



CENTER FOR ADVANCED MINERAL AND MATERIAL PROCESSING

Montana Tech of The University of Montana

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0.24" Flat Carbon Composite Plate

Testing Results

April 2016

PREPARED FOR:

**Rockwest Composites
3392 West 8600 South Unit A
West Jordan, UT 84088**

PREPARED BY:
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The Center for Advanced Minerals, Materials and Metallurgical Processing (CAMP) was contracted by Rockwest Composites to characterize an innovative Carbon/Epoxy composite material. All testing was performed within the CAMP Materials Testing Lab, located on the Montana Tech campus in Butte, Montana. Two panels fabricated from a balanced weave carbon fabric were sent for testing. It can be assumed that material properties in the 0° and 90° directions are equal, but tests were only performed on 0° oriented specimens. The data tables reflect which panel (#1 or #2) the samples were cut from. The specimens were also cut at two orientations (0° and 45°) for some tests which are noted in the results. The test matrix used for this program is shown in Table 1.

Table 1
Test Matrix

Test Type	ASTM	Specimen Orientation
Tensile	D3039	0° and 45°
Compression	D6641	0° and 45°
Bearing Stress	D5961	0°
Fastener Pull Thru	D7332, Proc A	0°
Coefficient of Thermal Expansion	D696	0° and 45°
Density	D792	0°

PROCEDURES

Tensile testing

The tensile tests were performed according to ASTM D3039. Specimens were cut to nominally 1.0 inch wide and 9.0 inches long. The samples were tabbed with G-10 fiberglass material. The tab ends were tapered 25° and cut to a final length of 2". Strain gages were applied mid-plane to record strain during the test. Micro-measurements axial gages CEA-06-250UW-350 were applied to each specimen. The modulus of each specimen was determined over the strain range of 1000-3000µε. All testing was performed on an MTS universal hydraulic test frame with a maximum load capacity of 55,000 pounds. Tests were run at 0.1in/min and data was collected at 50Hz for the 0° samples and 10Hz for the 45° samples due to their prolonged test times.

Data tables can be observed in the Results section. Plots with individual curves can be viewed in Appendix A.

Compression Testing

The compression tests were performed according to ASTM D6641. Specimens were cut to nominally 0.375" wide for the 0° specimens and 0.500" wide for the 45° specimens. All specimens were end ground to a final length of 5.5". Strain gages were applied mid-specimen to record strain during the tests. Micro-measurement axial gages EA-06-125EP-350. The modulus of each specimen was determined over the strain range of 1000-3000 $\mu\epsilon$. All testing was performed on an MTS universal hydraulic test frame with a maximum load capacity of 55,000 pounds. Tests were run at 0.05in/min and data was collected at 50Hz for the 0° samples and 10Hz for the 45° samples due to their prolonged test times.

Bearing Stress

The Bearing Stress tests were performed according to ASTM D5961. Specimens were cut to nominally 1.500" wide and 5.5" long. Per the ASTM the hardened pin was 0.250" 17-4 stainless steel and the hole was 0.250" diameter. Tests were run at 0.1in/min and data was collected at 10Hz.

Fastener Pull-Thru

The Fastener Pull-Thru tests were performed per ASTM D7332. Specimens were cut nominally 4.25" x 4.25" square with a 0.250" diameter hole in the center of the specimens. The holes had a countersink at 82° that allowed the fasteners to sit flush. The fasteners were Stainless Steel flat-head socket cap screws, 1/4"-20. The fasteners were tightened to 20 in-lb pre-test washers were used between the nut and plate and the nuts were 1/4"-20. All testing was performed on an MTS universal hydraulic test frame with a maximum load capacity of 55,000 pounds. Tests were run at 0.025in/min and data was collected at 5Hz. Data tables can be observed in the Results section.

Coefficient of Thermal Expansion

Coefficient of Thermal Expansion was determined per ASTM D696 on samples cut in both orientations; 0 and 45°. The tests were run on a Netzsch DIL over the temperature range of -18°C to 47°C.

Density

Density was performed per ASTM D792 by wet weight method. The data can be viewed in the Results section.

RESULTS-Tables

Tensile Test Results
D3039
Rockwest 0/90 Carbon Weave Panels

Specimen ID	Width (in)	Thickness (in)	Stress (ksi)	Modulus (Msi)
0°				
T0-1 (Panel 1)	0.989	0.235	140.3	9.4
T0-2 (Panel 1)	0.989	0.235	138.7	9.4
T0-3 (Panel 2)	0.991	0.225	143.0	9.5
T0-4 (Panel 2)	0.988	0.224	139.0	9.7
T0-5 (Panel 2)	0.993	0.226	141.2	9.4
Average	0.99	0.229	140	9.5
SD	0.002	0.006	1.8	0.1
CV(%)	0.20	2	1.2	1.4
45°				
T45-1 (Panel 1)	0.991	0.233	20.6	2.5
T45-2 (Panel 1)	0.989	0.232	19.9	2.0
T45-3 (Panel 1)	0.987	0.232	19.9	2.0
T45-4 (Panel 2)	0.990	0.229	20.1	2.0
T45-5 (Panel 2)	0.987	0.229	20.3	2.1
Average	0.989	0.231	20.2	2.1
SD	0.002	0.002	0.3	0.2
CV(%)	0.2	0.8	2	10

Compression Test Results
D6641
Rockwest 0/90 Carbon Weave Panels

Specimen ID	Width (in)	Thickness (in)	Stress (ksi)	Modulus (Msi)
0°				
C0-1 (Panel 1)	0.370	0.230	55.1	8.1
C0-2 (Panel 2)	0.369	0.229	52.3	8.1
C0-3 (Panel 1)	0.368	0.239	57.1	8.8
C0-4 (Panel 2)	0.368	0.230	51.2	8.5
C0-5 (Panel 1)	0.366	0.234	59.4	8.9
Average	0.368	0.232	55.0	8.5
SD	0.001	0.004	3.4	0.4
CV(%)	0.4	2	6	4
45°				
C45-1 (Panel 1)	0.498	0.233	18.8	2.0
C45-2 (Panel 2)	0.496	0.228	18.2	2.1
C45-3 (Panel 2)	0.497	0.231	17.2	2.0
C45-4 (Panel 1)	0.506	0.232	18.9	2.0
C45-5 (Panel 1)	0.500	0.235	18.9	2.0
Average	0.499	0.232	18.4	2.0
SD	0.004	0.003	0.7	0.04
CV(%)	0.8	1	4	2

Fastener Pull-Thru
ASTM D7332

Nominal Panel Thickness = 0.232”
Nominal Countersink Depth = 0.139”

Specimen ID Panel No. (Top/Bottom)	Failure Load (lb)	Max Load (lb)	Ca/D*	D/h	dcsk/h
1/1	2333	3214	10.80	1.09	0.668
1/2	2394	2716	10.90	1.09	0.665
2/1	2257	2917	10.69	1.10	0.668
2/1	2260	2482	10.69	1.12	0.680
2/2	2205	2517	10.82	1.12	0.686
Average	2290	2769	10.78	1.104	0.673
SD	73.96	303.57	0.090	0.015	0.009
CV	3	11	1	1	1

*Nominal hole diameter (D) of 0.250”

Bearing Stress
ASTM D5961
Rockwest Carbon/Epoxy Panels
Nominal Panel Thickness = 0.233”

Sample	Panel	Panel Thickness (in)	Initial Peak Bearing Stress (ksi)	Ultimate Bearing Stress (ksi)
B-1	2	0.230	57.4	70.9
B-2	2	0.228	59.8	n/a
B-3	1	0.235	56.8	64.9
B-4	1	0.238	61.4	65.8
B-5	2	0.231	55.6	66.3
B-6	1	0.235	56.6	68.4
Average		0.233	57.9	67.3
SD		0.004	2.0	2.2
CV(%)		2	3	3

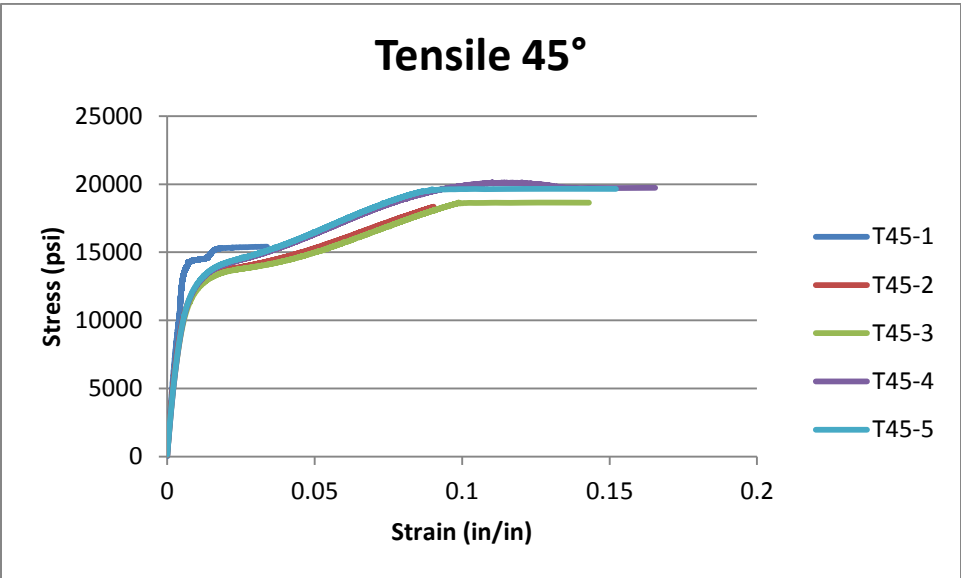
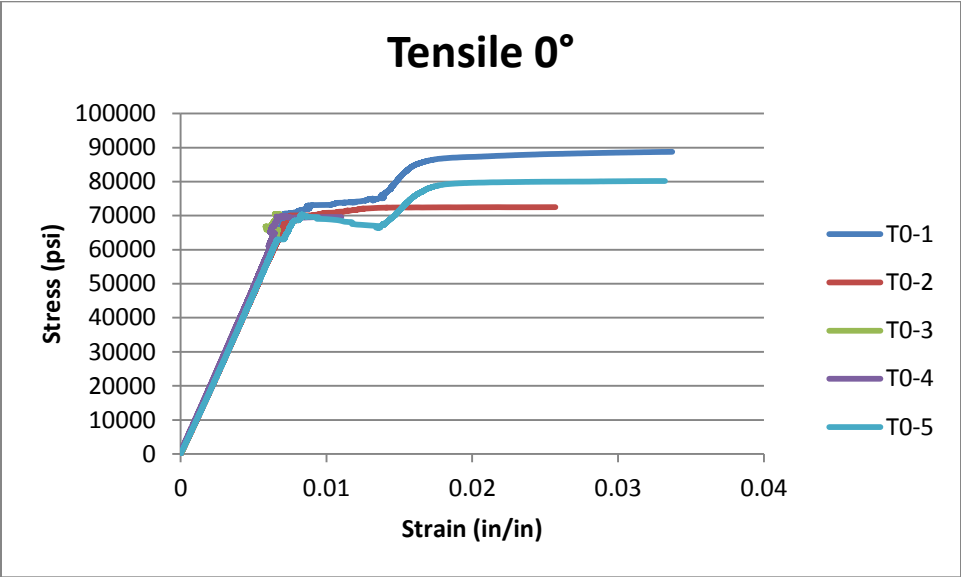
CTE by Dilatometer
ASTM D696
Rockwest Carbon/Epoxy Panels

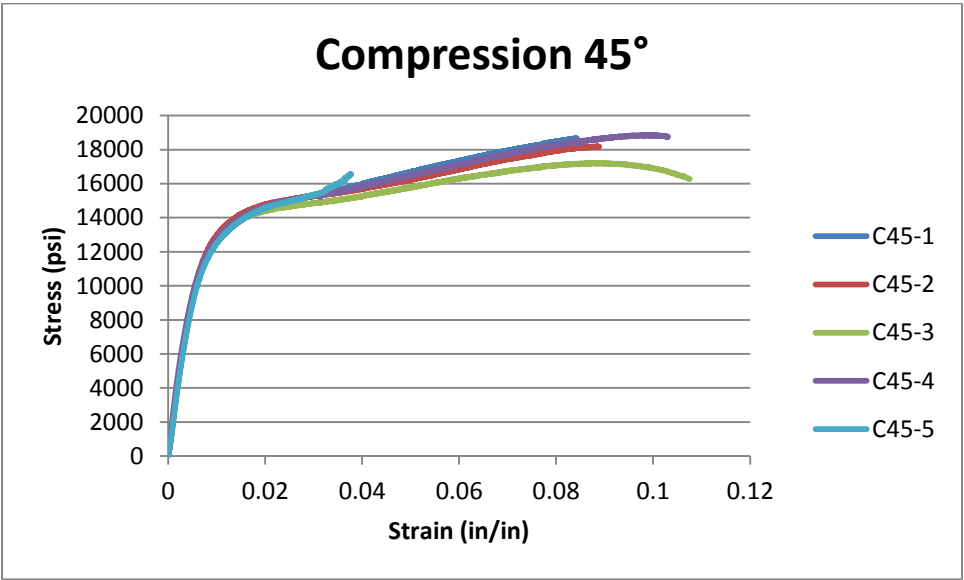
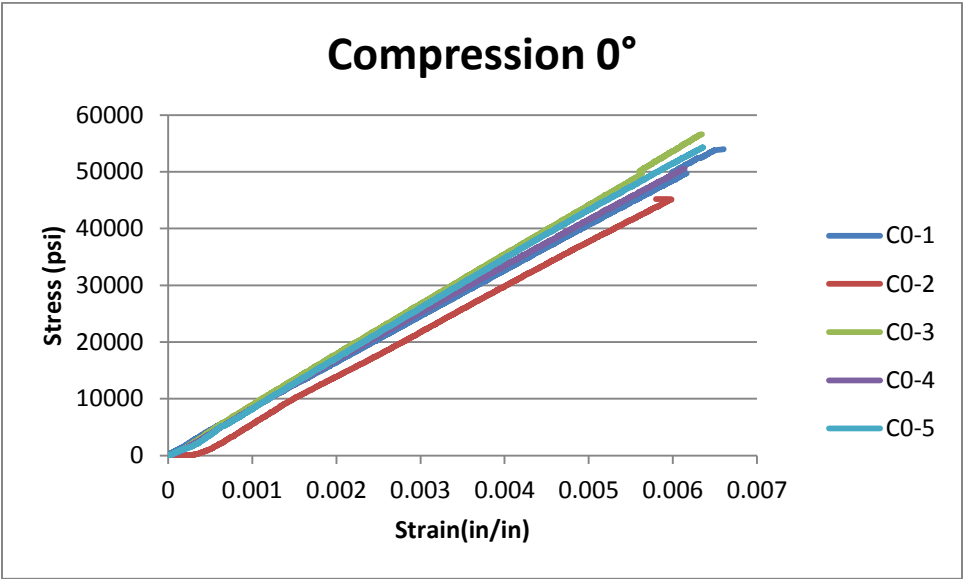
Specimen ID	Panel ID	CTE (-18 to 47°C)
0-A	1	4.08×10^{-6}
0-B	2	4.93×10^{-6}
45-C	1	7.55×10^{-6}
45-D	2	4.04×10^{-6}

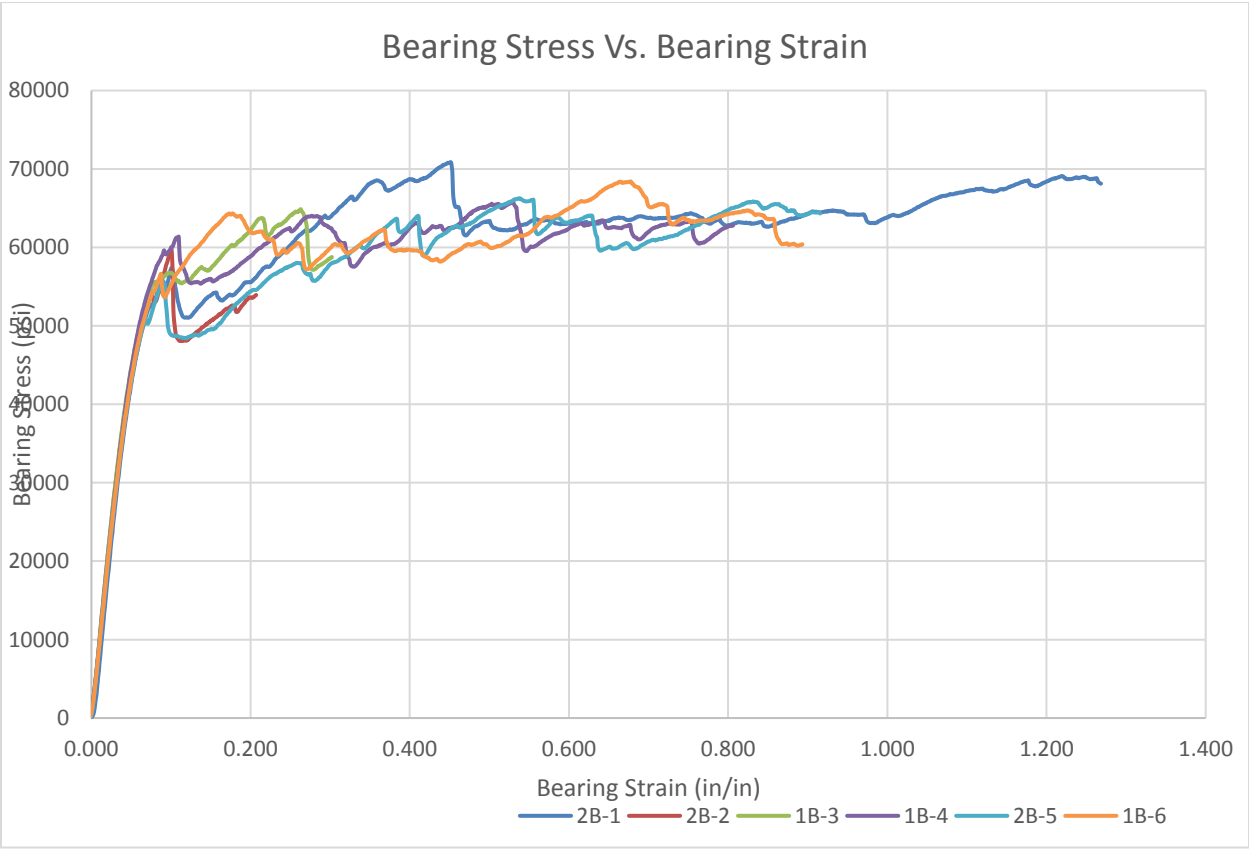
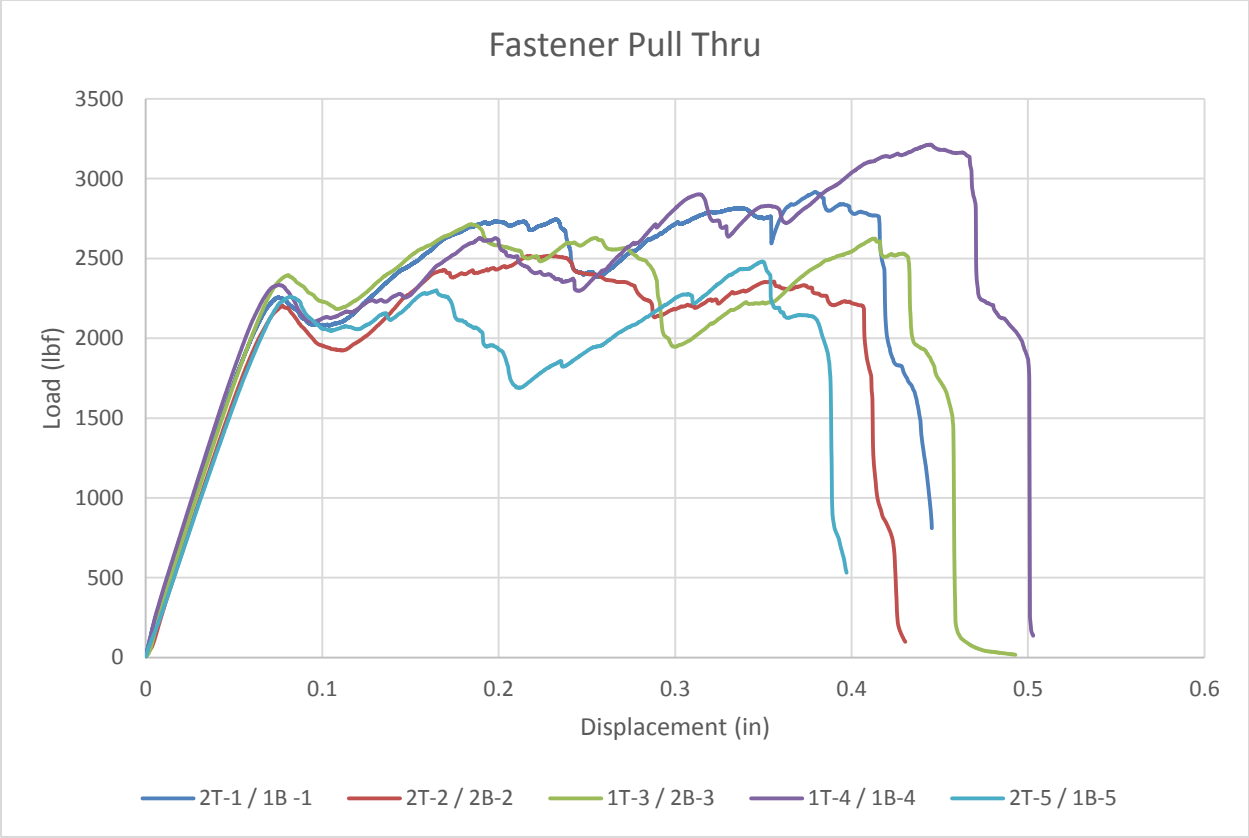
Density
D792

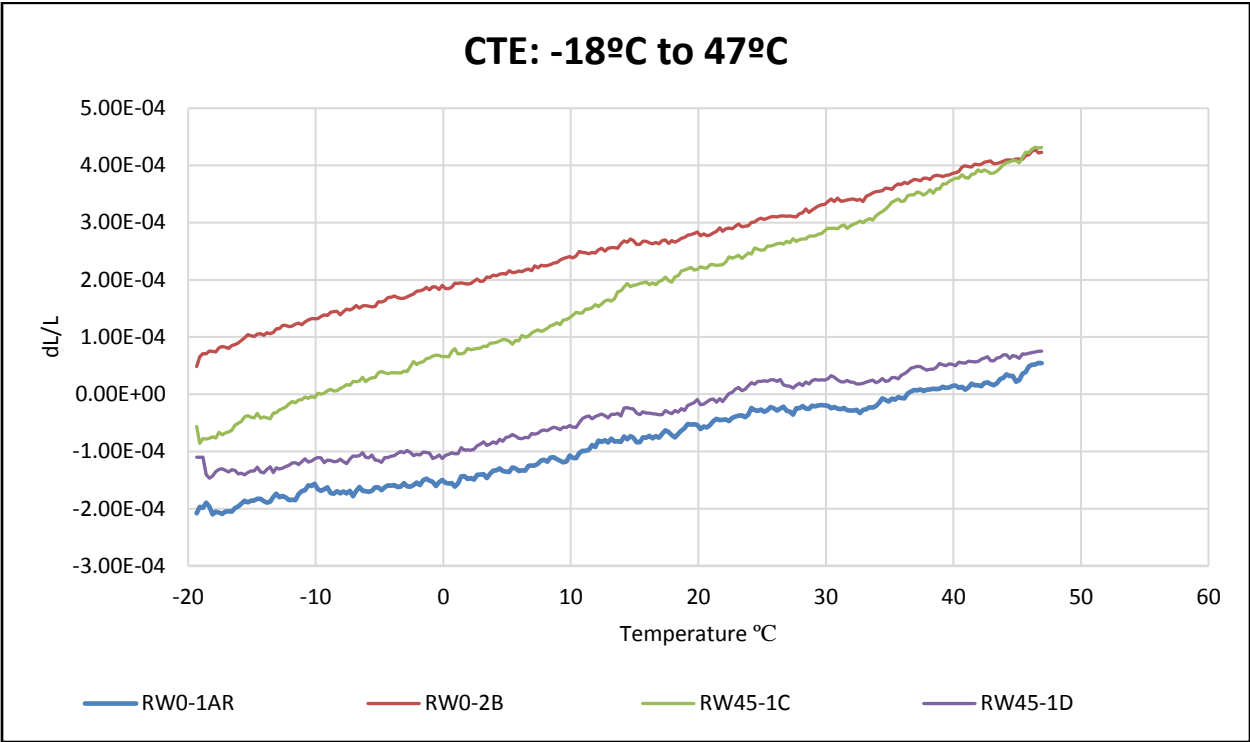
Sample ID	Density g/cm ³
Panel 1	1.5171
Panel 1	1.5206
Average	1.5189
Panel 2	1.5265
Panel 2	1.5300
Average	1.5283

RESULTS-Plots









Raw Materials

Raw Material	Weave	Aerial Weight	Fiber / Resin
Carbon Fiber	2x2 Twill	670 gsm	Standard Modulus
Resin System	PTM&W 2712	300 gsm	PTM&W PT2712 Epoxy Resin System , with B2 Hardener (PT2712B2)