



**PERMA-FIX OF FLORIDA
Gainesville, Florida**

VTD DEMONSTRATION TEST REPORT

August 2024

Volume 1

Prepared for:

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1.0 INTRODUCTION

Perma-Fix of Florida, Inc. (PFF), a Perma-Fix Environmental Services, Inc. (PESI) company, owns and operates a Resource Conservation and Recovery Act (RCRA) permitted hazardous and mixed waste storage and treatment facility located in Gainesville, Florida. The primary facility activities include storage and treatment of wastes within containers and specialized units, including a RCRA permitted vacuum thermal desorption (VTD) system. The VTD process applies controlled indirect heat, vacuum, and inert gas purge to separate contaminants from waste solids and sludges. The regulated contaminants (e.g., land disposal restricted organic compounds) and non-regulated substances (e.g., water vapor and oils) are condensed and recovered in a liquid form. The liquids are then processed using appropriate treatment technologies including combustion for organics. The facility is currently permitted for the storage of Toxic Substances Control Act (TSCA) regulated polychlorinated biphenyl (PCB) waste by approval of the United States Environmental Protection Agency (EPA) Region 4.

The performance testing of the VTD was conducted March 26 - March 30, 2024 as authorized by the EPA Risked-Based Approval dated June 15, 2023 and the PFF notification of testing dated January 19, 2024. The following EPA personnel were present for the testing:

Ms. Terri-Crosby Vega, EPA Region 4;

Mr. James Bennet, EPA Region 4; and

Mr. Paul Diss, EPA Headquarters

1.1 RCRA/TSCA Demonstration Test Objectives and Regulatory Basis for VTD

Performance testing of the VTD system to allow EPA designation as a TSCA 40 CFR §761.60(e) alternate PCB destruction technology¹ was the primary objective. Demonstration of waste treatment with emissions control performance equivalent to a RCRA combustion unit was a secondary goal². Hence, in support of both regulatory programs, a joint RCRA/TSCA Demonstration Test Plan (DTP) was prepared to communicate the proposed testing protocol. Rationale for the coordinated approach is presented in Section 2.2 of the DTP and considered the existing RCRA Subtitle C regulation of PCB wastes - that are also hazardous wastes.

The VTD demonstration test objectives are summarized below according to RCRA and TSCA standards of performance. 40 CFR Part 264 Subpart O and 40 CFR Part 63 Subpart EEE Incinerator criteria were selected for most RCRA metrics. However, the VTD is in fact a non-combustion contaminant separation and recovery process, and is technically more similar to 40 CFR §264.1030 regulated units (i.e., distillation, fractionation, air/steam strippers, etc.). The waste PCB separation process efficiency is dependent upon several factors. Hence, VTD performance

¹ Alternatively, the VTD may be authorized for continued operation under the 40 CFR §761.61(c) Risk Based Approval issued by EPA for conducting the performance testing.

² A treatment equivalency variance to the RCRA CMBST technology treatment standard in 268.42 may be requested in the future. Demonstration of equivalent emissions control to RCRA combustion units, as set forth by the 40 CFR Part 63 Subpart EEE incinerator NESHAPS, would become a key technical basis for that determination.

testing that can demonstrate replicate batch concentrations <2 ppmw would qualify for a TSCA Approval - contingent upon the emission metrics meeting the performance levels.

The TSCA standards were based upon historical guidance for Incinerators used to combust PCB wastes as a “destruction disposal process”. EPA guidance³ for alternate PCB disposal technologies, including units regulated under a §761.60(e) Approval, also stipulates the incinerator equivalent metrics.

TSCA

- $\geq 99.9999\%$ removal efficiency (RE) for total PCBs calculated from the mass of PCBs (as 1,2-dichlorobenzene (1,2-DCB) for the PCB surrogate) within waste batch versus mass emitted within the process gas discharged from the VTD;
- <2 or <10 ppmw (as 1,2-DCB mass) treated waste batch total 1,2-DCB concentration;
- < 4.0 lbs/hr HCl emission rate;
- < 0.20 ng TEQ/dscm combined Dioxins and Furans emission rate;

RCRA

- $\geq 99.99\%$ RE for designated hazardous semivolatile organic compounds (SVOCs) calculated by mass of individual compounds within waste batch versus mass emitted within the process gas discharged from the VTD;
 - $\geq 95\%$ RE for designated hazardous volatile organic compounds (VOCs) calculated by mass of individual compounds within waste batch versus mass emitted within the process gas discharged from the VTD;
 - < 0.015 grains/dscf Particulate Matter (PM) concentration;
 - Semi-volatile (i.e., lead + cadmium) <10, low volatile (i.e., arsenic + chromium + beryllium) <23, and volatile (i.e., mercury) <8.1 metals emissions concentrations [ug/dscm corrected to 7% O₂];
 - < 21 ppmvd as Cl⁻ equivalents combined HCl + Cl₂ concentration; and
 - < 0.20 ng TEQ/dscm combined Dioxins and Furans concentration.
- All concentrations were corrected to 7% O₂ concentration in the VTD process gas.

1.2 Demonstration Test Conditions Discussion

In accordance with the approved DTP, four (4) replicate batch treatment test runs were performed to evaluate the unit’s performance for comparison to the RCRA/TSCA performance levels. Section 3.0 of this report presents the specific waste composition parameters for each batch which were used without changes. To facilitate identical feed composition, pre-weighed and analyzed surrogate (i.e., non-waste/non-radioactive) product materials were used in conjunction with pre-weighed and analyzed contaminant spike fluid additions. The spiking of volatile and semi-volatile organics, high concentration 1,2-DCB liquid (as the PCB surrogate), and aqueous

³ USEPA Office of Pesticides and Toxic Substances internal document publication dated October 1, 1988: Guidance Manual for Writers of PCB Disposal Permits for Alternate Technologies

metal solutions into each batch was conducted per plan. EPA personnel visually witnessed the VTD vessel (trays) loading for each batch from two drums along with grab samples taken for independent lab analysis. PFF personnel performed video recording of each material addition into the feed drums, including a scale digital readout of the mass amounts added. Sub-samples of the organics and metals spikes were taken for independent analysis of mass concentrations for verification. These results are presented in Volume 2, Appendix B.

The batch treatment protocol containing the specific operating conditions to be followed for each test run was provided in the DTP Section 3.7. The runs were conducted in general agreement with the plan protocol; with adjustments to temperatures and ramp/hold durations based on system pre-testing results⁴. The treatment protocol followed for the testing is provided in Volume 2, Appendix A.

During the DTP development, consideration was given to the VTD organic feeds and emissions to assess the organic loading concentrations expected in the VTD process vent gas at the point of sample collection. It was determined from previous experience, that the proposed organic sampling methods, which are typically used for high efficiency combustion units, could have collection capacity issues with the potential VTD lower organic removal efficiencies and extended run durations. A reduction in organic feeds combined with a continuous, nominal 10-fold volumetric dilution of the process vent gas flow prior to sampling was conducted to prevent the organics sampling resins overloading problem. The process vent gas was combined with approximately 50 scfm of filtered makeup air throughout the testing. The combined flows were routed through a pipeline static mixer to achieve a well-mixed condition prior to entering a straight pipe section (to eliminate turbulence) followed by the nominal 3-inch diameter emissions sampling pipe section. The dilution flow and sampling arrangement was maintained during all batch runs as planned, but with a slightly higher volumetric dilution factor of the process vent flow as an artifact of the lower VTD vent gas flow rates. No organic collection resin overloading occurred in any test run.

The air-diluted VTD process vent flow (i.e. *combined gas flow*) contained oxygen at near ambient air levels (~19%) at the sampling locations. Certain numerical concentration-based emission standards (e.g., particulate matter, dioxins/furans, and others as noted in Section 1.1) employ a correction to the measured results for a 7% oxygen concentration basis. In order to properly determine the correction factor as intended by the regulations, monitoring of the VTD process vent gas oxygen level, prior to air dilution, was performed. The emissions testing contractor, Montrose Environmental, employed an oxygen/carbon monoxide/carbon dioxide-certified CEMS system that measured a vent gas sample that was extracted prior to any air dilution. Hence, oxygen levels from the run sampling periods were determined and applied from the CEMS recorded data. Continuous CO and CO₂ measurements were also recorded for process informational purposes.

⁴ Pre-testing of the VTD was performed to verify certain emissions data and establish the operating conditions to be used for the actual testing.

The combined gas flow parameters were measured using EPA or SW-846 reference methods during the entire duration of each batch test run. The gas parameters and their associated sampling methods included:

- Total 1,2-DCB (as the PCB surrogate) using SW-846 Method 0010;
- Dioxins and furans using EPA Method 23;
- Semi-volatile organic compounds (spiked naphthalene) using SW-846 Method 0010;
- Volatile organic compounds (tetrachloroethylene and m, o, p-xylenes) using SW-846 Method 0031;
- Particulate matter using EPA Method 5;
- HCl/Cl₂ using EPA Method 26A;
- Metals (arsenic, cadmium, chromium, lead, and mercury) using EPA Method 29;
- Carbon monoxide using EPA Method 10;
- O₂ and CO₂ using EPA Method 3A; and
- Volumetric flow rate using EPA Methods 1A (small duct sampling location and traverse points), 2C (small duct velocity and flow rate using a calibrated hot-wire anemometer), and 4 (moisture content measured in the isokinetic sampling trains).

In addition to measuring the combined gas flow rate, the flow rate of the VTD process vent gas prior to the combined gas flow static mixer was measured continuously using EPA Methods 1A and 2C. This flow rate measurement allowed for the calculation of the dilution factor, based upon the ratio of the average flow rates measured by the designated measurement point in both VTD process vent and combined gas flows. The dilution factor was applied to the emissions resulting in corrected concentrations emitted directly from the VTD process. Please refer to the DTP Figure 4-1, VTD Dilution Flow Emissions Sampling Arrangement, for the physical configuration and sampling location points.

On-site test activities occurred over a period of 5 days. The four runs were conducted sequentially and are chronologically detailed below:

- Run 1 – 1,065 minutes (17.75 hours)
Start - 3/26/2024 at 0925; Stop - 3/27/2024 at 0310
- Run 2 – 1,140 minutes (19.00 hours)
Start – 3/27/2024 at 0925; Stop – 3/28/2024 at 0417
- Run 3 – 1,080 minutes (18.00 hours)
Start – 3/28/2024 at 0840; Stop – 3/29/2024 at 0333

- Run 4 – 1,071 minutes (17.85 hours)
Start – 3/29/2024 at 0925; Stop – 3/30/2024 at 0312

1.3 Demonstration Test Report Organization

The information presented in this report is organized as follows:

Volume 1 VTD Demonstration Test Report

Section 1.0 - Introduction

Section 2.0 – Demonstration Test Performance Summary

Section 3.0 – Sampling and Monitoring Procedures

Section 4.0 – Demonstration Test Results

Section 5.0 – Test Results Calculations

Volume 2 VTD Operations

Appendix A - VTD Process Data

Appendix B – VTD Batch Feedstock Preparation and Spike Data

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2.0 VTD DEMONSTRATION TEST PERFORMANCE SUMMARY

This report section presents a summary of the test results and the proposed operational limits based on the four batch runs conducted during the PFF VTD Demonstration Test in March 2024. The results include mass feed and corresponding emissions data, with comparison to TSCA and RCRA emission standards as defined in the DTP Section 3.0. The treated batch solids residual 1,2-dichlorobenzene (1,2-DCB) concentrations, as the designated total PCBs surrogate, are also presented to relate the effectiveness of the VTD in removing the compound from the feed.

2.1 Compliance Summary of Results

Table 2-1 Compliance Summary table presents the feed, emissions, and removal efficiencies results that demonstrate regulatory standard compliance with the limits established in the approved test plan.

2.2 Process Data Summary of Results

Table 2-2, the PFF VTD Process Data Summary, presents the relevant process data from the four runs of the Demonstration Test.

2.3 Proposed Operating Parameter Limits

Table 2-3 presents the PFF VTD proposed feed and process operating parameter limits (OPLs) based on the demonstration test runs as well as operational safety basis. The OPLs will be used as continuous boundary limits during VTD operations.

**Table 2-1. PFF VTD Demonstration Test – Gainesville, Florida
March 2024
Compliance Summary**

Parameter	Units	Run 1	Run 2	Run 3	Run 4	Performance Standard
Run Duration	min/hrs	1,065/17.75	1,140/19.00	1,080/18.00	1,071/17.85	—
Moisture (average of sampling trains)	% vol	1.2	1.1	0.9	0.8	—
O ₂ concentration (process vent gas)	% vol	2.1	1.8	1.6	1.8	—
CO ₂ concentration (process vent gas)	% vol	0.5	0.5	0.2	0.2	—
CO concentration (process vent gas)	ppmvd	314	288	329	331	—
Temperature (process vent gas)	°F	77.6	72.6	72.5	73.0	—
Velocity (process vent gas)	std ft/min	310.8	277.1	257.1	217.4	—
Flow rate (process vent gas)	std ft ³ /min	7.89	7.03	6.52	5.52	—
Flow rate (combined gas vent)	std ft ³ /min	60.047	62.626	59.904	58.895	—
Combined gas/process vent gas dilution factor	—	7.61	8.90	9.18	10.67	—
RCRA and TSCA						
Particulate Matter concentration (adjusted for dilution factor; corrected to 7% O ₂ in process gas vent)	grains/dscf @7% O ₂	0.00094	0.00091	0.00531	0.00011	< 0.015
HCl emission rate (DF adjusted)	lb/hr	1.24E-06	7.00E-07	4.01E-07	3.01E-07	< 4.0
HCl concentration (DF/@ 7% O ₂)	ppmvd	0.020	0.013	0.0078	0.0070	—
Cl ₂ concentration (DF/@ 7% O ₂)	ppmvd	0.013	0.020	0.018	0.022	—
Total HCl/Cl ₂ concentration DF/@ 7% O ₂ as Cl ⁻)	ppmvd @7% O ₂	0.047	0.054	0.043	0.052	< 21
TSCA						
1,2-dichlorobenzene (PCB) feed	lb per batch	12.093	12.093	12.093	12.093	—
1,2-dichlorobenzene emitted (DF)	lb	1.18E-05	8.08E-06	9.60E-06	1.18E-05	—
1,2-dichlorobenzene SRE	%	99.999902	99.999933	99.999921	99.999903	≥99.9999
Discharge treated batch solids 1,2-dichlorobenzene concentration	mg/kg	0.505	ND (0.290)	ND (0.290)	0.525	< 2
RCRA						
2,3,7,8-TCDD TEQ concentration (adjusted for dilution factor; corrected to 7% O ₂ in process gas vent)	ng/dscm @7% O ₂	0.0046	0.0060	0.0044	0.0015	< 0.20
SVOC (naphthalene) feed	lb per batch	0.749	0.749	0.749	0.749	—
SVOC (naphthalene) emitted	lb	<8.80E-06	<9.98E-06	<9.88E-06	<1.07E-05	—
SVOC (naphthalene) SRE	%	>99.9988	>99.9987	>99.9987	>99.9986	≥99.99
VOC (total xylenes) feed	lb per batch	1.168	1.168	1.168	1.168	—
VOC (tetrachloroethylene) feed		0.840	0.840	0.840	0.840	—
VOC (total xylenes) emitted	lb	2.25E-05	4.32E-05	1.92E-05	2.79E-05	—
VOC (tetrachloroethylene) emitted		9.53E-06	1.50E-05	9.60E-06	8.27E-06	—
VOC (total xylenes) SRE	%	99.9981	99.9963	99.9984	99.9976	≥99.99
VOC (tetrachloroethylene) SRE		99.9989	99.9982	99.9989	99.9990	
Metals concentrations - Total Low-volatile metals (As, Cr) Total Semi-volatile metals (Cd, Pb) Volatile metals (Hg) (adjusted for dilution factor; corrected to 7% O ₂ in process gas vent)	ug/dscm @7% O ₂	1.08 1.05 3.0	5.24 1.34 4.0	1.19 0.464 2.5	5.71 0.985 0.24	<23 <10 <8.1

ND – Not Detected above the Method Detection Limit (MDL). Highest MDL is presented in parentheses.

**Table 2-2. PFF VTD Demonstration Test – Gainesville, Florida
March 2024
Process Data Summary**

Parameter	Run 1	Run 2	Run 3	Run 4	Average
Batch Mass Feed Rate (lb) ⁴	1,000.	1,000.	1,000.	1,000.	1,000.
Batch PCB-Surrogate Feed Rate (lb) ¹	12.093	12.093	12.093	12.093	12.093
Batch RCRA Organic Feed Rate (lb) ²	14.850	14.850	14.850	14.850	14.850
Batch RCRA Metal Feed Rate (lb) ³	0.609	0.609	0.609	0.609	0.609
VTD Vacuum Pressure (in Hg) Process Tag – PT-1	14.2	13.1	13.4	13.7	13.6
VTD Exit O ₂ Concentration (%) Process Tag – AIT-1-02	1.6	1.4	1.5	1.5	1.5
Carbon Bed Inlet Temperature (°F) Process Tag – TE-11	117.9	112.7	112.4	108.3	112.8

¹ PCB surrogate was 1,2-dichlorobenzene

² RCRA organic feed rate included 1,2-dichlorobenzene and naphthalene (semi-volatiles); and tetrachloroethene and total xylene (volatiles). See Southwest Research Institute (SwRI) spike data Appendix B. The ethylbenzene concentration was a spike background compound and **was not used** in the RCRA Organic Feed Rate result.

³ RCRA metal feed rate included As, Cd, Cr, Pb, and Hg

⁴ Two 500 lb surrogate drums/batch. See surrogate drum preparation videos in Volume 2, Appendix B

**Table 2-3. PFF VTD Demonstration Test – Gainesville, Florida
March 2024
Proposed Feed and Operating Parameter Limits (OPLs)**

Parameter	Proposed Limit	Limit Basis	Action & Documentation
Feed Rate (pounds/batch)	1,000.	Demo Test Runs 1 – 4 (average)	VTD batch log sheet operating record.
Maximum Total PCBs Mass Feed ¹ (lbs/batch)	12.093	Demo Test Runs 1 – 4 1,2-DCB Surrogate (average)	Administratively controlled by batch container analysis and mass. VTD batch analyses operating record.
Maximum Total PCBs Feed Concentration ¹ (ppmw or mg/kg)	12,093	Demo Test Runs 1 – 4 (average)	Administratively controlled by batch container analysis. VTD batch analyses operating record.
Maximum VOC Mass Feed ² (lbs/batch)	TBD ²	Demo Test Runs 1 – 4 (average)	Administratively controlled by batch feed analysis and mass. VTD batch analyses operating record.
Maximum SVOC Mass Feed ² (lbs/batch)	TBD ²	Demo Test Runs 1 – 4 (average)	Administratively controlled by batch feed analysis and batch mass. VTD batch analyses operating record.
Batch Cycle Time (Hours)	Per Protocol	Feed matrix and analyses	Administratively controlled based on batch matrix and analyses (moisture, VOCs/SVOCs, etc.) and batch treatment protocol. VTD batch log sheet operating record.
Off-Gas Oxygen Concentration AIT-1-02: (% O ₂)	<6.0 (10-min. rolling average)	Operational Safety	Suspend batch run until O ₂ levels restored. Document root cause and corrective actions within VTD operating log. VTD CMS data.
Desorber Vessel Internal Vacuum Pressure PT-1: (in. Hg gauge)	>0.0	Fugitive Emissions Control	Suspend batch run until vacuum restored. Document root cause and corrective actions within VTD operating log. VTD CMS log.
Carbon Bed Inlet Off-gas Temperature TE-11: (°F)	<125	Demo Test Runs 1 - 4 (average) Emissions Control	Suspend batch run until temperature excursion controlled. Document root cause and corrective actions within VTD operating log. VTD CMS data.

¹ Maximum total feed PCBs as determined from testing. Total is based on sum of Aroclors 1016, 1221, 1232, 1248, 1254, and 1260.

The 1,2-DCB, PCB surrogate spike concentration was adjusted lower from the 83.0% reported by SwRI. The total organic concentration of the spikes was reported as 102.29%, rather than 100.0%, and, as the most conservative measure based on the 1,2-DCB removal efficiencies results, the normalization to 100.0% was applied to the 1,2-DCB, only, by subtracting 2.29% from the reported 83.0% and used through all the affected calculations.

² Maximum RCRA VOC and SVOC feed rates to be established under RCRA combustion equivalency petition.

3.0 FEED COMPOSITION DATA AND EMISSIONS SAMPLING AND ANALYSIS PROCEDURES

In accordance with the approved Performance Demonstration Test Plan (DTP), the batch feed composition was maintained consistent for the four test runs. Pre-analyzed sand and diatomaceous earth, potable water, and TSCA/RCRA organic and metal spike mixtures were mass-loaded into individual drums to produce the target composition as shown in Table 3-2 VTD System Waste Batches Target and Actual Parameters. A digital platform scale was used to accurately measure the addition of each component. In lieu of manual log sheets, the feed preparation for each drum was captured by video recording to provide clear objective evidence of the loadings. Video recordings are provided in Volume 2, Appendix B. For tracking containers into batches and container sample references, a unique identification number was assigned to each drum. EPA personnel witnessed the transfer of material from the containers into the VTD feed trays for each batch loading. Hence, based on the feed preparation documentation with EPA visual witness of the drum transfers for each test batch, assurance of the feed composition was maintained for all test runs. Table 3-3 presents the actual test results of the waste batch target parameters.

At the request of EPA R4, feed samples were taken from each prepared container for independent analysis. Due to the limited feed mix homogeneity, the data only provide confirmation of the presence of the feed RCRA/TSCA constituents introduced from the spikes during drum loadings. For example, Table 3-1 below shows the RCRA spike metals for containers 12038 and 12043 used for the Batch 2 second test run.

**Table 3-1. PFF VTD Demonstration Test – Gainesville, Florida
Example Batch Container Feed Analysis Data**

Sample_No	Collect Date/Time	Receive_Date/Time	Prep_Date/Time	Analysis_Date/Time	Parameter	Lab_Result	Units
12038.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 08:30	04/03/24 15:15	Arsenic	68,700.0	ug/kg
12038.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 08:30	04/03/24 15:15	Barium	7,490.0	ug/kg
12038.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 08:30	04/03/24 15:15	Cadmium	48,300.0	ug/kg
12038.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 08:30	04/03/24 15:15	Chromium	48,900.0	ug/kg
12038.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 08:30	04/03/24 15:15	Lead	52,500.0	ug/kg
12038.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 14:45	04/04/24 10:40	Mercury	322,000.0	ug/kg
12038.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 08:30	04/03/24 15:15	Selenium	ND	ug/kg
12038.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 08:30	04/03/24 15:15	Silver	208.0	ug/kg
12043.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 08:30	04/03/24 15:35	Arsenic	91,400.0	ug/kg
12043.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 08:30	04/03/24 15:35	Barium	8,360.0	ug/kg
12043.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 08:30	04/03/24 15:35	Cadmium	71,200.0	ug/kg
12043.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 08:30	04/03/24 15:35	Chromium	71,100.0	ug/kg
12043.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 08:30	04/03/24 15:35	Lead	70,900.0	ug/kg
12043.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 14:45	04/04/24 11:43	Mercury	206,000.0	ug/kg
12043.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 08:30	04/03/24 15:35	Selenium	ND	ug/kg
12043.B2.Pre-Test.EPA	03/26/24 14:20	04/02/24 08:50	04/03/24 08:30	04/03/24 15:35	Silver	357.0	ug/kg

**Table 3-2. PFF VTD Demonstration Test – Gainesville, Florida
March 2024
VTD System Waste Batch Target Parameter Ranges¹**

Matrix Run	Solids (wgt. %)	Water (wgt. %)	Total Organic (wgt. %)	1,2-Dichlorobenzene PCB Surrogate (ppmw)	Total RCRA VOCs (ppmw)	Total RCRA SVOCs (ppmw)	Total RCRA Low Volatile Metals (mg/kg)	Total RCRA Semi-Volatile Metals (mg/kg)	RCRA Volatile Metal (mercury) (mg/kg)	Total Batch Waste Weight (lbs)
Solids 1	87 - 92	6 – 10	1.0 – 2.0	10,000 - 14,000	1,500 - 2,500	12,000 – 15,000	100 - 200	100 - 200	300 - 400	900 - 1,200
Solids 2	87 – 92	6 – 10	1.0 – 2.0	10,000 - 14,000	1,500 - 2,500	12,000 – 15,000	100 - 200	100 - 200	300 - 400	900 - 1,200
Solids 3	87 – 92	6 – 10	1.0 – 2.0	10,000 - 14,000	1,500 - 2,500	12,000 – 15,000	100 - 200	100 - 200	300 - 400	900 - 1,200
Solids 4	87 – 92	6 – 10	1.0 – 2.0	10,000 - 14,000	1,500 - 2,500	12,000 – 15,000	100 - 200	100 - 200	300 - 400	900 - 1,200

¹ Actual values based on pre-weighed and analyzed feeds; see Appendix B.

**Table 3-3. PFF VTD Demonstration Test – Gainesville, Florida
March 2024
VTD System Waste Batch Parameter Results**

Matrix Run	Solids (wgt. %)	Water (wgt. %)	Total Organic (wgt. %)	1,2-Dichlorobenzene PCB Surrogate ¹ (ppmw)	Total RCRA VOCs (ppmw)	Total RCRA SVOCs (ppmw)	Total RCRA Low Volatile Metals (mg/kg)	Total RCRA Semi-Volatile Metals (mg/kg)	RCRA Volatile Metal (mercury) (mg/kg)	Total Batch Waste Weight (lbs)
Solids 1	89.77	8.20	1.50	12,093	2,008	12,842	156.6	144.1	308.6	1,000
Solids 2	89.77	8.20	1.50	12,093	2,008	12,842	156.6	144.1	308.6	1,000
Solids 3	89.77	8.20	1.50	12,093	2,008	12,842	156.6	144.1	308.6	1,000
Solids 4	89.77	8.20	1.50	12,093	2,008	12,842	156.6	141.1	308.6	1,000

¹ See 1,2-DCB adjustment discussion from 83.0% to 80.7% due to normalizing of SwRI mass balance results of 102.29% to 100.0% in Section 4, Table 4-1 footnotes.

Table 3-2 summarizes the sampling and analysis parameters that were measured in the **combined gas** discharge duct the during each batch treatment test run. The gas parameters were measured using EPA or SW-846 reference methods during the entire duration of each batch treatment test run. The combined gas parameters and their associated sampling methods included:

- 1,2-dichlorobenzene (as the PCB surrogate) using SW-846 Method 0010 combined with EPA Method 23;
- Dioxins and furans using EPA Method 23 combined with SW-846 Method 0010;
- Semi-volatile organic compounds (naphthalene) using SW-846 Method 0010 combined with EPA Method 23;
- Volatile organic compounds (tetrachloroethylene and xylenes) using SW-846 Method 0031 (VOST);
- Particulate matter using EPA Method 5 combined with EPA Method 26A;
- HCl/Cl₂ using EPA Method 26A combined with EPA Method 5;
- Metals (arsenic, cadmium, chromium, lead, and mercury) using EPA Method 29;
- Carbon monoxide using EPA Method 10;
- O₂ and CO₂ using EPA Method 3A; and
- Volumetric flow rate using EPA Methods 1A and 2C.

In addition, the flow rate of the VTD process vent gas prior to the static gas mixer was measured continuously using EPA Methods 1A and 2C to generate a “dilution factor” to apply to the measured combined gas performance metric concentrations resulting in corrected concentrations representative of the VTD process vent gas. CO, O₂ and CO₂ measurements were also performed using continuous emission monitors.

3.1 Gas Sample Locations and Methods

Samples of the VTD combined gas were taken from a duct which was nominally 3 inches in diameter and three (3), horizontal-plane sampling ports aligned in series and strategically placed 8 diameters downstream and 2 diameters upstream from disturbances (i.e., elbows, other probes) and each other to comply with modified EPA Method 1A protocol. During sampling, each sampling probe was positioned in the center of the duct and no point traversing performed.

Each isokinetic sampling train was operated based on the velocity data provided by a calibrated hot-wire anemometer positioned 8 diameters downstream and 2 diameters upstream from disturbances (i.e., elbows, other probes).

During each batch test run, a continuous sample was collected for determination of dry molecular weight and oxygen corrections according to EPA Method 3A. During the collection of each isokinetic sampling train, velocity measurements from the anemometer were recorded to determine gas velocity and the isokinetic sampling rates (EPA Method 2). The velocity

measurements, along with the off-gas composition (CO_2 , O_2 , and N_2 by EPA Method 3A), moisture content (EPA Method 4), and the cross-sectional area of the duct, were used to determine the volumetric flow rate of the sample gas. The moisture content of the sample gas was determined from the total weight gain of the impingers used over each isokinetic sampling train sampling.

Combined Gas Sampling Procedures

Samples of the VTD combined gas emissions were collected for determination of the parameters indicated in Table 3-4. The methods that were employed are briefly described below. Data were recorded on pre-formatted data sheets during the sampling.

In addition to measuring the combined gas flow rate, the flow rate of the VTD process vent gas prior to the static gas mixer was measured continuously using EPA Methods 1A and 2C. This flow rate measurement allowed for the calculation of a “dilution factor”, based upon the ratio of the average flow rates measured by the designated pitot/temperature measurement points in both VTD process vent and combined mixed gas flows. The dilution factor was applied to the concentration-based emissions performance metrics (i.e. dioxins/furans, PM, and volatile & semi-volatile metals) resulting in corrected metric concentrations emitted solely from the VTD process. CO , O_2 and CO_2 measurements were also performed using continuous emission monitors.

**Table 3-4. PFF VTD Demonstration Test – Gainesville, Florida
March 2024
Combined Gas Sampling and Analytical Matrix**

Stream	Parameter	Sampling Method	Frequency	Sample Size	Analytical Method
Combined Gas	1,2-dichlorobenzene (as PCB surrogate)	SW-846 Method 0010 (MM5) w/dioxins/furans and SVOCs	Integrated sample once per run during entire batch processing	> 500 dscf	SW-846 Method 8270C (GC/MS)
	Dioxins/Furans	EPA Method 23 (MM5) w/ SVOCs	Integrated sample once per run during entire batch processing	> 500 dscf	SW-846 Method 8290 (GC/HRMS)
	Semi-Volatile Organics (naphthalene)	SW-846 Method 0010 (MM5) w/dioxins/furans	Integrated sample once per run during entire batch processing	> 500 dscf	SW-846 Method 8270C (GC/MS)
	Volatile Organics	SW-846 Method 0031 (VOST)	Three, 3-trap sets for duration of entire batch processing	Approx. 100-300 liters per set	SW-846 Method 5041A/ 8260B (GC/MS)
	Particulate Matter	Filter and probe rinse from EPA Method 5/26A (with EPA Method 26A)	Integrated sample once per run during entire batch processing	> 400 dscf	Gravimetric
	HCl/Cl ₂	EPA Method 5/26A impinger solutions (with EPA Method 5)	Integrated sample once per run during entire batch processing	> 400 dscf	SW-846 Method 9057 (ion chromatography for chloride)
	Metals (arsenic, cadmium, chromium, lead, mercury)	EPA Method 29	Integrated sample once per run during entire batch processing	> 500 dscf	SW-846 Method 6010B (trace ICAP) Mercury by Methods 7470A/7471B
	Velocity/Flow Rate	EPA Methods 1A, 2C, and 4	Calibrated anemometer every 15 minutes per CEMS protocol	NA	EPA Methods 1A, 2C, and 4
	CO (also in VTD Process Gas)	EPA Method 10	Continuous	NA	Nondispersive infrared
	CO ₂ (also in VTD Process Gas)	EPA Method 3A	Continuous	NA	Nondispersive infrared
	O ₂ (also in VTD Process Gas)	EPA Method 3A	Continuous	NA	Paramagnetic

Modified Method 5 Sampling Train for 1,2-DCB, PCDD/PCDF, and Semi-Volatile Organics

The Modified Method 5 (MM5) sampling protocol was used to collect samples of the combined gas for quantification of 1,2-DCB, PCDD/PCDF and semi-volatile organics (naphthalene). The MM5 protocol is outlined as Method 0010 in SW-846, Third Edition. The sampling train consisted of:

- Glass nozzle.
- Heated, glass-lined probe.
- Heated filter.
- Sorbent module.
- Dry modified Greenburg-Smith impinger.
- Modified Greenburg-Smith impinger containing 100 mL water.
- Greenburg-Smith impinger containing 100 mL water.
- Dry modified Greenburg-Smith impinger.
- Modified Greenburg-Smith impinger containing silica gel.

SW-846 Method 0031 (VOST) for Volatile Organics

SW-846 Method 0031 (VOST) was used to collect samples of combined gas for determination of the volatile organics - tetrachloroethylene, xylenes and volatile organic compounds. The VOST primarily consists of a quartz probe, water-cooled condensers, the three (3) Tenax sorbent traps in series, and sample gas metering system. During sample collection the Tenax traps are maintained at 20°C. To further increase the collection efficiency, the sample is cooled and dried by passing it through water-cooled condensers prior to its contact with the sorbent traps.

In the VOST, volatile organic species were removed from the sample gas by sorbent resin traps maintained at 20°C. The first and second resin traps contain Tenax and the third trap contains Tenax and petroleum-based charcoal. A dry gas meter is used to measure the volume of gas passed through the set of traps. Approximately 100-300 liters of sample gas were collected on each set of traps with a 0.5 liter per minute sampling rate during the entire duration of each batch run.

EPA Methods 5/26A for Particulate Matter and HCl/Cl₂

The combined gas was sampled for measurement of particulate matter and HCl/Cl₂ using EPA Methods 5/26A. The sampling train consisted of the following components:

- Glass nozzle.
- Heated, glass-lined probe.

- Heated Teflon-matted filter.
- Impinger containing 100 mL of 0.1 N H₂SO₄.
- Impinger containing 100 mL of 0.1 N H₂SO₄.
- Empty impinger.
- Impinger containing 100 mL of 0.1 N NaOH.
- Impinger containing 100 mL of 0.1 N NaOH.
- Impinger containing silica gel.

EPA Method 29 for Metals

During the Demonstration Test, the combined gas was sampled for measurement of metals (arsenic, cadmium, chromium, lead, and mercury) using EPA Method 29. The sampling train consisted of the following components:

- Glass nozzle.
- Heated, glass-lined probe.
- Heated quartz filter.
- Impinger containing 100 mL of 5% HNO₃ and 10% H₂O₂.
- Impinger containing 100 mL of 5% HNO₃ and 10% H₂O₂.
- Empty impinger.
- Impinger containing 100 mL of 4% KMnO₄ and 10% H₂SO₄.
- Impinger containing 100 mL of 4% KMnO₄ and 10% H₂SO₄.
- Impinger containing silica gel.

EPA Method 10 for CO

CO concentrations in the VTD process and combined gases were monitored according to the procedures specified in EPA Method 10. According to this method, sample gas is routed to an analyzer through a heated sample line and gas conditioning system, and is continuously monitored. The concentration of CO was determined using a TECO Model 48H CO monitor. This gas filter correlation monitor uses the characteristic absorption of infrared light by CO to measure its relative concentration.

EPA Method 3A for O₂, CO₂ and N₂ for Gas Composition

The O₂ and CO₂ concentrations in the VTD process and combined gases were monitored according to the procedures specified in EPA Method 3A. Sample gas was routed to the analyzers through a heated sample line and conditioning system and continuously monitored. The basis of operation for the O₂ analyzer is paramagnetic detection. The basis of operation for the CO₂ analyzer is infrared detection. The N₂ content was calculated as the difference from 100 percent. The results are used to calculate the molecular weight of the process gas and to correct parameter concentrations to a 7% O₂ basis.

4.0 DEMONSTRATION TEST RESULTS

This section of the test report presents the results of the spiked compounds introduced on a mass basis for each batch run and the corresponding emissions of compounds in the combined gas vent to determine the system removal efficiencies. The concentrations of particulate matter, dioxins and furans, and spiked metals, adjusted for the combined gas/process vent gas dilution factor and then corrected to 7% O₂ content in the process gas vent are presented. In addition, continuous emissions monitoring system (CEMS) data for O₂, CO₂, and CO for both the combined gas and process vent gas streams are presented.

The PFF VTD Demonstration Test Compliance Summary was presented in Table 2-1 demonstrating compliance with the designated limits established in the TSCA and RCRA regulations. The summary results are categorized by the governed regulation (i.e., both RCRA and TSCA, TSCA, and RCRA). Likewise, this section will present the results in a similar order.

On-site test activities occurred over a period of 5 days. The four runs were conducted sequentially as detailed below:

- Run 1 – 1,065 minutes (17.75 hours)
Start - 3/26/2024 at 0925; Stop - 3/27/2024 at 0310
- Run 2 – 1,140 minutes (19.00 hours)
Start – 3/27/2024 at 0925; Stop – 3/28/2024 at 0417
- Run 3 – 1,080 minutes (18.00 hours)
Start – 3/28/2024 at 0840; Stop – 3/29/2024 at 0333
- Run 4 – 1,071 minutes (17.85 hours)
Start – 3/29/2024 at 0925; Stop – 3/30/2024 at 0312

The emission testing was initiated at the start of each batch treatment and continued through to the conclusion of the batch cycle, including the cool down.

A fully documented appendix has been developed to support the data shown. Each results section indicates the corresponding appendix section that will lead the reviewer to the appropriate references.

The Demonstration Test produced data to address the two primary objectives. These were:

- Support EPA designation of the VTD as a TSCA 40 CFR §761.60(e) equivalent technology; and

- Demonstration of waste separation¹ treatment with emissions control performance equivalent to RCRA combustion unit standards below:

TSCA

- $\geq 99.9999\%$ removal efficiency (RE) for total PCBs² calculated from the mass of PCBs (as Aroclors summed total) within the waste batch feed versus mass emitted within the process gas discharged from the VTD; and
- < 4 lb/hr HCl.

TSCA/RCRA [CAA HWC NESHAP]

- $\geq 99.99\%$ RE for designated hazardous semi-volatile organic compounds (SVOCs) calculated by mass of individual compounds within waste batch feed versus mass emitted within the process gas discharged from the VTD;
- $\geq 99.99\%$ RE for designated hazardous volatile organic compounds (VOCs) calculated by total mass of individual compounds within waste batch feed versus mass emitted within the process gas discharged from the VTD;
- < 0.20 ng TEQ/dscm combined Dioxins and Furans emission rate;
- < 0.015 grains/dscf Particulate Matter (PM) emission rate;
- < 10 ug/dscm semi-volatile (lead + chromium) and < 23 ug/dscm low-volatile (arsenic + beryllium + chromium) metals emission rates;
- < 8.1 ug/dscm volatile (mercury) metal emission rate; and
- < 21 ppmvd hydrogen chloride and chlorine gas combined emission rate for RCRA.
[7% oxygen basis for all concentration limits]

4.1 Detailed Test Results

Test results are presented in tables with supporting explanations for each. The sample calculation methods (Section 5.0) can be applied to verify the reported results.

4.1.1 Feed Spike Results

Three spiked compound groups were precisely added to each batch feedstock just prior to each run and diligently recorded and reviewed by the PFF Quality Control Manager. The compound groups were:

- Semi-volatile organic compound spikes – 1, 2-dichlorobenzene (as PCB surrogate) and naphthalene,
- Volatile organic compound spikes – tetrachloroethylene and m, o, p-xylenes, and

¹ The 40 CFR Part 63 Subpart EEE incinerator criteria were selected for most RCRA metrics. However, the VTD is in fact a non-combustion contaminant separation and recovery process that is technically more comparable to 40 CFR §264.1030 regulated units (i.e., distillation, fractionation, and air/steam strippers).

² A surrogate organic compound for PCB, 1, 2-dichlorobenzene (1, 2-DCB), was used for this performance test as presented in Section 3.0.

- Metals – arsenic and chromium (low-volatile metals), chromium and lead (semi-volatile metals), and mercury (volatile metal).

Tables 4-1 and 4-2 present the mass feed results for the organic compounds and metals spikes, respectively.

QA/QC Discussion

The analyses of the organic feed spikes were performed by Southwest Research Institute (SWRI) located in San Antonio, Texas. The analyses of the metals feed spikes were performed by Noah Technologies located in San Antonio, Texas. During the analyses of the spike feed materials, there were no quality issues that affected the validity of the results or failed the data quality indicators. The detailed data for the spike feed materials analyses can be found in Volume 2, Appendix B.

**Table 4-1. PFF VTD Demonstration Test – Gainesville, Florida
March 2024**

Analyses of Organic Spikes and Mass Spiked per Run Summary

Compound	Compound Target Concentration (wgt %)	Compound Measured Concentration ¹ (wgt %)	Combined Spikes Weight per Container ² (grams)	Weight of Compound Spikes per Run ³ (lb)
Ethylbenzene (spike background compound)	---	0.890	3,398.2	0.133
m/p-Xylenes	6.67	6.40	3,398.2	0.958
o-Xylene	6.67	1.40	3,398.2	1.17
Total Xylenes	6.67	7.80	3,398.2	1.168
Tetrachloroethene	6.67	5.6	3,398.2	0.840
1,2-Dichlorobenzene (PCB Surrogate)	80.0	80.7 ⁴	3,398.2	12.903
Naphthalene	6.67	5.0	3,398.2	0.749

¹ As analyzed by Southwest Research Institute, San Antonio, Texas (SwRI)

² As measured by PFF

³ Each run of surrogate feedstock solids was spiked with two (2) containers comprised of organic spike compounds; e.g., For 1, 2-Dichlorobenzene (1,2-DCB): 80.7% wgt x 3,398.2 grams/453.59 grams per lb x 2 spike containers per run = 12.903 lb spiked per run.

⁴ The 1,2-DCB spike concentration was adjusted lower from the 83.0% reported by SwRI. The total organic concentration of the spikes was reported as 102.29%, rather than 100.0%, and, as the most conservative measure based on the 1,2-DCB removal efficiencies results, the normalization to 100.0% was applied to the 1,2-DCB, only, by subtracting 2.29% from the reported 83.0% and used through all the affected calculations.

**Table 4-2. PFF VTD Demonstration Test – Gainesville, Florida
March 2024**

Analyses of Metal Spikes and Mass Spiked per Run Summary

Compound	Compound Target Concentration (wgt %)	Compound Measured Concentration¹ (wgt %)	Combined Spikes Weight per Container² (grams)	Weight of Compound Spikes per Batch³ (lb)
Arsenic	1.72	1.67	1,130.8	0.0832
Cadmium	1.62	1.55	1,130.8	0.0772
Chromium	1.47	1.47	1,130.8	0.0732
Lead	1.46	1.34	1,130.8	0.0668
Mercury ⁴	---	---	70	0.309

¹ As analyzed by Southwest Research Institute, San Antonio, Texas (SwRI)

² As measured by PFF

³ Each run of surrogate feedstock solids was spiked with two (2) containers comprised of metals spike compounds;
e.g., For Arsenic: 1.67% wgt x 1,130.2 grams/453.59 grams per lb x 2 spike containers per run = 0.0832 lb spiked per run

⁴ Mercury spike was performed by liquid Hg addition of two, 70 grams vials per batch for a total of 140 grams

4.1.2 Combined Gas/Process Vent Gas Dilution Factor Results

As discussed in Section 1.0 of this report, during the DTP development, an analysis of the proposed test organic feed and emissions was performed to assess the organic loading concentrations expected in the VTD process vent gas at the point of sample collection. It was determined that the proposed sampling and analysis methodologies would likely have collection capacity issues and that an alternative operational approach should be developed and considered.

A reduction in organic inputs with a 10-fold volumetric dilution of the VTD process vent gas flow was expected to prevent the overloading problem during the long batch sampling intervals. The process vent flow from the VTD was combined with approximately 50 scfm of filtered makeup air flow³. The combined flows were routed through a pipeline static mixer to achieve a well-mixed condition prior to entering a straight pipe section (to eliminate turbulence) followed by the nominal 3" emissions sampling pipe section. An adjustable speed fan was used to pull (draft) the mixed flow, at a consistent volumetric flow rate, through the entire piping arrangement.

The filtered air-diluted VTD process vent flow contained oxygen at near ambient air levels (~19%) at the sampling location. Many of the combustion emission standards employ a correction to 7% oxygen concentration, e.g., particulate matter, dioxins/furans, etc. In order to properly apply the correction factor as intended by the regulations, monitoring of the VTD process vent gas oxygen level, prior to air dilution, was required. The emissions testing contractor, Montrose Environmental, measured the combined gas and process gas vent velocities and flow rates using a calibrated hot-wire anemometer that measures in feet/second velocity and calibrated thermocouples for temperature every 15 minutes (per CEMS protocol) simultaneously with the emissions sampling, and recorded the data for the run averages to calculate a continuous dilution factor to adjust the combined gas concentration to process gas vent basis. In addition, they employed an oxygen/carbon monoxide/carbon dioxide-certified CEMS system that measured a vent gas sample that was extracted prior to any air dilution. Hence, oxygen levels from the sampling periods were determined and applied from the CEMS recorded data to correct the adjusted concentrations to 7% O₂ basis. Table 4-3 presents the results of the combined gas/process vent gas dilution factor development. Table 4-4 presents the results of the combined gas and process vent gas CEMS. The detailed data for the dilution factor and CEMS can be found in Volume 3, Appendices E and F, respectively.

³ The dilution air was taken from conditioned (cooled) ambient air that was filtered through activated carbon and high efficiency particulate filters. The filtration was required to mitigate potential ambient air contaminant contributions.

Table 4-3. PFF VTD Demonstration Test – Gainesville, Florida**March 2024****Combined Gas and Process Vent Gas Dilution Factor Results Summary**

Run	Combined Gas Vent – Area 0.05796 ft ²			Process Gas Vent – Area 0.02538 ft ²			Dilution Factor ¹
	Temperature (°F)	Velocity (std ft/min)	Flow Rate (std ft ³ /min)	Temperature (°F)	Velocity (std ft/min)	Flow Rate (std ft ³ /min)	
1	74.8	1,036.0	60.047	77.6	310.8	7.889	7.61
2	71.6	1,080.5	62.626	72.6	277.1	7.033	8.90
3	70.4	1,033.5	59.904	72.5	257.1	6.525	9.18
4	71.1	1,016.1	58.895	73.0	217.4	5.519	10.67
Average	72.0	1,041.5	60.368	73.9	265.6	6.742	9.09

¹ The dilution factor was the combined gas vent flow rate ÷ process vent gas flow rate.**Table 4-4. PFF VTD Demonstration Test – Gainesville, Florida****March 2024****Combined Gas and Process Vent Gas Continuous Emission Monitoring Results Summary**

Run	Combined Gas Vent			Process Gas Vent		
	Oxygen Concentration (%)	Carbon Dioxide Concentration (%)	Carbon Monoxide Concentration (ppmv)	Oxygen Concentration (%)	Carbon Dioxide Concentration (%)	Carbon Monoxide Concentration (ppmv)
1	18.9	0.1	31.0	2.1	0.5	313.9
2	19.0	0.2	23.2	1.8	0.5	288.4
3	19.0	0.1	23.6	1.6	0.2	328.6
4	19.3	0.2	19.7	1.8	0.2	330.7
Average	19.1	0.2	24.4	1.8	0.4	315.4

4.1.3 Combined Gas Results

During the VTD Demonstration Test, sampling and analyses were performed in the combined gas stream for the isokinetic parameters of particulate matter and HCl/Cl₂ (a single Method 5/26A sampling train), PCB-surrogate 1, 2-DCB, semi-volatile compound (naphthalene), and dioxins and furans (a single Method 0010/23 sampling train), and metals (a single Method 29 sampling train). Sampling data for each train was collected and recorded every 15 minutes on pre-formatted data sheet during the entire duration of each batch run. The data was averaged for each train and isokinetic sampling rates were calculated. Table 4-5 presents the summary of the isokinetic sampling parameters as measured during the operation of each train. The raw data sheets and data reduction sheets for the isokinetic sampling trains can be found in Volume 3, Appendix D.

TSCA and RCRA Standards

Particulate Matter and HCl/Cl₂

The particulate matter concentrations and combined HCl/Cl₂ concentrations (as chloride equivalents) and HCl emission rates were two of the parameters that are both governed by TSCA and RCRA regulated standards. The combined gas emissions were sampled and analyzed for HCl and Cl₂ per EPA Method 26A in combination with the EPA Method 5 sampling train. The particulate matter concentrations were adjusted for the measured combined gas/process vent gas dilution factor then corrected to 7% O₂ for the process vent gas O₂ content. The combined total emission concentrations of HCl and Cl₂ were measured in the combined gas and required adjusted and corrected calculations. The HCl emission rates were adjusted for the dilution factors. All parameters were well below the regulated standards. Tables 4-6 and 4-7 present the results of the particulate matter concentrations and HCl/Cl₂ concentrations and emission rates, respectively.

QA/QC Discussion

The analyses of the particulate matter, HCl and Cl₂ samples were performed by Enthalpy Analytical Laboratories (EAL) in Durham, North Carolina. During the analyses of the samples, there were no quality issues that affected the validity of the results or failed the data quality indicators. The detailed data for the particulate matter, HCl and Cl₂ analyses can be found in Volume 4, Appendix J.

Table 4-5. PFF VTD Demonstration Test – Gainesville, Florida

March 2024

Combined Gas Sampling Parameters Summary

Run	Date	Time (EDT)	Sample Volume (dscf)	Combined Gas Velocity (std ft/min)	Combined Gas Volumetric Flow Rate (dscfm)	Combined Gas O ₂ Concentration (%)	Combined Gas Moisture Content (%)	Isokinetic Sampling Rate (%)
SW-846 Method 0010								
1	3/26-27/2024	0925 – 0310	512.078	1,036.0	60.05	18.9	1.0	96.1
2	3/27-28/2024	0925 – 0417	559.016	1,080.5	62.63	19.0	0.9	98.6
3	3/28-29/2024	0840 – 0333	587.487	1,033.5	59.90	19.0	0.8	102.3
4	3/29-30/2024	0925 - 0312	580.616	1,016.1	58.89	19.3	0.9	109.0
Average	-	-	559.799	1,041.5	60.37	19.1	0.9	101.5
EPA Method 5/26A								
1	3/26-27/2024	0925 – 0310	478.428	1,036.0	60.05	18.9	1.3	91.2
2	3/27-28/2024	0925 – 0417	524.567	1,080.5	62.63	19.0	1.2	94.0
3	3/28-29/2024	0840 – 0333	549.396	1,033.5	59.90	19.0	0.9	97.0
4	3/29-30/2024	0925 - 0312	529.881	1,016.1	58.89	19.3	0.7	100.6
Average	-	-	520.568	1,041.5	60.37	19.1	1.0	95.7
EPA Method 29								
1	3/26-27/2024	0925 – 0310	521.400	1,036.0	60.05	18.9	1.2	98.1
2	3/27-28/2024	0925 – 0417	563.458	1,080.5	62.63	19.0	1.1	99.7
3	3/28-29/2024	0840 – 0333	587.785	1,033.5	59.90	19.0	1.0	102.5
4	3/29-30/2024	0925 - 0312	562.992	1,016.1	58.89	19.3	0.9	105.6
Average	-	-	558.909	1,041.5	60.37	19.1	1.1	101.5

Table 4-6. PFF VTD Demonstration Test – Gainesville, Florida
March 2024

Particulate Matter Emissions Results Summary

Run	Amount Detected (mg)	Sample Volume (dscf)	Dilution Factor	DF-Adjusted Concentration (grains/dscf)	Process Gas Oxygen Concentration (%)	Process Gas Concentration @ 7% O ₂ (grains/dscf)
1	5.2	478.428	7.61	0.00128	2.1	0.00094
2	4.8	524.567	8.90	0.00126	1.8	0.00091
3	28.6	549.396	9.18	0.00737	1.6	0.00531
4	0.5	529.881	10.67	0.000155	1.8	0.00011
Average	11.3	520.568	9.09	0.00252	1.8	0.00211

Table 4-7. PFF VTD Demonstration Test – Gainesville, Florida
March 2024

HCl and Cl₂ Emissions Results Summary

Run	Sample Volume (dscf)	Dilution Factor (DF)	Process Gas Oxygen (%)	HCl				Cl ₂		Total Combined HCl/Cl ₂ Concentration as chloride Cl ⁻ (ppmvd@7% O ₂)
				Amount Detected (ug as HCl)	DF-Adjusted Concentration (ppmvd@7% O ₂)	Process Gas Flow Rate (dscf/min)	Emission Rate (lb/hr)	Amount Detected (ug as Cl ₂)	DF-Adjusted Concentration (ppmvd@7% O ₂)	
1	478.428	7.61	2.1	74.8	0.020	7.89	1.24E-06	93.8	0.013	0.047
2	524.567	8.90	1.8	44.4	0.013	7.03	7.00E-07	137	0.020	0.054
3	549.396	9.18	1.6	27.8	0.0078	6.52	4.01E-07	123	0.018	0.043
4	529.881	10.67	1.8	20.5	0.0070	5.52	3.01E-07	127	0.022	0.052
Average	520.568	9.09	1.8	41.9	0.012	6.74	6.61E-07	120	0.018	0.049

TSCA Only Standards

1,2-Dichlorobenzene (1,2-DCB) as PCB Surrogate

The 1,2-DCB (as the PCB surrogate) mass emissions and resulting system removal efficiencies (SRE), was the only parameter governed by TSCA-only regulated standards. The combined gas emissions were sampled and analyzed for 1, 2-DCB per SW-846 Method 0010 sampling train in combination with EPA Method 23. Table 4-8 presents the results of the 1,2-DCB removal efficiencies.

Samples of the discharge treated batch solids were collected and analyzed after the completion of each run. Samples were obtained from distinctly different sections of the discharge treated batches and analyzed for 1,2-DCB concentrations in units of ug/kg. Table 4-9 presents the results of the 1,2-DCB discharge treated batch solids concentrations.

Both 1,2-DCB parameter metrics were well within the criteria of the regulated TSCA standard values, $\geq 99.9999\%$ removal efficiency and < 2 mg/kg.

QA/QC Discussion

The analyses of the combined gas samples for 1,2-DCB were performed by Eurofins Laboratories in Knoxville, Tennessee. During the analyses of the samples, there were no quality issues that affected the validity of the results or failed the data quality indicators. The detailed data for the 1,2-DCB combined gas samples analyses can be found in Volume 4, Appendix H.

The analyses of the discharge treated batch samples for 1,2-DCB concentrations were performed by GEL Laboratories in Charleston, South Carolina. During the analyses of the samples, there were no quality issues that affected the validity of the results or failed the data quality indicators. The detailed data for the 1,2-DCB discharge treated batch samples analyses can be found in Volume 2, Appendix C.

**Table 4-8. PFF VTD Demonstration Test – Gainesville, Florida
March 2024**

1,2-Dichlorobenzene Emissions and System Removal Efficiencies Results Summary

Run	Mass of Spiked 1, 2-DCB per Batch ¹ IN (lb)	1, 2-DCB OUT (Combined Gas Duct)						1, 2-DCB SRE (%)
		Amount of 1, 2-DCB Detected (ug)	Sample Volume (dscf)	Combined Gas Flow Rate (dscf/min)	Run Duration (hr)	Dilution Factor	Emission Rate of 1, 2-DCB adjusted for Dilution Factor (lb)	
1	12.093	5.65	512.078	60.047	17.75	7.61	1.18E-05	99.999902
2	12.093	3.40	559.016	62.626	18.00	8.90	8.08E-06	99.999933
3	12.093	4.08	587.487	59.904	19.00	9.18	9.60E-06	99.999921
4	12.093	4.61	580.616	58.895	17.85	10.67	1.18E-05	99.999903
Average	12.093	4.44	559.799	60.368	18.15	9.09	1.03E-05	99.999915

¹ The 1,2-DCB spike concentration was adjusted lower from the 83.0% reported by SwRI. The total organic concentration of the spikes was reported as 102.29%, rather than 100.0%, and, as the most conservative measure based on the 1,2-DCB removal efficiencies results, the normalization to 100.0% was applied to the 1,2-DCB, only, by subtracting 2.29% from the reported 83.0% and used through all the affected calculations.

Table 4-9. PFF VTD Demonstration Test – Gainesville, Florida

March 2024

Discharge Treated Batch Solids 1, 2 Dichlorobenzene Concentrations Results

Batch Run	Batch Front			Batch Back		
	Top Concentration Detected (ug/kg)	Middle Concentration Detected (ug/kg)	Bottom Concentration Detected (ug/kg)	Top Concentration Detected (ug/kg)	Middle Concentration Detected (ug/kg)	Bottom Concentration Detected (ug/kg)
1	505	ND (290)	ND (297)	ND (276)	ND (293)	ND (279)
2	ND (285)	ND (290)	ND (278)	ND (276)	ND (276)	ND (275)
3	ND (285)	ND (290)	ND (278)	ND (276)	ND (276)	ND (275)
4	650	ND (292)	ND (294)	588	338	ND (274)

ND – Not Detected above the Method Detection Limit (MDL). MDL is presented in parentheses.

Dioxins and Furans

The dioxins and furans concentrations were governed by TSCA/RCRA regulated standards. The combined gas emissions were sampled and analyzed for dioxins and furans per EPA Method 23 in combination with the SW-846 Method 0010 sampling train. The dioxins and furans TEQ concentrations were adjusted for the measured combined gas/process vent gas dilution factor then corrected to 7% O₂ for the process vent gas O₂ content. The dioxins and furans concentrations were well below the regulated standard of 0.20 TEQ ng/dscm at 7% O₂. Table 4-10 presents the results of the dioxins and furans concentrations.

QA/QC Discussion

The analyses of the combined gas samples for dioxins and furans were performed by Eurofins Laboratories in Knoxville, Tennessee. During the analyses of the samples, there were no quality issues that affected the validity of the results or failed the data quality indicators. The detailed data for the dioxins and furans combined gas samples analyses can be found in Volume 4, Appendix H.

RCRA Only Standards

Semi-Volatile Organic Compounds

The semi-volatile organic compounds (SVOCs) mass emissions and resulting system removal efficiencies (SRE) (based on spiked naphthalene mass feed versus emitted), is governed by RCRA-only regulated standards. The combined gas emissions were sampled and analyzed for SVOCs per SW-846 Methods 0010/8270C in combination with the EPA Method 23 sampling train. Because the SVOC parameter removal efficiency is based on SVOC mass rate emitted relative to the spiked SVOCs mass rate in the batch feed stock, the total SVOCs mass rate emitted is the only result in the combined gas stream of relevance from an emissions basis. Table 4-11 presents the results of the SVOC SRE removal efficiencies. The SREs were well above the regulated RCRA standard values of $\geq 99.99\%$.

QA/QC Discussion

The analyses of the combined gas samples for SVOCs (naphthalene) were performed by Eurofins Laboratories in Knoxville, Tennessee. During the analyses of the samples, there were no quality issues that affected the validity of the results or failed the data quality indicators. The detailed data for the SVOCs combined gas samples analyses can be found in Volume 4, Appendix H.

**Table 4-10. PFF VTD Demonstration Test – Gainesville, Florida
March 2024
Dioxins and Furans Emissions Results Summary**

	Run 1	Run 2	Run 3	Run 4	Average
Toxicity Equivalent Factors Basis per EPA Method 23	Mass Detected as TEQ				
Total Toxicity Equivalents (pg)	11.91	14.77	10.95	3.26	10.22
Sample Volume (dscf)	512.078	559.016	587.487	580.616	559.799
Concentration (ng TEQ/dscm)	0.000821	0.000933	0.000658	0.000198	0.000653
Dilution Factor	7.61	8.90	9.18	10.67	9.09
DF Adjusted Concentration (ng TEQ/dscm)	0.00625	0.00830	0.00604	0.00211	0.00567
Process Gas Oxygen Concentration (%)	2.1	1.8	1.6	1.8	1.8
Concentration (ng TEQ/dscm @ 7% O₂)	0.00462	0.00604	0.00435	0.00154	0.00414

Non detectable results = 0 per EPA Method 23 convention.

**Table 4-11. PFF VTD Demonstration Test – Gainesville, Florida
March 2024**

Spiked SVOCs (Naphthalene) Emissions and System Removal Efficiencies Results Summary

Run	Mass of Spiked Naphthalene per Batch ¹ IN (lbs)	Naphthalene OUT (Combined Gas Duct)						Naphthalene SRE (%)
		Amount of Naphthalene Detected	Sample Volume	Combined Gas Flow Rate	Sampling Run Duration	Dilution Factor	Emission Rate of Naphthalene adjusted for Dilution Factor	
		(ug)	(dscf)	(dscf/min)	(hr)		(lb)	
1	0.749	<4.20	512.078	60.047	17.75	7.61	<8.80E-06	>99.9988
2	0.749	<4.20	559.016	62.626	18.00	8.90	<9.98E-06	>99.9987
3	0.749	<4.20	587.487	59.904	19.00	9.18	<9.88E-06	>99.9987
4	0.749	<4.20	580.616	58.895	17.85	10.67	<1.07E-05	>99.9986
Average	0.749	<4.20	559.799	60.368	18.15	9.09	<9.85E-06	>99.9987

¹ From Table 4-1

Volatile Organic Compounds

The volatile organic compounds (VOCs) mass emissions and resulting SREs based on spiked m,o,p-xylenes, presented also as total xylenes, and tetrachloroethylene mass feeds are governed by RCRA-only regulated standards. The combined gas emissions were sampled and analyzed for VOCs per SW-846 Method 0031 (VOST). Because the VOCs parameter SREs are based on VOCs mass rates emitted relative to the spiked VOCs mass rates in the batch feed stock, the total VOCs mass rates emitted is the only result in the combined gas stream of relevance from an emissions basis. Tables 4-12 and 4-13 present the results of the VOC SREs for total xylenes and tetrachloroethylene, respectively. The VOC SREs were well above the regulated RCRA standard values of $\geq 99.99\%$. Table 4-14 presents other VOC compounds that were detected in the emissions, ethylbenzene (a spiked “background” compound, see Table 4-1) and chloromethane (an emission by-product) and their emission rates.

QA/QC Discussion

The analyses of the combined gas samples for VOCs were performed by Eurofins Laboratories in Knoxville, Tennessee. During the analyses of the samples, there were no quality issues that affected the validity of the results or failed the data quality indicators. The detailed data for the VOCs combined gas samples analyses can be found in Volume 4, Appendix I.

**Table 4-12. PFF Demonstration Test – Gainesville, Florida
March 2024**

Total Xylenes Emissions and System Removal Efficiencies Results Summary

Run	Mass of Spiked Total Xylenes per Batch ¹ IN (lb)	Total Xylenes OUT (Combined Gas Duct)						Total Xylenes SRE (%)
		Amount of Total Xylenes Detected (ug)	Sample Volume (dsliters)	Combined Gas Flow Rate (dscf/min)	Sampling Run Duration (hr)	Dilution Factor	Emission Rate of Total Xylenes adjusted for Dilution Factor (lb)	
1	1.168	0.484	653.49	60.047	17.75	7.61	1.27E-06	99.9981
2	1.168	0.621	540.63	62.626	18.00	8.90	2.40E-06	99.9963
3	1.168	0.315	641.90	59.904	19.00	9.18	1.01E-06	99.9984
4	1.168	0.343	516.81	58.895	17.85	10.67	1.56E-06	99.9976
Average	1.168	0.441	588.21	60.368	18.15	9.09	1.56E-06	99.9976

¹ From Table 4-1

**Table 4-13. PFF Demonstration Test – Gainesville, Florida
March 2024**

Tetrachloroethylene Emissions and System Removal Efficiencies Results Summary

Run	Mass of Spiked Tetrachloroethylene per Batch ¹ IN (lb)	Tetrachloroethylene OUT (Combined Gas Duct)						Tetrachloroethylene SRE (%)
		Amount of Tetrachloroethylene Detected (ug)	Sample Volume (dsliters)	Combined Gas Flow Rate (dscf/min)	Sampling Run Duration (hr)	Dilution Factor	Emission Rate of Tetrachloroethylene adjusted for Dilution Factor (lb/hr)	
1	0.840	0.484	653.49	60.047	17.75	7.61	5.37E-07	99.9989
2	0.840	0.621	540.63	62.626	18.00	8.90	8.31E-07	99.9982
3	0.840	0.315	641.90	59.904	19.00	9.18	5.05E-07	99.9989
4	0.840	0.343	516.81	58.895	17.85	10.67	4.63E-07	99.9990
Average	0.840	0.441	588.21	60.368	18.15	9.09	5.84E-07	99.9987

¹ From Table 4-1

Table 4-14. PFF Demonstration Test – Gainesville, Florida**March 2024****Other Volatile Compound Emissions Results Summary**

Run	Sampling Parameters			Ethylbenzene		Chloromethane	
	Sample Volume (dsliters)	Combined Gas Flow Rate (dscf/min)	Dilution Factor	Amount Detected (ug)	Emission Rate adjusted for Dilution Factor (lb/hr)	Amount Detected (ug)	Emission Rate adjusted for Dilution Factor (lb/hr)
1	653.49	60.047	7.61	0.1079	2.83E-07	0.6395	1.68E-06
2	540.63	62.626	8.90	0.1336	5.16E-07	4.991	1.93E-05
3	641.90	59.904	9.18	0.0808	2.59E-07	5.876	1.89E-05
4	516.81	58.895	10.67	0.0814	3.71E-07	3.758	1.71E-05
Average	588.21	60.368	9.09	0.1009	3.57E-07	3.816	1.42E-05

Metals

The low-volatile metals - arsenic and chromium, semi-volatile metals - cadmium and lead, and volatile metal - mercury, concentrations were governed by RCRA-only regulated standards. The combined gas emissions were sampled and analyzed for the metals per the EPA Method 29 sampling train. The metals concentrations were adjusted for the measured combined gas/process vent gas dilution factors then corrected to 7% O₂ for the process vent gas O₂ content. Table 4-15 presents the low-volatile metals results, Table 4-16 presents the semi-volatile metals results, and Table 4-17 presents the volatile metal, mercury, results. The results indicated that the low-volatile, semi-volatile, and volatile mercury metals concentrations were well below the RCRA regulatory standards.

QA/QC Discussion

The analyses of the combined gas samples for metals were performed by EAL in Durham, North Carolina. During the analyses of the samples, there were no quality issues that affected the validity of the results or failed the data quality indicators. The detailed data for the metals combined gas samples analyses can be found in Volume 4, Appendix K.

**Table 4-15. PFF VTD Demonstration Test – Gainesville, Florida
March 2024**

Low-Volatile Metals Emissions Results Summary

Metal	Run	Sample Volume (dscf)	Amount Detected (ug)	Combined Gas Concentration (ug/dscm)	Dilution Factor¹	DF Adjusted Concentration (ug/dscm)	Process Gas Oxygen Concentration² (%)	Concentration @ 7% O₂ (ug/dscm)
Arsenic	1	521.400	0.866	0.0586	7.61	0.446	2.1	0.330
	2	563.458	0.903	0.0566	8.90	0.504	1.8	0.367
	3	587.785	0.866	0.0520	9.18	0.477	1.6	0.344
	4	562.992	0.867	0.0544	10.67	0.580	1.8	0.422
Chromium	1	521.400	1.965	0.133	7.61	1.01	2.1	0.749
	2	563.458	12.01	0.753	8.90	6.70	1.8	4.87
	3	587.785	2.117	0.127	9.18	1.17	1.6	0.841
	4	562.992	10.86	0.681	10.67	7.27	1.8	5.29
Total Low-Volatile Metals Process Gas Concentration @ 7% O₂							Run 1	1.08
							Run 2	5.24
							Run 3	1.19
							Run 4	5.71
							Average	3.30

¹ From Table 4-3

² From Table 4-4

**Table 4-16. PFF VTD Demonstration Test – Gainesville, Florida
March 2024**

Semi-Volatile Metals Emissions Results Summary

Metal	Run	Sample Volume (dscf)	Amount Detected (ug)	Combined Gas Concentration (ug/dscm)	Dilution Factor¹	DF Adjusted Concentration (ug/dscm)	Process Gas Oxygen Concentration² (%)	Concentration @ 7% O₂ (ug/dscm)
Cadmium	1	521.400	0.911	0.0617	7.61	0.470	2.1	0.347
	2	563.458	0.584	0.0366	8.90	0.326	1.8	0.237
	3	587.785	0.262	0.0157	9.18	0.144	1.6	0.104
	4	562.992	0.125	0.00790	10.67	0.0843	1.8	0.0610
Lead	1	521.400	1.832	0.124	7.61	0.999	2.1	0.698
	2	563.458	2.709	0.170	8.90	1.51	1.8	1.10
	3	587.785	0.907	0.0545	9.18	0.500	1.6	0.360
	4	562.992	1.897	0.119	10.67	1.27	1.8	0.924
Total Semi-Volatile Metals Process Gas Concentration @ 7% O₂							Run 1	1.05
							Run 2	1.34
							Run 3	0.464
							Run 4	0.985
							Average	0.960

¹ From Table 4-3

² From Table 4-4

**Table 4-17. PFF VTD Demonstration Test – Gainesville, Florida
March 2024**

Mercury Emissions Results Summary

Metal	Run	Sample Volume (dscf)	Amount Detected (ug)	Combined Gas Concentration (ug/dscm)	Dilution Factor¹	DF Adjusted Concentration (ug/dscm)	Process Gas Oxygen Concentration² (%)	Concentration @ 7% O₂ (ug/dscm)
Mercury	1	521.400	7.925	0.537	7.61	4.09	2.1	3.02
	2	563.458	9.880	0.619	8.90	5.51	1.8	4.01
	3	587.785	6.338	0.381	9.18	3.50	1.6	2.52
	4	562.992	0.498	0.0312	10.67	0.333	1.8	0.242
	Average	558.909	6.160	0.392	9.09	3.56	1.8	2.45

¹ From Table 4-3

² From Table 4-4

5.0 CALCULATIONS

This section presents the calculations that were utilized to generate the results for the VTD Demonstration Test testing parameters emissions and removal efficiencies.

5.1 Combined Gas/Process Vent Gas Dilution Factor

As an example of the Combined Gas/Process Vent Gas Dilution Factor development (Table 4-3) were calculated as follows:

	Combined Gas Flow		Process Vent Gas Flow		Dilution Factor (DF)
Run 1	$60.05 \frac{ft^3}{min}$	\div	$7.89 \frac{ft^3}{min}$	$=$	7.61
Run 2	$62.63 \frac{ft^3}{min}$	\div	$7.03 \frac{ft^3}{min}$	$=$	8.90
Run 3	$59.90 \frac{ft^3}{min}$	\div	$6.52 \frac{ft^3}{min}$	$=$	9.18
Run 4	$58.89 \frac{ft^3}{min}$	\div	$5.52 \frac{ft^3}{min}$	$=$	10.67

5.2 Particulate Matter Emissions Concentrations

As an example of the particulate matter emissions concentrations (Table 4-6), the particulate matter concentrations @ 7% O₂ were calculated as follows:

	Pre-Dilution PM Conc.		DF		Process Vent Gas O ₂ Correction		Process Vent Gas Concentration @ 7% O ₂
Run 1	$0.00128 \frac{grains}{dscf}$	\times	7.61	\times	$\frac{13.9}{20.9 - 2.1}$	$=$	$0.00094 \frac{grains}{dscf}$
Run 2	$0.00126 \frac{grains}{dscf}$	\times	8.90	\times	$\frac{13.9}{20.9 - 1.8}$	$=$	$0.00091 \frac{grains}{dscf}$

$$\text{Run 3} \quad 0.00737 \frac{\text{grains}}{\text{dscf}} \times 9.18 \times \frac{13.9}{20.9-1.6} = 0.00531 \frac{\text{grains}}{\text{dscf}}$$

$$\text{Run 4} \quad 0.000155 \frac{\text{grains}}{\text{dscf}} \times 10.67 \times \frac{13.9}{20.9-1.8} = 0.00011 \frac{\text{grains}}{\text{dscf}}$$

5.3 HCl and Cl₂ Emissions Concentrations

As an example of the HCl and Cl₂ concentrations (Table 4-7), the concentrations were calculated as follows:

	HCl Concentration	DF		Process Vent Gas O ₂ Correction	Process Vent Concentration @ 7% O ₂
Run 1	$\frac{74.8\mu\text{g}}{478.428\text{dscf}}$	7.61	$\times \frac{385.3\text{ft}^3 * \text{lbmolHCl}}{36.5\text{lbHCl} * 453.59\text{ft}^3}$	$\times \frac{13.9}{20.9-2.1}$	$= 0.020\text{ppmvd}$
Run 2	$\frac{44.4\mu\text{g}}{524.567\text{dscf}}$	8.90	$\times \frac{385.3\text{ft}^3 * \text{lbmolHCl}}{36.5\text{lbHCl} * 453.59\text{ft}^3}$	$\times \frac{13.9}{20.9-1.8}$	$= 0.013\text{ppmvd}$
Run 3	$\frac{27.8\mu\text{g}}{549.396\text{dscf}}$	9.18	$\times \frac{385.3\text{ft}^3 * \text{lbmolHCl}}{36.5\text{lbHCl} * 453.59\text{ft}^3}$	$\times \frac{13.9}{20.9-1.6}$	$= 0.0078\text{ppmvd}$
Run 4	$\frac{20.5\mu\text{g}}{529.881\text{dscf}}$	10.67	$\times \frac{385.3\text{ft}^3 * \text{lbmolHCl}}{36.5\text{lbHCl} * 453.59\text{ft}^3}$	$\times \frac{13.9}{20.9-1.8}$	$= 0.0070\text{ppmvd}$
	Cl ₂ Concentration	DF		Process Vent Gas O ₂ Correction	Process Vent Concentration @ 7% O ₂
Run 1	$\frac{93.8\mu\text{g}}{478.428\text{dscf}}$	7.61	$\times \frac{385.3\text{ft}^3 * \text{lbmolHCl}}{71\text{lbCl}_2 * 453.59\text{ft}^3}$	$\times \frac{13.9}{20.9-2.1}$	$= 0.013\text{ppmvd}$
Run 2	$\frac{137\mu\text{g}}{524.567\text{dscf}}$	8.90	$\times \frac{385.3\text{ft}^3 * \text{lbmolHCl}}{71\text{lbCl}_2 * 453.59\text{ft}^3}$	$\times \frac{13.9}{20.9-1.8}$	$= 0.020\text{ppmvd}$
Run 3	$\frac{123\mu\text{g}}{549.396\text{dscf}}$	9.18	$\times \frac{385.3\text{ft}^3 * \text{lbmolHCl}}{71\text{lbCl}_2 * 453.59\text{ft}^3}$	$\times \frac{13.9}{20.9-1.6}$	$= 0.018\text{ppmvd}$
Run 4	$\frac{127\mu\text{g}}{529.881\text{dscf}}$	10.67	$\times \frac{385.3\text{ft}^3 * \text{lbmolHCl}}{71\text{lbCl}_2 * 453.59\text{ft}^3}$	$\times \frac{13.9}{20.9-1.8}$	$= 0.022\text{ppmvd}$

Note: Total Combined HCl/Cl₂ Concentration as Cl⁻ Equivalents = (HCl Conc. x 1.028) + (Cl₂ Conc. x 2)

5.4 Spiked 1,2-DCB (PCB Surrogate) System Removal Efficiencies

As an example of the spiked 1,2-DCB (PCB surrogate) system removal efficiencies (SREs) (Table 4-8), the SREs were calculated as follows:

	$\frac{[(\text{IN Spiked 1,2-DCB Mass Feed Rate}) - (\text{OUT 1,2-DCB Emission Rate}^1)]}{\text{IN Spiked 1,2-DCB Mass Feed Rate}} \times 100$					SRE
Run 1	[(12.093	-	1.18E-05 lb)	÷	12.093]	x 100 = 99.999902%
Run 2	[(12.093	-	8.08E-06 lb)	÷	12.093]	x 100 = 99.999933%
Run 3	[(12.093	-	9.60E-06 lb)	÷	12.093]	x 100 = 99.999921%
Run 4	[(12.093	-	1.18E-05 lb)	÷	12.093]	x 100 = 99.999903%

¹ 1,2-DCB emission rates were adjusted for the Dilution Factors.

Note: Spiked SVOC (Naphthalene, Table 4-11); and VOCs (Xylenes, Table 4-12 and Tetrachloroethylene, Table 4-13) SREs were calculated similarly.

5.5 Dioxins and Furans Emissions Concentrations

As an example for the dioxins and furans emissions concentrations for the 2,3,7,8-Tetra CDD (TEQ) isomer (Table 4-10) as TEQ @ 7% O₂ were calculated as follows:

	Pre-Dilution TEQ Conc.		DF		Process Vent Gas O ₂ Correction		Process Vent Gas Concentration @ 7% O ₂
Run 1	$8.21E-04 \frac{ng}{dscm}$	x	7.61	x	$\frac{13.9}{20.9-2.1}$	=	$0.00462 \frac{ngTEQ}{dscm}$
Run 2	$9.33E-04 \frac{ng}{dscm}$	x	8.90	x	$\frac{13.9}{20.9-1.8}$	=	$0.00604 \frac{ngTEQ}{dscm}$
Run 3	$6.58E-04 \frac{ng}{dscm}$	x	9.18	x	$\frac{13.9}{20.9-1.6}$	=	$0.00435 \frac{ngTEQ}{dscm}$
Run 4	$1.98E-04 \frac{ng}{dscm}$	x	10.67	x	$\frac{13.9}{20.9-1.8}$	=	$0.00154 \frac{ngTEQ}{dscm}$

5.6 Metals Emissions Concentrations

As an example of the metals emissions concentrations, the Low-Volatile (arsenic and chromium, Table 4-15), Semi-Volatile (cadmium and lead, Table 4-16), and Volatile (mercury, Table 4-17) metals concentrations @ 7% O₂ were calculated as follows:

Low-Volatile Metals

Arsenic

	Pre-Dilution Arsenic Conc.		DF		Process Vent Gas O ₂ Correction		Process Vent Gas Concentration @ 7% O ₂
Run 1	$0.0586 \frac{ug}{dscm}$	×	7.61	×	$\frac{13.9}{20.9 - 2.1}$	=	$0.330 \frac{ug}{dscm}$
Run 2	$0.0566 \frac{ug}{dscm}$	×	8.90	×	$\frac{13.9}{20.9 - 1.8}$	=	$0.367 \frac{ug}{dscm}$
Run 3	$0.0520 \frac{ug}{dscm}$	×	9.18	×	$\frac{13.9}{20.9 - 1.6}$	=	$0.344 \frac{ug}{dscm}$
Run 4	$0.0544 \frac{ug}{dscm}$	×	10.67	×	$\frac{13.9}{20.9 - 1.8}$	=	$0.422 \frac{ug}{dscm}$

Chromium

	Pre-Dilution Arsenic Conc.		DF		Process Vent Gas O ₂ Correction		Process Vent Gas Concentration @ 7% O ₂
Run 1	$0.133 \frac{ug}{dscm}$	×	7.61	×	$\frac{13.9}{20.9 - 2.1}$	=	$0.749 \frac{ug}{dscm}$
Run 2	$0.753 \frac{ug}{dscm}$	×	8.90	×	$\frac{13.9}{20.9 - 1.8}$	=	$4.87 \frac{ug}{dscm}$
Run 3	$0.127 \frac{ug}{dscm}$	×	9.18	×	$\frac{13.9}{20.9 - 1.6}$	=	$0.841 \frac{ug}{dscm}$
Run 4	$0.681 \frac{ug}{dscm}$	×	10.67	×	$\frac{13.9}{20.9 - 1.8}$	=	$5.29 \frac{ug}{dscm}$

Semi-Volatile Metals

Cadmium

	Pre-Dilution Arsenic Conc.		DF		Process Vent Gas O ₂ Correction		Process Vent Gas Concentration @ 7% O ₂
Run 1	$0.0617 \frac{ug}{dscm}$	×	7.61	×	$\frac{13.9}{20.9 - 2.1}$	=	$0.347 \frac{ug}{dscm}$
Run 2	$0.0366 \frac{ug}{dscm}$	×	8.90	×	$\frac{13.9}{20.9 - 1.8}$	=	$0.237 \frac{ug}{dscm}$
Run 3	$0.0157 \frac{ug}{dscm}$	×	9.18	×	$\frac{13.9}{20.9 - 1.6}$	=	$0.104 \frac{ug}{dscm}$
Run 4	$0.00790 \frac{ug}{dscm}$	×	10.67	×	$\frac{13.9}{20.9 - 1.8}$	=	$0.0610 \frac{ug}{dscm}$

Lead

	Pre-Dilution Arsenic Conc.		DF		Process Vent Gas O ₂ Correction		Process Vent Gas Concentration @ 7% O ₂
Run 1	$0.124 \frac{ug}{dscm}$	×	7.61	×	$\frac{13.9}{20.9 - 2.1}$	=	$0.698 \frac{ug}{dscm}$
Run 2	$0.170 \frac{ug}{dscm}$	×	8.90	×	$\frac{13.9}{20.9 - 1.8}$	=	$1.10 \frac{ug}{dscm}$
Run 3	$0.0545 \frac{ug}{dscm}$	×	9.18	×	$\frac{13.9}{20.9 - 1.6}$	=	$0.360 \frac{ug}{dscm}$
Run 4	$0.119 \frac{ug}{dscm}$	×	10.67	×	$\frac{13.9}{20.9 - 1.8}$	=	$0.924 \frac{ug}{dscm}$

Volatile Metals

Mercury

	Pre-Dilution Arsenic Conc.		DF		Process Vent Gas O ₂ Correction		Process Vent Gas Concentration @ 7% O ₂
Run 1	$0.537 \frac{ug}{dscm}$	×	7.61	×	$\frac{13.9}{20.9 - 2.1}$	=	$3.02 \frac{ug}{dscm}$
Run 2	$0.619 \frac{ug}{dscm}$	×	8.90	×	$\frac{13.9}{20.9 - 1.8}$	=	$4.02 \frac{ug}{dscm}$
Run 3	$0.381 \frac{ug}{dscm}$	×	9.18	×	$\frac{13.9}{20.9 - 1.6}$	=	$2.52 \frac{ug}{dscm}$
Run 4	$0.0312 \frac{ug}{dscm}$	×	10.67	×	$\frac{13.9}{20.9 - 1.8}$	=	$0.242 \frac{ug}{dscm}$