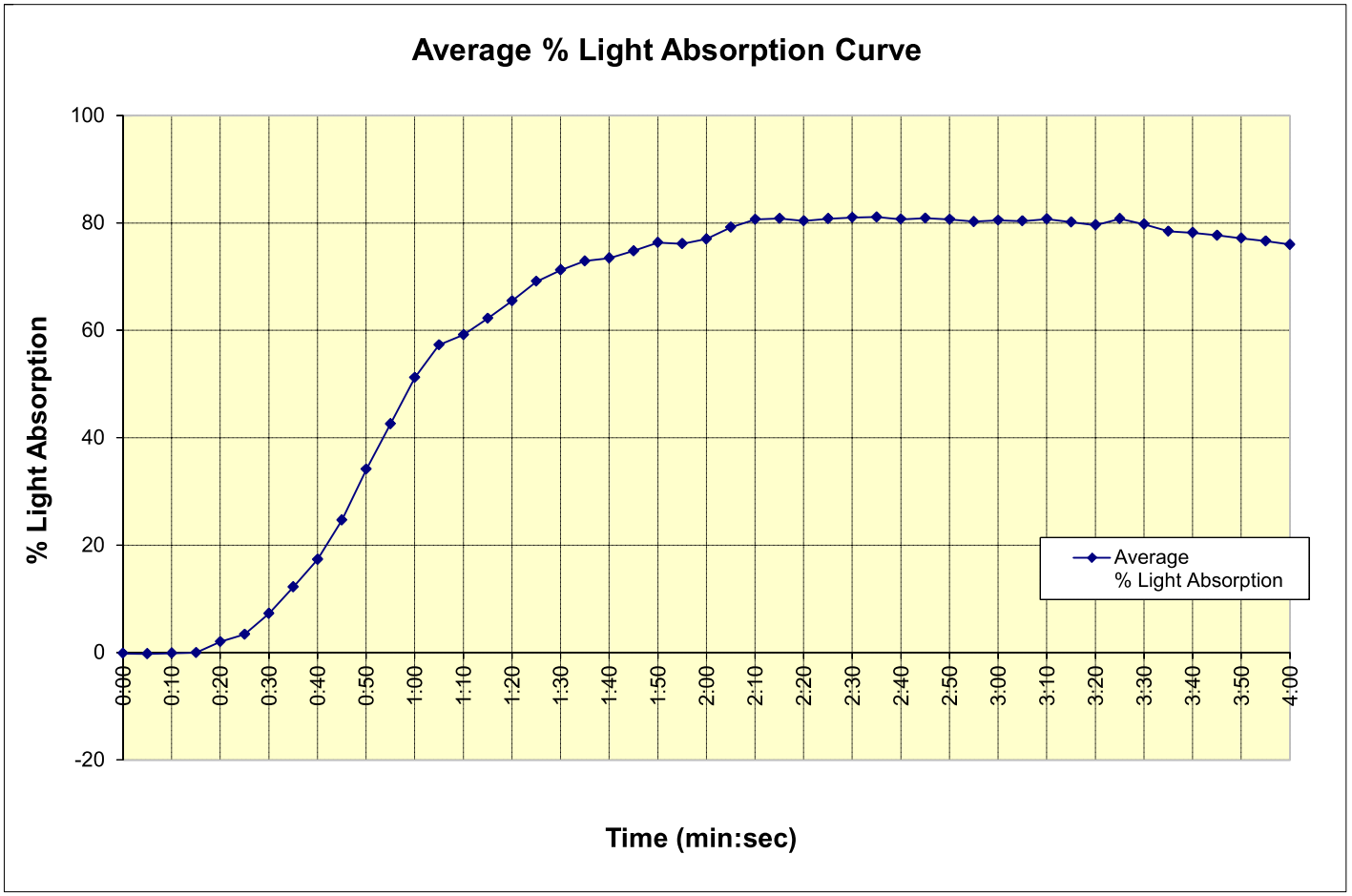
Smoke Density Testing per ASTM D 2843

Exit Sign Chamber

ATI No.: D3964.02-106-31
Test Date: 3/1/2014
Technician: DMC

Time (min:sec)	Average % Light Absorption
0:00	-0.15
0:05	-0.22
0:10	-0.11
0:15	0.00
0:20	2.04
0:25	3.40
0:30	7.27
0:35	12.24
0:40	17.36
0:45	24.71
0:50	34.15
0:55	42.58
1:00	51.21
1:05	57.32
1:10	59.20
1:15	62.26
1:20	65.50
1:25	69.11
1:30	71.26
1:35	72.93
1:40	73.49
1:45	74.80
1:50	76.37
1:55	76.16
2:00	77.03
2:05	79.19
2:10	80.70
2:15	80.87
2:20	80.40
2:25	80.80
2:30	81.01
2:35	81.11
2:40	80.71
2:45	80.91
2:50	80.66
2:55	80.26
3:00	80.51
3:05	80.36
3:10	80.76
3:15	80.16
3:20	79.60
3:25	80.80
3:30	79.79
3:35	78.47
3:40	78.19
3:45	77.71
3:50	77.17
3:55	76.65
4:00	76.00

Sample #	Manufacturer	Product Name	Material Type	Width (in)	Length (in)	Thickness (in)
AVERAGE	Velux America Inc.	Dome	Polycarbonate	1.023	1.019	0.253



Calibration	Resistance (kΩ)
100% Light	2.368

Plot Area	240	Maximum Smoke Density	81.39 %
Area Under Curve	145.3	**Smoke Density Rating***	**60.6**

* Note: Miami-Dade County requires the Smoke Density Rating to be less than 75.