



**R&D Services, Inc.**  
209 Tennessee Blvd.  
Watertown, Tennessee 37184

## ***Physical Property Testing According to ASTM C1224***

*“Standard Specification for Reflective Insulation for Building Applications”*

### **PRODUCT IDENTIFICATION: “AstroShield II”**

Reflective Thermal Insulation

### **REPORT ISSUED TO:**

#### **Innovative Energy, Inc.**

1204 Erie Court  
Lowell, IN 46356

**REPORT NUMBER: RD23873**

**REPORT DATE: SEPTEMBER 29, 2023**



A handwritten signature in black ink, appearing to read 'Stuart Ruis', written over a horizontal line.

Stuart Ruis  
President

ISO/IEC 17025:2017  
Testing Laboratory TL-566

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<b>TEST REPORT PREPARED FOR</b>
<b>Innovative Energy, Inc.</b>
<b>DATE OF TESTS</b>
<b>June 22 – September 15, 2023</b>
<b>R&amp;D SERVICES WORK ORDER NUMBER</b>
<b>1021W230510-048</b>
<b>R&amp;D SERVICES PRODUCT NUMBER</b>
<b>230516-016</b>
<b>MANUFACTURE DATE OF SPECIMENS</b>
<b>Unknown</b>

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#### **SAMPLE IDENTIFICATION**

Reflective insulation identified as “AstroShield II; Nominal Thickness: 0.3125-Inch (Reflective/Double Bubble/Reflective).” The product is classified as a vapor retarder.

#### **SAMPLING INFORMATION**

R&D Services, Inc. received this product for evaluation from the Innovative Energy, Inc. facility in Lowell, IN on May 16, 2023. No evidence of sampling was provided.

#### **SAMPLE CONDITIONING**

Specimens were conditioned for a minimum of 24 hours at  $73 \pm 4$  °F ( $23 \pm 2$  °C), and  $50 \pm 5$  % relative humidity prior to the start of tests or as specified in the applicable test procedure.

#### **SUMMARY OF TEST RESULTS**

The following results were determined from the evaluation of the product.

**Table 1: Results Summary for Physical Properties**

MATERIAL PROPERTY	Result	Requirement per ASTM C1224-22	PASS/FAIL
<b>Thermal Emittance</b>	0.1	≤0.1	PASS
<b>Water Vapor Permeance (Initial) (perm)</b>	0	≤1 for Vapor Retarder	PASS
<b>Surface Burning Characteristics<sup>1</sup> (Silver Surface)</b>			
Flame Index	0	≤25	PASS
Smoke Developed Index	5	≤50 plenum application or ≤450 exposed application	PASS
<b>Surface Burning Characteristics<sup>2</sup> (Simulated Field Joint)</b>			
Flame Index	10	≤25	PASS
Smoke Developed Index	15	≤50 plenum application or ≤450 exposed application	PASS
<b>Humidity Resistance</b>			
Corrosion (%)	0	≤2	PASS
Delamination	No Delamination	No Delamination	PASS
<b>Water Vapor Permeance (Post ASTM C1258) (perm)</b>	0	≤1 for Vapor Retarder	PASS
<b>Bleeding and Delamination</b>	No Bleeding or Delamination	No Bleeding or Delamination ≥ 2% of Specimen Area	PASS
<b>Pliability</b>	No Delamination or Cracking	No Delamination or Cracking	PASS
<b>Fungi Resistance</b>	Growth ≤ Comparative Item	Growth ≤ Comparative Item	PASS

Numerical results shown in Table 2 have been rounded to the same significance as the physical property requirements of ASTM C1224.

<sup>1</sup> Results of ASTM E84 are contained in Capital Testing and Certification Services report no. T-17170, Appendix A1.

<sup>2</sup> Results of ASTM E84 are contained in Capital Testing and Certification Services report no. T-17169, Appendix A2.

## A. THERMAL EMITTANCE

### ASTM C1224, Section 9.1 and ASTM C1371, Section 7.4

Date of Test: June 30, 2023

The results of the test specimen were obtained using a Model AE emissometer manufactured by Devices and Services Company of Dallas, Texas. The emissometer is powered to provide warm-up prior to use. A warm-up time of one hour in a conditioned laboratory has been found to be acceptable. Calibration at high and low emittance was performed, after the warm-up period, using calibration disks supplied by Devices and Services Company.

The test specimen was placed in good contact with the thermal sink that is part of the apparatus. The measurement head of the emissometer was placed on the test specimen and held in place at least 90 seconds for each measurement. The emissometer was calibrated prior to use and calibration was verified at the end of testing. The average emittance reported below is based on three measurements.

A specimen of facer film used to manufacture the final product was measured.

**Table 2: Test Parameters**

<b>High Emittance Calibration</b>	0.86
<b>Low Emittance Calibration</b>	0.06
<b>Temperature (°F)</b>	72
<b>Relative Humidity (%)</b>	49

**Table 3: Thermal Emittance Results**

Specimen Description	Thickness as Tested (mm)	Thermal Emittance Measurements			Average	Standard Deviation
		1	2	3		
Metallized Film	0.05	0.061	0.062	0.056	0.060	0.003

## B. WATER VAPOR PERMEANCE BEFORE HUMIDITY RESISTANCE EXPOSURE

### ASTM C1224, Section 9.2 and ASTM E96, Desiccant Method

Date of Test: July 4 – August 8, 2023

Three test specimens measuring 5.75-inch  $\phi$  were tested with a round pan design similar to the example in ASTM E96, Figure 1. Test specimens were sealed to the open mouth of a test dish containing desiccant or water, with the edges of the specimen sealed around the top ledge of the pan with microcrystalline wax (60%) mixed with refined crystalline paraffin wax (40%). An additional blank dish was prepared to serve as a control.

Assemblies were placed into a controlled atmosphere maintained at  $73 \pm 4$  °F ( $23 \pm 2$  °C) and  $50 \pm 5$  %RH. Periodic mass collections determine the rate of water vapor movement through the specimens. The reported permeance was calculated using the method outlined in ASTM E96, Section 15.2.1. The permeance was corrected using the “Edge Mask Correction” method outlined in ASTM E96, Section 15.6.2 where the mouth area defines the test area of the specimen.

The tests were conducted in a controlled atmosphere maintained at  $23 \pm 1$  °C ( $73 \pm 2$  °F) and  $50 \pm 2$  %RH.

**Table 4: Test Conditions**

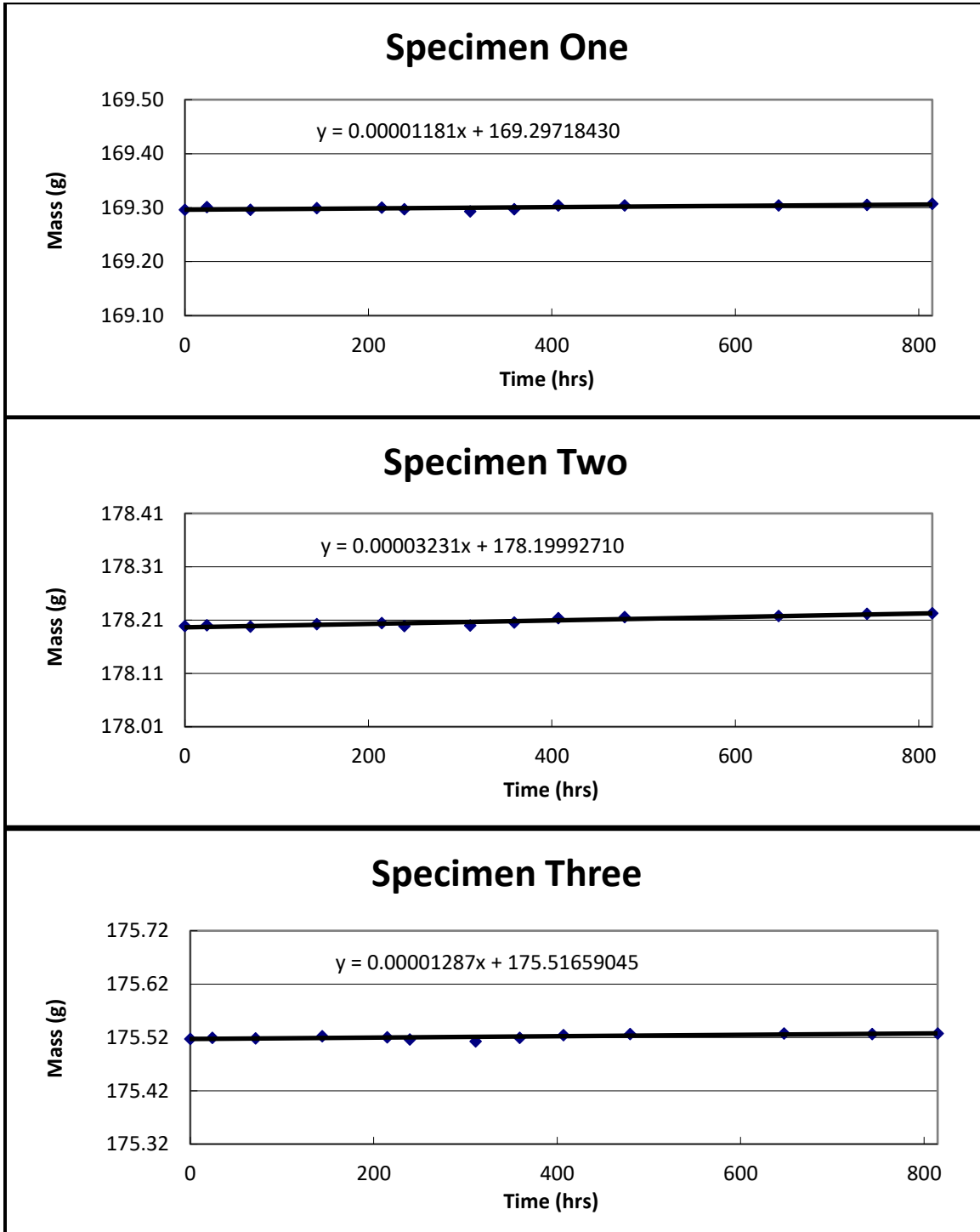
<b>Procedure Used</b>	A - Desiccant
<b>Temperature (°F)</b>	73.4
<b>Relative Humidity (%) Dry Side</b>	0.0
<b>Relative Humidity (%) Wet Side</b>	50.0
<b>Relative Humidity (%) Mean</b>	25.0
<b>Test Duration (h)</b>	815

**Table 5: Water Vapor Permeance Results**

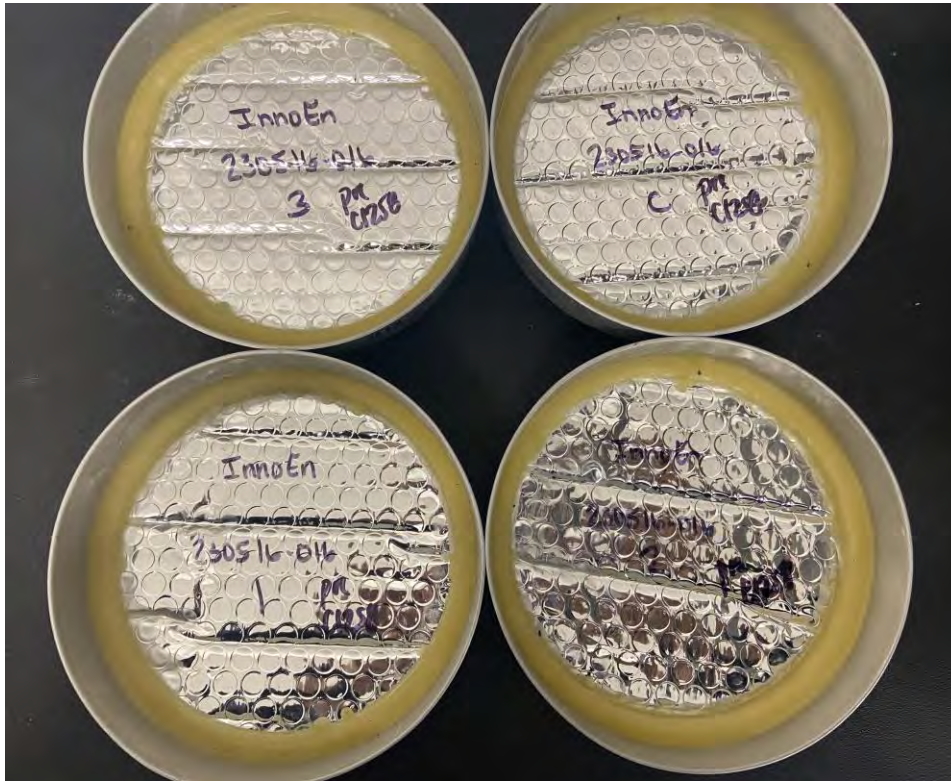
<b>Specimen</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>Average</b>
<b>Mass Change (g)</b>	0.0096	0.026	0.011	0.016
<b>Specimen Area (ft<sup>2</sup>)</b>	0.145	0.145	0.145	0.145
<b>Water Vapor Transmission (gr/h·ft<sup>2</sup>)</b>	0.0012	0.0033	0.0013	0.0020
<b>Saturation Pressure (in Hg)</b>	0.829	0.829	0.829	0.829
<b>Pressure Difference (in Hg)</b>	0.415	0.415	0.415	0.415
<b>Permeance (perm, gr/ft<sup>2</sup>·h·(in Hg))<sup>3</sup></b>	0.003	0.01	0.003	0.005
<b>Thickness (in)</b>	0.20	0.20	0.20	0.20
<b>Permeability* (perm·in)</b>	NA	NA	NA	NA

\* Permeability can only be determined for materials that are homogenous and  $\geq 0.5$ -inch thick.

<sup>3</sup> ASTM E96/E96M-22, Section 16.1.7.1: When reporting in Inch-Pound units, for results 1.0 perm and greater, report the results to two significant figures. For results less than 1.0 perm, report the result to two decimals.



Figures 1 – 3. Water Vapor Permeance – Mass Tracking



**Figure 4. Samples as Tested**

### **C. SURFACE BURNING CHARACTERISTICS**

**ASTM C1224, Section 9.3, ASTM E84, and ASTM E2599**

Date of Tests: August 29, 2023

Surface burning characteristics were determined using multiple configurations including a simulated field joint. The specimens were mounted in accordance with ASTM E2599. The maximum flame spread index and smoke development results are shown in Table 2 of this report.

Section 6.3 of ASTM C1224 states:

- 1) *Maximum surface burning characteristics shall not exceed 25 flame spread and 50 smoke development index for inside plenum applications.*
- 2) *Maximum surface burning characteristics shall not exceed 25 flame spread and 450 smoke development index in exposed building applications.*

Tests were conducted by Capital Testing and Certification Services and reported under test report numbers T-17170 and T-17169. The test reports are included in the appendix of this report in their entirety.

#### **D. HUMIDITY RESISTANCE**

##### **ASTM C1224, Section 9.4 and ASTM C1258**

Date of Test: July 5 – August 2, 2023

This test method covers the determination of the resistance of flexible low permeance vapor retarders for thermal insulation to elevated temperature and humidity. Water vapor permeance measurement and visual inspection after exposure at elevated temperature and humidity are used to assess vapor retarder response.

Five specimens spaced evenly across the product's width dimension, with minimum dimensions of 6 by 6-inch (150 by 150 mm) were prepared while wearing cotton gloves. Four specimens were vertically suspended in an environmental chamber in a manner that all sides of specimens were subjected to the chamber atmosphere and a minimum of 0.5-inch (13 mm) airspace between them. The fifth specimen was retained as an unexposed control.

The specimens were subjected to elevated temperature and humidity at  $120 \pm 2$  °F ( $49 \pm 2$  °C) and  $95 \pm 2$  %RH for a period of 28 days, then visually inspected over a lighted box for signs of corrosion and delamination. Metallized products are examined for evidence of corrosion in the form of pinholes, large holes, increased translucency, or other signs of metallization loss as compared to a control specimen. Foil laminates are examined for evidence of corrosion in the form of pinholes, large holes, increased translucency, and crystalline deposits as compared to a control specimen. No tested specimen shall exhibit visible corrosion exceeding 2% of the test area nor exhibit unaided delamination of layers.

**Table 6: Humidity Resistance Observations**

<b>Specimen</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
<b>Delamination</b>	No	No	No	No
<b>Corrosion %</b>	0	0	0	0



**Figure 5. Specimens after Exposure – Light Box Observation**

**E. WATER VAPOR PERMEANCE AFTER HUMIDITY RESISTANCE EXPOSURE**

**ASTM C1224, Section 9.2, ASTM C1258, Section 9.1.3, and ASTM E96, Desiccant Method**

Date of Test: August 14 – September 15, 2023

Three test specimens measuring 5.75-inch  $\phi$  were tested with a round pan design similar to the example in ASTM E96, Figure 1. Test specimens were sealed to the open mouth of a test dish containing desiccant or water, with the edges of the specimen sealed around the top ledge of the pan with microcrystalline wax (60%) mixed with refined crystalline paraffin wax (40%). An additional blank dish was prepared to serve as a control.

Assemblies were placed into a controlled atmosphere maintained at  $73 \pm 4$  °F ( $23 \pm 2$  °C) and  $50 \pm 5$  %RH. Periodic mass collections determine the rate of water vapor movement through the specimens. The reported permeance was calculated using the method outlined in ASTM E96, Section 15.2.1. The permeance was corrected using the “Edge Mask Correction” method outlined in ASTM E96, Section 15.6.2 where the mouth area defines the test area of the specimen.

The tests were conducted in a controlled atmosphere maintained at  $23 \pm 1$  °C ( $73 \pm 2$  °F) and  $50 \pm 2$  %RH.

**Table 7: Test Conditions**

<b>Procedure Used</b>	A - Desiccant
<b>Temperature (°F)</b>	73.4
<b>Relative Humidity (%) Dry Side</b>	0.0
<b>Relative Humidity (%) Wet Side</b>	50.0
<b>Relative Humidity (%) Mean</b>	25.0
<b>Test Duration (h)</b>	770

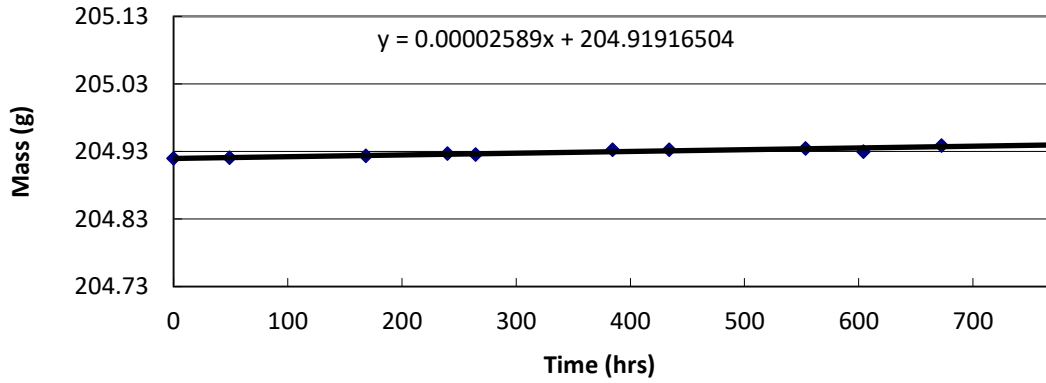
**Table 8: Water Vapor Permeance Results**

<b>Specimen</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>Average</b>
<b>Mass Change (g)</b>	0.020	0.046	0.021	0.026	0.028
<b>Specimen Area (ft<sup>2</sup>)</b>	0.145	0.145	0.145	0.145	0.145
<b>Water Vapor Transmission (gr/h·ft<sup>2</sup>)</b>	0.0027	0.0061	0.0028	0.0034	0.0038
<b>Saturation Pressure (in Hg)</b>	0.829	0.829	0.829	0.829	0.829
<b>Pressure Difference (in Hg)</b>	0.415	0.415	0.415	0.415	0.415
<b>Permeance (perm, gr/ft<sup>2</sup>·h·(in Hg))<sup>4</sup></b>	0.01	0.01	0.01	0.01	0.01
<b>Thickness (in)</b>	0.22	0.22	0.21	0.22	0.22
<b>Permeability* (perm·in)</b>	NA	NA	NA	NA	NA

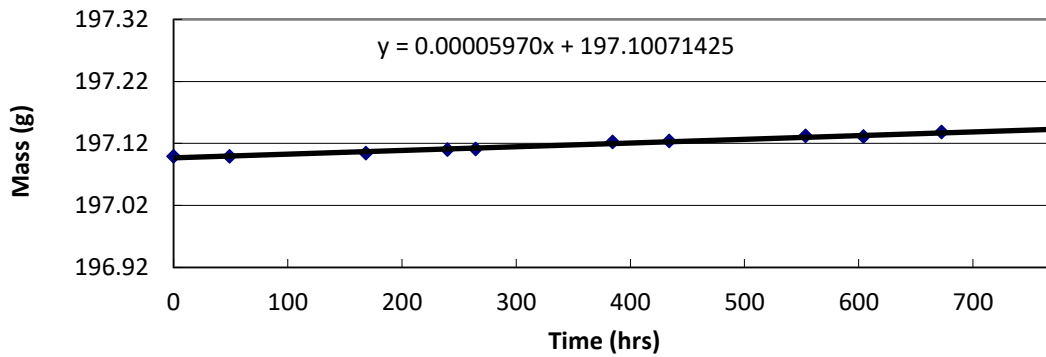
\* Permeability can only be determined for materials that are homogenous and  $\geq 0.5$ -inch thick.

<sup>4</sup> ASTM E96/E96M-22, Section 16.1.7.1: When reporting in Inch-Pound units, for results 1.0 perm and greater, report the results to two significant figures. For results less than 1.0 perm, report the result to two decimals.

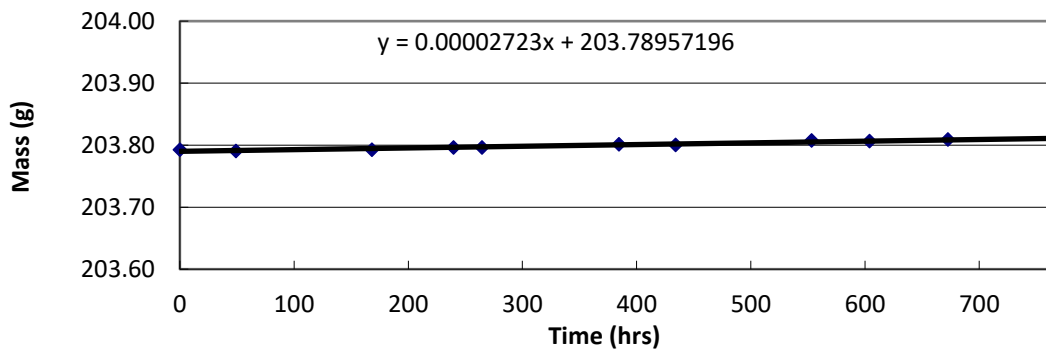
### Specimen One

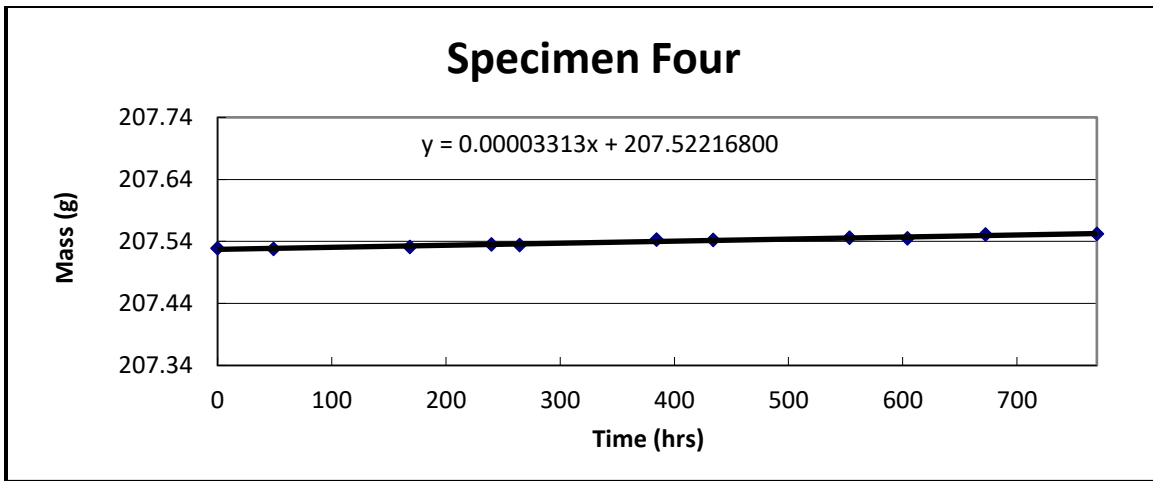


### Specimen Two



### Specimen Three





Figures 6 – 9. Water Vapor Permeance – Mass Tracking

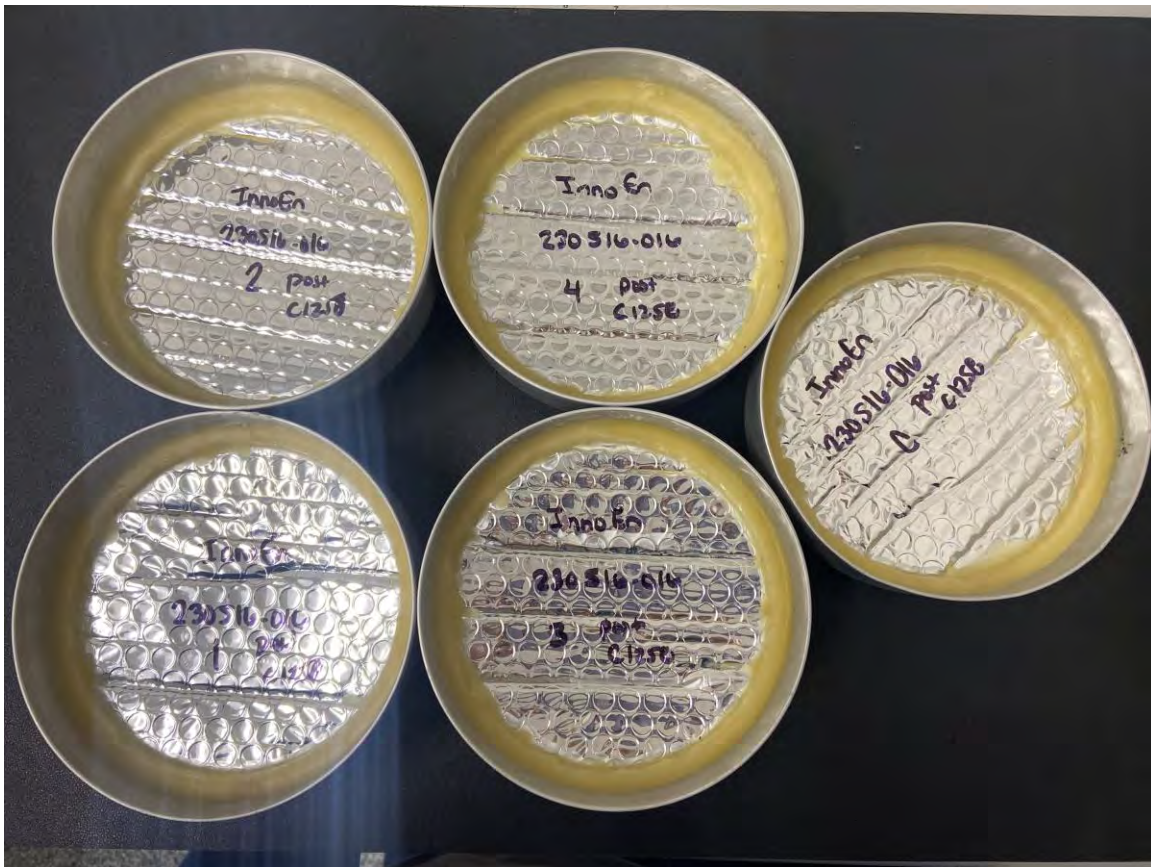


Figure 10. Samples as Tested

## F. BLEEDING AND DELAMINATION

### ASTM C1224, Section 9.5.1

Date of Test: June 22, 2023

This test method determines the structural integrity of the product by adhesive bleeding and delamination.

Three specimens approximately 3 by 6-inch (75 by 150 mm) were collected from separate locations of the product. Specimens were vertically suspended in an oven and heated to a temperature of  $180 \pm 5$  °F (82.2 °C) for a minimum of 5 hours. Specimens were evaluated under 5X magnification for evidence of adhesive bleeding through surface of specimens, or if separation of foil from substrate (delamination) occurred.

**Table 9: Bleeding and Delamination Observations**

<b>Bleeding Observed</b>	No
<b>Delamination Observed</b>	No

## G. PLIABILITY

### ASTM C1224, Section 9.5.2

Date of Test: June 26 – 28, 2023

This test method determines the structural integrity of the product by cracking or delamination of specimens due to folding and bending.

Three specimens approximately 3 by 6-inch (75 by 150 mm) were collected from different locations of the product with one specimen containing a factory produced edge.

Specimens were conditioned at a temperature of  $70 \pm 2$  °F (21 °C) and  $50 \pm 5$  %RH  $\geq$ 24 hours. Specimens were folded in accordance with TAPPI T512 using light finger pressure. Specimens were observed for evidence of cracking or delamination when folded to a 180° bend.

Specimens were then conditioned at  $32 \pm 2$  °F (0 °C)  $\geq$ 24 hours. Specimens were folded in accordance with TAPPI T512 using light finger pressure. Specimens were observed for evidence of cracking or delamination when folded to a 180° bend.

**Table 10: Pliability Observations**

<b>Cracking Observed</b>	No
<b>Delamination Observed</b>	No

## H. FUNGI RESISTANCE

### ASTM C1224, Section 9.6 and ASTM C1338

Date of Test: June 26 – July 24, 2023

Evaluations for fungi growth are based on visual examinations at 40X magnification. The examinations at 40X magnification compare fungal growth on material being evaluated with the fungal growth on an untreated comparative material that was exposed to the same environment as the test specimens.

Five inoculums defined in ASTM C1338, Section 4.2 were used for this evaluation and are shown below. The inoculums were maintained separately on Czapek Dox, or Sabouraud Dextrose agars as defined in ASTM C1338, Section 4.3.

**Table 11: Inoculum**

<b>Aspergillus niger</b>	ATCC 9642
<b>Aspergillus flavus</b>	ATCC 9643
<b>Aspergillus versicolor</b>	ATCC 11730
<b>Penicillium funiculosum</b>	ATCC 11797
<b>Chaetomium globosum</b>	ATCC 6205

A mixed spore suspension was prepared in accordance with ASTM C1338, Section 6.1 and stored at  $43 \pm 7$  °F ( $6 \pm 4$  °C) until the viability test indicates poor growth, or until growth appears in the sealed storage bottle.

Three specimens approximately 2 by 2-inch (50 by 50 mm) and a comparative material were inoculated with the mixed spore suspension. One set of two prepared hardened Czapek Dox agar specimens and one prepared Sabouraud Dextrose agar inoculated with the mixed spore suspension were used as viability specimens to determine the viability of the spore suspension during incubation.

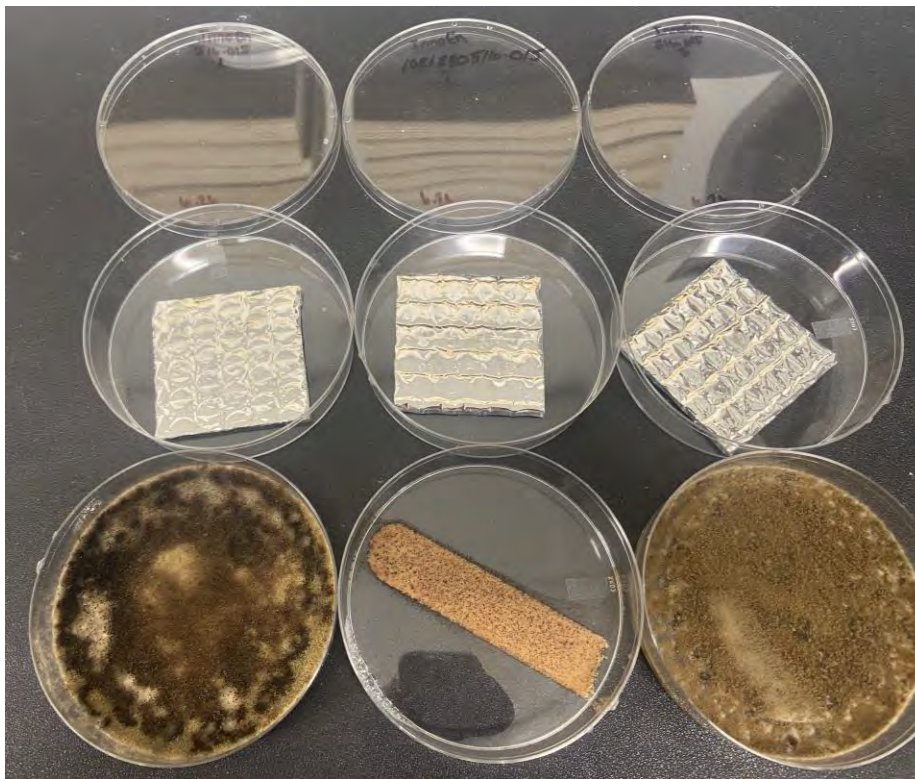
The prepared test specimens were maintained in a test chamber maintained at  $86 \pm 4$  °F ( $30 \pm 2$  °C) and a relative humidity of  $95 \pm 4$  % for a minimum period of 28 days  $\pm$  8 hours with weekly observations for the duration of the test. Test specimens were evaluated using the observation scale shown below.

**Table 12: Observation Scale**

<b>Rating</b>	<b>Description</b>
<b>1</b>	No Growth
<b>2</b>	Growth
<b>3</b>	Specimen has less growth than the control
<b>4</b>	Specimen has same amount of growth as the control
<b>5</b>	Specimen has more growth than the control

**Table 13: Observations**

Observation Intervals	Viability	Comparative Material: White Birch	Specimen 1	Specimen 2	Specimen 3
Day 7	2	2	1	1	1
Day 14	2	2	3	3	3
Day 21	2	2	3	3	3
Day 28	2	2	3	3	3
<b>Test Result:</b>	<b>PASS</b>				



**Figure 11. Specimens After 28 Day Exposure**



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**CONCLUSION**

Upon completion of the tests outlined in this report, it has been determined that this product meets the requirements outlined in ASTM C1224.

**UNCERTAINTY**

R&D Services, Inc. has applied the “Simple Acceptance” rule, also called “Shared Risk approach,” of ILAC-G8:09/2019, Guidelines on Decision Rules and Statements of Conformity for this report.

**R&D Services, Inc.**

<b>Completed By:</b>	Carla King	<b>Reviewed By:</b>	Stuart Ruis
TITLE	Reporting Manager	TITLE	President
Signature	<i>Carla King</i>	Signature	<i>Stuart Ruis</i>
Date	09/29/23	Date	09/29/23

**REVISION LOG**

Revision Number	Date	Page(s)	Revision
0	09/29/23		Initial Report



**Figure 12. Specimen As Received**

## **APPENDIX**

### **A1. SURFACE BURNING CHARACTERISTICS (SILVER SURFACE)**

### **A2. SURFACE BURNING CHARACTERISTICS (SIMULATED FIELD JOINT)**



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## **A1. SURFACE BURNING CHARACTERISTICS (SILVER SURFACE)**



## CAPITAL TESTING AND CERTIFICATION SERVICES

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### TEST REPORT

**Test Method:** ASTM E84-23a, Surface Burning Characteristics of Building Materials

**Rendered To:** R&D Services, Inc.  
209 Tennessee Blvd  
Watertown, TN 37184

**Product Description:** AstroShield II; Manufactured by Innovative Energy, Inc.

**Report Number:** T-17170

**Original Issue Date:** 09/05/2023

**Test Date:** 08/29/2023

**Pages:** 7



TL-224

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**I. SCOPE**

This test report contains the results of a specimen tested in accordance with ASTM E84, *Surface Burning Characteristics of Building Materials*. The ASTM E84 test method is intended to provide comparative measurements of surface flame spread and smoke density measurements with that of select grade red oak and fiber-cement board surfaces under the specific fire exposure conditions. The results of ASTM E84 testing are commonly used by building code officials and regulatory agencies to determine whether interior finish materials are suitable for their intended application. This standard is often used interchangeably with UL 723, NFPA 255, and UBC 8-1.

**II. TEST SPECIMENS**

Test specimens should be representative of the material which the test is intended to examine. All test specimens should be 20 – 24 inches in width and 24 feet (+12 inches, - 6 inches) in length. The test specimen can be provided in a continuous, unbroken length or multiple sections that will be butted together. Prior to testing, the specimens are conditioned to a constant weight in an environment that is held at 73.4 ± 5°F and 50 ± 5% relative humidity.

TEST SPECIMEN INFORMATION	
Product Description	AstroShield II; Manufactured by Innovative Energy, Inc.; Product Type: Double Bubble Reflective/Reflective Insulation; Dimensions (as sold): 48" x 25'. *
Samples Selected By	Client
Date Received	08/03/2023
Conditioning Time (days)	26
Specimen Size (in.)	22 x 99
Continuous / Sectioned	Sectioned
Number of Sections	3
Total Weight (lbs.)	3.1
Average Thickness (in.)	0.185
Color	Silver
Exposed Surface	Silver side (both sides equivalent)
Mounting Method	ASTM E2599-22: Sample material was mounted onto three aluminum frames measuring 22" x 99". The aluminum frames provided a 2" air gap behind the sample material. Sample material was attached to the frames using 1-1/2" x 2-3/4" strips of aluminum tape. The tape strips were spaced approximately 18" apart on-center down the long edges of the sample/frame.

\* Information provided by the Client



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### III. PROCEDURE

The tunnel is preheated to a minimum of 150°F as measured by a thermocouple embedded 1/8 inch below the tunnel floor and 23-1/4 feet downstream of the centerline of the burner. The tunnel is then cooled to 105 ± 5°F as measured by a thermocouple embedded 1/8" below the tunnel floor and 13 feet downstream of the centerline of the burner.

After the tunnel has cooled to the required temperature range, the tunnel lid is lifted, and the test specimen is placed on the ledges of the tunnel. The specimen is mounted in a ceiling orientation with the side that will be exposed to the flame facing downward. A 1/4-inch fiber-cement board is placed on the backside of the specimens to protect the tunnel lid during testing.

Once the sample has been loaded into the test chamber, the lid is lowered, and a 240 ft/min airflow is established. The test specimen is preheated for approximately 2 minutes prior to applying the 88-kW burner. The burner is positioned at the front end of the tunnel. It has two ports that point upward toward the face of the specimen. After the 2-minute preheat, the burner is ignited, and it remains on for the duration of the 10-minute test. The flame is tracked by an observer, referred to as the Reader, as it progresses down the length of the tunnel. Smoke density is measured with the use of the photometer system on the exhaust duct. Temperature data is recorded throughout the test by a thermocouple probe that is 23 feet from the centerline of the burner and approximately 1 inch below the sample surface.

### IV. CALCULATION OF RESULTS

The results of ASTM E84 testing are reported as Flame Spread Index (FSI) and Smoke Developed Index (SDI).

The Flame Spread Index is derived by plotting the flame spread distance versus time. Only progressive flame spread is plotted. The total area ( $A_T$ ) under the flame spread distance-time plot is determined by ignoring any flame front recession. FSI values are rounded to the nearest multiple of 5. The calculation of FSI is described below:

$$\text{When } A_T \leq 97.5 \text{ ft}\cdot\text{min:} \quad \text{FSI} = 0.515 * A_T$$

$$\text{When } A_T > 97.5 \text{ ft}\cdot\text{min:} \quad \text{FSI} = 4900 / (195 - A_T)$$

The Smoke Developed Index is derived by plotting the photoelectric cell readings versus time. The area under the curve for the tested material is then divided by the area under the curve for heptane (the material used for smoke calibration). The resulting value is then multiplied by 100. SDI values that are less than 200 are rounded to the nearest multiple of 5. SDI values that are greater than 200 are rounded to the nearest multiple of 50.



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### V. TEST RESULTS

FLAME SPREAD INDEX (FSI)	SMOKE DEVELOPED INDEX (SDI)
0	5

Test Date	08/29/2023
Equipment Operator	Chris Kaiser
Flame Spread Reader	Chris Palumbo
Ignition Time (sec)	13
FSI (unrounded)	1.467
SDI (unrounded)	7.0
Maximum Temperature (°F)	476.2
Time to Maximum Temperature (min)	5.116
Maximum Flame Spread Distance (ft)	0.3
Time to Maximum Distance (min)	0.533

### VI. OBSERVATIONS

During Testing: Melting and dripping of the sample material onto the tunnel floor. Sample material melted ahead of the flame front. Sample material was seen sagging downward towards the tunnel floor. Melted material continued to burn on the tunnel floor.

After Testing: Melted material on the tunnel floor to 8'. Sample material melting and shrinking towards the mounting frame to 24'. The melted sample material on the tunnel floor and ledges continued to burn after the test was concluded and the burner port was extinguished.

- Yes    No   Flames were present after the test concluded and the burner was extinguished.  
 Yes    No   Smoldering/glowing was present after the test concluded and the burner was extinguished.

### VII. REMARKS

Temperature readings from the exposed thermocouple were lower than expected. The material likely contacted the exposed thermocouple during the test and caused the lower-than-expected readings. Temperature readings from the exposed thermocouple do not impact the final results.

Note: Reported observation distances are relative to the entire length of the test specimen. Reported flame spread distances do not include the first 4-1/2 feet of material due to the length of the burner flame.



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## VIII. DATA SHEET AND GRAPHS

Test Method  Project #  Date  Time (Test Start)  Test No.

Specimen ID

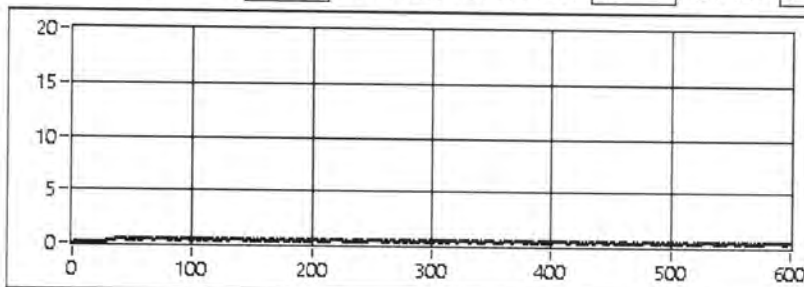
Specimen Description

Mounting Procedure

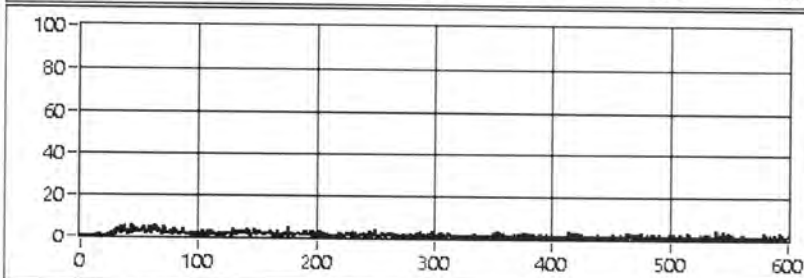
Fuel (CF)  Time to 980F (min)  Max Temp (F)  Time to Max Temp (min)

FS Area  Maximum FS  MAX FS Time (min)

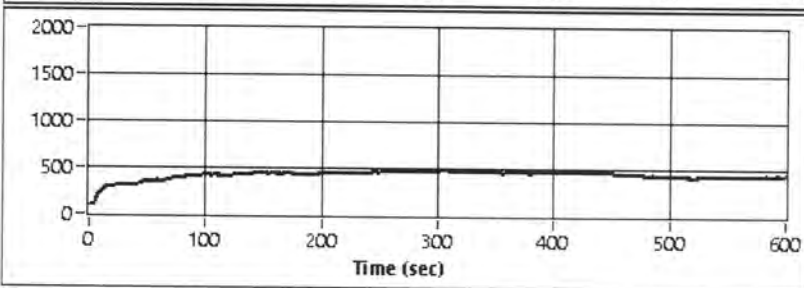
Smoke Area (%A min)  Calibration Smoke Area  Raw SD  Raw FSI



FI Spread



Smoke (%A)



23 ft Temp

Final FSI  Final SD

Test Room Temperature (°F): 73.0

Test Room Humidity (%RH): 46.7



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### IX. DISCUSSION

#### ASTM E84 Standard Language and Disclaimers

The following language was taken directly from the ASTM E84 standard. It has been included for information purposes.

*The purpose of this test method is to determine the relative burning behavior of the material by observing the flame spread along the specimen. Flame spread and smoke developed index are reported. However, there is not necessarily a relationship between these two measurements.* – ASTM E84-22, Section 1.3

*The use of supporting materials on the underside of the test specimen has the ability to lower the flame spread index from those which might be obtained if the specimen could be tested without such support. These test results do not necessarily relate to indices obtained by testing materials without such support.* – ASTM E84-22, Section 1.4

*Testing of materials that melt, drip, or delaminate to such a degree that the continuity of the flame front is destroyed, results in low flame spread indices that do not relate directly to indices obtained by testing materials that remain in place.* – ASTM E84-22, Section 1.5

*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.* – ASTM E84-22, Section 1.8

*This test method does not provide for the following: Measurement of heat transmission through the tested surface; the effect of aggravated flame spread behavior of an assembly resulting from the proximity of combustible walls and ceilings; or classifying or defining a material as noncombustible, by means of a flame spread index by itself.* – ASTM E84-22, Section 4.3

#### Classification

ASTM E84 results are frequently used by code officials and regulatory agencies to determine whether a product is suitable for its intended application. The test standard itself does not establish specific performance criteria or contain a classification system. The most commonly used classification system can be found in the International Code Council publication International Building Code (*IBC*), the National Fire Protection Association publication NFPA 101 (*Life Safety Code*), and the National Fire Protection Association publication NFPA 5000 (*Building Construction and Safety Code*).

Class	Flame Spread Index (FSI)	Smoke Developed Index (SDI)
A	0 - 25	0 - 450
B	26 - 75	0 - 450
C	76 - 200	0 - 450

Class A, B and C correspond to Type I, II, and II respectively in other codes such as SBCCI, BOCA and ICBO. The classifications above do not preclude a material being otherwise classified by the authority having jurisdiction (AHJ).



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### X. AUTHORIZED SIGNATURES

Report Written By:

Chris Kaiser  
Lab Technician II

08/31/2023

Date

Reviewed and Approved By:

Chris Palumbo  
Sr. Manager of Product Testing

09/05/2023

Date

### XI. REVISION HISTORY

Revision Number	Date	Summary
0	09/05/2023	Original Report Issued

### XII. ACCREDITATION

Capital Testing and Certification Services is an ISO/IEC 17025 accredited testing laboratory whose scope includes ASTM E84. Accrediting Body: International Accreditation Service, Inc. (IAS). Testing Laboratory TL-224.



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## **A2. SURFACE BURNING CHARACTERISTICS (SIMULATED FIELD JOINT)**



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### TEST REPORT

**Test Method:** ASTM E84-23a, Surface Burning Characteristics of Building Materials

**Rendered To:** R&D Services, Inc.  
209 Tennessee Blvd  
Watertown, TN 37184

**Product Description:** AstroShield II; Manufactured by Innovative Energy, Inc. – Simulated field joint

**Report Number:** T-17169

**Original Issue Date:** 09/05/2023

**Test Date:** 08/29/2023

**Pages:** 7



TL-224

The observations and test results in this report are relevant only to the sample(s) tested. Capital Testing and Certification Services (herein referred to as Capital Testing) does not verify information that is provided by the client. This test report in no way constitutes or implies product certification, approval or endorsement by Capital Testing. Capital Testing assumes no liability to any party, other than to the Client in accordance with the terms and conditions agreement, for any loss, expense or damage occasioned by the use of this report. This report, the Capital Testing name or any of its marks, shall not be used for the sale or advertisement of the tested material. This report shall not be reproduced, except in full, or modified in any way.



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**I. SCOPE**

This test report contains the results of a specimen tested in accordance with ASTM E84, *Surface Burning Characteristics of Building Materials*. The ASTM E84 test method is intended to provide comparative measurements of surface flame spread and smoke density measurements with that of select grade red oak and fiber-cement board surfaces under the specific fire exposure conditions. The results of ASTM E84 testing are commonly used by building code officials and regulatory agencies to determine whether interior finish materials are suitable for their intended application. This standard is often used interchangeably with UL 723, NFPA 255, and UBC 8-1.

**II. TEST SPECIMENS**

Test specimens should be representative of the material which the test is intended to examine. All test specimens should be 20 – 24 inches in width and 24 feet (+12 inches, - 6 inches) in length. The test specimen can be provided in a continuous, unbroken length or multiple sections that will be butted together. Prior to testing, the specimens are conditioned to a constant weight in an environment that is held at 73.4 ± 5°F and 50 ± 5% relative humidity.

TEST SPECIMEN INFORMATION	
Product Description	AstroShield II; Manufactured by Innovative Energy, Inc.; Product Type: Double Bubble Reflective/Reflective Insulation; Dimensions (as sold): 48" x 25'. *  Tested with a simulated field joint cut through the sample material longitudinally along the center. Simulated field joint was then taped over.
Samples Selected By	Client
Date Received	08/03/2023
Conditioning Time (days)	26
Specimen Size (in.)	22 x 99
Continuous / Sectioned	Sectioned
Number of Sections	3
Total Weight (lbs.)	3.1
Average Thickness (in.)	0.181
Color	Silver
Exposed Surface	Silver side (both sides equivalent)
Mounting Method	ASTM E2599-22: Sample material was mounted onto three aluminum frames measuring 22" x 99". The aluminum frames provided a 2" air gap behind the sample material. Sample material was attached to the frames using 1-1/2" x 2-3/4" strips of aluminum tape. The aluminum tape strips were spaced approximately 18" apart on-center down the long edges of the sample/frame. The sample material is cut longitudinally down the center of each panel and taped over using 3M VentureTape™ 1507 Reflective BOPP Tape. The 3M VentureTape™ 1507 Reflective BOPP Tape was specified by the client.

\* Information provided by the Client



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### III. PROCEDURE

The tunnel is preheated to a minimum of 150°F as measured by a thermocouple embedded 1/8 inch below the tunnel floor and 23-1/4 feet downstream of the centerline of the burner. The tunnel is then cooled to 105 ± 5°F as measured by a thermocouple embedded 1/8" below the tunnel floor and 13 feet downstream of the centerline of the burner.

After the tunnel has cooled to the required temperature range, the tunnel lid is lifted, and the test specimen is placed on the ledges of the tunnel. The specimen is mounted in a ceiling orientation with the side that will be exposed to the flame facing downward. A 1/4-inch fiber-cement board is placed on the backside of the specimens to protect the tunnel lid during testing.

Once the sample has been loaded into the test chamber, the lid is lowered, and a 240 ft/min airflow is established. The test specimen is preheated for approximately 2 minutes prior to applying the 88-kW burner. The burner is positioned at the front end of the tunnel. It has two ports that point upward toward the face of the specimen. After the 2-minute preheat, the burner is ignited, and it remains on for the duration of the 10-minute test. The flame is tracked by an observer, referred to as the Reader, as it progresses down the length of the tunnel. Smoke density is measured with the use of the photometer system on the exhaust duct. Temperature data is recorded throughout the test by a thermocouple probe that is 23 feet from the centerline of the burner and approximately 1 inch below the sample surface.

### IV. CALCULATION OF RESULTS

The results of ASTM E84 testing are reported as Flame Spread Index (FSI) and Smoke Developed Index (SDI).

The Flame Spread Index is derived by plotting the flame spread distance versus time. Only progressive flame spread is plotted. The total area ( $A_T$ ) under the flame spread distance-time plot is determined by ignoring any flame front recession. FSI values are rounded to the nearest multiple of 5. The calculation of FSI is described below:

$$\text{When } A_T \leq 97.5 \text{ ft}\cdot\text{min:} \quad \text{FSI} = 0.515 * A_T$$

$$\text{When } A_T > 97.5 \text{ ft}\cdot\text{min:} \quad \text{FSI} = 4900 / (195 - A_T)$$

The Smoke Developed Index is derived by plotting the photoelectric cell readings versus time. The area under the curve for the tested material is then divided by the area under the curve for heptane (the material used for smoke calibration). The resulting value is then multiplied by 100. SDI values that are less than 200 are rounded to the nearest multiple of 5. SDI values that are greater than 200 are rounded to the nearest multiple of 50.



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### V. TEST RESULTS

FLAME SPREAD INDEX (FSI)	SMOKE DEVELOPED INDEX (SDI)
<b>10</b>	<b>15</b>

Test Date	08/29/2023
Equipment Operator	Chris Kaiser
Flame Spread Reader	Chris Palumbo
Ignition Time (sec)	13
FSI (unrounded)	8.093
SDI (unrounded)	17.1
Maximum Temperature (°F)	482.9
Time to Maximum Temperature (min)	2.895
Maximum Flame Spread Distance (ft)	1.7
Time to Maximum Distance (min)	1.33

### VI. OBSERVATIONS

During Testing: Melting and dripping of the sample material onto the tunnel floor. Sample material melted ahead of the flame front.

After Testing: Melted material on the tunnel floor to 12'. Sample material melting and shrinking towards the mounting frame to 24'. The melted sample material on the tunnel floor and ledges continued to burn after the test was concluded and the burner port was extinguished.

- Yes    No   Flames were present after the test concluded and the burner was extinguished.
- Yes    No   Smoldering/glowing was present after the test concluded and the burner was extinguished.

### VII. REMARKS

Temperature readings from the exposed thermocouple were lower than expected. The material likely contacted the exposed thermocouple during the test and caused the lower-than-expected readings. Temperature readings from the exposed thermocouple do not impact the final results.

Note: Reported observation distances are relative to the entire length of the test specimen. Reported flame spread distances do not include the first 4-1/2 feet of material due to the length of the burner flame.



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## VIII. DATA SHEET AND GRAPHS

Test Method  Project #  Date  Time (Test Start)  Test No.

Specimen ID

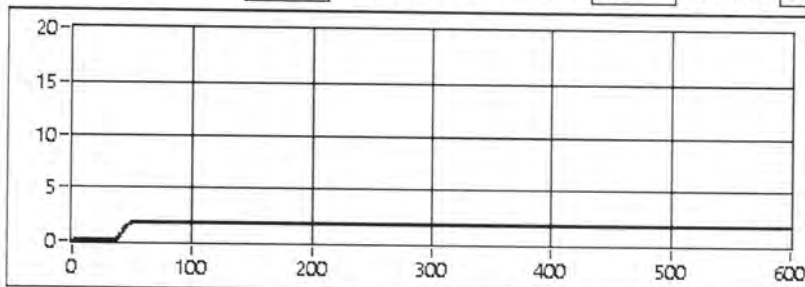
Specimen Description

Mounting Procedure

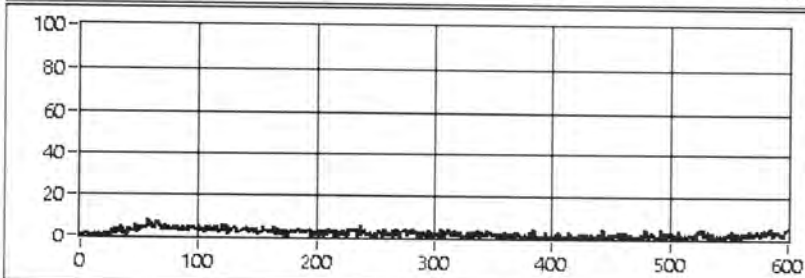
Fuel (CF)  Time to 980F (min)  Max Temp (F)  Time to Max Temp (min)

FS Area  Maximum FS  MAX FS Time (min)

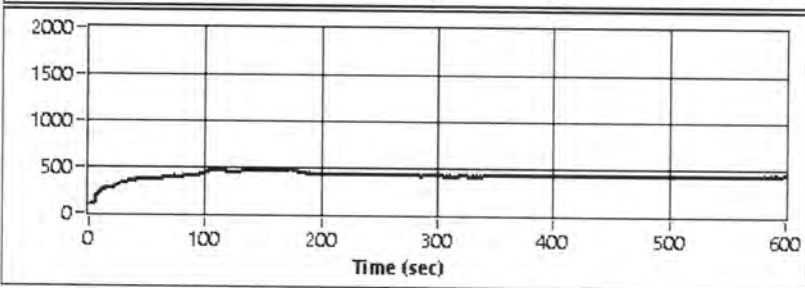
Smoke Area (%A min)  Calibration Smoke Area  Raw SD  Raw FSI



FI Spread



Smoke (%A)



23 ft Temp

Final FSI  Final SD

Test Room Temperature (°F): 72.6

Test Room Humidity (%RH): 46.7



## CAPITAL TESTING AND CERTIFICATION SERVICES

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### IX. DISCUSSION

#### ASTM E84 Standard Language and Disclaimers

The following language was taken directly from the ASTM E84 standard. It has been included for information purposes.

*The purpose of this test method is to determine the relative burning behavior of the material by observing the flame spread along the specimen. Flame spread and smoke developed index are reported. However, there is not necessarily a relationship between these two measurements.* – ASTM E84-22, Section 1.3

*The use of supporting materials on the underside of the test specimen has the ability to lower the flame spread index from those which might be obtained if the specimen could be tested without such support. These test results do not necessarily relate to indices obtained by testing materials without such support.* – ASTM E84-22, Section 1.4

*Testing of materials that melt, drip, or delaminate to such a degree that the continuity of the flame front is destroyed, results in low flame spread indices that do not relate directly to indices obtained by testing materials that remain in place.* – ASTM E84-22, Section 1.5

*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.* – ASTM E84-22, Section 1.8

*This test method does not provide for the following: Measurement of heat transmission through the tested surface; the effect of aggravated flame spread behavior of an assembly resulting from the proximity of combustible walls and ceilings; or classifying or defining a material as noncombustible, by means of a flame spread index by itself.* – ASTM E84-22, Section 4.3

#### Classification

ASTM E84 results are frequently used by code officials and regulatory agencies to determine whether a product is suitable for its intended application. The test standard itself does not establish specific performance criteria or contain a classification system. The most commonly used classification system can be found in the International Code Council publication International Building Code (IBC), the National Fire Protection Association publication NFPA 101 (Life Safety Code), and the National Fire Protection Association publication NFPA 5000 (Building Construction and Safety Code).

Class	Flame Spread Index (FSI)	Smoke Developed Index (SDI)
A	0 - 25	0 - 450
B	26 - 75	0 - 450
C	76 - 200	0 - 450

Class A, B and C correspond to Type I, II, and II respectively in other codes such as SBCCI, BOCA and ICBO. The classifications above do not preclude a material being otherwise classified by the authority having jurisdiction (AHJ).



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### X. AUTHORIZED SIGNATURES

Report Written By:

Chris Kaiser  
Lab Technician II

08/31/2023

Date

Reviewed and Approved By:

Chris Palumbo  
Sr. Manager of Product Testing

09/05/2023

Date

### XI. REVISION HISTORY

Revision Number	Date	Summary
0	09/05/2023	Original Report Issued

### XII. ACCREDITATION

Capital Testing and Certification Services is an ISO/IEC 17025 accredited testing laboratory whose scope includes ASTM E84. Accrediting Body: International Accreditation Service, Inc. (IAS). Testing Laboratory TL-224.