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WHA Test Report on In-Line and Tee Type Filters

For

Chase Filters and Components, LLC

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WHA Test Report on Chase Filters

Introduction

Chase Filters and Components, LLC requested that Wendell Hull & Associates Inc. (WHA) conduct pneumatic impact testing in gaseous oxygen to evaluate the ignition propensity of the test articles indicated below:

Test Article:	In-Line and Tee Type Filters
Test Articles Supplied by:	Chase Filters and Components, LLC

Test Document

ASTM G175 *"Standard Test Method for Evaluating the Ignition Sensitivity and Fault Tolerance of Oxygen Regulators Used for Medical and Emergency Applications"* Phase 2: Regulator Inlet Promoted Ignition Test

Typical test conditions applied to the filters were based on the requirements of the test document listed above, however, were modified to be more applicable to the service conditions of the filters. The test conditions are summarized below.

Phase 2 Testing

Test Pressure:	3000/5000 psig, (see Test Results for details)
Test Gas:	Oxygen – 99.5% (minimum)
Pressurization Rate:	20 ms (+0, -5 ms)
Test Gas Temperature:	60 ^{o}C (+/- 3 ^{o}C)
Ignition Pill	Standard ASTM G175
Ignition Pill Location:	Immediately upstream of the test article inlet

Test Setup:

The test system consisted of an accumulator to supply heated (~ 60 ^{o}C), high-pressure oxygen to a rapid opening or "impact valve". Prior to testing, calibration cycles were performed on the WHA test system to ensure that the required pressure rise time of 15 to 20 milliseconds was achieved at the end of a capped, 1 meter long, 5-mm inside-diameter tube. A test article was affixed to the WHA test system at an interface located a distance of 1 meter from the impact valve. A vent valve to relieve pressure in the test system was located between the WHA impact valve and the test article. A high frequency response pressure transducer was provided to ensure that the required test article pressurization rate was achieved for each cycle. Pressurization rates were monitored and recorded during each pressure shock. An oxygen supply was provided to replenish the test system accumulator between test cycles. The test was performed under computer control and data was recorded digitally.

Test Article Description

The test articles were Brass Inline, Brass Tee Type, Stainless Steel Inline and Stainless Steel Tee Type filters. The Brass filters utilized Brass filter elements and the Stainless Steel filters utilized Stainless Steel filter elements. One Stainless Steel Inline Filter (TA-SI-1) and one Stainless Steel Tee Type Filter (TA-ST-1) were tested. Five Brass Inline Filters (TA-BI-1 to TA-BI-5) and five Brass Tee Type Filters (TA-BT-1 to TA-BT-5) were tested. A typical Stainless Steel Tee Type Filter, Stainless Steel Inline Filter, Brass Tee Type Filter and Brass Inline Filter are shown in their "as received" condition in Photos 1-4, respectively. Photo 5 shows a typical Tee Type Filter installed on the WHA test system. Photo 6 shows a typical Inline Filter installed on the WHA test system.

Modified ASTM G175 Phase 2 Test Conditions

All filters were tested according to the WHA Modified Phase 2 test procedure. The ASTM G175 Phase 2 procedure was modified by WHA to better simulate the actual service conditions of the filters. An ignition pill was installed immediately upstream from the filter inlet. Additional contaminant was applied to the filter element and placed at the filter inlet. This additional contaminant was based on contaminant potentially present in a filter that has been in service for some time. A back pressure was applied to the filters to ensure that the filters were pressurized during the time frame that the fire from the ignition pill entered the filters. An orifice was placed just downstream of the filter outlet. This orifice was used to simulate the flow rate of a typical component that would be installed downstream of these filters during normal use. The filters were impacted with oxygen at the desired test pressure. The oxygen pressure surge was applied to the filter inlet and thus igniting the ignition pill. Table 1 provides further details regarding the test pressure, additional contaminant, downstream orifice size and other specifics for each filter tested.

Table 1: Chase Filters Modified ASTM G175 Test Matrix.

Filter Type	Test Press	Contaminant	Downstream Orifice	Tests Performed	Result
Inline/ SS	5000	100 mg Al powder, 250 mg iron particles inserted at the filter inlet. A thin layer of Krytox was smeared on the filter element.	0.040 in	1	Ignition pill and contaminant ignited and propagated through the filter body.
Tee/ SS	3000	1 g Al powder, 2.5 g iron particles inserted at the filter inlet. A thin layer of Krytox was smeared on the filter element.	0.040 in	1	Ignition pill and contaminant ignited and propagated through the filter body.
Tee/ Brass	5000	1 g Al powder, 2.5 g iron particles inserted at the filter inlet. A thin layer of Krytox was smeared on the filter element.	0.040 in	5	Ignition pill and contaminant ignited but didn't kindle the filter element and propagate through the filter body. Note: The first test had a test pressure of 3000 psi, the rest were 5000 psi.
Inline/ Brass	5000	100 mg Al powder, 250 mg iron particles inserted at the filter inlet. A thin layer of Krytox was smeared on the filter element.	0.040 in	5	Ignition pill and contaminant ignited but didn't kindle the filter element and propagate through the filter body.
Note: 1. All tests were performed with a back pressure of 2000 psi on the filter. 2. A standard ASTM G175 ignition pill and an 82 mg nylon blank were placed just upstream of the filters, pretest.					

Test Results

Twelve (12) test articles were subjected to positive ignition testing according to the requirements of the WHA Modified ASTM G175 testing. Testing was performed on the following test articles: Five (5) Brass Inline filters (TA-BI-1, TA-BI-2, TA-BI-3, TA-BI-4 and TA-BI-5), five (5) Brass Tee type filters (TA-BT-1, TA-BT-2, TA-BT-3, TA-BT-4 and TA-BT-5), one (1) Stainless Steel Inline filter (TA-SI-1) and one Stainless Steel Tee type filter (TA-ST-1). The test articles were exposed to the ignition and combustion of a standardized ignition pill and a typical 82mg nylon ignition pill blank. This ignition pill blank was used to seal the back pressure within the filter before the impact event.

Stainless Steel Filters:
For the Stainless Steel Inline and Tee type filter, sustained promoted ignition of the Stainless Steel filters bodies occurred. Post-test photographs of the Stainless Steel Inline and Tee type filters are shown in Photos 7-14.

Based on the results observed during this testing, both of the Stainless Steel filters (Inline and Tee type) that were tested were judged by WHA personnel to have FAILED the requirements of the WHA Modified ASTM G 175 Phase 2 Promoted Ignition Test.

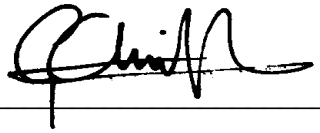
Brass Filters:
For the Brass Inline and Tee type filters, sustained promoted ignition of the filter bodies and internal components did not occurred. Some heat deterioration on each test article was observed, due to the energy delivered by the pill and the additional contaminant that was consumed. No external flame or breach of the pressurized filter was observed during the testing. Post-test photographs of the Brass Inline and Tee type filters are shown in Photos 15-22.

Based on the results observed during this testing, all ten (10) of the Brass filters (Inline and Tee type) that were tested were judged by WHA personnel to have successfully PASSED the requirements of the WHA Modified ASTM G 175 Phase 2 Promoted Ignition Test.

Test Conducted By:

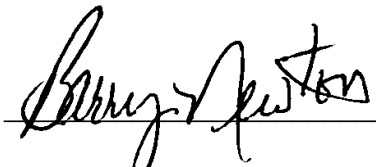
Greg Odom, BSME
Wendell Hull & Associates, Inc.

Test Results Reviewed by:



Gwenael Chiffoleau, BEng, PhD
Wendell Hull & Associates, Inc.

Test Results Approved By:



Barry Newton, BSME, PE
Wendell Hull & Associates, Inc.

DISCLAIMER:

WHA does not endorse or warrant any component or item tested by WHA personnel as being suitable for any design function or service application what-so-ever. Wendell Hull & Associates, Inc. has not performed any evaluation or testing beyond that stated herein, and expressly denies any responsibility for having evaluated the test article for function or safety. WHA disavows any responsibility for the function or safety of test articles.

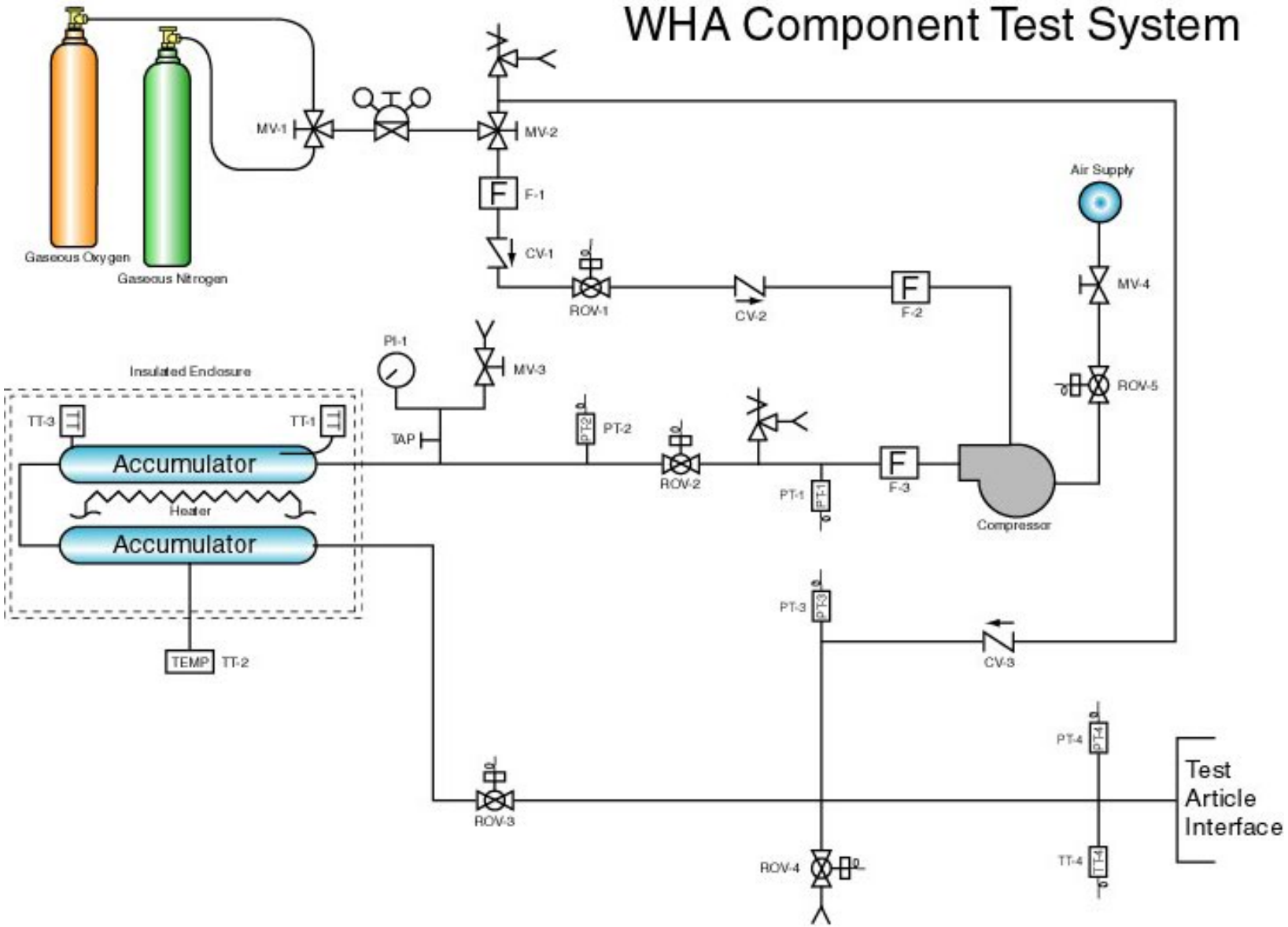


Figure 1: WHA Test System Schematic.

Photo 1: Typical Stainless Steel Tee Type Filter in its "as received" condition.

Photo 2: Typical Stainless Steel Inline Filter in its "as received" condition.

Photo 3: Typical Brass Tee Type Filter in its "as received" condition.

Photo 4: Typical Brass Inline Filter in its "as received" condition.

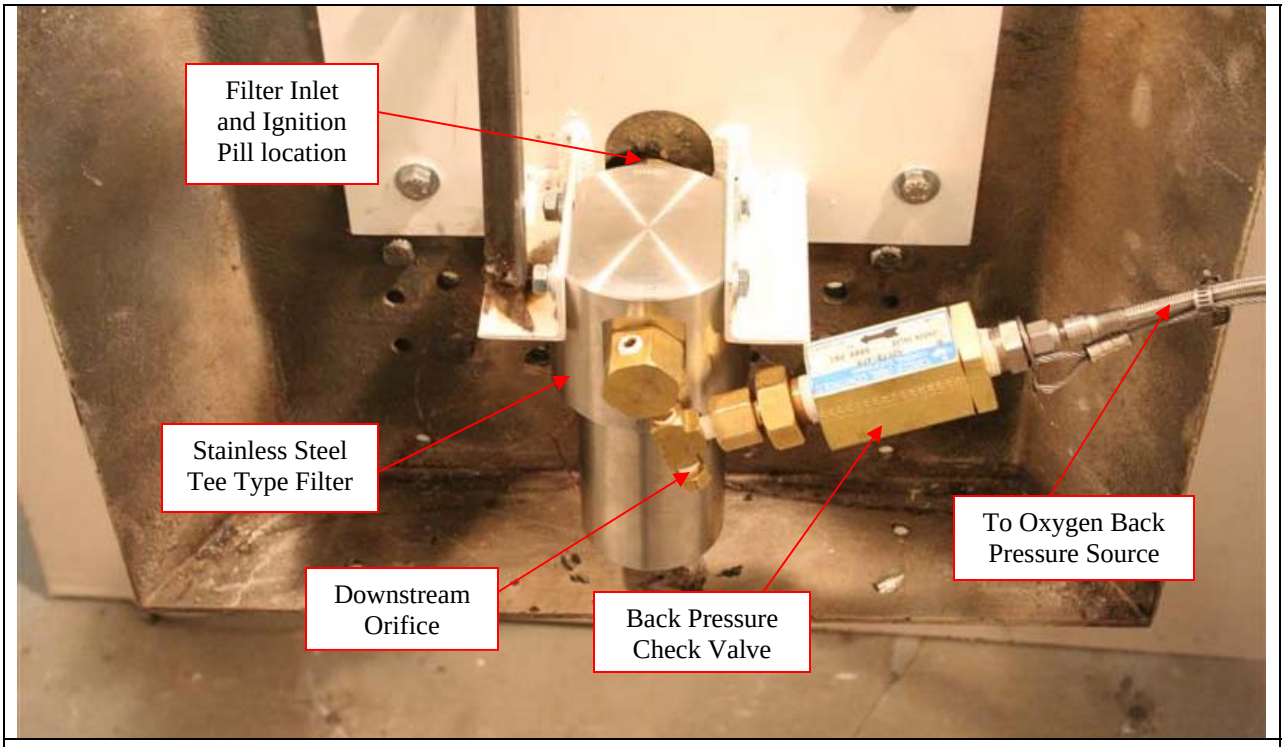


Photo 5: Typical Tee Type Filter as installed on the WHA test system.

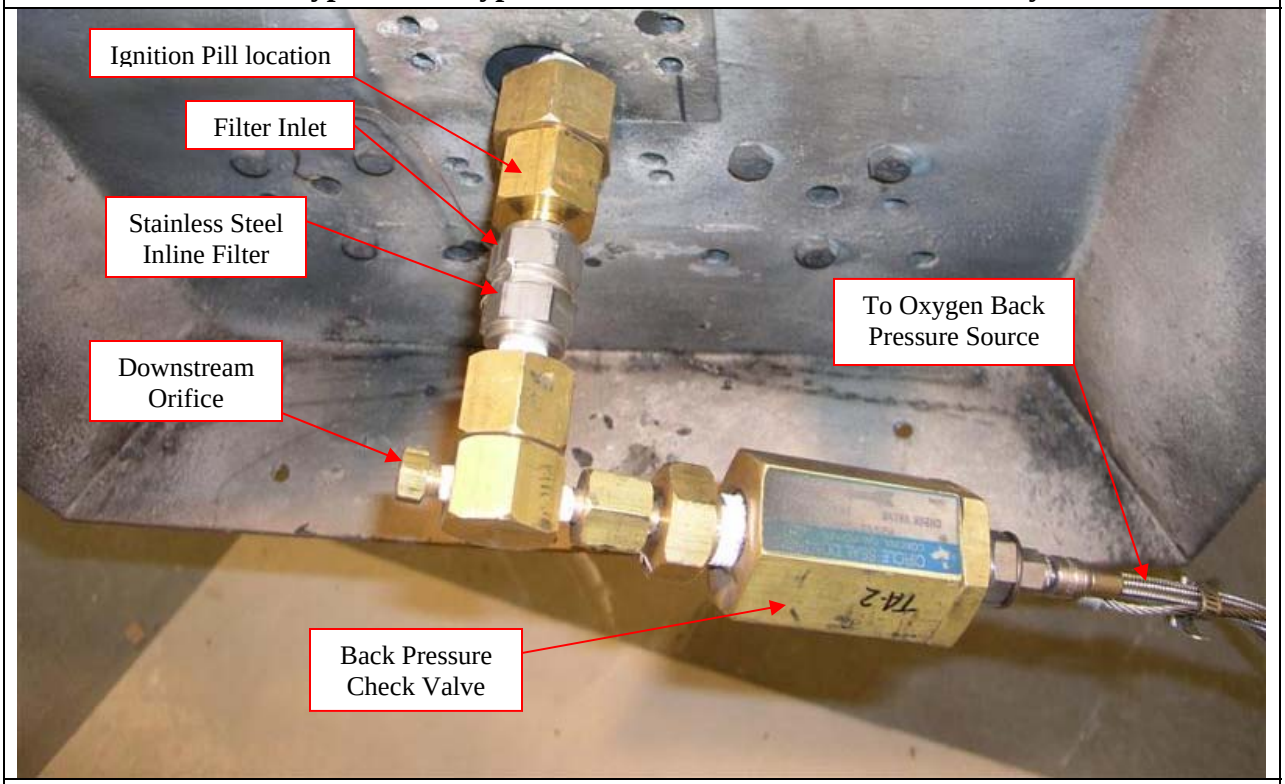


Photo 6: Typical Inline Filter as installed on the WHA test system.

Photo 7: Post-test view of test article TA-ST-1 (Stainless Steel Tee Filter).

Photo 8: Post-test view of test article TA-ST-1 (Stainless Steel Tee Filter).

Photo 9: Post-test view of test article TA-ST-1 (Stainless Steel Tee Filter Housing).

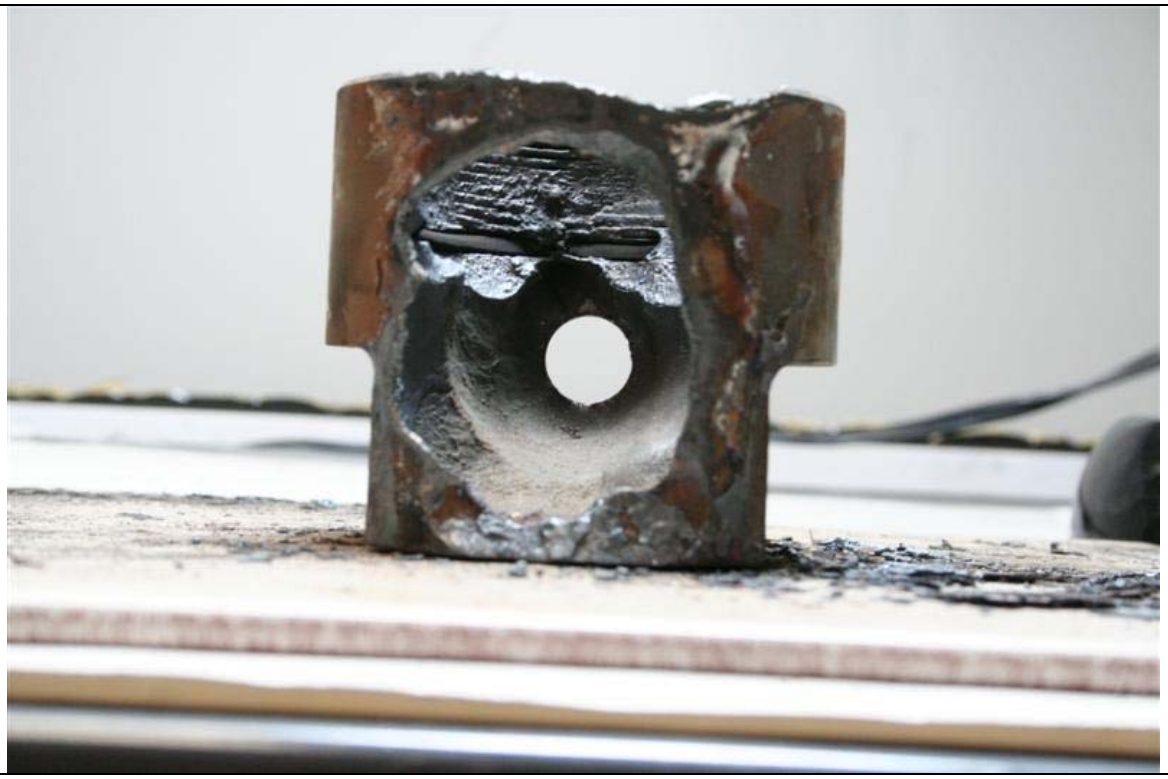


Photo 10: Post-test view of test article TA-ST-1 (Inlet, near side/Outlet, far side).

Photo 11: Post-test view of test article TA-SI-1 (SS Inline Filter).

Photo 12: Post-test view of test article TA-SI-1 (SS Inline Filter).

Photo 13: Post-test view of test article TA-SI-1 (SS Inline Filter).

Photo 14: Post-test view of test article TA-SI-1 (SS Inline Filter).

Photo 15: Post-test disassembled view of test article TA-BT-2 (Typical).

Photo 16: Post-test close-up view of test article TA-BT-2 filter element (Typical).

Photo 17: Post-test close-up view of test article TA-BT-2 filter element (Typical).

Photo 18: Post-test close-up view of test article TA-BT-2 filter element.

Photo 19: Post-test view of test article TA-BI-1 (Typical).

Photo 20: Post-test view of test article TA-BI-1 (Typical).

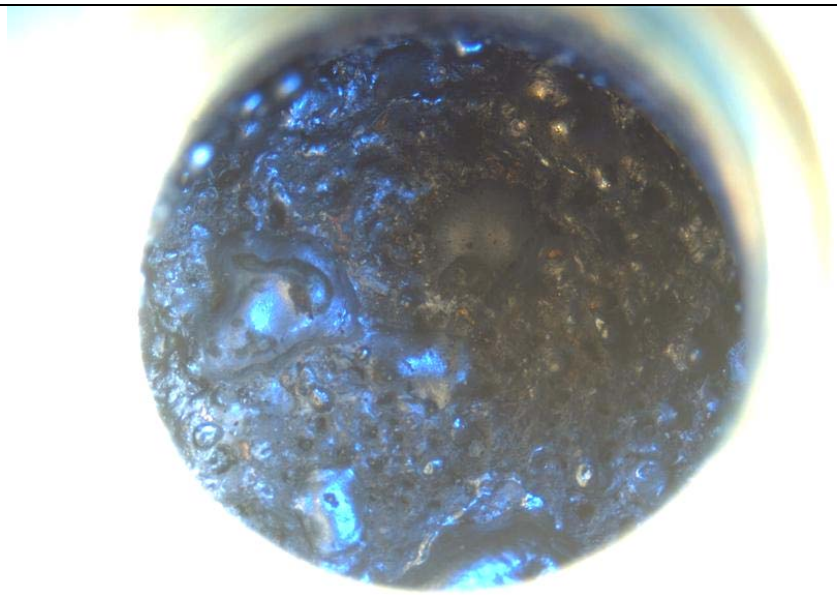


Photo 21: Post-test close-up view of test article TA-BI-1 Filter Element (Inlet Side).

Photo 22: Post-test close-up view of test article TA-BI-1 Filter Element (Outlet Side).