Element Materials Technology
2475 Speers Road,
Oakville, ON
Canada, L6L 2X9

P: 1 905 822 4111
info.toronto.industrials@element.com
element.com

EVALUATION OF "ALUMINIUM FLUTED PANELS" IN ACCORDANCE WITH VARIOUS ASTM METHODS FOR NORTEM

A Report to:	**Nortem** 133 Romina Drive Concord, L4K 4Z9 ON, Canada
Attention:	**Sam Karafarin**.
Phone: E-mail:	(888).308.8898 sam@nortem.ca
Proposal No.:	23-006-502522 RV3
Report No.:	24-06-P0055 4 pages
Date:	July 30, 2024

1.0 INTRODUCTION

At the request of Nortem, Element was retained to evaluate a aluminium fluted panel for physical properties in accordance with the ASTM methods identified in this report.

Upon receipt, the material was assigned the following Element sample number:

Client Sample Identification	Element Sample No.
Aluminum Fluted Panel	24-06-P0055

2.0 PROCEDURE

Testing was conducted in accordance with the following test methods:

Test Method	Description
ASTM E136 – 22, Option A	Standard Test Method for Assessing Combustibility of Materials Using Vertical Tube Furnace at 750°C
ASTM B117-19	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D2244-23	Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
ASTM C518-21	Standard Test Method for Steady State Thermal Transmission Properties by means of Heat Flow Meter
E84-23D	Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E1980-11(2019)	Practice For Calculating Solar Reflectance Index of Horizontal and Low -Sloped Opaque Surfaces
ASTM E408-13(2019) Method A	Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques
ASTM E903-20	Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres

The ASTM E1980, ASTM E408 and ASTM E903 tests were subcontracted to the University of Waterloo, Ontario, Canada, Solar Thermal Research Laboratory.

3.0 RESULTS

A summary of the test results is presented in the table below.

Test	Average Results/ Observations	
ASTM C518-21	Mean Temp Thermal Conductivity	24.1 °C 0.48 W/mK (R/inch = 0.3)
ASTM E1980-11 (2019)	Solar reflectance Solar absorbance Long wave reflectance Emissivity	0.052 0.948 0.17 0.83
ASTM B117-19	Visual Observations: Front Panel: significant discoloration and a few white corrosion spots on one of 3 panels tested. Back Panel: Significant discoloration	
ASTM D2224-23	Color Change after 250hour salt spray: Average ΔE* Front panel.....13.22 Average ΔE* Back panel.....8.52	
ASTM E84-23D	No flame spread	
ASTM E136	Product met the requirements for non-combustible materials	

4.0 CONCLUSION

The aluminum fluted panels submitted by Nortem were evaluated for physical properties as detailed in this report. The results are summarized in Section 3 of this report. Detailed results are provided in the Appendix to this report.

Revision No:	**Date:**	**Description of Revisions:**
Original	July 30, 2024	Original Document

Reported by:

Joy Obande
P. +1 (289)- 633-7044
Building Products Evaluation Technician
Building Science

Reviewed by:

Joe DeRose, P. Eng.
P. +1 (289)- 326-6128
Technical Manager
Building Science

APPENDIX

Detailed Results

Appendix A1: Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750 °C (ASTM E136-22)

Project: 24-06-P0055
Client: Nortem

Standard Test Methods for Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750 °C

Operator: Rubaiyat Khondker
Date: 26/06/2024
Method : ASTM E136-22
Air Velocity 25(mm/sec)

Test Equipment:
Furnace MI# B16215
Balance MI# A07338

Sample Details
Description: Aluminum Fluted Panel

Sample Identification	Specimen No.	Test Temperature °C	Flamming Occurred after 30 sec.	Flamming Occurred Before 30 sec.	Mass Loss %	T3 Center of Specimen °C	T4 Surface of Specimen °C
24-06-P0055	1	748.0	No	No	2.10	755.9	753.6
	2	43.3	Yes	Yes	0.00	38.7	30.0
	3	43.6	Yes	Yes	0.00	39.2	30.0
	4	43.7	Yes	Yes	0.00	39.4	30.1

Aluminium fluted panel met requirement for non-combustible material.

Appendix A2: Standard Practice for Operating Salt Spray (Fog) Apparatus (B117-19)

Element Lab Ref.: G408031-Issue 1
Date: May 14, 2024

Item 001: Salt Spray Test per ASTM B117-2019, 250 hours

Figure 1: Photographs illustrating the Specimens after 250 hours of exposure. Observations are presented in Table 1.

Element Lab Ref.: G408031-Issue 1
Date: May 14, 2024

Table 1: Salt Spray Test Results, 250 hours

Sample I.D.	Observations	Pass/Fail
Front-#1	Significant discoloration was evident.	N/A
Front-#2	Significant discoloration was evident.	N/A
Front-#3	Evidence of a few white corrosion spots with significant discoloration.	N/A
Back-#1	Significant discoloration was evident.	N/A
Back-#2	Significant discoloration was evident.	N/A
Back-#3	Significant discoloration was evident.	N/A

Requirements: **N/A.**

Appendix A3: Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates (D2244-23)

Project: 24-06-P0055
Client: Nortem

Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates

Operator: Joy Obande
Date: 21/05/2024
Method : ASTM D2244-16
Test Condition: 23 ± 2°C and 50 ± 5% RH

Test Equipment:
Conditioning Room: MII # B13334

DATE:	21/05/2024
Project No.:	24-06-P0055
Proposal No.:	23-006-510947
Client:	Nortem
Contact:	Sam Karafarin
Specimen Description:	Aluminium Fluted Panels
Test Description:	Spectrophotometric Colour Measurments Delta E Summary
No. of Samples.:	6
No. of Specimens / Sample:	6
Test Method(s):	ASTM D2244-16 Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
Equipment:	Gretag Macbeth ColourEye XTH Spectrophotometer, MII: A13519, Cal. Date: 2021-02-18, Cal. Due Date: 2021-08-18
	Reverification: 2021-08-18, Cal. Due Date: 2024-05-21
Display:	COLORMETRIC
Colour Equation:	CIELAB
Illuminate:	D65
Observer Angle:	10°
Area View:	Regular
Specular:	Included

Client Identification	Element ID	Interval (hours)	Measured Colour			Colour Change from Initial			
			L*	a*	b*	ΔL*	Δa*	Δb*	***ΔE****
Front-1		0	25.18	0.02	0.19				
		250	13.37	-0.20	-0.22	-11.81	-0.23	-0.40	***11.82***
Front -2		0	25.42	-0.03	0.18				
		250	11.32	0.63	-0.99	-14.10	0.66	-1.18	***14.16***
Front-3		0	24.91	-0.01	0.30				
		250	11.82	3.99	0.44	-13.10	4.00	0.14	***13.69***
Back-1		0	25.06	0.06	0.30				
		250	15.39	-0.65	-2.31	-9.67	-0.71	-2.60	***10.04***
Back-2		0	24.66	-0.02	0.17				
		250	17.97	-0.80	-3.67	-6.69	-0.78	-3.84	***7.75***
Back-3		0	25.08	0.00	0.19				
		250	17.31	0.36	-0.14	-7.76	0.36	-0.33	***7.78***

Appendix A4: Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus (C518-21)

Thermal Transmission Properties of Aluminum Fluted Panels

Applicable standard: ASTM C518 – 21

Element Sample No.: 24-06-P0055

Description	Results			
	Value	SI Units	Value	Imperial Units
Measured Length	609.00	mm	24.00	in
Measured Width	609.00	mm	24.00	in
Test Thickness	97.03	mm	3.820	in
Measured Mass	12681	g	27.96	lb.
Density	351.69	kg/m^3	21.96	$lb./ft^3$
Upper Surface Temperature	13.01	°C	55.42	°F
Lower Surface Temperature	35.00	°C	95.00	°F
Temperature Differential	21.99	°C	39.58	°F
Mean Temperature	24.01	°C	75.21	°F
Rate of Heat Flux	109.67	W/m^2	34.76	$BTU/h \cdot ft^2$
Thermal Conductance	4.99	$W/m^2 \cdot K$	0.88	$BTU/h \cdot ft^2 \cdot °F$
Thermal Resistance	0.20	$K \cdot m^2/W$	1.14	$°F \cdot ft^2 \cdot h/BTU$
Thermal Conductivity	0.4839	W/m·K	3.3549	$BTU \cdot in/h \cdot ft^2 \cdot °F$
Thermal Resistivity	2.07	K·m/W	0.298	$°F \cdot ft^2 \cdot h/BTU \cdot in$

Appendix A5: STANDARD TEST METHOD FOR BURNING CHARACTERISTICS OF BUILDING MATERIALS (ASTM E84-23

Element Materials Technology
2475 Speers Road
Oakville, ON
Canada, L6L 2X9

P: 1 905 822 4111
info.toronto.fire@element.com
element.com

ASTM E84 Surface Burning Characteristics of "Aluminum Fluted Panels"

A Report To:	**Nortem** 178 Pennsylvania Ave. Woodbridge, ON, Canada L4K 4B1
Phone:	+1 888-308-8898
Attention: E-mail:	Sam Karafarin sam@nortem.ca
Submitted by:	Element Fire Testing
Report No.	24-002-172 4 Pages
Date:	July 22, 2024

1.0 ACCREDITATION

ISO/IEC 17025 for a defined Scope of Testing by the American Association for Laboratory Accreditation (A2LA), Certificate Number: 6524.03.

2.0 SPECIFICATIONS OF ORDER

Determine the Flame Spread and Smoke Developed Indices based upon a single test conducted in accordance with ASTM E84-23d, as per Element Products Project No. 24-06-P0055, Element Work Order No. 006-10005, and Element Proposal No. 24-006-502522.

2.1 History of Revision

This is the original.

3.0 SAMPLE INFORMATION

Material Identification	**"Aluminum Fluted Panels"**
Supplied Material Description	Coated Aluminum Bar
Material Thickness	1.25 inch (32 mm)
Date of Material Receipt	2024-05-21
Element Sample Identification No.	24-06-P0055
Test Date	2024-07-17

4.0 TEST PROCEDURE

The method, designated as ASTM E84-23d "*Standard Method of Test for Surface Burning Characteristics of Building Materials*", is designed to determine the relative surface burning characteristics of materials under specific test conditions, where the material under test is mounted so that it forms the ceiling of a horizontal fire tunnel. A specified airflow is introduced through the tunnel and a specified flame is applied to one end. Observations are then made regarding the rate of flame spread along the specimen. Results are expressed in terms of Flame Spread Index (FSI) and Smoke Developed Index (SDI). There is no established relationship between those two values.
Although the procedure is applicable to materials, products and assemblies used in building construction for development of comparative surface spread of flame data, the test results may not reflect the relative surface burning characteristics of tested materials under all building fire conditions.

5.0 SAMPLE PREPARATION

The test specimen consisted of a total of nine sections of material, each approximately 96 inches (2438 mm) in length. Six sections were each approximately 9 inches (229 mm) in length and three sections were approximately 3.75 inches (95 mm) in width. The sections were butted together side-by-side and end-to-end to create the total specimen area. Prior to testing, the specimen was conditioned to constant weight at a temperature of 73 ± 5°F (23 ± 3°C) and a relative humidity of 50 ± 5%. During testing, the specimen was supported across the width by 0.25 inch (6 mm) steel rods spaced nominally at 24 inch (610 mm) intervals.

6.0 SUMMARY OF TEST PROCEDURE

The tunnel is preheated to 150 ± 5°F (66 ± 2.8°C), as measured by the floor-embedded thermocouple located 23.25 feet (7087 mm) downstream of the burner ports, and is allowed to cool to 105 ± 5°F (40.5 ± 2.8°C), as measured by the floor-embedded thermocouple located 13 feet (3962 mm) from the burners. The tunnel lid is then raised and the test specimen is placed along the ledges of the tunnel so as to form a continuous ceiling 24 feet (7315 mm) long,

approximately 12 inches (305 mm) above the floor. Three 96 inch (2438 mm) sections of 0.25 inch (6 mm) cement board are then placed on the back side of the specimen and the lid is then lowered into place. Upon ignition of the gas burners, the flame spread distance is observed and recorded every second. Flame spread distance versus time is plotted. Calculations ignore all flame front recessions and Flame Spread Index (FSI) is determined by calculating the total area under the curve for the test sample. If the area under the curve (A) is less than or equal to 97.5 min·ft, then FSI = 0.515·A; if greater, FSI = 4900/(195-A). FSI is then rounded to the nearest multiple of 5.
Smoke Developed Index (SDI) is determined by dividing the total area under the obscuration curve by that established for liquid heptane, and multiplying by 100. SDI is then rounded to the nearest multiple of 5 if less than 200. SDI values over 200 are rounded to the nearest multiple of 50.

7.0 TEST RESULTS

SAMPLE: "Aluminum Fluted Panels"

Approx. Time to Ignition (s)	Maximum Flame Front Distance	Time to Maximum Flame Front (s)	Maximum Temperature (° F)	Flame Spread Index (FSI)	Smoke Developed Index (SDI)
-	(ft.): 0.0 (m): 0.00	0	530	**0**	**10**

7.1 Observations of Burning Characteristics

The material did not ignite. Discoloration was observed in the area of direct test burner flame impingement. observed. Material that fell to the floor of the apparatus also ignited (at approximately 428 seconds).

8.0 INTERPRETATION OF RESULTS

Industry documents such as the International Building Code (IBC), NFPA 101 Life Safety Code, etc. refer to ASTM E84 (UL 723, NFPA 255) test results using the following material classification categories:

	Flame-Spread Index (FSI)	Smoke Developed Index (SDI)
Class 1 or Class A	0 - 25	450 Maximum
Class 2 or Class B	26 - 75	450 Maximum
Class 3 or Class C	76 - 200	450 Maximum
Tested Material Results Classification (if applicable):		**Class 1 or Class A**

Francis Williams,
Technician.

Ian Smith,
Technical Manager.

Notes: This report is related only to the sample identified and shall not be reproduced, except in full, without approval. It is covered under Element Materials Technology Canada Inc. Standard Terms and Conditions of Contract, which are accessible at www.element.com, or by calling 1-866-263-9268. ASTM E84 is a well-established test method that reports data in the form of indices. As such, MU cannot be calculated. In the reporting instructions, calculated values are rounded to the nearest multiple of 5 for FSI, and 5 or 50 for SDI, depending on the result. Since the rounding ranges establish precision and include potential uncertainty, by following the reporting instructions, the lab is considered to have satisfied the MU reporting requirements of ISO/IEC 17025.

9.0 TEST CHARTS

ASTM E84-23d

Sample: "Aluminum Fluted Panels"

Chart 1. FLAME SPREAD

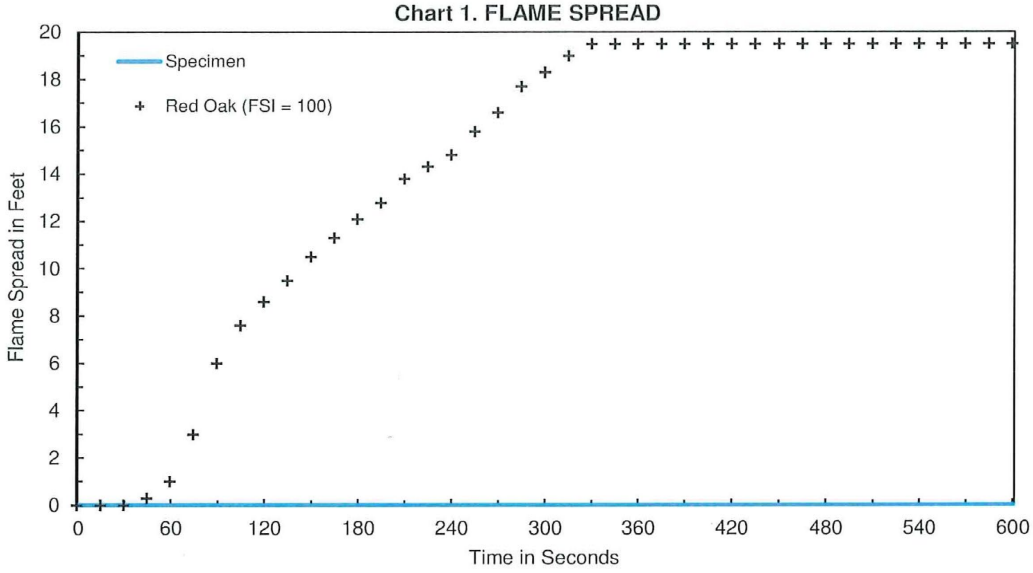
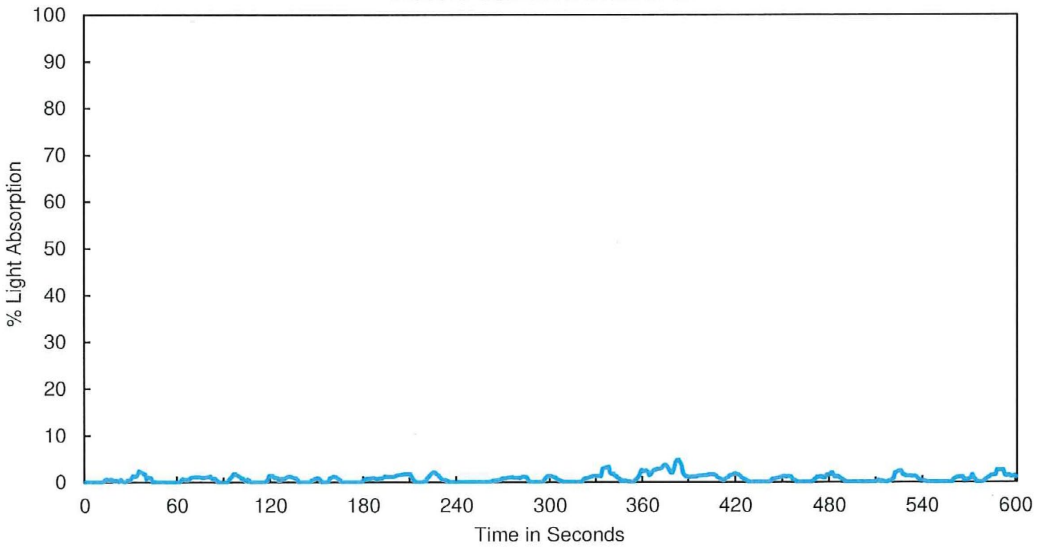


Chart 2. SMOKE DEVELOPED



Calculated Flame Spread (CFS)	Rounded Flame Spread Index (**FSI**)	Calculated Smoke Developed (CSD)	Rounded Smoke Developed Index (**SDI**)	Maximum 23' Air Temperature (°F)
0.0	**0**	8.3	**10**	530

Appendix A6: E1980-11 (2019) PRACTICE FOR CALCULATING SOLAR REFLECTANCE INDEX OF HORIZONTAL AND LOW SLOPED OPAQUE SURFACES

University of Waterloo

Solar Thermal Research Laboratory

Department of Mechanical Engineering
University of Waterloo
Waterloo, ON, Canada, N2L 3G1

1.0 Procedure and Methodology

1.1 Equipment

Solar and Photometric measurements were made using a Varian Cary 5000 UV/VIS/NIR Spectrophotometer. The UV/VIS/NIR Spectrophotometer is a double beam, direct ratio recording, rapid scanning high performance spectrophotometer with exceptional scan rate, resolution, and repeatability characteristics. This device has an extended spectral range allowing it to scan between 0.17 and 3.30 micrometers. For the present analysis, an integrating sphere attachment was used. The attachment allowed for the measurement of the total, diffuse-only, and specular-only directional-hemispherical reflection[1] between 250 and 2500 nm at a resolution of 0.05 nm. All measurements are spectral (as a function of wavelength).

The equipment is calibrated before each use.

Longwave (A) measurements were made using a Surface Optics Corporation (SOC) 400T Infrared Reflectometer. The SOC 400T is a Fourier Transform Infrared Reflectometer (FTIR) for accurately determining the total emittance of samples. The measurement is a spectral measurement (from 2 to 25 μm). The main advantage of the measurement method employed is that the measurement is independent of sample temperature. The sample temperature need not be measured or controlled, and can be varying during measurement. Insulating materials and thin films can be measured with as much precision as highly conductive materials.

The equipment is calibrated before each use.

[1] For an incoming ray at near normal incidence to the sample, all of the reflected/transmitted rays are included in the measurement.

University of Waterloo
Solar Thermal Research Laboratory
Department of Mechanical Engineering
University of Waterloo
Waterloo, ON, Canada, N2L 3G1

1.2 Samples

Three samples of what appeared to be a coated aluminum extrusion were examined. The samples were unlabeled and otherwise not distinguishable from one another. For the purpose of this work, they are referred to as samples A, B, and C. All three were tested on April 26th, 2024. Shortwave and longwave properties were measured on each of the samples.

1.3 Procedure

Solar and Photometric tests and data analysis were performed in accordance with ASTM Standard E903-12 *Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres*. The reader is referred to that standard for complete details on the theory and methods used to perform the analysis.

Zero/Baseline correction was performed using a calibration standard[2] as per Section 8.2.1 of ASTM E903-12. Zero/Baseline measurements were performed on start-up and after 4 hours of operation. The correction was applied by the Cary 5000 Operating Software.

Calculation of the solar reflectivity was done using a 50-point selected ordinate method as specified in Sections 8.3.1 and 8.3.4 of ASTM E903-12. By that method, the solar irradiance distribution for a 1.5 air mass spectrum is divided into 50 sections containing 1/50th of the total energy in the spectrum. The solar reflectivity/transmissivity is the average of spectral reflectivity/transmissivity taken at the centroids of those 50 sections. ASTM G159 *Standard Tables for Reference Solar Spectral Irradiances: Direct Normal and Hemispherical on 37° Tilted Surface* was used to determine the wavelengths.

Measurements of total reflectivity were performed. All measurements and data analysis were performed at the University of Waterloo by Prof. Mike Collins.

Longwave tests were performed in accordance with Method A of ASTM E408-13 *Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques*. The reader is referred to that standard for complete details on the theory and methods used to perform the analysis.

The SOC 400T reflectometer measures reflectance for room temperature thermal radiation. The reflectivity of a sample is calculated by comparing it to a polished gold film with a constant (spectral) reflectivity of 98%.

For opaque samples, the NIR absorptance (equal to the emittance) is calculated by subtracting the infrared reflectance from 100%.

Measurements of emissivity were performed. All measurements and data analysis were performed at the University of Waterloo by Prof. Mike Collins.

[2] Labsphere SRS-99-010; Serial No: OD11C-5349; NIST Traceable to SRS-99-020-WS-3, Nov 14, 2008.

University of Waterloo

Solar Thermal Research Laboratory

Department of Mechanical Engineering
University of Waterloo
Waterloo, ON, Canada, N2L 3G1

1.4 Precision

The precision of the Spectrophotometer measurements are good to +/- 0.1%. It is noted, however, that this error changes depending on the sensor and light source being used. Shortwave measurements for example, taken using a Silicon sensor below 800 nm, are far more precise than the long wave measurements taken using a photomultiplier.

ASTM E903 notes that there are errors associated with the measurements, computation method, and spectral irradiation distribution. As these errors are difficult to quantify, the standard suggests that +/- 2% error be assigned to the solar transmission and reflection. To account for differences in the solar spectrum, an error of +/- 3% is suggested. A complete discussion of those errors is given in ASTM E903-12.

The SOC 400T measurements are accurate to +/-1%.

University of Waterloo

Solar Thermal Research Laboratory

Department of Mechanical Engineering
University of Waterloo
Waterloo, ON, Canada, N2L 3G1

2.0 Results

The test results are summarized in the table.

Sample Name	Solar Reflectance	Solar Absorptance	Longwave Reflectance	Emissivity
A	0.052	0.948	0.16	0.84
B	0.052	0.948	0.17	0.83
C	0.051	0.949	0.17	0.83

The results strongly suggest that there is no difference between the samples measured.

Complete wavelength/property files for each measurement have been mailed the Element.

3.0 Comments

- NA

University of Waterloo

Solar Thermal Research Laboratory

Department of Mechanical Engineering
University of Waterloo
Waterloo, ON, Canada, N2L 3G1

4.0 References

ASTM E903-12 *Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres.*

ASTM G173 *Standard Tables for Reference Solar Spectral Irradiances: Direct Normal and Hemispherical on 37° Tilted Surface.*

ASTM E408-13 *Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques.*

ASTM E1980-11 *Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces.*

Siegel and Howell *Thermal Radiation Heat Transfer, 4th Ed*, Taylor & Francis, 2002.

U.S. Green Building Council (2012). Heat Island Reduction: SS7. Retrieved April 6, 2015, from http://www.usgbc.org/credits/ss7