CERAKOTE OUTGAS TEST

We submitted samples of C-138 Jet Black and LR-100 Black of Cerakote coatings to Element Laboratories, Inc., a third-party testing facility. This test was to measure the outgassing of the coatings in a vacuum environment to support Cerakote's usage in the space industry.

Test Conducted:

ASTM E595-15 Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment

Cerakote Coatings Tested:

- C-138 Jet Black
- LR-100 Black

Conclusion:

• Both coatings tested **meet** the ASTM E595-15 requirements.

Test Results: See below



In account with	Date			
	6/13/2023	Page 1 of 5 Pages		
	W. O. No.	P. O. No.		
WHITE CITY, OR 97503	T 63930	0025854		
,	Identification	Shipper		
	As noted	N/A		

Revision Letter:	Original Issue	Issue Date:	6/13/2023
Prepared By:	Hosein Shahnazi	Approved by:	See Below

IDENTIFICATION	:	Two (2) lots of material, identified as C138; and LRB P38, were submitted for testing per NIC Industries Purchase Order No. 0025854.
SPECIFICATIONS	:	ASTM E595-15 (2021), Sect. 1.5
REFERENCES	:	 NIC Industries Purchase Order No. 0025854, dated 5/26/2023. Element Los Angeles Quotation No. ELO0034743Q/0, dated 4/11/2023.
		3. Email Correspondence Between NIC Industries and Element LA dated 5/24/2023 to 5/26/2023.
		4. ASTM E595-15 (2021), "Standard Test Method for Total Mass Loss and Collected

Volatile Condensable Materials from Outgassing in a Vacuum Environment".

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TEST METHODS

A. OUTGASSING

The 100-300 mg test specimen was preconditioned at 23°C and 50 % relative humidity for 24 hours in a preformed, degreased preweighed aluminum container. The container with specimen was reweighed following preconditioning and placed into the test apparatus specimen heating compartment. The test apparatus was sealed and the specimen was subjected to a vacuum of at least 7×10^{-3} Pa (5×10^{-5} torr) and a temperature of 125°C. Any evolved gases vaporized from the heated specimen streaming from the specimen compartment are condensed and collected on a preweighed chromium-plated collector plate maintained at 25°C. Each specimen compartment and collector plate combination is physically isolated from other specimens by a compartmented separator plate to prevent cross contamination.

The test apparatus was cooled to ambient laboratory temperature after 24 hours at vacuum and the vacuum chamber was repressurized with dry nitrogen gas. The specimen and the collector plates were removed and weighed. The percentage TML and percentage CVCM were calculated as directed in ASTM E595 using the pre- and post- vacuum exposure specimen mass values.

The WVR was determined following a specimen post- conditioning for 24 hours at 23°C and 50 % relative humidity to permit sorption of water vapor. The specimen mass after the post- exposure was measured and the WVR value was calculated as directed in ASTM E595.

Specimen ID	Testing Conducted	Test	Test Value		Results
		TML	0.16	1.00 MAX	Meets Specification
C138		CVCM	0.00	0.10 MAX	Meets Specification
	ASTM E595-15 (2021)	WVR	0.03	REPORT	Information Only
	Outgassing (%)	TML	0.14	1.00 MAX	Meets Specification
LRB P38		CVCM	0.01	0.10 MAX	Meets Specification
		WVR	0.03	REPORT	Information Only

SUMMARY:

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REMARKS: 1. Test results are submitted herein for client evaluation.

Respectfully submitted,

15. Shahli

Hosein Shahnazi Department Manager Element Materials Technology Los Angeles

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5 4 Page of Pages 6/13/2023 Date

w.o. No. Т 63930

	001045	onite per Ao					
Customer: NIC Industries				Order No.:	T63930	12222	
Material ID: C138				Date:	6/6/2023 - 6/9	/2023	
Part Number:				Serial No.			
Lot/Batch No.:				Other ID:			
Specification: ASTM E595-15 (2	021)			•			
Method: ASTM E595-15 (2)	021)			•			
Lab Temp °C: 23.5			H	lumidity %RH:	44.8		
Pre Test Conditionin	g: 23°C and 50% RH for 24 hou	rs			Technician:	BS	
Post Test Conditionin	g: 23°C and 50% RH for 24 hou	rs					-
Drying Chamber Start Date/Tim	e: 6/6/2023 at 5:50	pm	E	nd Date/Time:	6/7/2023 a	t 10:00 am	
Vacuum Chamber Start Date/Tim	e: 6/7/2023 at 2:10	pm	Ei	nd Date/Time:	6/8/2023 a	at 2:10 pm	
Test Parameter	rs: Outgas for 24 hours at 125°C	Cunder vacuur	n of 5 x 10-5 or	r less Tor			
Collector Dista Devenueta	Nr. 25°C						
Collector Plate Paramete	1. 25 C						
	Test No.	1	2	3	Blank	Average	Required
	Test No. Compartment:	1 17	2 18	3 19	Blank 20	Average	Required Max.
	Test No. Compartment: Initial Collector Mass (mg)	1 17 2059.921	2 18 1846.286	3 19 1936.127	Blank 20 2139.711	Average	Required Max.
	Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg)	1 17 2059.921 254.864	2 18 1846.286 231.227	3 19 1936.127 224.405	Blank 20 2139.711 198.098	Average	Required Max.
Lonector Plate Paramete	Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) al Boat + Specimen Mass (mg)	1 17 2059.921 254.864 437.119	2 18 1846.286 231.227 410.512	3 19 1936.127 224.405 404.293	Blank 20 2139.711 198.098 198.098	Average	Required Max.
Initia Pre Test Conditione	Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) al Boat + Specimen Mass (mg) d Boat + Specimen Mass (mg)	1 2059.921 254.864 437.119 437.144	2 18 1846.286 231.227 410.512 410.543	3 19 1936.127 224.405 404.293 404.314	Blank 20 2139.711 198.098 198.098 198.116	Average	Required Max.
Initia Pre Test Conditione Post Outgassing (Cooled to R1	Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) al Boat + Specimen Mass (mg) d Boat + Specimen Mass (mg) F) Boat + Specimen Mass (mg)	1 2059.921 254.864 437.119 437.144 436.851	2 18 1846.286 231.227 410.512 410.543 410.280	3 19 1936.127 224.405 404.293 404.314 404.026	Blank 20 2139.711 198.098 198.098 198.116 198.101	Average	Required Max.
Initia Pre Test Conditione Post Outgassing (Cooled to RT Post Outgass	Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) al Boat + Specimen Mass (mg) d Boat + Specimen Mass (mg) F) Boat + Specimen Mass (mg) sing Collector Plate Mass (mg)	1 17 2059.921 254.864 437.119 437.144 436.851 2059.946	2 18 1846.286 231.227 410.512 410.543 410.280 1846.282	3 19 1936.127 224.405 404.293 404.314 404.026 1936.133	Blank 20 2139.711 198.098 198.098 198.116 198.101 2139.718	Average	Required Max.
Initia Pre Test Conditione Post Outgassing (Cooled to R1 Post Outgass Water Vapor Regai	Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) al Boat + Specimen Mass (mg) d Boat + Specimen Mass (mg) F) Boat + Specimen Mass (mg) sing Collector Plate Mass (mg) n Boat + Specimen Mass (mg)	1 17 2059.921 254.864 437.119 437.144 436.851 2059.946 436.914	2 18 1846.286 231.227 410.512 410.543 410.280 1846.282 410.337	3 19 1936.127 224.405 404.293 404.314 404.026 1936.133 404.084	Blank 20 2139.711 198.098 198.098 198.116 198.101 2139.718 198.121	Average	Required Max.
Initia Pre Test Conditione Post Outgassing (Cooled to RT Post Outgass Water Vapor Regai	Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) al Boat + Specimen Mass (mg) d Boat + Specimen Mass (mg) Sing Collector Plate Mass (mg) n Boat + Specimen Mass (mg)	1 17 2059.921 254.864 437.119 437.144 436.851 2059.946 436.914	2 18 1846.286 231.227 410.512 410.543 410.280 1846.282 410.337	3 19 1936.127 224.405 404.293 404.314 404.026 1936.133 404.084	Blank 20 2139.711 198.098 198.116 198.101 2139.718 198.121	Average	Required Max.
Initia Pre Test Conditione Post Outgassing (Cooled to RT Post Outgass Water Vapor Regai	Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) al Boat + Specimen Mass (mg) d Boat + Specimen Mass (mg) Sing Collector Plate Mass (mg) n Boat + Specimen Mass (mg) Total Mass Loss (% TML)	1 17 2059.921 254.864 437.119 437.144 436.851 2059.946 436.914 0.16%	2 18 1846.286 231.227 410.512 410.543 410.280 1846.282 410.337 0.15%	3 19 1936.127 224.405 404.293 404.314 404.026 1936.133 404.084 0.16%	Blank 20 2139.711 198.098 198.098 198.116 198.101 2139.718 198.121	Average 0.16%	Required Max.
Initia Pre Test Conditione Post Outgassing (Cooled to RT Post Outgass Water Vapor Regai	Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) al Boat + Specimen Mass (mg) d Boat + Specimen Mass (mg) f) Boat + Specimen Mass (mg) n Boat + Specimen Mass (mg) n Boat + Specimen Mass (mg) Total Mass Loss (% TML) adensable Materials (%CVCM)	1 17 2059.921 254.864 437.119 437.144 436.851 2059.946 436.914 0.16% 0.01%	2 18 1846.286 231.227 410.512 410.543 410.280 1846.282 410.337 0.15% 0.00%	3 19 1936.127 224.405 404.293 404.314 404.026 1936.133 404.084 0.16% 0.00%	Blank 20 2139.711 198.098 198.098 198.116 198.101 2139.718 198.121	Average	Required Max.

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by the used and based upon specific component and system requirements. Historically, TML of 1.00% and CVMC of 0.10% have been used as screening levels for rejection of spacecraft materials."

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EQUIPMENT	EC#	CAL DUE
Microbalance	3071	03/10/24
Vacuum Gage	3087-3	05/22/24
Temperature Controller	3091 & 3092	05/11/24
Conditioning Chamber Internal Sensor	1658	06/16/23

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5 5 Page of Pages 6/13/2023 Date

w.o. No. Т 63930

Customer: NIC Industries			010011001	103330		
Material ID: LRB P38		-	Date:	6/6/2023 - 6/9	/2023	
Part Number:		•	Serial No.			
Lot/Batch No.:			Other ID:			
Specification: ASTM E595-15 (2021)						
Method: ASTM E595-15 (2021)						
Lab Temp °C:23.5		ŀ	Humidity %RH:	44.8		
Pre Test Conditioning: 23°C and 50% RH for 24 hou	ırs			Technician:	BS	_
Post Test Conditioning: 23°C and 50% RH for 24 hou	irs					_
Drying Chamber Start Date/Time: 6/6/2023 at 5:50	pm	E	nd Date/Time:	6/7/2023 a	t 10:00 am	
Vacuum Chamber Start Date/Time: 6/7/2023 at 2:10	pm	E	nd Date/Time:	6/8/2023 a	at 2:10 pm	
Test Parameters: Outgas for 24 hours at 125°	C under vacuu	m of 5 x 10-5 or	r less Tor			
Test Parameters: Outgas for 24 hours at 125°C Collector Plate Parameter: 25°C	C under vacuu	m of 5 x 10-5 or	r less Tor			•
Test Parameters: Outgas for 24 hours at 125°C Collector Plate Parameter: 25°C Test No.	C under vacuur	m of 5 x 10-5 or 2	r less Tor 3	Blank	Average	Requi
Test Parameters: Outgas for 24 hours at 125°C Collector Plate Parameter: 25°C Test No. Compartment:	C under vacuur <u>1</u> 21	m of 5 x 10-5 or 2 22	r less Tor <u>3</u> 23	Blank 24	Average	Requi
Test Parameters: Outgas for 24 hours at 125°C Collector Plate Parameter: 25°C Test No. Compartment: Initial Collector Mass (mg)	C under vacuur 1 21 2028.499	m of 5 x 10-5 or 2 2005.255	3 23 1852.591	Blank 24 1937.075	Average	Requi Ma
Test Parameters: Outgas for 24 hours at 125°C Collector Plate Parameter: 25°C Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg)	C under vacuur 1 21 2028.499 235.273	m of 5 x 10-5 or 2 2005.255 254.684	3 23 1852.591 193.848	Blank 24 1937.075 275.243	Average	Requi Ma
Test Parameters: Outgas for 24 hours at 125°C Collector Plate Parameter: 25°C Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) Initial Boat + Specimen Mass (mg)	C under vacuur 1 2028.499 235.273 417.432	n of 5 x 10-5 or 22 2005.255 254.684 437.632	3 23 1852.591 193.848 375.457	Blank 24 1937.075 275.243 275.243	Average	Requi Ma
Test Parameters: Outgas for 24 hours at 125°C Collector Plate Parameter: 25°C Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) Initial Boat + Specimen Mass (mg) Pre Test Conditioned Boat + Specimen Mass (mg)	C under vacuur 1 2028.499 235.273 417.432 417.437	m of 5 x 10-5 or 2 2005.255 254.684 437.632 437.635	3 23 1852.591 193.848 375.457 375.460	Blank 24 1937.075 275.243 275.243 275.250	Average	Requi Max
Test Parameters: Outgas for 24 hours at 125°C Collector Plate Parameter: 25°C Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) Initial Boat + Specimen Mass (mg) Pre Test Conditioned Boat + Specimen Mass (mg) Post Outgassing (Cooled to RT) Boat + Specimen Mass (mg)	C under vacuur 21 2028.499 235.273 417.432 417.437 417.171	m of 5 x 10-5 or 2 2005.255 254.684 437.632 437.635 437.377	3 23 1852.591 193.848 375.457 375.460 375.211	Blank 24 1937.075 275.243 275.243 275.250 275.221	Average	Requi Ma
Test Parameters: Outgas for 24 hours at 125°C Collector Plate Parameter: 25°C Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) Initial Boat + Specimen Mass (mg) Pre Test Conditioned Boat + Specimen Mass (mg) Post Outgassing (Cooled to RT) Boat + Specimen Mass (mg) Post Outgassing Collector Plate Mass (mg)	C under vacuur 21 2028.499 235.273 417.432 417.437 417.171 2028.503	m of 5 x 10-5 or 2 2005.255 254.684 437.632 437.635 437.377 2005.267	3 23 1852.591 193.848 375.457 375.460 375.211 1852.607	Blank 24 1937.075 275.243 275.243 275.250 275.221 1937.073	Average	Requi
Test Parameters: Outgas for 24 hours at 125°C Collector Plate Parameter: 25°C Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) Initial Boat + Specimen Mass (mg) Pre Test Conditioned Boat + Specimen Mass (mg) Post Outgassing (Cooled to RT) Boat + Specimen Mass (mg) Post Outgassing Collector Plate Mass (mg) Water Vapor Regain Boat + Specimen Mass (mg)	C under vacuum 2028.499 235.273 417.432 417.437 417.171 2028.503 417.227	m of 5 x 10-5 or 2 2005.255 254.684 437.632 437.635 437.377 2005.267 437.432	3 23 1852.591 193.848 375.457 375.460 375.211 1852.607 375.270	Blank 24 1937.075 275.243 275.243 275.250 275.221 1937.073 275.249	Average	Requi Max
Test Parameters: Outgas for 24 hours at 125°C Collector Plate Parameter: 25°C Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) Initial Boat + Specimen Mass (mg) Pre Test Conditioned Boat + Specimen Mass (mg) Post Outgassing (Cooled to RT) Boat + Specimen Mass (mg) Post Outgassing Collector Plate Mass (mg) Water Vapor Regain Boat + Specimen Mass (mg)	L under vacuum 2028.499 235.273 417.432 417.437 417.171 2028.503 417.227	m of 5 x 10-5 or 2 2005.255 254.684 437.632 437.635 437.377 2005.267 437.432	3 23 1852.591 193.848 375.457 375.460 375.211 1852.607 375.270	Blank 24 1937.075 275.243 275.243 275.250 275.221 1937.073 275.249	Average	Requi
Test Parameters: Outgas for 24 hours at 125°C Collector Plate Parameter: 25°C Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) Initial Boat + Specimen Mass (mg) Post Outgassing (Cooled to RT) Boat + Specimen Mass (mg) Post Outgassing Collector Plate Mass (mg) Water Vapor Regain Boat + Specimen Mass (mg) Total Mass Loss (% TML)	L under vacuum 2028.499 235.273 417.432 417.437 417.171 2028.503 417.227 0.15%	m of 5 x 10-5 or 2 2005.255 254.684 437.632 437.635 437.377 2005.267 437.432 0.14%	3 23 1852.591 193.848 375.457 375.460 375.211 1852.607 375.270 0.14%	Blank 24 1937.075 275.243 275.243 275.250 275.221 1937.073 275.249	Average 0.14%	Requi Ma:
Test Parameters: Outgas for 24 hours at 125°C Collector Plate Parameter: 25°C Test No. Compartment: Initial Collector Mass (mg) Initial Boat Mass (mg) Initial Boat + Specimen Mass (mg) Pre Test Conditioned Boat + Specimen Mass (mg) Post Outgassing (Cooled to RT) Boat + Specimen Mass (mg) Post Outgassing Collector Plate Mass (mg) Water Vapor Regain Boat + Specimen Mass (mg) Water Vapor Regain Boat + Specimen Mass (mg) Collected Volatile Condensable Materials (%CVCM)	C under vacuum 21 2028.499 235.273 417.432 417.437 417.171 2028.503 417.227 0.15% 0.00%	m of 5 x 10-5 or 2 2005.255 254.684 437.632 437.635 437.377 2005.267 437.432 0.14% 0.01%	3 23 1852.591 193.848 375.457 375.460 375.211 1852.607 375.270 0.14% 0.01%	Blank 24 1937.075 275.243 275.243 275.250 275.221 1937.073 275.249	Average	Requi

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ASTM E595 Section 1.5, "The criteria used for acceptance and rejection of materials shall be determined by the used and based upon specific component and system requirements. Historically, TML of 1.00% and CVMC of 0.10% have been used as screening levels for rejection of spacecraft materials."

EQUIPMENT EC# CAL DUE	
Microbalance 3071 03/10/24	
Vacuum Gage 3087-3 05/22/24	
Temperature Controller 3091 & 3092 05/11/24	
Conditioning Chamber Internal Sensor 1658 06/16/23	

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