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Certificate of Analysis

MRA Report #:	M17-124T, Phase #1 (Extract)
Report Date:	January 08, 2018
Report Type:	EEStor, Inc. Samples Performance Testing
Prepared for:	Mr. Ian Clifford EEStor, Inc. 715 Discovery Boulevard #107 Cedar Park, TX 78613
P.O. No:	3025-01'17

The following sample was submitted and identified on behalf of the client as:

Sample ID's:	CS-17-19E – Polymer-ceramic disk, Customer ID# Ultra #2
Material types:	Polymer-ceramic disk capacitor
Quantity:	One per sample
Testing Period:	December 18, 2017 – January 08, 2018
Objective:	To independently illustrate the performance of EEStor materials across the range of operating conditions

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Performed tests: **Test #1:** Temperature Coefficient of Capacitance @ 1kHz and 1MHz, -55°C – 85°C temperature range, 0V dc-bias;
Test #2: Temperature Coefficient of Capacitance at dc-bias @ 1kHz, -55°C – 85°C temperature range, 300V dc-bias;
Test #3: Insulation Resistance @1000V, RT and 85°C;

Summary: The results are given on the following pages as tables and plots for information only.

Customer Samples Dimensions

Sample ID#	Customer ID#	Electrode dimensions (diameter or length and width), mm	Sample thickness, mm	Electrodes area, mm^2
CS-17-19E	**Ultra #2**	6.68x6.40	0.013	42.759
Used equipment: Precision micrometer, 210-A. Measured uncertainty: ±0.001mm. Room temperature: 19.6°C. Relative humidity: 7.3%.				

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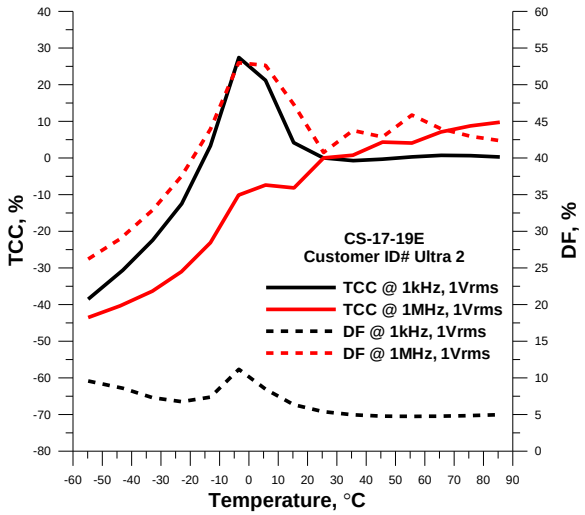
Test Results:

Test #1: Temperature Coefficient of Capacitance
(@ 1 kHz and 1 MHz, -55°C – 85°C temperature range, 1Vrms, 0V dc-bias)

Temp., °C	CS-17-19E (Ultra #2)			
	1kHz		1MHz	
	Cap, %	DF, %	Cap, %	DF, %
-55	-38.54	9.57	-43.54	26.20
-45	-30.64	8.58	-40.36	28.96
-35	-22.45	7.29	-36.35	32.86
-25	-12.50	6.75	-31.03	37.49
-15	3.30	7.37	-23.11	43.93
-5	27.41	11.16	-10.14	52.98
5	21.17	8.45	-7.40	52.62
15	4.15	6.34	-8.18	47.25
25	0.00	5.38	0.00	40.74
35	-0.73	4.95	0.73	43.74
45	-0.34	4.77	4.33	42.86
55	0.29	4.74	4.06	45.85
65	0.70	4.77	7.07	43.98
75	0.62	4.85	8.75	42.95
85	0.25	4.98	9.75	42.35
Used equipment: HP 4278A Capacitance meter and Delta 9023 environmental chamber. Measured uncertainty: C, DF ±0.25%. Room temperature: 19.6°C. Relative humidity: 7.3%.				



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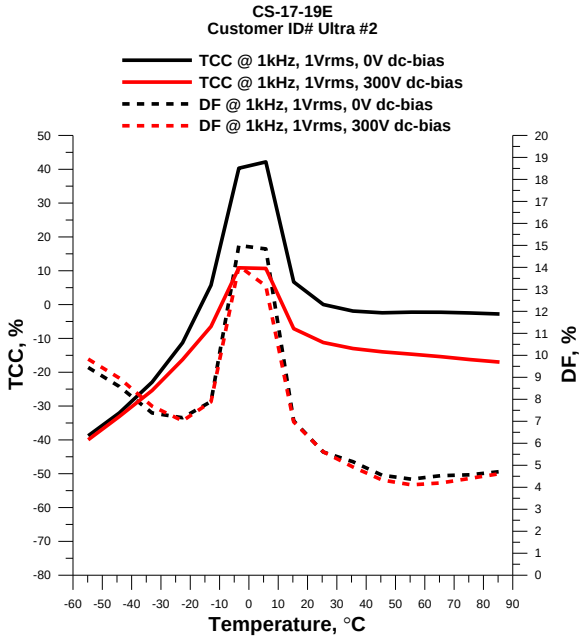
Test #2: Temperature Coefficient of Capacitance at dc-bias
(@ 1 kHz, -55°C – 85°C temperature range, 0Vdc bias & 300V dc-bias)

Temp., °C	CS-17-19E (Ultra #2)			
	0V dc-bias		300V dc-bias	
	Cap, %	DF, %	Cap, %	DF, %
-55	-38.81	9.45	-39.98	9.83
-45	-32.06	8.58	-33.12	8.96
-35	-22.95	7.38	-25.42	7.69
-25	-11.29	7.16	-16.28	7.02
-15	5.71	7.89	-6.48	7.88
-5	40.29	15.00	10.85	14.06
5	42.16	14.84	10.66	13.15
15	6.66	7.02	-7.14	6.97
25	0.00	5.60	-11.24	5.61
35	-1.94	5.16	-13.00	4.92
45	-2.45	4.54	-13.97	4.32
55	-2.26	4.36	-14.68	4.11
65	-2.28	4.53	-15.42	4.19
75	-2.51	4.57	-16.28	4.40
85	-2.81	4.71	-17.01	4.61

Used equipment: HP 4278A Capacitance meter and Delta 9023 environmental chamber.
Measured uncertainty: C, DF ±0.25%.
Room temperature: 19.6°C. Relative humidity: 7.3%.



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Test #3: INSULATION RESISTANCE

(@ 1000Vdc, RT and 85°C)

Electrical Parameters	**CS-17-19E (Ultra #2)**	
	Room Temperature	**85**
IR, Ω	$4.58*10^{8}$	$2.85*10^{8}$
ρ, Ω*m	$1.51*10^{9}$	$9.37*10^{8}$
R*C, MΩ*μF	0.456	0.196
Used equipment: Beckman Megaohmmeter and Delta 9023 environmental chamber. Measured uncertainty: IR ±0.25%. Room temperature: 19.6°C. Relative humidity: 7.3%.		

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Test Methods

The below methods were used to perform the tests.

General

All measurement equipment was powered up at least 30 minutes prior to testing and allowed to reach a stable temperature.

Test #1: Temperature Coefficient of Capacitance

Temperature coefficient of capacitance was measured using HP 4278A 1kHz/1MHz Capacitance Meter coupled with Rokem Scanner and Delta 9023 Environmental Chamber. The measurements were performed in the temperature range from -55°C to 85°C. Three minutes were allowed for temperature stabilization prior to measurements of capacitance and dissipation factor at each temperature steps. Open/short correction was performed prior to measurements in order to compensate for stray admittance and residual impedance of the scanner. The measurements were performed one time per sample.

Test #2: Temperature Coefficient of Capacitance at dc-bias

Temperature coefficient of capacitance at dc-bias was measured using HP 4278A 1kHz/1MHz Capacitance Meter coupled with Rokem Scanner, Sorensen DLM 300-2 Programmable dc Power Supply, ART ASY0360 HV Bias Module, and Delta 9023 Environmental Chamber. The measurements were performed in the temperature range from -55°C to 85°C. Three minutes were allowed for temperature stabilization prior to measurements of capacitance and dissipation factor at each temperature steps with and without 300V dc-bias. Open/short correction was performed prior to measurements in order to compensate for stray admittance and residual impedance of the scanner. The measurements were performed one time per sample.

Test #3: Insulation Resistance

Insulation resistance at 1000V dc-bias was measured using Beckman Megaohmmeter coupled with Delta 9023 Environmental Chamber. The measurements were performed at room temperature and at 85°C. 10 minutes were allowed for the temperature stabilization inside the chamber before each measurements. The insulation resistance was recorded after 2 minutes of dc-bias being applied. The measurements were performed one time per sample.

Affirmation: I certify the above to be true and correct and to have witnessed the testing as described


_____ Anton Polotai, Senior Scientist

Cc: RM, SM, JW

NOTICE: *MRA Laboratories, Inc. strives to maintain a high standard in the conduct and reporting of its testing and professional services. Best efforts are made to assure equipment is properly maintained and calibrated and that correct procedures are followed. All results are discussed and reviewed by the project lead and at least one other qualified technical person prior to reporting.*

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