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

TEST REPORT
EAR-CONTROLLED DATA

In account with	Date	Page 1 of 5 Pages
NIC INDUSTRIES 7050 SIXTH STREET WHITE CITY, OR 97503	6/13/2023	
	W. O. No. T 63930	P. O. No. 0025854
	Identification As noted	Shipper 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 :

1. NIC Industries Purchase Order No. 0025854, dated 5/26/2023.
2. 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".

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.

SUMMARY:

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

element

TEST REPORT
EAR-CONTROLLED DATA

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

Respectfully submitted,

Hosein Shahnazi

Department Manager

Element Materials Technology Los Angeles

TEST REPORT
EAR-CONTROLLED DATA

Date 6/13/2023

W.O. No. T 63930

OUTGASSING per ASTM E595

Customer: NIC Industries
Material ID: C138
Part Number:
Lot/Batch No.:

Order No.: T63930
Date: 6/6/2023 - 6/9/2023
Serial No.
Other ID:

Specification: ASTM E595-15 (2021)
Method: ASTM E595-15 (2021)
Lab Temp °C: 23.5

Humidity %RH: 44.8

Pre Test Conditioning: 23°C and 50% RH for 24 hours
Post Test Conditioning: 23°C and 50% RH for 24 hours
Drying Chamber Start Date/Time: 6/6/2023 at 5:50 pm
Vacuum Chamber Start Date/Time: 6/7/2023 at 2:10 pm

Technician: BS
End Date/Time: 6/7/2023 at 10:00 am
End Date/Time: 6/8/2023 at 2:10 pm

Test Parameters: Outgas for 24 hours at 125°C under vacuum of 5 x 10-5 or less Tor
Collector Plate Parameter: 25°C

Test No.	1	2	3	Blank	Average	Required
Compartment:	17	18	19	20		Max.
Initial Collector Mass (mg)	2059.921	1846.286	1936.127	2139.711		
Initial Boat Mass (mg)	254.864	231.227	224.405	198.098		
Initial Boat + Specimen Mass (mg)	437.119	410.512	404.293	198.098		
Pre Test Conditioned Boat + Specimen Mass (mg)	437.144	410.543	404.314	198.116		
Post Outgassing (Cooled to RT) Boat + Specimen Mass (mg)	436.851	410.280	404.026	198.101		
Post Outgassing Collector Plate Mass (mg)	2059.946	1846.282	1936.133	2139.718		
Water Vapor Regain Boat + Specimen Mass (mg)	436.914	410.337	404.084	198.121		

Total Mass Loss (% TML)	0.16%	0.15%	0.16%		0.16%	1.00%
Collected Volatile Condensable Materials (%CVCM)	0.01%	0.00%	0.00%		0.00%	0.10%
Water Vapor Regain (% WVR)	0.03%	0.03%	0.03%		0.03%	Report

The above test results: ***Meet*** requirements of the specification as noted in accordance with 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

Date 6/13/2023

W.O. No. T 63930

TEST REPORT
EAR-CONTROLLED DATA

OUTGASSING per ASTM E595

Customer: NIC Industries
Material ID: LRB P38
Part Number:
Lot/Batch No.:

Order No.: T63930
Date: 6/6/2023 - 6/9/2023
Serial No.
Other ID:

Specification: ASTM E595-15 (2021)
Method: ASTM E595-15 (2021)
Lab Temp °C: 23.5

Humidity %RH: 44.8

Pre Test Conditioning: 23°C and 50% RH for 24 hours
Post Test Conditioning: 23°C and 50% RH for 24 hours
Drying Chamber Start Date/Time: 6/6/2023 at 5:50 pm
Vacuum Chamber Start Date/Time: 6/7/2023 at 2:10 pm

Technician: BS
End Date/Time: 6/7/2023 at 10:00 am
End Date/Time: 6/8/2023 at 2:10 pm

Test Parameters: Outgas for 24 hours at 125°C under vacuum of 5 x 10-5 or less Tor
Collector Plate Parameter: 25°C

Test No.	1	2	3	Blank	Average	Required
Compartment:	21	22	23	24		Max.
Initial Collector Mass (mg)	2028.499	2005.255	1852.591	1937.075		
Initial Boat Mass (mg)	235.273	254.684	193.848	275.243		
Initial Boat + Specimen Mass (mg)	417.432	437.632	375.457	275.243		
Pre Test Conditioned Boat + Specimen Mass (mg)	417.437	437.635	375.460	275.250		
Post Outgassing (Cooled to RT) Boat + Specimen Mass (mg)	417.171	437.377	375.211	275.221		
Post Outgassing Collector Plate Mass (mg)	2028.503	2005.267	1852.607	1937.073		
Water Vapor Regain Boat + Specimen Mass (mg)	417.227	437.432	375.270	275.249		

Total Mass Loss (% TML)	0.15%	0.14%	0.14%		0.14%	1.00%
Collected Volatile Condensable Materials (%CVCM)	0.00%	0.01%	0.01%		0.01%	0.10%
Water Vapor Regain (% WVR)	0.03%	0.03%	0.03%		0.03%	Report

The above test results: ***Meet*** requirements of the specification as noted in accordance with 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."

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