Graver Technologies

ZTEC-E Series

Microelectronics Grade Polyethersulfone Membrane Filter Cartridges

Performance Guide

ISO 9001:2015

Preface

The Graver Technologies ZTEC-E (0.03 µm, 0.1 µm, 0.2 µm, and 0.45 µm) pleated filter cartridges are designed as an exceptionally clean, non-leaching, non-shedding barrier for membrane filtration. These filters offer reliable performance in removing minute contaminants larger than their rated pore sizes. All ZTEC-E filter cartridges incorporate polyethersulfone membrane and all other ZTEC-E cartridge components (cage, core, end caps and support layers) are entirely polypropylene. ZTEC-E filters are manufactured in an ISO Class 7 cleanroom environment. Each filter is rinsed with 18 megohm-cm resistivity de-ionized water to single digit TOC readings and integrity tested before release from manufacture. All the ZTEC-E filter products are fabricated in an ISO 9001, Rev. 2015 Registered manufacturing facility.

Each section of this Performance Guide represents only the summary portion of the actual test. If your company has a need for expanded detail on any specific test method or the actual data, please contact Graver Technologies Filtration & Separation Group for assistance at 1-888-353-0303.

Table of Contents

Nomenclature & Construction

Nomenclature Information						
ZTEC E **Filter Type**	0.2 **Retention Rating (microns)**	-10 **Nominal length (inches)**	P **End Configuration**		E **Gasket or O-Ring**	
ZTEC E	0.03	5	P	DOE		
	0.1	9.75	P2	226/flat Single Open End	S	Silicone
	0.2	10	P3	222/flat Single Open End	B	Buna-N
	0.45	20	P7	226/fin Single Open End	E	EPDM
		30	P8	222/fin Single Open End	V	Viton
		40	AM	Single Open End, Internal O-Ring	T	TEV
			NPC	Double Open End, Internal O-Ring		

Materials of Construction

Membrane:	Single layer expanded polyethersulfone (PES) – 7.6 ft^2 (0.7 m^2)
Drainage Layer:	Polypropylene
Core:	Polypropylene
Cage/Outer Sleeve:	Polypropylene
End Caps:	Polypropylene
O-Rings:	Viton (standard)
	Silicone
	EPDM
	Buna-N
	Teflon Encapsulated Viton

Filter End Configurations

Graver offers a wide variety of end configurations on our filter cartridges to meet customer requirements and for fit in installed housings. The following guide will familiarize you with the options available.

Style	DOE or SOE	Visual
P	DOE	Thermally bonded-plastic caps with flat gasket seal on both open ends 
P3	SOE	222 double o-ring on open end — Flat on closed end 
P8	SOE	222 double o-ring on open end — Spear on closed end 
P2	SOE	226 double o-ring on open end — Flat on closed end 
P7	SOE	226 double o-ring on open end — Spear on closed end 
AM	SOE	Internal o-ring on open end — Recessed cup on closed end 

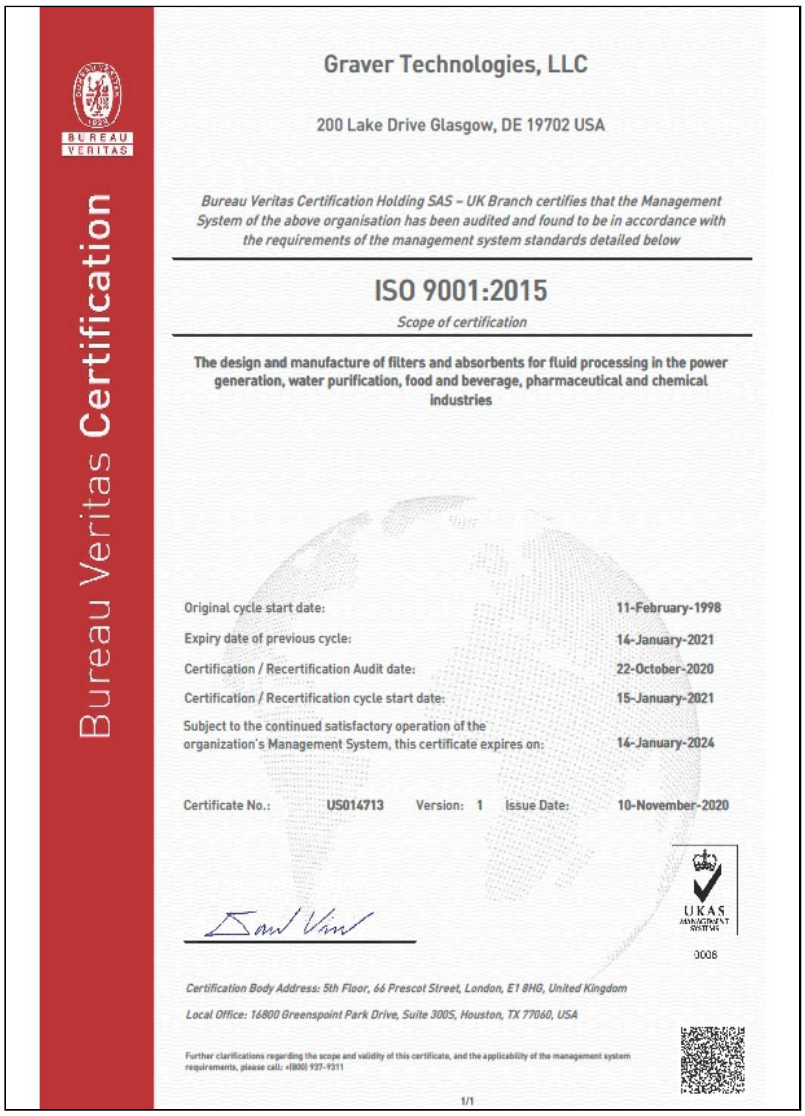
Style	DOE or SOE	Visual
NPC	DOE	Internal o-rings on both open ends 
P28	SOE	222 double o-ring with tabs on open end — Spear on closed end 

*DOE = Double Open End / SOE = Single Open End
Note: not all configurations are available on every product.
Please consult specific product data sheets for more detail.

The following trademarks are used throughout:
Viton® — Registered trademark of DuPont Performance Elastomers
Teflon® — registered trademark of Dupont
Chemraz® — Registered trademark of Greene Tweed
Kalrez® — Registered trademark of DuPont Performance Elastomers
Santoprene® — Registered trademark of Advanced Elastomer Systems

Product Traceability

ZTEC E Filter Elements are manufactured in conformance with established current Good Manufacturing Practice (cGMP) standards. The filter elements are produced and distributed according to a Quality Management System that is registered for compliance to EN ISO 9001:2015. All ZTEC E filters are non-destructively integrity tested and flushed with Purified Water with a maximum conductivity of 1.1 µS/cm @ 20°C (68°F) and a maximum TOC (Total Organic Carbon) content of 0.5 mg (500ppb) of carbon per liter. They are then dried using HEPA filtered air and sealed in a protective polyethylene bag within the cleanroom. To enable full traceability of all ZTEC E filter products, each filter module is marked with an individual serial number, a lot number, product code and general description which is also shown on both the bag label and on the outer product box, therefore all data concerning materials used and production data are documented, accessible and fully traceable.



Bureau Veritas Certification

Graver Technologies, LLC

200 Lake Drive Glasgow, DE 19702 USA

Bureau Veritas Certification Holding SAS – UK Branch certifies that the Management System of the above organisation has been audited and found to be in accordance with the requirements of the management system standards detailed below

ISO 9001:2015

Scope of certification

The design and manufacture of filters and absorbents for fluid processing in the power generation, water purification, food and beverage, pharmaceutical and chemical industries

Original cycle start date:	11-February-1998
Expiry date of previous cycle:	14-January-2021
Certification / Recertification Audit date:	22-October-2020
Certification / Recertification cycle start date:	15-January-2021
Subject to the continued satisfactory operation of the organization's Management System, this certificate expires on:	14-January-2024

Certificate No.: US014713 Version: 1 Issue Date: 10-November-2020

UKAS MANAGEMENT SYSTEMS 0008

Certification Body Address: 5th Floor, 66 Prescot Street, London, E1 8HG, United Kingdom

Local Office: 16800 Greenspoint Park Drive, Suite 300S, Houston, TX 77060, USA

Further clarifications regarding the scope and validity of this certificate, and the applicability of the management system requirements, please call: +(800) 937-9311

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Cartridge Integrity Test

Graver Technologies, as part of its quality process, integrity tests all ZTEC-E filter cartridges before release from manufacturing. The specific test used is a Diffusion Test. A discussion of this testing procedure is included in the package insert accompanying the ZTEC-E product. For an integral cartridge, the air diffusion rate which is a measure of the rate at which air diffuses through the water-filled pores of the membrane, must be below a specified value at the Integrity Test pressure. A cartridge with even a minor defect will exhibit much higher airflow rates when measured by this test.

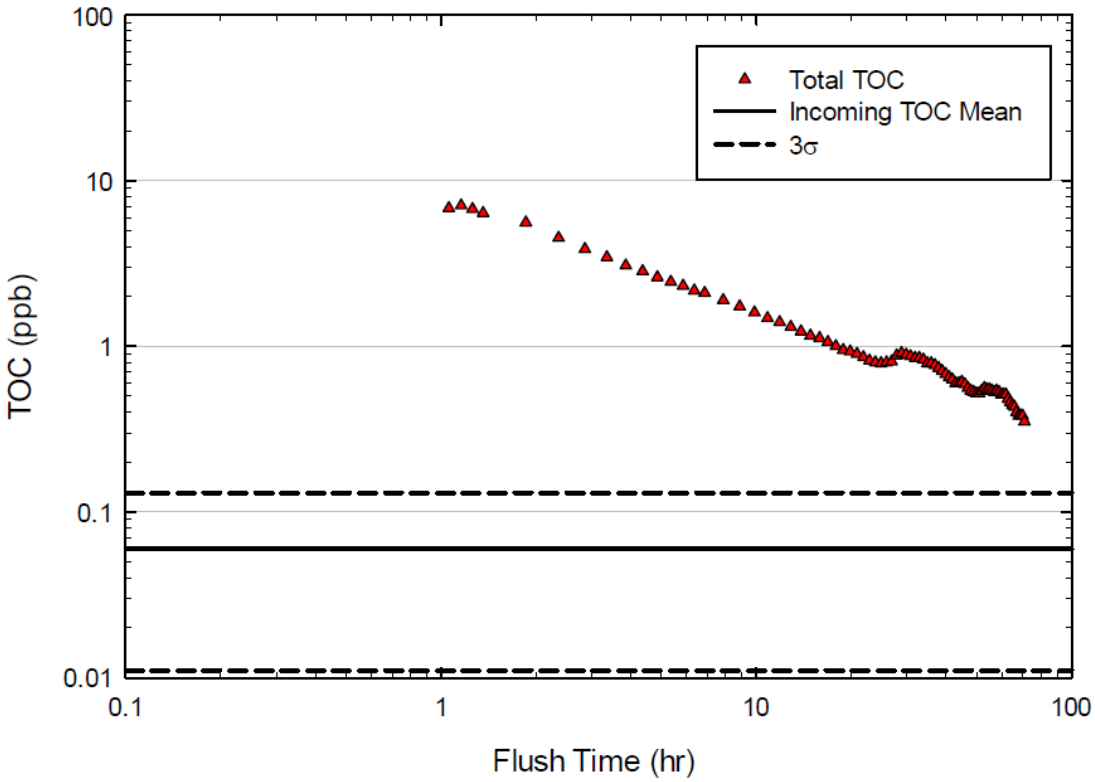
Test Procedure

1) A filter cartridge is installed into the test system and wetted with de-ionized water by flowing water through the cartridge.
2) The water flow is shut off and a pressure of 5 psid (0.34 bard) of compressed air is applied upstream of the filter. Any excess water in the housing passes through the filter and is drained from the downstream side of the housing.
3) The air pressure is increased to the value shown in Table below, “Diffusion Pressure” and the system is allowed to stabilize for 2 minutes
4) The diffusive air flow through the filter system is measured and the filter passes the integrity test only if the diffusion flow value is less than the “Maximum Diffusion” shown in the table below.

Pore Size	Test Pressure psig (bar)	Maximum Diffusion (cc/min) per 10-Inch Cartridge Length
0.03 µm	45 (3.0)	≤ 60
0.1 µm	40 (2.8)	≤ 50
0.2 µm	30 (2.1)	≤ 35
0.45 µm	20 (1.4)	≤ 35

TOC Rinse-up

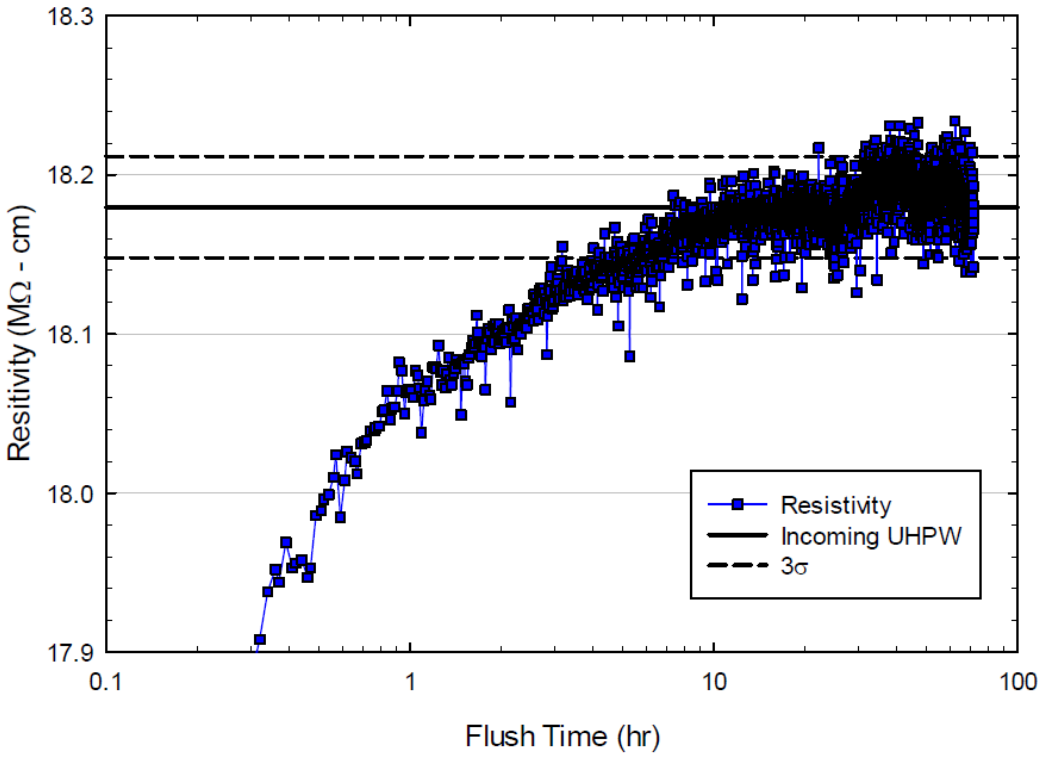
Testing was conducted on ZTEC-E cartridges by flushing with 18 megohm-cm DI water. TOC levels were measured throughout the duration of the test using an Anatel A-1000 Organic Analyzer. Single digit TOC levels are reached within one hour of rinsing and fall below 1 PPB within 18 hours.



During manufacture, each ZTEC-E filter is flushed with semiconductor grade ultrapure water for 50 minutes at a flow rate of 10 GPM, assuring the high purity of each filter shipped. For on-site purposes, customers are advised that a rinse-up of no more than 60 minutes at a flow of 3 GPM will achieve single digit TOC level.

Resistivity Rinse-up

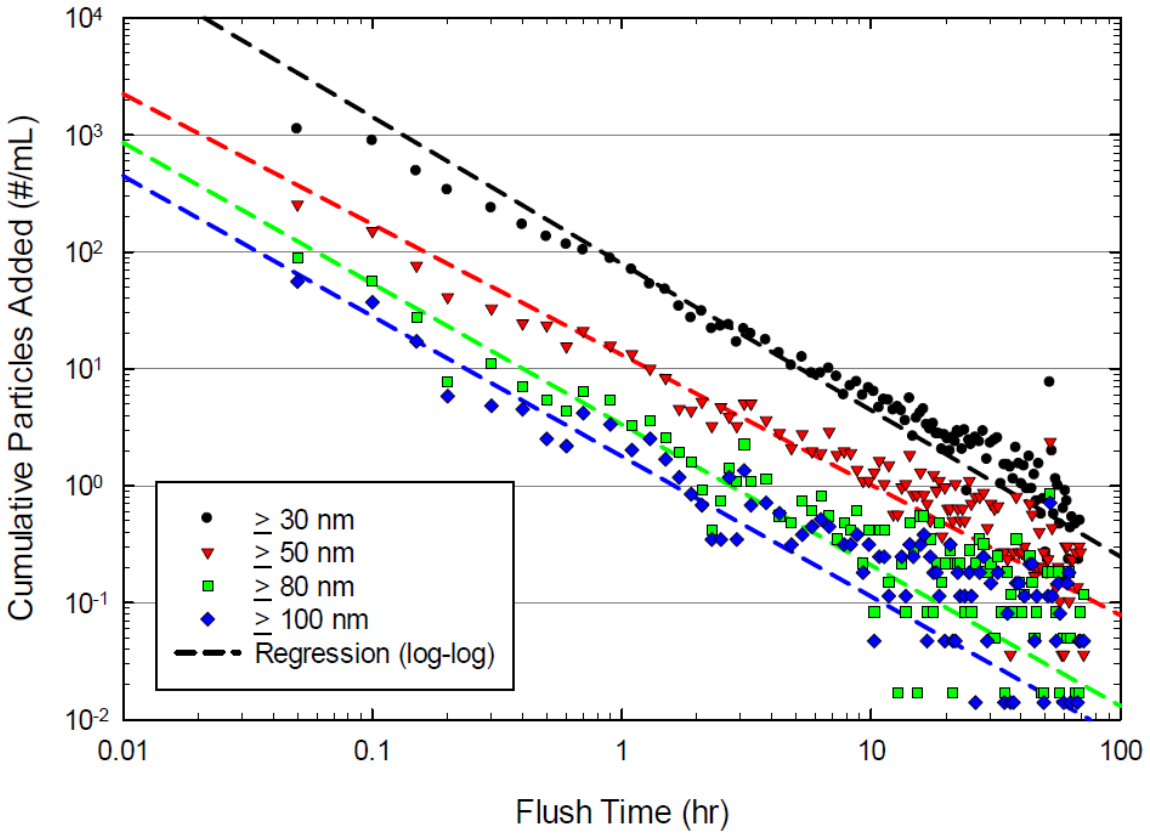
A ZTEC-E sample filter was flushed with ultrapure DI water at a flow rate of 8.5 LPM. Incoming Ultra High Purity Water was showing 18.2 megohm-cm resistivity. The resistivity exceeds 18.0 megohm-cm within 30 minutes of flushing and is equal to the incoming water within 10 hours of flushing.



In production, each ZTEC-E filter is flushed with semiconductor grade UPW for 50 minutes at a flow rate of 10 GPM, assuring the high purity of each filter shipped. For on-site purposes, customers are advised that a rinse-up of no more than 35 minutes at a flow of 3GPM will achieve 18 megohm-cm resistivity.

Particle Shedding

A ZTEC-E sample filter was flushed with ultrapure DI water at a flow rate of 8.5 LPM. Particle shedding from the cartridge was measured over time using Lighthouse NC30+ optical particle counter which is capable of measuring particles as small as 30 nm (0.03 microns). Single digit particle counts above 80 nm are reached within 1 hour and single digit counts for particles as small as 30 nm can be reached with 6 hours.



In production, each ZTEC-E filter is flushed with semiconductor grade UPW for 50 minutes at a flow rate of 10 GPM, assuring the high purity of each filter shipped. For on-site purposes, customers are advised that a rinse-up of no more than 120 minutes at a flow of 3 GPM will achieve single digit particle counts.

Leachables

A factory flushed Graver ZTEC-E 0.03 µm filter was sent to Balazs Analytical Services to determine leachable Anions and Metals in UPW. The cartridge was soaked for 24 hours in 1.5 liters of UPW at ambient temperature and the fluid then analyzed by ion chromatography (IC-ICP-MS)

ANION_PPB		
Analysis / Rep	Result Value	Units
Bromide	<3	ppb
Chloride	<5	ppb
Fluoride	<5	ppb
Nitrate	<4	ppb
Nitrite	<5	ppb
Phosphate	<6	ppb
Sulfate	<4	ppb

Metals					
Analysis / Rep	Result Value	Units	Analysis / Rep	Result Value	Units
Aluminum	<0.005	ppb	Lithium	<0.004	ppb
Antimony	<0.004	ppb	Magnesium	0.015	ppb
Arsenic	<0.007	ppb	Manganese	<0.004	ppb
Barium	<0.002	ppb	Molybdenum	<0.003	ppb
Bismuth	<0.005	ppb	Nickel	<0.003	ppb
Boron	<0.006	ppb	Niobium	<0.005	ppb
Cadmium	<0.004	ppb	Potassium	0.056	ppb
Calcium	0.889	ppb	Silver	<0.006	ppb
Chromium	<0.005	ppb	Sodium	0.089	ppb
Cobalt	<0.003	ppb	Strontium	0.003	ppb
Copper	0.174	ppb	Tin	<0.004	ppb
Gallium	<0.004	ppb	Titanium	0.007	ppb
Germanium	<0.004	ppb	Tungsten	0.006	ppb
Iron	<0.005	ppb	Vanadium	<0.005	ppb
Lead	<0.003	ppb	Zinc	0.077	ppb

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Flow Rate Testing

To contribute to the overall operating economics of an existing filter system, it is important that process filter cartridges offer high flow rates at low-pressure drops. For new systems, this can also allow a smaller filter housing to be used with a resultant savings in capital cost.

Test Procedure

1) A filter cartridge is installed into the test system and wetted with clean water. An integrity test is performed, and the results are recorded. (See Page 7 for Integrity Test Procedure.)
2) The filter system is connected to a source of clean water. The pressure of water can be regulated and was adjusted to 18 psi (1.2 bar).
3) The flow through the filter is adjusted to establish a test differential pressure across the filter of 1 psid (.07 bard).
4) The flow rate through the filter housing is recorded.
5) The test is repeated with several cartridges for each pore size.

Results

The filter cartridges at each pore size tested showed flow rates as summarized below, meeting the minimum specifications for that pore size.

Cart. ID #	US GPM Flow at 1 PSID
0.03 µm	1.3
0.1 µm	2.3
0.2 µm	2.8
0.45 µm	5.1

Specification

Based on this testing, the typical flow rate/pressure drop characteristics of ZTEC-E cartridges per 10-inch cartridge length are:

0.03 µm: 1.3 gpm/psid
0.1 µm: 2.3 gpm/psid
0.2 µm: 2.8 gpm/psid
0.45 µm: 5.1 gpm/psid

Core Collapse (Differential Pressure Stress) Testing

In normal use a filter cartridge will be exposed to an increasing differential pressure as the filter accumulates contaminants. In addition, due to normal stops and starts in a production line, the filter will be subjected to numerous differential pressure surges. The limiting factor in a filter cartridge's resistance to differential pressure is the strength of the cartridge core.

The testing regimen below was designed to stress the ZTEC-E filter core under more rigorous conditions than the filter would normally be exposed to in "real world" operation. To pass this test, the filter cartridge must remain integral throughout the pressure testing.

Test Procedure

1) A filter core, bonded to an adapter suitable for a test housing (e.g., -226 or -222 adapter), is encased in a non-porous film to prevent permeability of a test liquid.
2) The core is installed into the filter housing, which is attached to a hydraulic test system.
3) At ambient temperature, hydraulic pressure is slowly increased until the core collapses.
4) The temperature of the hydraulic fluid, and hence the housing/filter core, is increased to 176°F (80°C).
5) The hydraulic pressure is slowly increased until the core collapses.

Results

The filter cores consistently avoided collapse until well over 100 psid (6.9 bard) at ambient temperature (70°F/21°C). The filter cores consistently avoided collapse until well over 60 psid (4.1 bard) at an elevated temperature of 176°F (80°C).

Collapse Strength	Temperature
100 psid (6.9 bard)	70°F (21°C)
60 psid (4.1 bard)	176°F (80°C)

Conclusion

Based on this testing and Graver Technologies ZTEC-E cartridge fabrication methodology, ZTEC-E cartridge filters can withstand differential pressures up to 80 psid @ 70°F (5.5 bard @ 21°C), and 40 psid @ 176°F (2.8 bard @ 80°C) and remain integral.

Recommended Max Operating Conditions	Temperature
80 psid (5.5 bard)	70°F (21°C)
40 psid (2.8 bard)	176°F (80°C)

Appendix

CT Associates, Inc.
7121 Shady Oak Road, Eden Prairie, MN 55344-3516
Telephone: (952) 470-0166 Fax: (952) 942-0293
Website: http://www.ctassociatesinc.com

Cartridge Filter Extraction Test Report

Date: 11/21/2021
To: Robert Tumberlinson– Graver Technologies
From: Gary Van Schooneveld – CT Associates, Inc.
Filter tested: E210918A Lot 11
Test method: CTA GEN 1664.2
Report number: GVT 1986 4688

A Graver filter, ID # E210918A Lot 11, was flushed in UHPW at CT Associates (Eden Prairie, MN) for 72 hours beginning 11/15/2021. Test procedure was carried out according to CTA GEN 1664.2. Flow rate during flush testing was held at 8.5 LPM. Test system background levels for the measured contaminates and contaminate indicators are found in Table 1. Rinse performance metrics are found in Tables 2 to 4. Rinse graphs are presented in Figures 1 to 7.

Table 1. – System background levels

Contaminant	*Mean*	*σ*
NVR (ppb)	0.06	< 0.01
TOC (ppb)	0.06	0.02
Resistivity (MΩ-cm)	18.17	< 0.01
Particles (#/mL ≥ 100 nm)	0.153	0.533

Table 2. – NVR and TOC cleanliness summary.

Contaminant	*Rinse Time to Conc. Added (h)*	
	1 ppb	*0.1 ppb*
NVR	52	1000*
TOC	19	450*

**Projected*

Table 3. – Inorganic cleanliness summary.

Instrument	*Rinse Time to Ω Decrease (h)*	
	1 MΩ-cm	*0.1 MΩ-cm*
Thornton CR200	< 0.1	1.2

Table 4. – Particulate cleanliness summary.

Particle Size (nm)	*Rinse Time to Conc. Added (h)*		
	10 #/mL	*1 #/mL*	*0.1 #/mL*
≥ 30	5	35	200*
≥ 50	1.3	10	80*
≥ 80	0.40	2.7	18
≥ 100	0.23	1.6	11

**Projected*

Figure 1. – NVR added vs. time.

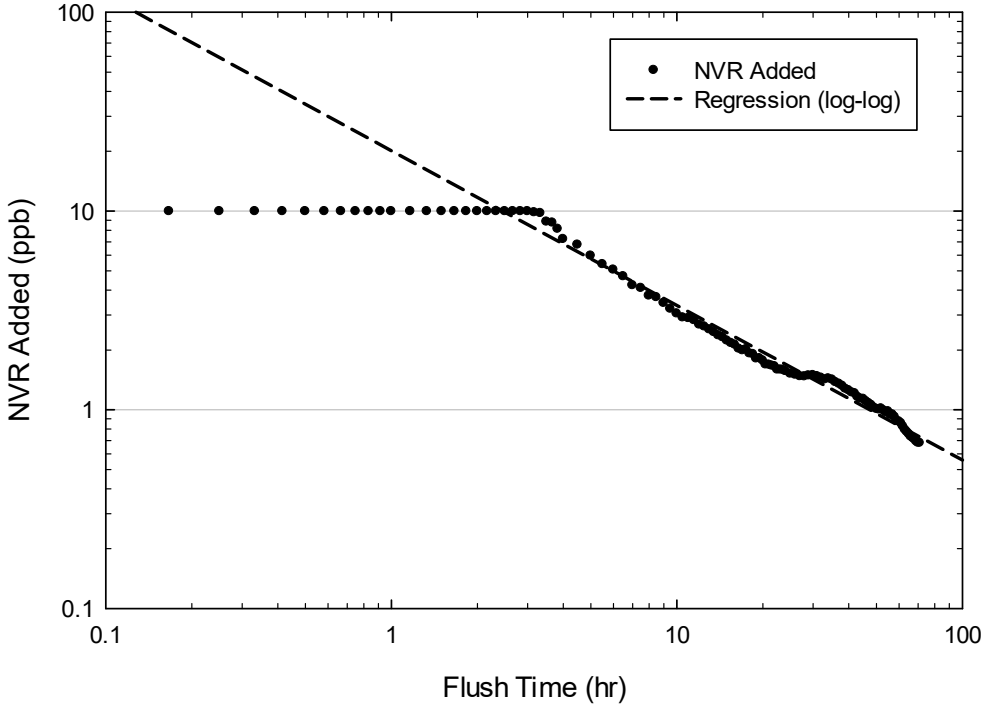


Figure 2. – Total NVR vs. time.

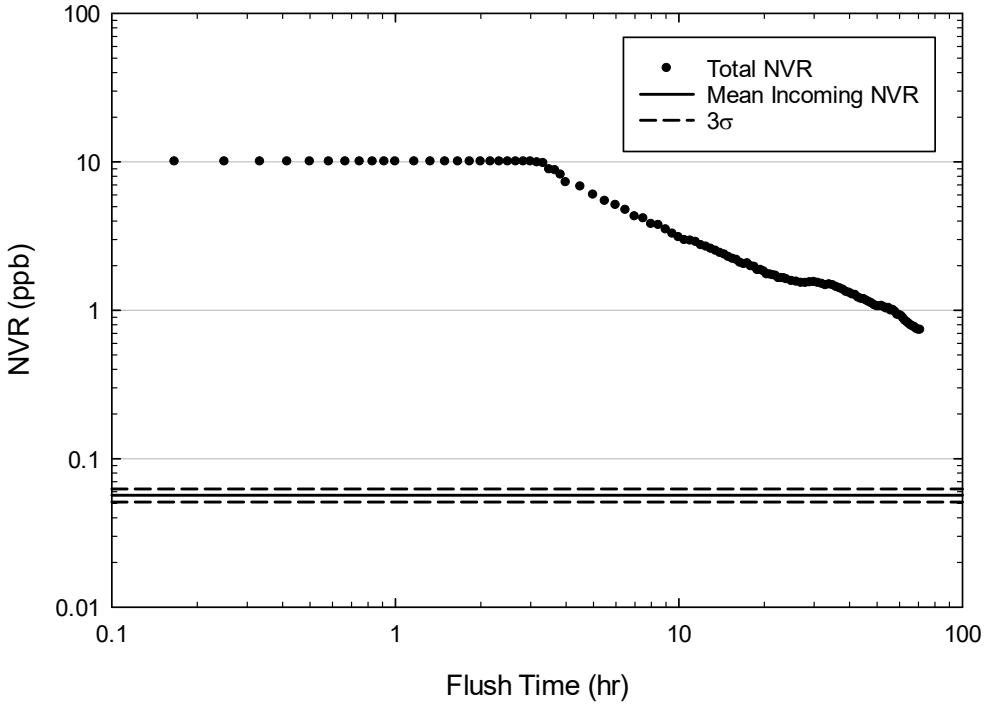


Figure 3. – TOC added vs. time.

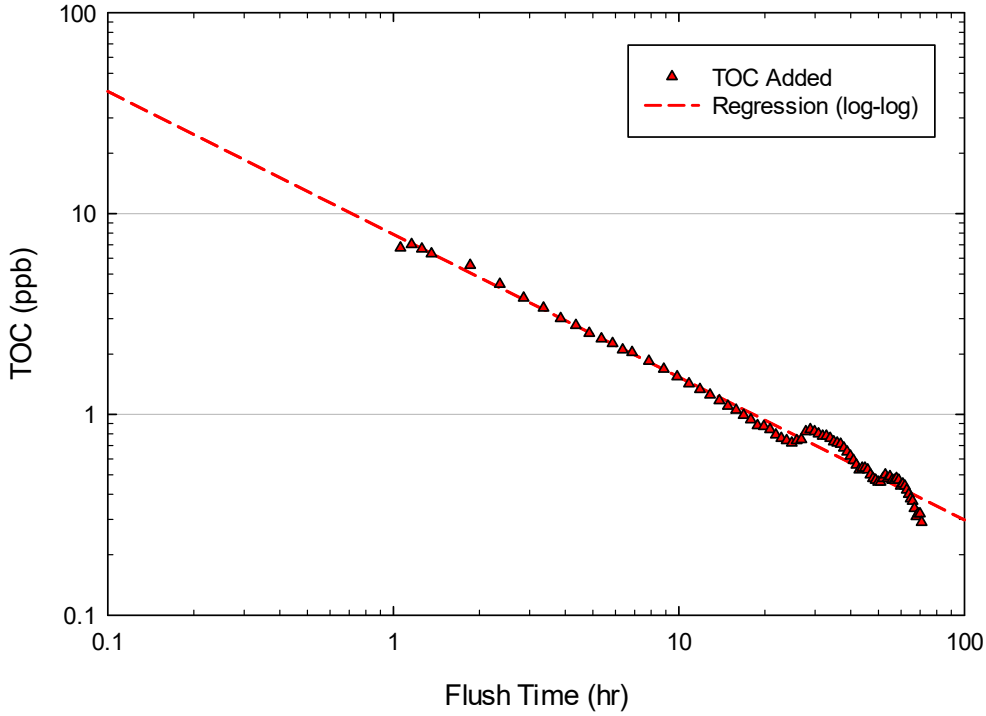


Figure 4. – Total TOC vs. time.

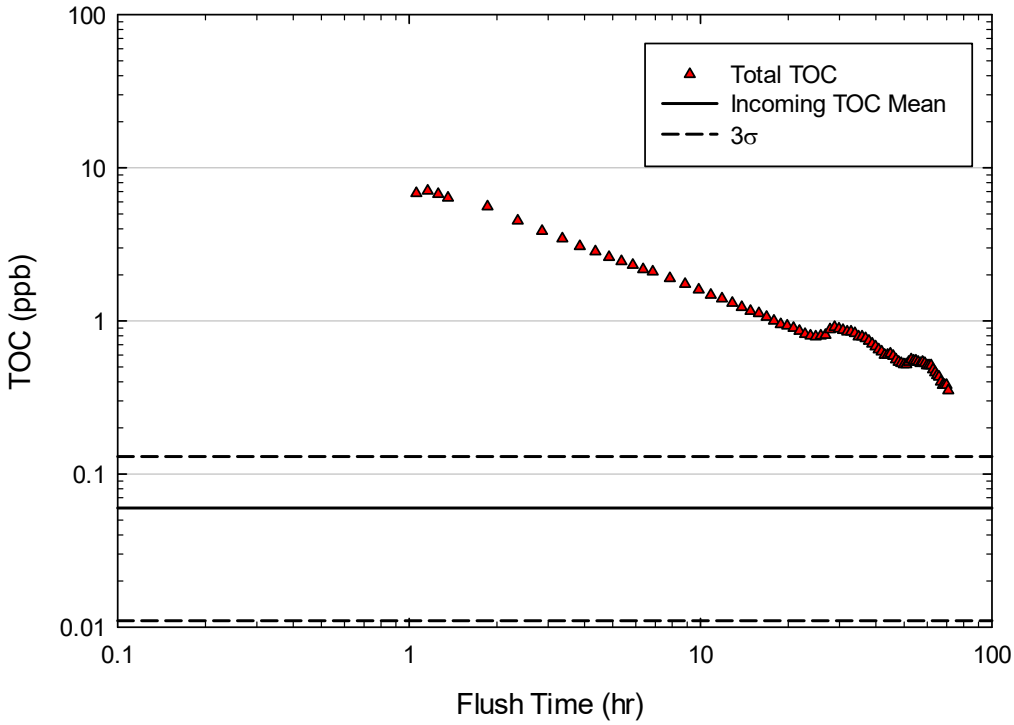


Figure 5. – Resistivity Decrease vs. Time.

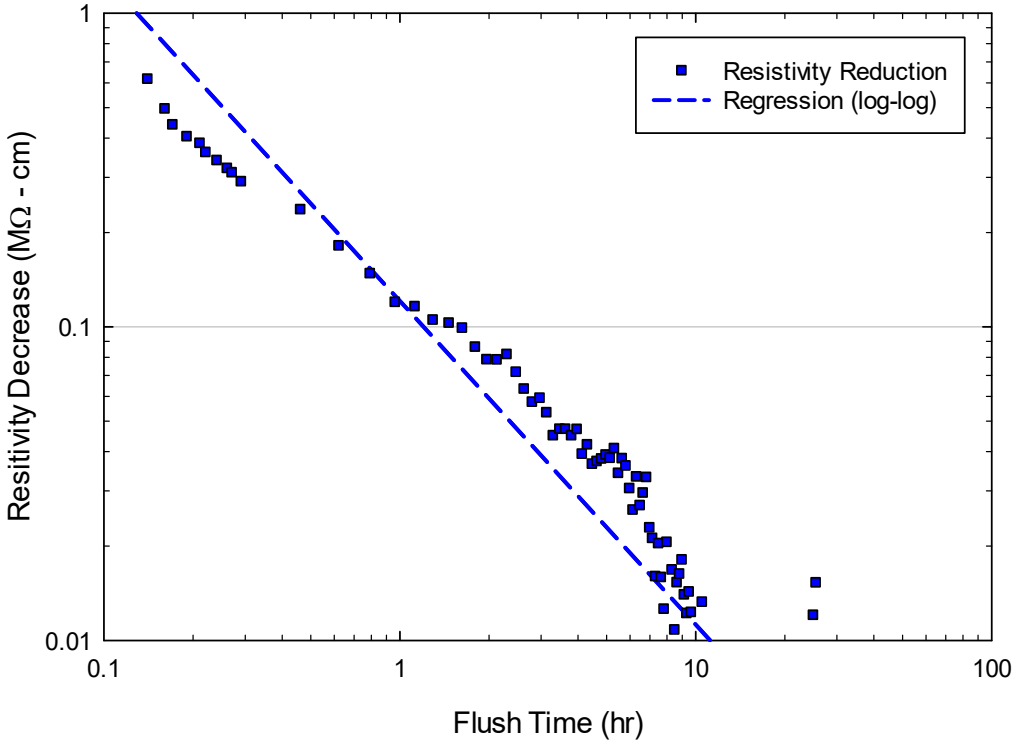


Figure 6. – Resistivity recovery vs. time.

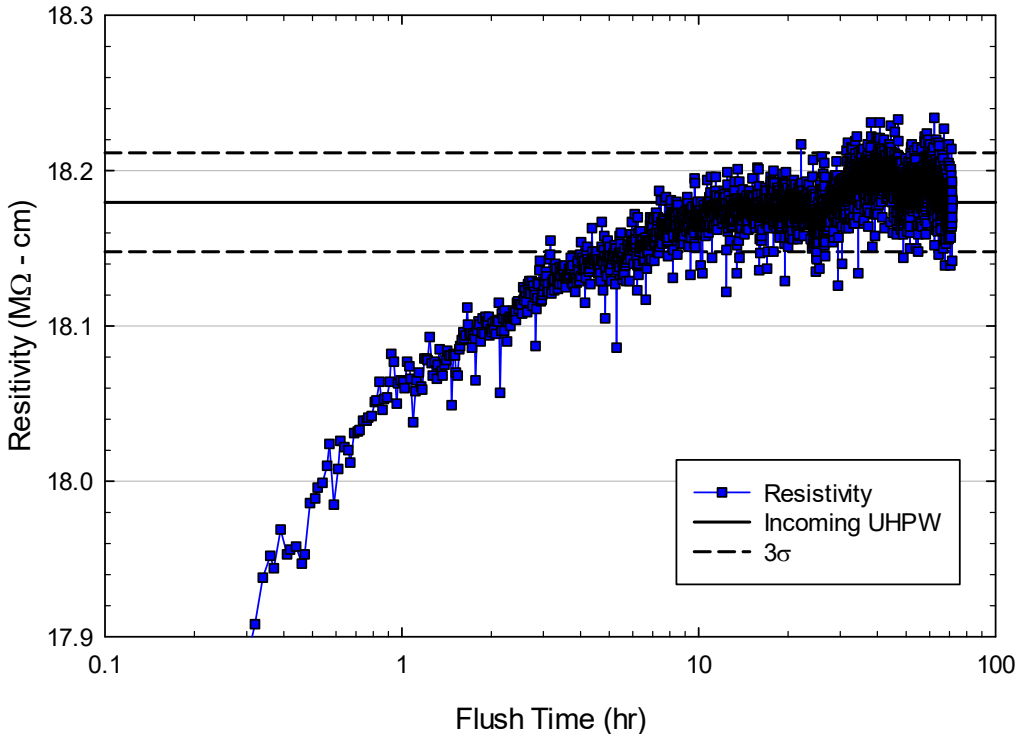
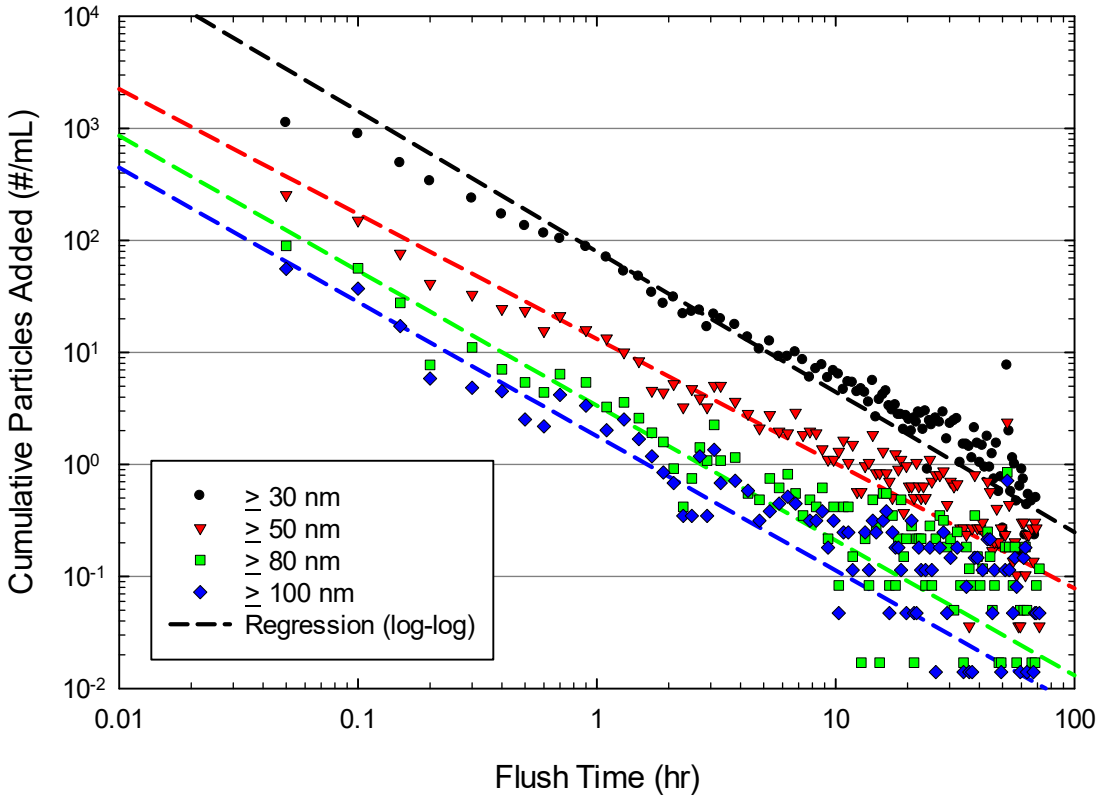


Figure 7. – Particle release vs. time.



Air Liquide Electronics, U.S. LP - Balazs™ Analytical Services
13456 North Central Expressway, Dallas TX 75243
Telephone (214) 878-4573

ANALYTICAL TEST RESULTS

Customer Information

Name: Graver technologies-
Address:
Contact:
Phone: 302-731-3540 **Fax:**

Spec Number	DI_EXTRACT_EXT-GENERAL	Sample Number	1411083
Harmony Part No.		Status	Authorized
Chemical:	EXTRACTIONS	Logged By	NPHUNG
Sample Type		Received Date	10/28/2021 12:25:59PM
Vessel:		Completed Date:	10/29/2021 12:48:49PM
Vessel Serial #:	BLANK	PO Number	N-154058
Lot Number:	BLANK	Quote # :	None
Sample In-Spec:	Yes	IC Bottle ID:	None
Date Sample Pulled:	10/21/2021 12:23:42PM	Metals Bottle ID:	None
Description:	LEACH CONDITION: LEACH FOR 24 HRS AT AMBIENT TEMP IN 1.5L UPW. RESULTS REPORTED IN PPBW REF LIMS#1309680		

DI_EXTRACT **Authorized** **Approval By: Michael Sloane,Production Laboratory Manager**

Test Comments: Extracted at ambient temperature

Analysis / Rep	Result Value	LCL	UCL	LSL	USL	Units	Entered By
Extraction Time	24					Hour	RODZ
Extraction Volume	1.5					L	RODZ

ANION_PPB **Authorized** **Approval By: Michael Sloane,Production Laboratory Manager**

Test Comments: There are no comments associated with this test

Analysis / Rep	Result Value	LCL	UCL	LSL	USL	Units	Entered By
Bromide	<3					ppb	KUPRETY
Chloride	<5					ppb	KUPRETY
Fluoride	<5					ppb	KUPRETY
Nitrate	<4					ppb	KUPRETY
Nitrite	<5					ppb	KUPRETY
Phosphate	<6					ppb	KUPRETY
Sulfate	<4					ppb	KUPRETY

TOC_DIW **Authorized** **Approval By: Michael Sloane,Production Laboratory Manager**

Test Comments: There are no comments associated with this test

Analysis / Rep	Result Value	LCL	UCL	LSL	USL	Units	Entered By
TOC	<0.85					ppm	RODZ

ICPMS_DIW3 **Authorized** **Approval By: Michael Sloane,Production Laboratory Manager**

Test Comments: There are no comments associated with this test

Analysis / Rep	Result Value	LCL	UCL	LSL	USL	Units	Entered By
Aluminum	<0.005					ppb	LABSTATION
Antimony	<0.004					ppb	LABSTATION
Arsenic	<0.007					ppb	LABSTATION
Barium	<0.002					ppb	LABSTATION
Bismuth	<0.005					ppb	LABSTATION
Boron	<0.006					ppb	LABSTATION
Cadmium	<0.004					ppb	LABSTATION
Calcium	0.889					ppb	LABSTATION
Chromium	<0.005					ppb	LABSTATION
Cobalt	<0.003					ppb	LABSTATION
Copper	0.174					ppb	LABSTATION
Gallium	<0.004					ppb	LABSTATION
Germanium	<0.004					ppb	LABSTATION
Iron	<0.005					ppb	LABSTATION
Lead	<0.003					ppb	LABSTATION
Lithium	<0.004					ppb	LABSTATION
Magnesium	0.015					ppb	LABSTATION
Manganese	<0.004					ppb	LABSTATION
Molybdenum	<0.003					ppb	LABSTATION
Nickel	<0.003					ppb	LABSTATION
Niobium	<0.005					ppb	LABSTATION
Potassium	0.056					ppb	LABSTATION
Silver	<0.006					ppb	LABSTATION
Sodium	0.089					ppb	LABSTATION
Strontium	0.003					ppb	LABSTATION
Tin	<0.004					ppb	LABSTATION
Titanium	0.007					ppb	LABSTATION
Tungsten	0.006					ppb	LABSTATION
Vanadium	<0.005					ppb	LABSTATION
Zinc	0.077					ppb	LABSTATION

NOTES