THERMAL OXIDIZER PERFORMANCE TEST REPORT CHEMOURS COMPANY FAYETTEVILLE WORKS

PREPARED FOR:

THE CHEMOURS COMPANY, FC, LLC
FAYETTEVILLE WORKS PLANT
22828 NC HWY 87 WEST
FAYETTEVILLE, NC 28306

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FOCUS PROJECT NO. P-001446

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Tables of Contents

List of Tables

List of Figures

List of Appendices (Provided on Compact Disk)

Appendix A: Thermal Oxidizer Operating Data

Appendix B: *Source Test Report,* The Chemours Company, FC, LLC, Fayetteville, NC*, Source Tested: Thermal Oxidizer, Monomer Line, Polymer Line, Test Date: February 8, 2022, AST Project No. 2022-0417*, Alliance Source Testing, LLC, East Syracuse, NY

Appendix C: Summary Analyses

Summaries of the following analyses performed by Eurofins TestAmerica are presented as Appendix C of this report. The complete analytical data packages are provided with this report on compact disk.

Eurofins TestAmerica Analytical Data Packages	
Data Pkg. No.	**Description**
140-26367-1	Monomer Line #1 Method 18
140-26369-1	Polymer Line #2 Method 18
140-26368-1	Waste Gas Line Method 18 QC
140-26364-1	Stack Gas Method 18
140-26365-1	Stack Gas Method 18 QC
140-26362-1	Stack Gas Method 0010
140-26361-1	Stack Gas Method 0010 QC
140-26366-1	Process Water Samples

List of Acronyms

amu	atomic mass units
ASTM	American Society for Testing and Materials
CaF_2	calcium fluoride
CF_4	tetrafluoromethane
CO	carbon monoxide
CO_2	carbon dioxide
COC	chain of custody
COF_2	carbonyl difluoride
DE	destruction efficiency
DQO	data quality objective
DMC	dimethyl carbonate
dscf	dry standard cubic feet (EPA standard at 68°F, 1 atmosphere)
dscm	dry standard cubic meter (EPA standard at 68°F, 1 atmosphere)
E-1	Heptafluoropropyl-1,2,2,2-tetrafluoroethyl ether (Fluoroether E-1)
EPA	Environmental Protection Agency
HF	hydrogen fluoride (gas) or hydrofluoric acid (aqueous)
HFPO	hexafluoropropylene oxide (HFPO), a.k.a., “HFPO monomer” or simply “monomer”
HFPO-DA	hexafluoropropylene dimer acid or C_3-dimer, a.k.a., “HFPO dimer”, “dimer acid”, “dimer”, or Gen X
HFPO-DAF	hexafluoropropylene dimer acid fluoride, a.k.a., “HFPO dimer fluoride”, “dimer acid fluoride”, or simply “dimer fluoride”
HFPO-$DOCH_3$	HFPO dimer, methyl ester
HPLC/MS/MS	high performance precision liquid chromatography/tandem mass spectrometry
hr	hour
GC/MS	gas chromatography/mass spectrometry
LCS	laboratory control sample
lpm	liters per minute
MDL	method detection limit
min	minute
MMBtu	million British thermal units
2-MTP	methyl-2-methoxy-tetrafluoro-propionate
NCDAQ	North Carolina Department of Air Quality
N_2	nitrogen
O_2	oxygen
OPL	operating parameter limit
OTM	Other Test Method
PFAS	per- or poly-fluorinate alkyl substance
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonic acid
psia	pounds per square inch absolute (psig + atmospheric pressure)
psig	pounds per square inch gauge
QA	quality assurance
QC	quality control
RFA	request for analysis
RL	reporting limit
RPD	relative percent difference
RSD	relative standard deviation
SOP	standard operating procedure
SVOC	semi-volatile organic compound
TFE	tetrafluoroethylene
VOC	volatile organic compound

1.0 EXECUTIVE SUMMARY

This report presents the results of per- and poly-fluoroalkyl substance (PFAS) destruction efficiency (DE) performance testing conducted February 8-9, 2022 on the thermal oxidizer located at The Chemours Company FC, LLC (Chemours) facility, Fayetteville, North Carolina. Chemours holds a Title V permit which contains thermal oxidizer requirements and requires the testing protocol *"to address how the Permittee will ensure the Thermal Oxidizer and 4-Stage Scrubber System will achieve the emission reduction* [of 99.99%]*, including the use of a surrogate for all PFAS, such as the hexafluoropropylene oxide (HFPO)."* A test plan delineating the thermal oxidizer DE performance test target operating conditions, and the sampling and analytical protocols, was submitted to the North Carolina Department of Air Quality (NCDAQ) on December 9, 2019. Chemours conducted the initial performance test February 4-5, 2020. The first recurrent test was performed January 26-28, 2021. This report presents the PFAS DE results of the second recurrent performance test conducted February 8-9, 2022. All testing was performed in substantial conformance with the approved test plan

During the test, both the monomer and polymer manufacturing operations directed PFAS-bearing waste gases to the thermal oxidizer. The test program characterized the waste gas feed materials and measured the emission rates of five (5) target PFAS compounds:

- HFPO (Hexafluoropropylene oxide), a.k.a., "HFPO monomer" or simply "monomer",
- HFPO-DA (Hexafluoropropylene Dimer Acid or C_3-Dimer), a.k.a., "HFPO dimer", "dimer acid", "dimer" or "Gen X",
- HFPO-DAF (Hexafluoropropylene Dimer Acid Fluoride),
- COF_2 (Carbonyl Difluoride), and
- Fluoroether E-1 (Heptafluoropropyl-1,2,2,2-tetrafluoroethyl ether).

System DE performance was calculated based on the sum of the system inlet feed rates and sum of the stack emissions rates of these five (5) compounds. "Total PFAS" is the arithmetic sum of HFPO, HFPO-DA, HFPO-DAF, COF_2, and Fluoroether E-1 under these conditions. The total PFAS DE results are summarized in Table 1-1.

Table 1-1. Thermal Oxidizer Total PFAS Destruction Efficiency
Chemours Company FC, LLC, Fayetteville, North Carolina, February 8-9, 2022

Run 1	Run 2	Run 3	Average
99.99951%	99.99966%	99.99967%	99.99961%

The total PFAS DE performance exceeded 99.999% during all three (3) test runs. The balance of this report presents the details of the testing performed.

2.0 INTRODUCTION

2.1 FACILITY BACKGROUND INFORMATION

The Chemours Company FC, LLC (Chemours) manufactures chemicals, plastic resins, plastic sheeting, and plastic film at the facility located at 22828 NC Highway 87 West, Fayetteville, Bladen County, North Carolina (the facility). Under the consent order executed and filed February 25, 2019 Chemours was required to install a thermal oxidizer for control of per- and poly-fluoroalkyl substance (PFAS) process stream emissions from identified manufacturing operations. A test plan delineating the thermal oxidizer destruction efficiency (DE) performance test target operating conditions, and the sampling and analytical protocols, was and submitted to the North Carolina Department of Air Quality (NCDAQ) on December 9, 2019. NCDAQ gave approval of the test plan via letter dated January 27, 2020. The initial DE performance test was conducted February 28-29, 2020. Subsequent recurrent testing has been performed under the same test plan. This test report documents the operating conditions, and the sampling and analytical test results of the second recurrent DE performance test conducted February 8-9, 2022.

2.2 BRIEF ENGINEERING DESCRIPTION

The thermal oxidizer and its associated 4-stage scrubber are identified in the Air Quality Permit respectively as control devices NCD-Q1 and NCD-Q2. Please refer to Figure 2-1. The thermal oxidizer is a 10 million BTU per hour (MMBtu), natural gas-fired device. Waste gases from the manufacturing operations process streams are collected via header systems, compressed and delivered by pipeline to the thermal oxidizer for destruction of the entrained PFAS compounds. Thermal oxidizer emissions are treated in the scrubber system to control hydrogen fluoride (HF) generated by PFAS compound combustion. The scrubber system consists of a 4-stage packed bed column with three water scrubbing stages and one caustic scrubbing stage.

2.3 THERMAL OXIDIZER TEST PROTOCOL DEVELOPMENT

The properties of each PFAS compound are sufficiently unique such that no single sampling and analysis approach is appropriate for a comprehensive characterization of the test plan target PFAS compounds. The physical and chemical properties of each of the potential target PFAS compounds were considered in the development of the sampling and analytical protocol.

The sampling and analytical protocols employed for this test program were developed by Chemours through consultation with Eurofins TestAmerica, Inc. The technical discussion presented in the following sections underlies the sampling and analytical technical basis used to conduct this performance test, and the performance conclusions derived from the results presented in this test report.

2.3.1 Test Plan Target Compounds

The thermal oxidizer DE performance test program was designed based on the characterizations of site-specific target PFAS compounds. The five (5) target compounds were:

- HFPO (Hexafluoropropylene oxide), a.k.a., "HFPO monomer" or simply "monomer",
- HFPO-DA (Hexafluoropropylene Dimer Acid or C_3-Dimer), a.k.a., "HFPO dimer", "dimer acid", "dimer" or "Gen X",
- HFPO-DAF (Hexafluoropropylene Dimer Acid Fluoride),
- COF_2 (Carbonyl Difluoride), and
- Fluoroether E-1 (Heptafluoropropyl-1,2,2,2-tetrafluoroethyl ether).

Table 2-1 presents a summary of the chemical composition and structural information, and key chemical and physical property data for the five (5) PFAS compounds targeted for this test program.

The base compounds handled and used at the Fayetteville facility are HFPO and HFPO-DA. HFPO-DAF is a synthetic precursor to HFPO-DA in the chemical process. The molecular structure of HFPO-DAF is identical to HFPO-DA except fluorine (F) is substituted in place of the hydroxyl (-OH) group. This difference between HFPO-DA and HFPO-DAF has substantial impact on the physical properties and chemical reactivity of these otherwise structurally similar compounds. An additional reactant compound, COF_2, is a major constituent in the waste gas. Fluoroether E-1 is a thermal decarboxylation product of HFPO-DA and appears as an intermittent major constituent in the waste gas. The combined feed rates to the thermal oxidizer and the concurrently measured emission rates of HFPO, HFPO-DA, HFPO-DAF, COF_2, and Fluoroether E-1 from the thermal oxidizer were established to demonstrate PFAS DE performance.

2.3.2 Sampling and Analytical Design Basis

HFPO, HFPO-DAF, and COF_2 react with methanol (MeOH) to form ester compounds as depicted below:

- $\text{HFPO} + \text{MeOH} \rightarrow \text{2-MTP} + 2\text{HF}$
- $\text{HFPO-DAF} + \text{MeOH} \rightarrow \text{HFPO-DOCH}_3 + \text{HF}$
- $\text{COF}_2 + 2\text{MeOH} \rightarrow \text{DMC} + 2\text{HF}$.

The 2-MTP stands for methyl-2-methoxy-tetrafluoro-propionate. The HFPO-$DOCH_3$ stands for HFPO dimer, methyl ester. The DMC stands for dimethyl carbonate. All three (3) ester compounds are analyzed via SW-846 Method 8260. The sampling and analytical strategy for HFPO, HFPO-DAF, and COF_2 is designed based on the reaction of these compounds with methanol to form derivative reaction products, and quantifying them based on analysis of their reaction products.

The Fluoroether E-1 and HFPO-DA sampling and analytical strategy was designed based on capturing the compounds via condensation and dissolution in the methanol impingers. Fluoroether E-1 is captured as a volatile organic compound (VOC), and then quantified via direct analysis using SW-846 Method

8260. HFPO-DA is captured as a semi-volatile organic compound (SVOC) and then quantified via direct analysis using EPA Method 537.

2.3.3 Developed Sampling Methods

Two (2) sampling methods were developed and employed for this test program. Please refer to Figures 2-2 and 2-3. One method is based on EPA Method 18. The second is based on SW-846 Method 0010. [Note: The modified SW-846 Method 0010 sampling methodology set forth in the approved test plan and used during this test program is substantially equivalent to Other Test Method-45 (OTM-45) posted to EPA's Air Emission Measurement Center (EMC) website on January 13, 2021:

https://www.epa.gov/sites/production/files/2021-01/documents/otm_45_semivolatile_pfas_1-13-21.pdf].

The following sections describe the sampling methods, the associated specialized techniques, and their application during this test program.

2.3.3.1 Modified Method 18 Sampling

The Modified Method 18 (MM18) sampling train consists of six (6) PFA fluoropolymer impingers and connectors configured in series. The impingers are charged with methanol. For sampling, the impingers are immersed in a methanol bath chilled using dry ice to maintain a temperature of -73°C (-100°F) or less. The principle of operation is to capture the target PFAS compounds by condensation and/or chemical reaction within the methanol media. The six (6) successive impingers are designed to provide sufficient condensing, absorbing, and reaction capacity to capture the target PFAS analytes. The sampling train is connected to a dry gas meter sampling system to measure the volume of dry gas sampled. At the conclusion of a test run, the six (6) sampling train impingers are recovered as discrete (individual) samples and analyzed separately.

The Modified Method 18 sampling method captures the target PFAS compound vapors via condensing and/or reaction with methanol as the sampled gas is sparged through the successive chilled methanol matrix. Two (2) of the five (5) target compounds, Fluoroether E-1 and HFPO-DA, are captured by simply condensing them from the gas stream and dissolving them in methanol. Three (3) of the five (5) compounds, HFPO, HFPO-DAF, and COF_2, react with the methanol to form ester compounds as previously described. The HFPO and COF_2 have respective boiling points of -28°C and -85°C, but their reaction with methanol to form the higher boiler point derivative ester compounds is key to facilitating the measurement of these compounds. The boiling points of the ester compounds formed from HFPO and COF_2 are higher and therefore easier to recover and retain similar to standard EPA volatile organic compound (VOC) analytes. Post-sampling preservation of these samples is by refrigeration using wet ice to 4°C.

2.3.3.2 Modified Method 0010 Sampling

Based on its boiling point of 151°C, HFPO-DA is classified by EPA as a semi-volatile organic compound (SVOC) that can potentially condense and possibly attach to particulate matter. Therefore, to accurately measure the stack emissions of HFPO-DA, the sampling is conducted using an iso-kinetic sampling method.

The sampling train is generally configured like a standard Method 0010 sampling train with a heated probe and filter, condenser coil, XAD-2 resin cartridge, deionized water impingers, and a silica gel impinger. An added feature is a second XAD-2 resin cartridge located between the last deionized water impinger and the silica gel impinger. The purpose of the second XAD-2 resin cartridge is to act as a quality indicator to assess possible target analyte breakthrough. Other specialized aspects of the Modified Method 0010 sampling are:

- During sampling collection, the sampling probe temperature is maintained only a few degrees above the dew point of the moisture in the gas stream (nominally 10-15°F above the stack gas temperature), well below the normal Method 5 operating temperature range of 248°F (120°C) (to preclude thermal decarboxylation of HFPO-DA to form Fluoroether E-1)
- Maintaining the coil condenser and XAD-2 resin jacket as cold as reasonably possible below the normal Method 0010 prescribed maximum of 68°F (20°C) temperature for best possible conditions for HFPO-DA retention on the resin, and
- Use of 95% methanol / 5% NH_4OH solution as the recovery solvent for the rinsing of sampling train components to recover HFPO-DA from glassware surfaces.

A total of seven (7) sample fractions are generated during the Modified Method 0010 sampling train recovery:

- Particulate filter
- Solvent (95% methanol / 5% NH_4OH) rinses of the probe, nozzle, and the front-half of the filter holder
- Primary XAD-2 resin tube
- Back-half of the filter holder, coil condenser, and connecting glassware 95% methanol / 5% NH_4OH solvent glassware rinses
- Condensate and impinger contents of Impingers #1, #2 and #3 charged with deionized (DI) water and includes DI water rinses of the glassware
- Impingers #1, #2 and #3 solvent (95% methanol / 5% NH_4OH) glassware rinses as a separate sample (NOT combined with the impinger water and DI water rinses), and
- Breakthrough XAD-2 resin tube.

2.3.4 Sampling Locations and Methods

The test program sampling campaign was designed to characterize the feed materials to the thermal oxidizer and the corresponding emissions of the target PFAS compounds. The sampling locations are:

1) the monomer waste gas feed line (Line #1),

2) the polymer waste gas feed line (Line #2), and

3) the thermal oxidizer/scrubber stack.

The sampling techniques used at each location are discussed in the following sections. During testing, all locations were sampled concurrently.

2.3.4.1 Waste Gas Feed Line Sampling

The two (2) waste gas feed lines to the thermal oxidizer were sampled separately at points on the 3-inch lines from the accumulator tanks to the thermal oxidizer. The gas pressure in these lines is nominally 10-30 psig. To perform the sampling, Chemours designed, fabricated, and installed permanent sampling probes in these lines. Please refer to Figure 2-4. The permanently installed probes include a nozzle centered in the line and oriented to face into the stream flow, similar to the orientation of an isokinetic sampling probe when sampling stack gas. The installed sampling probe apparatus includes Swagelok® connectors that allow for connection of the sampling trains to the feed lines without line breaks. Ball valves allow for starting and stopping the flow of pressurized gas. The “bleed” connection allows for connection to a compressed nitrogen line to purge and clear the sampling location of any buildup of liquid or debris prior to sampling, and after sampling is completed. The previously described Modified Method 18 sampling train was used to sample the waste gas lines for the five (5) target PFAS compounds: HFPO, HFPO-DA, HFPO-DAF, COF_2, and Fluoroether E-1.

The sampling train meter box includes a needle control valve. No vacuum pump is required; the waste gas feed line pressure provides the sampled gas motive force. The meter box needle control valve is used to throttle and control the flow rate of the waste gas through the sampling train. The dry gas meter is used to measure the dry gas flow rate and the total volume of dry inert gas sampled.

The two (2) waste gas feed lines were sampled concurrently using two sampling trains, one on each of the waste gas feed lines. The target sampling rate was maintained at approximately 0.50 liters per minute. Waste gas feed lines sampling was also performed concurrently with the stack gas emissions sampling at the thermal oxidizer/scrubber stack. Dry gas meter flow, pressure, and temperature data were used to determine the total mass of dry gas sampled. Nitrogen is used in the system as the inert sweep gas for the waste gases in the vent header systems. Therefore, the waste gas dry gas composition was assumed to be 100% nitrogen and assigned a molecular weight of 28 atomic mass units (amu). Pre- and post- sampling impinger differential weights were used to determine the mass of organic constituent vapors condensed in the sampling train from the sampled waste gases.

2.3.4.2 Stack Gas Modified Method 18 Sampling

A Modified Method 18 sampling train was used to sample the stack gas for four (4) of the five (5) target PFAS compounds: HFPO, HFPO-DAF, COF_2, and Fluoroether E-1. The Modified Method 18 sampling protocol is similar as described for the waste gas feed lines except use of a vacuum pump equipped metering system was required to draw the sampled stack gas through the sampling train. The target sampling rate was 1.5-2.0 liters per minute. Dry gas meter flow, pressure, and temperature data were used to determine the total volume of dry gas sampled. Dry gas molecular weight was determined via Method 3A analysis of the dry gas meter exhaust.

2.3.4.3 Stack Gas Modified Method 0010 Sampling

As previously noted, HFPO-DA is classified as a SVOC by EPA that can potentially condense and/or attach to particulate matter. The HFPO-DA stack emissions are sampled iso-kinetically using a modified SW-846 Method 0010 sampling train as previously described.

The Modified Method 0010 sampling train was operated for 180 minutes during each sampling run to sample a minimum volume of three (3) dry standard cubic meters (dscm). The stack sampling location traverse points were determined and performed in accordance with EPA Method 1. Stack velocity and flow rate were determined based on EPA Method 2 (pitot tube) measurements. Dry gas meter flow, pressure, and temperature data were used to determine the total volume of dry gas sampled. Dry gas molecular weight was determined via Method 3A analysis of the dry gas meter exhaust. Impinger moisture gain was used to determine stack gas moisture content per EPA Method 4.

2.3.5 Sample Analyses

Waste line and stack gas samples are analyzed as described in the following sections.

2.3.5.1 Waste Gas Line Analyses

The characterization of the five (5) target PFAS compounds in the waste gas feed lines was determined via analysis of the Modified Method 18 impinger contents. Please refer to Table 2-2. HFPO, HFPO-DAF, COF_2, and Fluoroether E-1 were determined using Method 8260B analysis. HFPO, HFPO-DAF, and COF_2 were quantified via analysis for their respective derivative ester compounds and reported respectively as HFPO, HFPO-DA, and COF_2 equivalents. Fluoroether E-1 was quantified via direct analysis using Method 8260B. HFPO-DA was quantified via direct analysis using EPA Method 537.

Each of the Modified Method 18 impinger samples was recovered and analyzed separately. Analysis results were then used to calculate target analyte feed rates. The sum of the positive analysis results for each target compound was used to determine the waste gas feed line concentration with zero being used for non-detect values.

2.3.5.2 Stack Gas Method 18 Analyses

The emissions of the HFPO, HFPO-DAF, COF_2, and Fluoroether E-1 were determined via analysis of the Modified Method 18 impinger contents. Please refer to Table 2-2. Like the waste gas feed lines, HFPO, HFPO-DAF, COF_2, and Fluoroether E-1 are determined using Method 8260B analysis. HFPO, HFPO-DAF, and COF_2 were quantified via analysis for their respective derivative ester compounds and reported respectively as HFPO, HFPO-DA, and COF_2 equivalents. Fluoroether E-1 was quantified via direct analysis using Method 8260B.

Each of the Modified Method 18 impinger samples was recovered and analyzed separately. In calculating target analyte emission rates, the following approach is used:

- For cases where all the impinger analysis results are non-detect (ND) for a target analyte, the earliest (first) impinger reporting limit (RL) is used as the Modified Method 18 train total catch for that analyte.
- For cases where some, but not all the impinger analysis results are non-detect (ND) for a target analyte, the sum of the positive analysis results and the RL of earliest or last non-detect impinger is used as the Modified Method 18 train total catch for that analyte.
- For cases where all the impinger analysis results are positive for a target analyte, the sum of the positive analysis results is used as the Modified Method 18 train total catch for that analyte.

All stack gas Modified Method 18 analytical results for HFPO, HFPO-DAF, COF_2, and Fluoroether E-1 were non-detect values. Therefore, the HFPO, HFPO-DAF, COF_2, and Fluoroether E-1 emission rates were based on the methodology noted in the first bullet, above.

2.3.5.3 Stack Gas Method 0010 Analyses

The seven (7) fractions from the Modified Method 0010 sampling train components were prepared using SW-846 Method 3542 and analyzed for HFPO-DA via EPA Method 537. Sampling train fractions were combined as noted below and a total of four (4) separate analyses were performed per sampling train:

- Front-half composite (probe, nozzle, and filter holder front half solvent rinses, and particulate filter)
- Back-half composite (XAD-2 resin, coil condenser and filter holder back half solvent rinses, and impinger solvent rinses)
- Condensate and impinger contents, and
- Breakthrough XAD-2 resin tube.

The sum of the first three (3) sampling train fraction analyses noted above is used for the sampling train total catch. The fourth fraction, the breakthrough XAD-2 resin tube, was analyzed to assess breakthrough and is excluded from the emissions determination calculations.

2.3.6 PFAS Feed and Stack Emission Rates

Waste gas feed line sampling and analysis data were reduced and reported as mass of HFPO, HFPO-DA, HFPO-DAF, COF_2, and Fluoroether E-1 per total mass of waste gas feed. These data and thermal oxidizer waste gas line mass flow meter data were used to determine the HFPO, HFPO-DA, HFPO-DAF, COF_2, and Fluoroether E-1 mass feed rates to the thermal oxidizer.

The Modified Method 18 sampled volume data and analysis results were used to determine the HFPO, HFPO-DAF, COF_2, and Fluoroether E-1 stack emission concentrations. The Modified Method 0010 sampled volume data and analysis results were used to determine the HFPO-DA stack emission concentration. The Modified Method 0010 stack flow data were used to determine the HFPO, HFPO-DA, HFPO-DAF, COF_2, and Fluoroether E-1 stack emission rates.

Example equations are presented in Section 4.0 of this test report.

2.3.7 Other Sampling and Analysis

In addition to the waste gas feed lines and thermal oxidizer stack emissions, the demineralized water make-up used in the scrubber system, and the HF acid and Stage 4 purge streams from the scrubber system were sampled and analyzed for the same five (5) target PFAS compounds. The purpose of the analysis of the demineralized water make-up samples was to evaluate possible target analyte contamination introduced to the stack gas scrubbing system that could impact the stack gas emissions sampling results. The purpose for the analysis of the acid and purge samples was to evaluate the possible fate of the target analytes.

Table 2-1. Properties and Structures of Target Destruction Efficiency PFAS Compounds

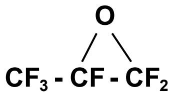
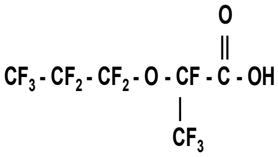
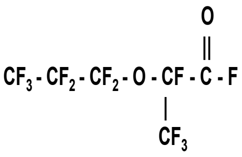
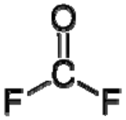
Compound	Hexafluoropropylene oxide	Hexafluoropropylene Dimer Acid or C_3-Dimer	Hexafluoropropylene Dimer Acid Fluoride	Carbonyl Difluoride	Heptafluoropropyl-1,2,2,2-tetrafluoroethyl ether
Acronym	HFPO	HFPO-DA	HFPO-DAF	COF_2	Fluoroether E-1
CAS No.	428-59-1	13252-13-6	2062-98-8	353-50-4	3330-15-2
Molecular Formula	C_3F_6O	$C_6HF_{11}O_3$	$C_6F_{12}O_2$	COF_2	$C_5HF_{11}O$
Mole Weight	166.02	330.05	332.04	66.01	286.04
Molecular Structure		 $CF_3-CF_2-CF_2-O-\underset{\underset{CF_3}{\mid}}{CF}-\overset{\overset{O}{\parallel}}{C}-OH$	 $CF_3-CF_2-CF_2-O-\underset{\underset{CF_3}{\mid}}{CF}-\overset{\overset{O}{\parallel}}{C}-F$		CF3-CF2-CF2-O-CF–F3
Normal B.P., °C @ 760 mmHg	-28	151	56	-85	40
V.P. @ 25°C, psia	98.7 (Gas)	0.0224	0.551	Gas	8.1
V.P. @ 25°C, mmHg abs	5,103 (Gas)	1.16	28.5	Gas	419
Note	Reacts with methanol to form methyl-2-methoxy-tetrafluoro-propionate (2-MTP), B.P. 41°C.	None	Reacts with methanol to form HFPO dimer, methyl ester ($HFPO-DOCH_3$), B.P. 116°C.	Reacts with methanol to form dimethyl carbonate (DMC), B.P. 90°C.	Thermal decarboxylation product of HFPO-DA

Table 2-2. Analysis and Reporting Convention for Test Samples

Target Analyte	Derivative Compound or Target Analyte Actually Measured in the Laboratory	Analytical Method	Reported Equivalent Compound
HFPO Monomer CAS #428-59-1	Methyl 2-methoxytetrafluoropropionate (2-MTP) CAS #10186-63-7	SW-846 Method 8260	HFPO Monomer CAS #428-59-1
HFPO-DAF CAS #2062-98-8	HFPO, Dimer Methyl Ester CAS #13140-34-6	SW-846 Method 8260	HFPO-DAF CAS #2062-98-8
Carbonyl Difluoride CAS #353-50-4	Dimethyl Carbonate CAS #616-38-6	SW-846 Method 8260	Carbonyl Difluoride CAS #353-50-4
Fluoroether E-1 CAS #3330-15-2	Fluoroether E-1 CAS #3330-15-2	SW-846 Method 8260	Fluoroether E-1 CAS #3330-15-2
HFPO-DA (C_3-Dimer) CAS #13252-13-6	HFPO-DA (C_3-Dimer) CAS #13252-13-6	EPA Method 537	HFPO-DA (C_3-Dimer) CAS #13252-13-6

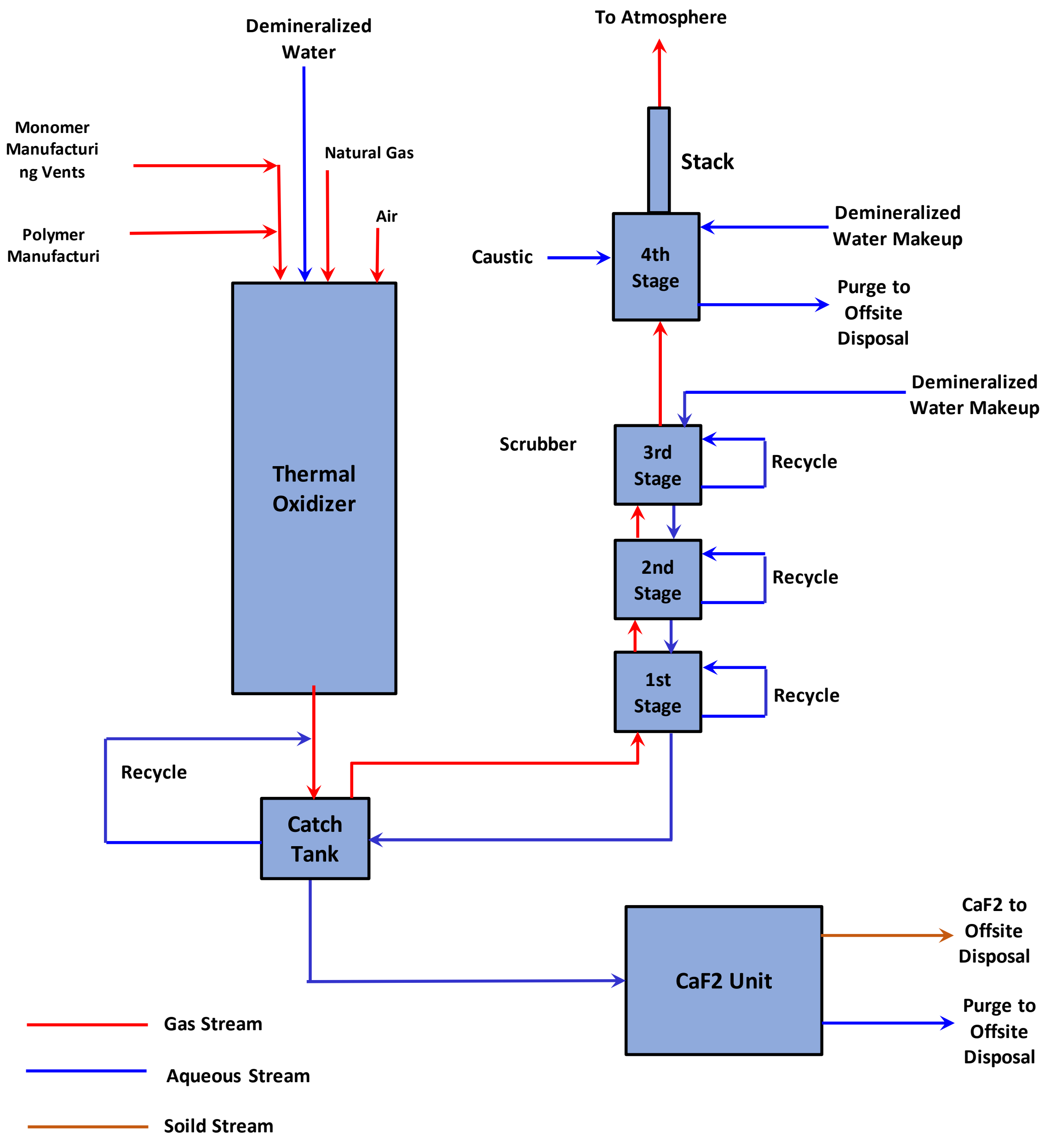
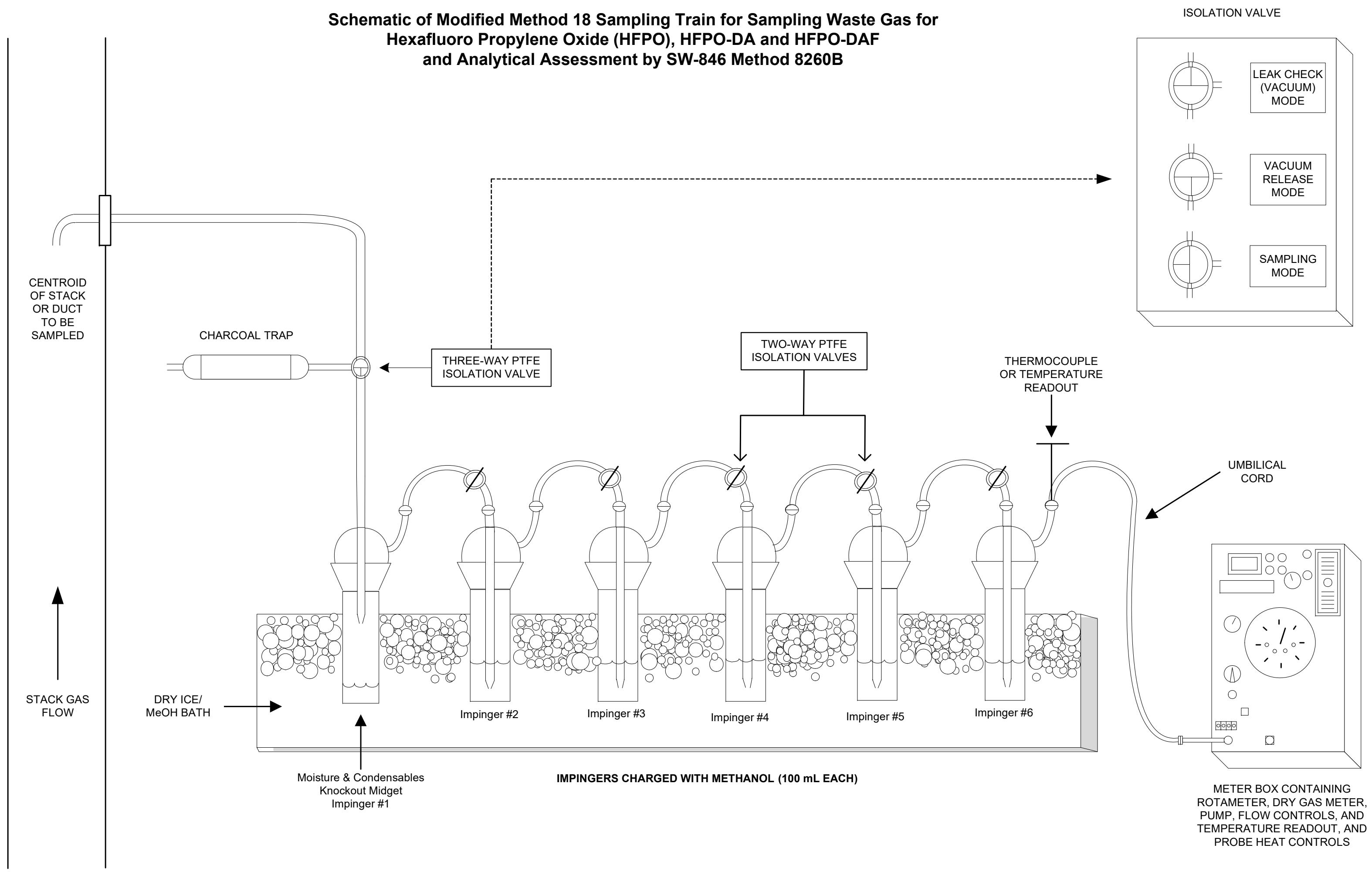


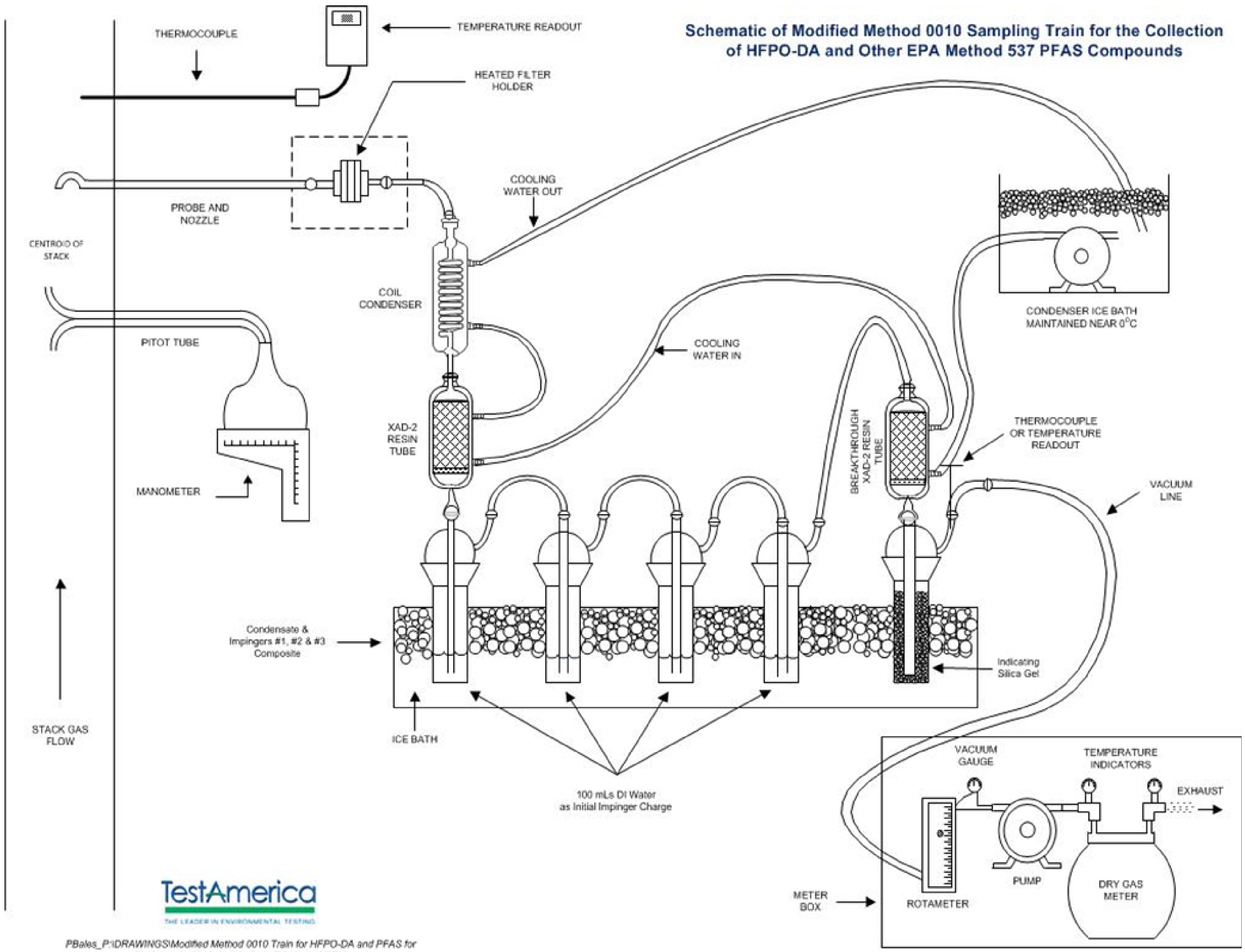
Figure 2-1. Thermal Oxidizer Process Flow Schematic



Schematic of Modified Method 18 Sampling Train for Sampling Waste Gas for Hexafluoro Propylene Oxide (HFPO), HFPO-DA and HFPO-DAF and Analytical Assessment by SW-846 Method 8260B

P:\1_PBB Project Files\Chemours_102017\Handout for Raleigh NC Meeting on December 6 2019\Modified Method 18 Train Schematic for Chemours_3 Compounds_FINAL_112719.vsd
Created by Patti Bales_Last Edited on 3/17/2020 12:40 PM

Figure 2-2. Modified Method 18 Sampling Train Schematic



Schematic of Modified Method 0010 Sampling Train for the Collection of HFPO-DA and Other EPA Method 537 PFAS Compounds

PBales_P:\DRAWINGS\Modified Method 0010 Train for HFPO-DA and PFAS for Procedures_011819.vsd Last Edited 1/18/2019

Figure 2-3. Modified Method 0010 Sampling Train Schematic

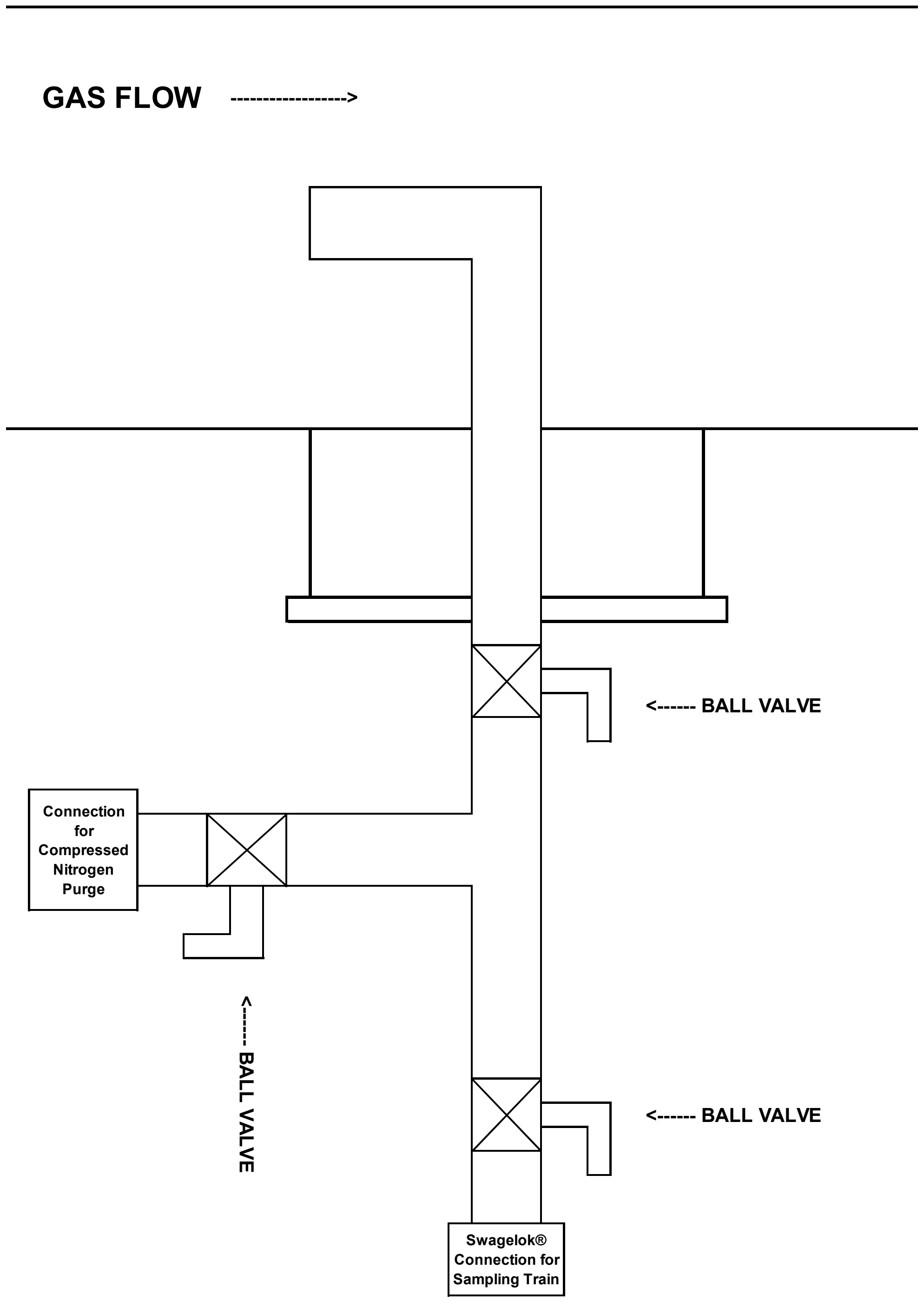


Figure 2-4. Installed Waste Gas Sampling Point Schematic

3.0 TEST PROGRAM SUMMARY

3.1 PERFORMANCE OBJECTIVE

The thermal oxidizer test performance objective was to demonstrate 99.99% DE of PFAS compounds. The test program was designed to characterize and determine the inlet feed rates, and the stack emissions rates of five (5) site-specific target compounds: HFPO, HFPO-DA, HFPO-DAF, COF_2, and Fluoroether E-1. The development details of the sampling and analysis methodologies used are presented in the preceding Section 2.0. System DE performance was calculated based on the sum of the system inlet feed rates, and sum of the stack emissions rates of these five (5) compounds.

3.2 TEST IMPLEMENTATION SUMMARY

Table 3-1 summarizes the test program sampling and analysis. The thermal oxidizer test program was conducted February 8-9, 2022. Three (3) runs of waste gas feed line sampling and thermal oxidizer emissions sampling were performed. Table 3-2 summarizes the sampling dates and times. The performance test was conducted in substantial conformance with the approved test plan.

3.3 TEST OPERATING OBJECTIVES

The thermal oxidizer operating conditions are summarized in Table 3-3. The one-minute operating data are included as Appendix A of this report.

3.4 DEVIATIONS FROM THE TEST PLAN

Two (2) deviations from the approved test plan are noted:

- Sampling and analysis of the fifth compound, Fluoroether E-1, was not in the original December 2019 performance test plan. This compound was added to the sampling and analysis scope following communication with DAQ. This addition to the test program expanded the amount of target PFAS compounds potentially characterized in the waste gas feed and emissions for DE performance determination.

- Sampling of the Stage 1 scrubber purge stream was deleted from the test program. Sampling of this stream was primarily included in the test plan as an option to sampling of the HF acid stream. Sampling of either stream provides similar process information. Deletion of the Stage 1 scrubber purge stream sampling had no impact on test results or determinations.

Table 3-1. Thermal Oxidizer Performance Test Sampling and Analysis

Sample Name	Sampling Location/ Access	Sampling Equipment	Sampling Reference Method [1]	Sample Size/Frequency-	Target Analyte(s)	Analytical Reference Method [2]
Monomer Waste Gas Feed Line #1	Specially fabricated sampling port	Modified Method 18 Sampling Train	EPA Method 18	0.5-1.0 liters per minute concurrent with Method 0010 stack gas sampling	HFPO-DAF, HFPO, COF_2, & Fluoroether E-1 HFPO-DA	SW8-46 Method 8260B (Reaction Products) EPA Method 537 [2]
Polymer Waste Gas Feed Line #2	Specially fabricated sampling port	Modified Method 18 Sampling Train	EPA Method 18	0.5-1.0 liters per minute concurrent with Method 0010 stack gas sampling	HFPO-DAF, HFPO, COF_2, & Fluoroether E-1 HFPO-DA	SW-846 Method 8260B (Reaction Products) EPA Method 537 [2]
Stack Gas	Stack Port	Modified Method 18 Sampling Train	EPA Method 18	~2.0 liters per minute concurrent with Method 0010 stack gas sampling	HFPO, HFPO-DAF, COF_2, & Fluoroether E-1	SW-846 Method 8260B (Reaction Products)
Stack Gas	Isokinetic Port	Modified Method 0010 Sampling Train	SW-846 Method 0010	Minimum sampled volume of 3.0 dry standard cubic meters [3,4]	HFPO-DA	EPA Method 537 [2]
Demineralized Makeup Water	Tap on line	50-100 mL Plastic Graduated Cylinder; 60 and 1000 mL HDPE Sample Bottles	ASTM E-300-86	Sampling Frequency: At the start of the test run and at 60-minute intervals during each test run. Sample Size: Note 5	HFPO, HFPO-DAF, COF_2, & Fluoroether E-1 HFPO-DA	SW-846 Method 8260B (Reaction Products) EPA Method 537
HF Acid Stream	Tap on line	50-100 mL Plastic Graduated Cylinder; 60 and 1000 mL HDPE Sample Bottles	ASTM E-300-86	Same as Demineralized Water	HFPO, HFPO-DAF, COF_2, & Fluoroether E-1 HFPO-DA	SW-846 Method 8260B (Reaction Products) EPA Method 537

Table 3-1. Thermal Oxidizer Performance Test Sampling and Analysis

Sample Name	Sampling Location/ Access	Sampling Equipment	Sampling Reference Method [1]	Sample Size/Frequency-	Target Analyte(s)	Analytical Reference Method [2]
Stage 4 Purge	Tap on line	50-100 mL Plastic Graduated Cylinder; 60 mL HDPE Sample Bottles	ASTM E-300-86	Same as Demineralized Water	HFPO, HFPO-DAF, COF_2, & Fluoroether E-1 HFPO-DA	SW846 Method 8260B (Reaction Products) EPA Method 537

Notes:

[1] Reference Sampling Method Sources:

“ASTM” refers to American Society for Testing Materials, Annual Book of ASTM Standards, Annual Series
“SW-846" refers to Test Methods for Evaluating Solid Waste, Third Edition, November 1986, and Updates.
“EPA Method" refers to New Source Performance Standards, Test Methods and Procedures, Appendix A, 40 CFR 60.

[2] Reference Analysis Methods Sources:

- Modified Method 18 – “Measurement of Gaseous Organic Compound Emissions by Gas Chromatography.” EPA 40 CFR Part 60, Appendix A.
- Method 0010 – “Modified Method 5 Sampling Train”. Taken from Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium, SW-846, Third Edition, September 1986 and its updates, USEPA, OSWER, Washington, D.C. 20460.
- Method 5, Appendix A, Test Methods and Procedures, New Source Performance Standards, 40 CFR 60.
- Method 8260B – “Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)”. Taken from Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium, SW-846, Third Edition, September 1986 and its updates, USEPA, OSWER, Washington, D.C. 20460.
- Method 3542A – “Extraction of Semivolatile Analytes Collected Using Method 0010 ("Modified Method 5 Sampling Train")”. Taken from Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium, SW-846, Third Edition, September 1986 and its updates, USEPA, OSWER, Washington, D.C. 20460.
- Method 537 – “Determination of Selected Perfluorinated Alkyl Acids In Drinking Water By Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)”, Version 1.1, September 2009, EPA/600/R-08/092.

Table 3-1. Thermal Oxidizer Performance Test Sampling and Analysis

[3] The exact volume of gas sampled will depend on the isokinetic sampling rate.

[4] Isokinetic sampling trains include:

- Sampling traverse points determined in accordance with EPA Method 1.
- Performing stack gas velocity, pressure, and temperature profile measurement for each sampling location (EPA Method 2)
- Oxygen and carbon dioxide concentrations measured to determine stack gas molecular weight (EPA Method 3A)
- Determining the moisture content of the stack gas for each sampling train sample (EPA Method 4).

[5] Two sample portions of these process streams are collected at each sampling interval:

- For samples receiving the HFPO, HFPO-DAF, COF_2, and Fluoroether E-1 analyses, a graduated cylinder was used to measure a 40 mL aliquot of the collected material and transfer it to a 60 mL HDPE bottle containing methanol. The lid was placed on the sample bottle and sealed. The methanol reacts with HFPO, HFPO-DAF, and COF_2 under these conditions to form derivative products that are evaluated by the laboratory. The grab portions of these samples were composited in the laboratory to provide a single representative result for each test run.
- For the HFPO-DA analysis sample, a 100 ml aliquot of the collected material was placed into a 1000 ml HDPE bottle. The lid was placed on the sample bottle and sealed. Each additional aliquot was added to the bottle to build a field composite of the process sample. The laboratory analyzed the composited sample to provide a single representative result for each test run.

The different sample portions are labeled to distinguish between those receiving analysis for the HFPO, HFPO-DAF, COF_2, and Fluoroether E-1, and those receiving analysis for HFPO-DA. The final number of discrete sample aliquot portions collected was dependent on the final run duration.

Table 3-2. Thermal Oxidizer Performance Test Sampling Dates and Times

Run No.:	Run 1	Run 2	Run 3
Date:	08-Feb-22	09-Feb-22	09-Feb-221
Start:	13:15	09:11	14:19
Finish:	16:22	12:18	17:25
Duration:	3:07	3:07	3:06

Table 3-3. Thermal Oxidizer Destruction Efficiency Test Operating Data

Parameter	Tag No.	Units	Permit	Statistic	Run 1	Run 2	Run 3	Average
Monomer Waste Gas	A41756FC	lb/hr	NA	Average	587.0	563.5	484.9	545.1
				Maximum	638.2	637.6	634.1	636.7
				Minimum	520.8	493.9	365.5	460.0
				Std Dev	23.6	31.6	82.4	45.9
Polymer Waste Gas	A41103FC	lb/hr	NA	Average	184.9	190.5	191.3	188.9
				Maximum	194.7	208.1	203.9	202.2
				Minimum	179.0	175.1	175.3	176.4
				Std Dev	2.8	9.8	7.8	6.8
Total Waste Gas	Calculated	lb/hr	<2,200	Average	771.9	754.0	676.2	734.1
				Maximum	821.1	817.6	826.8	821.8
				Minimum	710.6	679.2	545.6	645.2
				Std Dev	23.0	30.1	87.3	46.8
Combustion Temperature	A40937TC	deg F	>1,800	Average	2,012	2,013	2,011	2,012
				Maximum	2,015	2,016	2,018	2,016
				Minimum	2,009	2,009	2,004	2,008
				Std Dev	1	1	3	2
Scrubber Flow Rate	Calculated	gpm	>40	Average	87.1	87.2	87.2	87.1
				Maximum	87.7	88.3	87.9	88.0
				Minimum	86.2	86.0	85.6	86.0
				Std Dev	0.3	0.3	0.3	0.3
Scrubber pH	A41261XC	SU	>7.1	Average	8.54	8.41	8.44	8.46
				Maximum	8.62	8.49	8.53	8.54
				Minimum	8.49	8.36	8.38	8.41
				Std Dev	0.04	0.04	0.03	0.03

4.0 TEST RESULTS

4.1 TEST DATA REDUCTION BASIS

The strategy for the determination of the PFAS target analyte feed rates and their emissions evaluation are conducted to provide the most conservative assessment of the thermal oxidizer performance. Specifically:

- Calculation of PFAS target analyte feed rates use zero (0) for laboratory non-detect (ND) values determined from the waste gas line Modified Method 18 sampling and analyses. No feed rate credit or contribution is taken for constituents below the sampling and analysis measurement limits.
- The stack gas ND values represent the quantitative limits of the sampling and analytical measurements under the test conditions. Actual emissions are not assumed to be zero (0), but are assigned the reporting limit (RL) value for the method. The Modified Method 18 sampling train includes six (6) impingers in-series that are recovered and analyzed separately. The calculation of PFAS Modified Method 18 measured stack emission rates is based on the RL for the first in-series impinger when all six (6) impingers are ND for a target analyte. For any impingers with positive results for a specific analyte, the detected value is used and summed with the RL for any preceding impingers in-series and the RL of the last ND impinger in-series for the analyte.
- The Modified Method 0010 measured stack emission rates are based on separate analysis of three (3) sampling train fractions [front-half composite (FH), back-half composite (BH), and the combined impinger contents and rinses composite]. During this test program, HFPO-DA was detected in all three (3) sampling fractions during all three (3) sampling runs. Therefore, the calculation of HFPO-DA Modified Method 0010 measured stack emission rates is based on the sum of all three (3) analysis fraction detected values. The breakthrough XAD-2 resin analyses serve as quality control (QC) indicators and are excluded from the HFPO-DA emissions determinations.

The balance of Section 4.0 details how the test data were reduced to determine thermal oxidizer PFAS DE performance.

4.2 WASTE GAS CHARACTERIZATION AND TARGET PFAS COMPOUND FEED RATES

The waste gas feed lines were sampled using the Modified Method 18 sampling train. Tables 4-1 and 4-2 summarize the analyses of the polymer and monomer waste gas feed lines. Tables 4-3 and 4-4 summarize the calculated feed rates of the target PFAS compounds. The detailed waste gas feed line sampling data are included in *Source Test Report,* The Chemours Company, FC, LLC, Fayetteville, NC, *Source Tested: Thermal Oxidizer, Monomer Line, Polymer Line, Test Date: February 8, 2022*, *AST Project No. 2022-0417*, Alliance Source Testing, LLC, East Syracuse, NY included as Appendix B to this test report. Please note that a zero "0" was applied for calculations used for sample fractions that were reported by the laboratory as non-detect (ND).

The waste gas feed rates to the thermal oxidizer are measured by mass flow meters. To determine the target compound feed rates, the waste gas feed sampling and analysis data were reduced to yield mass of target compound per total mass feed.

Please refer to Tables 4-1 and 4-2. Each of the waste gas feed line sampling train fraction mass concentrations for a target analyte were added together to provide the total mass of each target compound during a test run. The compound mass totals were determined from sum of the individual impinger analyses:

$$C_{TOTi} = \sum C_{Ni}$$

Where: C_{TOTi} = Total mass of individual target compound for a test run,

C_{Ni} = Individual mass results of each target compound.

The total mass of all target PFAS compounds captured during a test run was determined from the sum of the individual target PFAS compounds:

$$C_{PFAS} = \sum C_{TOTi}$$

Where: C_{PFAS} = Total mass of target PFAS compounds

C_{TOTi} = Total mass of each target compound.

Please refer to Tables 4-3 and 4-4. From the Modified Method 18 sampling train recovery data, the total mass of waste gas vapors condensed was determined from the sum of the changes in the impinger masses:

$$\Delta IM_{TOT} = \sum \Delta IM_N$$

Where: ΔIM_{TOT} = Total impinger mass change

ΔIM_N = Individual impinger mass changes.

From the Modified Method 18 sampling train dry gas metering system data, the mass of dry gas sampled was determined:

$$DG_M = V_M{*}DGMC{*}(T_S/T_M){*}[(P_B)/(P_S)]{*}MW_G/MV_{STP}$$

Where: DG_M = Dry gas mass

V_M = Dry gas meter measured volume

DGMC = Dry gas meter coefficient

T_S = Standard temperature in °R or °K

T_M = Dry gas meter temperature in °R or °K

P_B = Barometric pressure

P_S = Standard pressure

MW_G = Dry gas molecular weight

MV = Molar volume (volume per mole of gas at STP)

STP = Standard temperature and pressure.

Tables 4-3 and 4-4 show the reduced sampled volumes from the previously referenced Alliance report for the waste gas feed line Modified Method 18 sampling trains in dry standard liters. The waste gas feed line dry gas fraction was assumed to be 100% nitrogen and was assigned a molecular weight of 28 amu. The mass of dry gas sampled was determined by multiplying the measured dry gas standard sample volume by the molecular weight of nitrogen and dividing by the molar volume at standard temperature and pressure, 24.055 liter/gram mole. The total mass sampled from the waste gas feed line is the sum of dry gas total mass and the impinger mass gain:

$$M_{TOT} = DG_M + \Delta IM_{TOT}$$

Where: M_{TOT} = Total organic vapor and dry gas mass sampled

ΔIM_{TOT} = Total impinger mass change

DG_M = Dry gas mass.

The mass fraction of the target PFAS compounds per total mass feed was determined dividing total mass of target PFAS compounds captured by the total mass sampled:

$$FC_{PFAS} = C_{PFAS}/M_{TOT}$$

Where: FC_{PFAS} = Feed concentration of target PFAS compounds in mass/total mass sampled

C_{PFAS} = Total mass of target compound

M_{TOT} = Total mass of organic vapor and dry gas mass sampled.

The total PFAS target compound mass feed rate was determined by multiplying the calculated mass fraction of total PFAS target compounds by the mass feed rate measured by the thermal oxidizer mass flow meters:

$$FR_{PFAS} = FC_{CPFAS} * MF$$

Where: FR_{PFAS} = Mass feed rate of target compound

FC_{CPFAS} = Feed concentration of target compound in mass/total mass

MF = Mass feed rate measured by the mass flow meter.

4.3 TARGET PFAS COMPOUND STACK EMISSION RATES

Two (2) sampling trains were used to measure the stack emission rates of the target PFAS compounds:

- Modified Method 0010 for HFPO-DA, and
- Modified Method 18 for HFPO, HFPO-DAF, COF_2, and Fluoroether E-1.

The detailed stack gas sampling data and laboratory analysis reports are included in Appendices B and C, respectively of this report.

4.3.1 Modified Method 0010 Measured Emissions

Please refer to Table 4-5. From the Modified Method 0010 sampling train fraction analysis, the total mass of the target compound was determined from sum of the individual fraction composite analyses:

$$C_{TOT} = C_{FH} + C_{BH} + C_{IMP}$$

Where: C_{TOT} = Total mass of target compound

C_{FH} = Mass of target compound in front half fraction (probe, nozzle, and front half solvent rinses and particulate filter)

C_{BH} = Mass of target compound in back half fraction (XAD-2 resin, and back half and impinger solvent rinses)

C_{IMP} = Mass of target compound in impinger fraction (condensate and impinger liquid).

From the Modified Method 0010 sampling train dry gas metering system data, the volume of dry gas sampled was determined:

$$DG_V = V_M*DGMC*(T_S/T_M)*[(P_B+\Delta H)/(P_S)]$$

Where: DG_V = Dry gas volume sampled at standard temperature and pressure

V_M = Dry gas meter measured volume

DGMC = Dry gas meter coefficient

T_S = Standard temperature in °R or °K

T_M = Dry gas meter temperature in °R or °K

P_B = Barometric pressure

ΔH = Delta H sampling pressure (vacuum)

P_S = Standard pressure.

The details of the stack gas Modified Method 0010 sampled volume determinations are included in the previously referenced Alliance report. The sampled stack gas volumes from the Alliance report reduced to standard conditions are presented in Table 4-5. The stack gas concentration of the HFPO-DA was determined by dividing the total mass of HFPO-DA by the sampled volume:

$$EC_C = C_{TOT}/DG_V$$

Where: EC_C = Emission concentration of target compound in mass/dry volume

C_{TOT} = Total mass of target compound

DG_V = Dry gas volume sampled at standard temperature and pressure.

The stack flow rates from the Alliance report reduced to standard conditions are presented in Table 4-5. The emission rate of the HFPO-DA was determined by multiplying the stack gas concentration by the stack flow rate:

$$ER_C = EC_C * SF_{DG}$$

Where: ER_C = Emission rate of target compound

EC_C = Emission concentration of target compound in mass/dry volume

SF_{DG} = Dry gas stack flow rate at standard temperature and pressure
(as determined from Method 0010 data)
(Method 1, 2, 3A, and 4 data).

4.3.2 Modified Method 18 Measured Emissions

Please refer to Table 4-6. From the Modified Method 18 sampling train fraction analysis, the total mass of each target compound was determined from sum of the individual impinger analyses:

$$C_{TOT} = \sum C_N$$

Where: C_{TOT} = Total mass of target compound

C_N = Individual impinger mass analysis results.

Analysis results for all four (4) target compounds measured using Modified Method 18 were non-detect (ND). As noted in Section 2.3.5.2, only the reporting limit (RL) for the first impinger was used to calculate PFAS emissions results for these four compounds.

From the Modified Method 18 sampling train dry gas metering system data, the volume of dry gas sampled was determined:

$$DG_V = V_M*DGMC*(T_S/T_M)*[(P_B+\Delta H)/(P_S)]$$

Where: DG_V = Dry gas volume sampled at standard temperature and pressure

V_M = Dry gas meter measured volume

DGMC = Dry gas meter coefficient

T_S = Standard temperature in °R or °K

T_M = Dry gas meter temperature in °R or °K

P_B = Barometric pressure

ΔH = Delta H sampling pressure (vacuum)

P_S = Standard pressure.

P_S = Standard pressure.

The details of the stack gas Modified Method 18 sampled volume determinations are included in the previously referenced Alliance report. The sampled stack gas volumes from the Alliance report reduced to standard conditions are presented in Table 4-6. The stack gas concentration of target compounds was determined by dividing the total mass of the target compounds by the sampled volume:

$$EC_C = C_{TOT}/DG_V$$

Where: EC_C = Emission concentration of target compounds in mass/dry volume

C_{TOT} = Total impinger mass of target compounds

DG_V = Dry gas volume sampled at standard temperature and pressure.

Please refer to Table 4-7. The emission rate of the target compounds was determined by multiplying the stack gas concentration by the stack flow rate:

$$ER_C = EC_C * SF_{DG}$$

Where: ER_C = Emission rate of target compound

EC_C = Emission concentration of target compound in mass/dry volume

SF_{DG} = Dry gas stack flow rate at standard temperature and pressure (as determined from Method 0010 data) (Method 1, 2, 3A, and 4 data).

4.4 TOTAL PFAS DESTRUCTION EFFICIENCY

Please refer to Table 4-8, “Total PFAS” is the arithmetic sum of HFPO, HFPO-DA, HFPO-DAF, COF_2, and Fluoroether E-1. The total PFAS destruction efficiency (DE) was calculated by dividing the difference of the total PFAS feed rate and the total PFAS emission rate by the total PFAS feed rate:

$$DE = (FR-ER)/FR *100\%$$

Where: DE = Total PFAS destruction efficiency, percent (%)

FR = Total PFAS mass feed rate

ER = Total PFAS mass emission rate.

The total PFAS DE performance results presented in Table 4-8 demonstrate that the thermal oxidizer controls all PFAS at an efficiency greater than 99.99%.

Table 4-1. Thermal Oxidizer Monomer Tank Feed (Line #1) Summary Analyses

Target Compound	Train Fraction	Units	Run 1	Run 2	Run 3
COF2	Impinger 1	ug	55,000,000	40,400,000	50,400,000
COF2	Impinger 2	ug	1,410,000	5,980,000	12,200,000
COF2	Impinger 3	ug	93,100	224,000	539,000
COF2	Impinger 4	ug	6,360	26,300	59,200
COF2	Impinger 5	ug	ND	5,000	8,720
COF2	Impinger 6	ug	ND	ND	ND
COF2	**Total**	**ug**	**56,509,460**	**46,635,300**	**63,206,920**
HFPO-DAF	Impinger 1	ug	186,000	154,000	ND
HFPO-DAF	Impinger 2	ug	6,760	20,900	27,500
HFPO-DAF	Impinger 3	ug	1,710	3,730	1,380
HFPO-DAF	Impinger 4	ug	ND	2,230	894
HFPO-DAF	Impinger 5	ug	ND	1,610	ND
HFPO-DAF	Impinger 6	ug	ND	ND	ND
HFPO-DAF	**Total**	**ug**	**194,470**	**182,470**	**29,774**
HFPO	Impinger 1	ug	158,000	105,000	76,900
HFPO	Impinger 2	ug	346,000	386,000	728,000
HFPO	Impinger 3	ug	347,000	195,000	783,000
HFPO	Impinger 4	ug	239,000	159,000	672,000
HFPO	Impinger 5	ug	160,000	103,000	558,000
HFPO	Impinger 6	ug	117,000	64,400	548,000
HFPO	**Total**	**ug**	**1,367,000**	**1,012,400**	**3,365,900**
Fluoroether E-1	Impinger 1	ug	228,000	110,000	140,000
Fluoroether E-1	Impinger 2	ug	16,800	27,100	53,900
Fluoroether E-1	Impinger 3	ug	5,940	5,170	7,660
Fluoroether E-1	Impinger 4	ug	ND	ND	ND
Fluoroether E-1	Impinger 5	ug	ND	ND	ND
Fluoroether E-1	Impinger 6	ug	ND	ND	ND
Fluoroether E-1	**Total**	**ug**	**250,740**	**142,270**	**201,560**
HFPO-DA	Impinger 1	ug	73,500	2,140	5,570
HFPO-DA	Impinger 2	ug	1,640	2,380	2,400
HFPO-DA	Impinger 3	ug	180	384	217
HFPO-DA	Impinger 4	ug	162	256	141
HFPO-DA	Impinger 5	ug	116	164	81.2
HFPO-DA	Impinger 6	ug	57.8	86.5	50.6
HFPO-DA	**Total**	**ug**	**75,656**	**5,411**	**8,460**
Total Target PFAS Mass		**grams**	**58.40**	47.98	66.81

Table 4-2. Thermal Oxidizer Polymer Tank Feed (Line #2) Summary Analyses

Target Compound	Train Fraction	Units	Run 1	Run 2	Run 3
COF2	Impinger 1	ug	695	3,720	2,850
COF2	Impinger 2	ug	85.0	313	ND
COF2	Impinger 3	ug	ND	229	ND
COF2	Impinger 4	ug	ND	1,780	ND
COF2	Impinger 5	ug	63.5	ND	ND
COF2	Impinger 6	ug	51.5	ND	ND
COF2	**Total**	**ug**	**895**	**6,042**	**2,850**
HFPO-DAF	Impinger 1	ug	226.0	599.0	ND
HFPO-DAF	Impinger 2	ug	91.4	ND	49.9
HFPO-DAF	Impinger 3	ug	52.3	499	ND
HFPO-DAF	Impinger 4	ug	21.6	2,640	ND
HFPO-DAF	Impinger 5	ug	23.2	18	5.80
HFPO-DAF	Impinger 6	ug	11.4	ND	ND
HFPO-DAF	**Total**	**ug**	**426**	**3,756**	**55.7**
HFPO	Impinger 1	ug	ND	ND	ND
HFPO	Impinger 2	ug	ND	ND	ND
HFPO	Impinger 3	ug	ND	ND	ND
HFPO	Impinger 4	ug	ND	ND	2.73
HFPO	Impinger 5	ug	ND	ND	ND
HFPO	Impinger 6	ug	ND	ND	ND
HFPO	**Total**	**ug**	**0**	**0**	**2.73**
Fluoroether E-1	Impinger 1	ug	2,450	1,630	2,360
Fluoroether E-1	Impinger 2	ug	221	270	18.9
Fluoroether E-1	Impinger 3	ug	24.9	212	ND
Fluoroether E-1	Impinger 4	ug	ND	627	ND
Fluoroether E-1	Impinger 5	ug	ND	ND	ND
Fluoroether E-1	Impinger 6	ug	ND	ND	ND
Fluoroether E-1	**Total**	**ug**	**2,696**	**2,739**	**2,379**
HFPO-DA	Impinger 1	ug	ND	ND	ND
HFPO-DA	Impinger 2	ug	ND	ND	ND
HFPO-DA	Impinger 3	ug	ND	ND	ND
HFPO-DA	Impinger 4	ug	ND	ND	ND
HFPO-DA	Impinger 5	ug	ND	ND	ND
HFPO-DA	Impinger 6	ug	ND	ND	ND
HFPO-DA	**Total**	**ug**	**0**	**0**	**0**
Total Target PFAS Mass		grams	0.004017	0.01254	0.005287

Table 4-3. Thermal Oxidizer Monomer Tank (Line #1) Sampling Results and Feed Rates

Parameter	Units	Run 1	Run 2	Run 3
Net Inlet Condensed Mass	grams	117.4	71.0	126.8
Speciated Compounds in Condensed Mass				
Total COF2	ug	56,509,460	46,635,300	63,206,920
Total HFPO-DAF	ug	194,470	182,470	29,774
Total HFPO	ug	1,367,000	1,012,400	3,365,900
Total Fluoroether E-1	ug	250,740	142,270	201,560
Total HFPO-DA	ug	75,656	5,411	8,460
Target PFAS Sample Mass	grams	58.40	47.98	66.81
Total Dry Gas and Condensed Mass Sampled				
Sampled Dry Gas Volume (@ 20ºC, 1 atm)	Liters	98.525	87.916	92.938
Sampled Dry Gas Mass (24.055 L/gmol, MW=28)	grams	114.683	102.335	108.180
Total Mass Sampled (Condensed + Dry Gas)	grams	232.083	173.335	234.980
Constituent Concentrations in Total Sampled Mass				
Total COF2	g/g flow	2.4E-01	2.7E-01	2.7E-01
Total HFPO-DAF	g/g flow	8.4E-04	1.1E-03	1.3E-04
Total HFPO	g/g flow	5.9E-03	5.8E-03	1.4E-02
Total Fluoroether E-1	g/g flow	1.1E-03	8.2E-04	8.6E-04
Total HFPO-DA	g/g flow	3.3E-04	3.1E-05	3.6E-05
Total Target PFAS Characterized	g/g flow	2.5E-01	2.8E-01	2.8E-01
Calculated Constituent Feed Rates				
Monomer Tank Gas Flow	lb/hr	587.0	563.5	484.9
Monomer Tank Gas Flow	kg/hr	266.3	255.6	219.9
Total COF2	g/hr	64,834	68,772	59,162
Total HFPO-DAF	g/hr	223	269	28
Total HFPO	g/hr	1,568	1,493	3,151
Total Fluoroether E-1	g/hr	288	210	189
Total HFPO-DA	g/hr	86.80	7.98	7.92
Total Target PFAS Feed	**g/hr**	**67,000**	**70,751**	**62,537**

Table 4-4. Thermal Oxidizer Polymer Tank (Line # 2) Sampling Results and Feed Rates

Parameter	Units	Run 1	Run 2	Run 3
Net Inlet Condensed Mass	grams	-29.6	-2.4	0.6
Speciated Compounds in Condensed Mass				
Total COF2	ug	895	6,042	2,850
Total HFPO-DAF	ug	426	3,756	56
Total HFPO	ug	0	0	3
Total Fluoroether E-1	ug	2,696	2,739	2,379
Total HFPO-DA	ug	0	0	0
Target PFAS Sample Mass	grams	0.00402	0.01254	0.00529
Total Dry Gas and Condensed Mass Sampled				
Sampled Dry Gas Volume (@ 20^{o}C, 1 atm)	Liters	95.356	90.742	89.454
Sampled Dry Gas Mass (24.055 L/gmol, MW=28)	grams	110.994	105.623	104.124
Total Mass Sampled (Condensed + Dry Gas)	grams	81.394	103.223	104.724
Constituent Concentrations in Total Sampled Mass				
Total COF2	g/g flow	1.1E-05	5.9E-05	2.7E-05
Total HFPO-DAF	g/g flow	5.2E-06	3.6E-05	5.3E-07
Total HFPO	g/g flow	0.0E+00	0.0E+00	2.6E-08
Total Fluoroether E-1	g/g flow	3.3E-05	2.7E-05	2.3E-05
Total HFPO-DA	g/g flow	0.0E+00	0.0E+00	0.0E+00
Total Target PFAS Characterized	g/g flow	4.9E-05	1.2E-04	5.0E-05
Calculated Constituent Feed Rates				
Polymer Tank Gas Flow	lb/hr	184.9	190.5	191.3
Polymer Tank Gas Flow	kg/hr	83.9	86.4	86.8
Total COF2	g/hr	0.922	5.058	2.362
Total HFPO-DAF	g/hr	0.439	3.1442	0.046
Total HFPO	g/hr	0.000	0.000	0.002
Total Fluoroether E-1	g/hr	2.778	2.293	1.971
Total HFPO-DA	g/hr	0.0	0.0	0.0
Total Target PFAS Feed	**g/hr**	**4.14**	**10.5**	**4.38**

Table 4-5. Thermal Oxidizer Modified Method 0010 Emissions Sampling Results

Parameter	Units	Run 1	Run 2	Run 3
Stack Flow	dscfm	6,153	6,345	6,354
Method 0010 Sampled Volume	dscf	175.549	181.140	181.774
Method 0010 Front Half HFPO-DA	ug	0.970	9.78	1.88
Method 0010 Back Half HFPO-DA	ug	0.0674	0.0992	4.89
Method 0010 Impingers HFPO-DA	ug	0.0111	0.0366	1.71
Method 0010 Breakthrough XAD HFPO-DA (Breakthrough Indicator Only)	ug	< 0.00160	< 0.00160	0.0902
Method 0010 Train Total HFPO-DA (Excludes Breakthrough XAD)	ug	1.05	9.916	8.480
Method 0010 Train Total HFPO-DA (Excludes Breakthrough XAD)	ug/dscm	0.211	1.93	1.65
Method 0010 HFPO-DA Emissions	g/hr	0.00220	0.0208	0.0178

Table 4-6. Thermal Oxidizer Stack Modified Method 18 Sample Analyses

Parameter	Units		Run 1		Run 2		Run 3
Speciated Compounds in Impingers							
COF2, Impinger 1	ug	<	4.00	<	2.62	<	2.28
COF2, Impinger 2	ug	<	2.46	<	2.04	<	2.26
COF2, Impinger 3	ug	<	2.48	<	2.15	<	2.34
COF2, Impinger 4	ug	<	2.51	<	2.31	<	2.25
COF2, Impinger 5	ug	<	2.13	<	2.37	<	2.40
COF2, Impinger 6	ug	<	2.44	<	2.54	<	2.61
Total COF2 including ND Values	**ug**	**<**	**16.0**	**<**	**14.0**	**<**	**14.1**
Total COF2 only Impinger 1	**ug**	**<**	**4.00**	**<**	**2.62**	**<**	**2.28**
Total COF2 only Impinger 1 or Positive Results	**ug**	**<**	**4.00**	**<**	**2.62**	**<**	**2.28**
HFPO-DAF, Impinger 1	ug	<	1.32	<	0.864	<	0.750
HFPO-DAF, Impinger 2	ug	<	0.811	<	0.672	<	0.745
HFPO-DAF, Impinger 3	ug	<	0.818	<	0.706	<	0.772
HFPO-DAF, Impinger 4	ug	<	0.828	<	0.760	<	0.740
HFPO-DAF, Impinger 5	ug	<	0.699	<	0.779	<	0.788
HFPO-DAF, Impinger 6	ug	<	0.803	<	0.837	<	0.859
Total HFPO-DAF including ND Values	**ug**	**<**	**5.28**	**<**	**4.62**	**<**	**4.65**
Total HFPO-DAF only Impinger 1	**ug**	**<**	**1.32**	**<**	**0.864**	**<**	**0.750**
Total HFPO-DAF only Impinger 1 or Positive Results	**ug**	**<**	**1.32**	**<**	**0.864**	**<**	**0.750**
HFPO, Impinger 1	ug	<	0.0597	<	0.0390	<	0.0340
HFPO, Impinger 2	ug	<	0.0367	<	0.0304	<	0.0337
HFPO, Impinger 3	ug	<	0.0307	<	0.0320	<	0.0349
HFPO, Impinger 4	ug	<	0.0375	<	0.0344	<	0.0355
HFPO, Impinger 5	ug	<	0.0316	<	0.0353	<	0.0356
HFPO, Impinger 6	ug	<	0.0363	<	0.0378	<	0.0389
Total HFPO including ND Values	**ug**	**<**	**0.233**	**<**	**0.2089**	**<**	**0.2126**
Total HFPO only Impinger 1	**ug**	**<**	**0.0597**	**<**	**0.0390**	**<**	**0.0340**
Total HFPO only Impinger 1 or Positive Results	**ug**	**<**	**0.060**	**<**	**0.0390**	**<**	**0.0340**
Fluoroether E-1, Impinger 1	ug	<	0.0683	<	0.0447	<	0.0389
Fluoroether E-1, Impinger 2	ug	<	0.0420	<	0.0348	<	0.0386
Fluoroether E-1, Impinger 3	ug	<	0.0424	<	0.0366	<	0.0400
Fluoroether E-1, Impinger 4	ug	<	0.0429	<	0.0394	<	0.0384
Fluoroether E-1, Impinger 5	ug	<	0.0362	<	0.0404	<	0.0408
Fluoroether E-1, Impinger 6	ug	<	0.0416	<	0.0433	<	0.0445
Total Fluoroether E-1 including ND Values	**ug**	**<**	**0.273**	**<**	**0.239**	**<**	**0.241**
Total Fluoroether E-1 only Impinger 1	**ug**	**<**	**0.0683**	**<**	**0.0447**	**<**	**0.0389**
Total Fluoroether E-1 only Impinger 1 or Positive Results	**ug**	**<**	**0.0683**	**<**	**0.0447**	**<**	**0.0389**
Total Characterized Including NDs	**ug**	**<**	**21.8**	**<**	**19.1**	**<**	**19.2**
Total Characterized only Impinger 1	**ug**	**<**	**5.45**	**<**	**3.57**	**<**	**3.10**
Total Characterized only Impinger 1 or Positive Results	**ug**	**<**	**5.45**	**<**	**3.57**	**<**	**3.10**

Table 4-7. Thermal Oxidizer Modified Method 18 Emissions Sampling Results

Parameter	Units	Run 1	Run 2	Run 3
Sampled Stack Volume	dsl	174.535	173.837	171.769
Sampled Stack Volume	dscf	6.148	6.224	6.339
Stack Flow	dscfm	6,153	6,345	6,354
Total Characterized only Impinger 1 or Positive Results	ug	< 5.45	< 3.57	< 3.10
Total Characterized only Impinger 1 or Positive Results	g/hr	< 0.327	< 0.218	< 0.187

Table 4-8. Thermal Oxidizer Total PFAS Emissions Sampling Results and Destruction Efficiency

Parameter	Units		Run 1		Run 2		Run 3
Monomer Feed Characterized Inlet by Modified Method 18 (ND=0)	g/hr		67,000		70,751		62,537
Polymer Feed Characterized Inlet by Modified Method 18 (ND=0)	g/hr		4.14		10.5		4.38
Total Characterized Inlet by Modified Method 18 (ND=0)	g/hr		67,004		70,762		62,542
Characterized Outlet HFPO-DA by Modified Method 0010	g/hr		0.00220		0.0208		0.0178
Characterized Outlet Other PFAS by Modified Method 18	g/hr	<	0.327	<	0.218	<	0.187
Total PFAS Characterized Outlet	**g/hr**	**<**	**0.329**	**<**	**0.239**	**<**	**0.204**
Total PFAS Characterized DE	**%**	**>**	**99.99951%**	**>**	**99.99966%**	**>**	**99.99967%**
Average Target PFAS DE				**>**	**99.99961%**		

5.0 QUALITY CONTROL

5.1 WASTE GAS SAMPLING

The waste gas constituents and their concentrations vary based on the product(s) being manufactured at any particular time. Waste gas sampling was performed using the Modified Method 18 sampling train that was developed for the Chemours Fayetteville Works test program. Both waste gas feed lines were sampled independently to determine the concentrations of the five (5) target PFAS compounds. The waste gas sampling was performed at a constant sampling rate from the start of stack gas sampling and through completion of the stack gas sampling. The samples obtained represent the average composition during each test run. The sampling and analysis data were reduced to yield mass of target analyte per total mass of waste gas in each feed line. This information and the respective waste gas feed line mass feed rate data were used to determine inlet feed rates of the target PFAS compounds. The following sections examine the quality of the waste gas feed characterization results and their associated impacts on the measurement of the thermal oxidizer DE performance.

5.1.1 Monomer Waste Gas Sampling

COF_2, HFPO-DAF, HFPO, Fluoroether E-1, and HFPO-DA were all detected in the monomer waste gas feed (Line #1). Figures 5-1 through 5-5 graphically show the relative loadings of each the target compounds in the six (6) Modified Method 18 impingers.

COF_2, HFPO-DAF, Fluoroether E-1, and HFPO-DAF are primarily captured in the first two or three impingers. COF_2 and Fluoroether E-1 readily react with methanol. During all three (3) runs, no COF_2 or HFPO-DAF were detected after the fifth impinger and no Fluoroether E-1 was detected after the third impinger. The capture of HFPO-DA is assumed to occur via condensation and dissolution, and HFPO-DA does not react with methanol. The distribution of HFPO-DA was detected in all six (6) impingers with >90% of the train total being captured in Impingers 1-3. These data show COF_2, HFPO-DAF, Fluoroether E-1, and HFPO-DA are all being captured with a high degree of efficiency.

HFPO was detected in all six (6) impingers distributed at comparable levels throughout. Capture of HFPO is dependent on both condensation and chemical reaction. These data show HFPO is being detected at a lesser degree of efficiency, thus its measured concentration and actual feed rate is higher than is being measured. A low bias to this concentration translates to a low bias in the DE determination. Therefore, a higher concentration determined for HFPO for this feed line would result in a higher DE demonstration. Despite a low bias in feed rate measurement, all PFAS DE is demonstrated to exceed 99.99% efficiency.

5.1.2 Polymer Waste Gas Sampling

COF_2, HFPO-DAF, and Fluoroether E-1 were present in the polymer waste gas feed (Line #2), but no HFPO-DA was detected. Only the fourth impinger from Run 3 displayed a positive result for HFPO at just above the method detection limit (MDL). Figures 5-6, 5-7, and 5-8 graphically show the relative loadings of each of HFPO-DAF, COF_2, and Fluoroether E-1 in the six (6) Modified Method 18 impingers.

Except for Run 1, no COF_2 was captured after Impinger 4. COF_2 was detected in all six (6) impingers during Run 1 with less than 6% of the catch being in Impinger 6.

Except for Run 1, no HFPO-DAF was detected after the fifth impinger with >97% of the train total being captured in Impingers 1-3. HFPO-DAF was detected in all Run 1 six (6) impingers with less than 3% being captured in Impinger 6.

No Fluoroether E-1 was captured after Impinger 4 during any of the three test runs.

The HFPO detected in the fourth impinger of Run 3 is suspect and a possible artifact or contaminant.

These data show the low concentrations of COF_2, HFPO-DAF, and Fluoroether E-1 are being captured with a high degree of efficiency. No HFPO-DA or HFPO were expected to be present in the polymer line.

5.2 WASTE GAS ANALYSES

Tables 5-1 through 5-6 summarize the surrogate spike compound recoveries for the waste gas analyses.

5.2.1 Monomer Waste Gas Analyses

Please refer to Table 5-1 for the monomer waste gas (Line # 1) SW-846 Method 8260B analysis surrogate spike recoveries. For the SW-846 Method 8260B (volatile organic) analyses for COF_2, HFPO, HFPO-DAF, and Fluoroether E-1, surrogate spike recoveries ranged from 87-108%. Four (4) standard surrogate spike compounds spanning the volatile range were reported. Some samples required dilution and re-analysis to accurately quantify the specific target analytes. The narrow range and high degree of surrogate recoveries represent a relatively high precision and accuracy with regard to the measurements of these target analytes in the high concentration waste gas samples.

Table 5-2 refers to the monomer waste gas (Line # 1) EPA Method 537 analysis isotope dilution internal standard (IDIS) spike recoveries related to the determination of HFPO-DA. Target recovery range is 25-150%. The IDIS spike recoveries of the labeled HFPO-DA ($^{13}C_3$ HFPO-DA) ranged from 79-228. Three (3) analyses exceeded the 150% target. These three samples should be considered high-biased for HFPO-DA.

The monomer waste gas analysis data are appropriately accurate and useable for the intended purposes.

5.2.2 Polymer Waste Gas Analyses

The analysis results show the concentrations of target compounds in the polymer gas (Feed Line #2) were nominally four (4) orders of magnitude lower than in Feed Line #1. Please refer to Table 5-3 for the polymer waste gas (Line # 2) SW-846 Method 8260B analysis surrogate spike recoveries.

For the SW-846 Method 8260B (volatile organic) analyses for COF_2, COF_2, HFPO, HFPO-DAF, and Fluoroether E-1 surrogate spike recoveries ranged from 91-111%. Four (4) standard surrogate spike compounds spanning the volatile range are reported. The narrow range and high degree of surrogate recoveries represent a relatively high degree of precision and accuracy with regard to the measurements of these target analytes in the high concentration waste gas samples.

Table 5-4 displays the polymer waste gas (Line # 2) EPA Method 537 analysis IDIS spike recoveries. The IDIS spike recoveries of the isotopically-labeled HFPO-DA ($^{13}C_3$ HFPO-DA) ranged from 89-124%.

The polymer waste gas data are appropriately accurate, and useable for the intended purposes.

5.2.3 Waste Gas Quality Control Analyses

Tables 5-5 and 5-6 summarize the waste gas quality control (QC) sample SW-846 Method 8260B analysis surrogate spike recoveries and the EPA Method 537 analysis IDIS spike recoveries, respectively.

The data in Table 5-5 show the SW-846 Method 8260B (volatile organic) analyses for COF_2, COF_2, HFPO, HFPO-DAF, and Fluoroether E-1 surrogate spike recoveries ranged from 94-104%. Four (4) standard surrogate spike compounds spanning the volatile range are reported. The narrow range and high degree of surrogate recoveries represent a relatively high degree of precision and accuracy with regard to the measurements of these target analytes. All sample fractions were non-detect for the target analytes.

The data in Table 5-6 show the EPA Method 537 analysis IDIS spike recoveries for the isotopically-labeled HFPO-DA ($^{13}C_3$ HFPO-DA) ranged from 90-102%. All sample fractions were non-detect for HFPO-DA.

The waste gas QC sample analyses show the absence of artifact or contaminant target analytes in the sampling equipment and media.

5.3 STACK GAS SAMPLING

Measurement of the stack gas emission rates of the five (5) target PFAS compounds involved two (2) sampling trains:

- Modified Method 18 for COF_2, HFPO, HFPO-DAF, and Fluoroether E-1, and
- Modified Method 0010 for HFPO-DA.

The Modified Method 0010 stack was performed for 180 minutes during each test run to sample a minimum of three (3) dry standard cubic meters (dscm) of stack gas. The Modified Method 18 sampling was performed concurrently. The following sections examine the quality of the thermal oxidizer stack gas emissions sampling and analysis data results, and the associated impacts on the measurement of the thermal oxidizer DE performance.

5.3.1 Stack Gas Modified Method 18 Results

Please refer to Table 5-7 for the Modified Method 18 analysis surrogate spike recoveries.

For the SW-846 Method 8260B (volatile organic) analyses for COF_2, HFPO, HFPO-DAF, and Fluoroether E-1, surrogate spike recoveries ranged from 90-110% with the target recovery being 50-150%. The stack gas Modified Method 18 samples were analyzed using selected ion monitoring (SIM) technique to reduces the detection (reporting) limits to substantially lower levels. For this reason, recoveries of only the two (2) surrogate compounds associated with the target analytes are reported. Conversely, the previously discussed waste gas line Modified Method 18 analyses were analyzed at normal Method 8260B levels with all four (4) of the standard surrogate spike compounds spanning the volatile range being reported. The narrow range and high degree of surrogate recoveries represent a relatively high degree of both precision and accuracy with regard to the measurements of these target analytes in the stack gas.

COF_2, HFPO-DAF, HFPO, and Fluoroether E-1 were “non-detect” in all Modified Method 18 stack gas sample fractions. The stack gas Modified Method 18 blank train, proof blank, and reagent blank samples were also non-detect for all four target analytes. The analytical data quality indicators display sufficient accuracy of the low measurements, and indicate that the data is reliable for demonstrating that the actual DE of the measured compounds exceeds 99.99%.

5.3.2 Stack Gas Modified Method 0010 Results

Please refer to Table 5-8 for the Modified Method 0010 sampling and analysis surrogate spike recoveries.

For the EPA Method 537 analyses of the Modified Method 0010 sampling train fractions, two (2) types of surrogate spikes and five (5) isotopically labeled spiking compounds were used:

- Two (2) sampling surrogates applied to the XAD-2 resin before field sampling:
  - Isotopically labeled perfluorooctanoic acid (PFOA) ($^{13}C_8$ PFOA)
  - Isotopically labeled perfluorooctanesulfonic acid (PFOS) ($^{13}C_8$ PFOS)
- Three (3) analysis IDIS compounds were used:
  - Isotopically labeled HFPO ($^{13}C_3$ HFPO-DA)
  - Isotopically labeled perfluorooctanoic acid (PFOA) ($^{13}C_4$ PFOA)
  - Isotopically labeled perfluorooctanesulfonic acid (PFOS) ($^{13}C_4$ PFOS).

The two (2) sampling surrogate compounds applied to the primary XAD-2 resins provide a comprehensive assessment of the system's ability to capture and retain the target analyte through all the sampling and analysis processes. [Note: These sampling surrogate compounds were not applied to the breakthrough XAD-2 resins.] The analysis IDIS compounds applied to analytical fractions provide an assessment of the ability to recover the target analyte through the sample preparation and analysis processes. The Modified Method 0010 fractions were analyzed using high performance precision liquid chromatography/tandem mass spectrometry (HPLC/MS/MS).

The recoveries for the two sampling surrogate spike compounds for the back-half samples (XAD-2 resin, and condenser and impinger solvent rinses) ranged from 82-118% for $^{13}C_8$ PFOA and 88-89% for $^{13}C_8$ PFOS.

Table 5-8 also shows recoveries for the three (3) analysis IDIS compounds in the back-half, impinger, and breakthrough XAD-2 fractions. Recoveries ranged from 85-119% for $^{13}C_3$ HFPO-DA, $^{13}C_4$ PFOA and $^{13}C_4$ PFOS for these analysis fractions. Recoveries ranged from 85-103% for $^{13}C_3$ HFPO-DA applied to the front-half fractions. The excellent recoveries demonstrate the ability to recover the target analyte through the sample preparation and analysis processes.

These analytical data quality indicators for the Modified Method 0010 sampling and analysis indicate the data are accurate for these very low-level stack gas measurements and the data are usable for their intended purpose.

5.3.3 Positive HFPO-DA Results

Positive results for HFPO-DA were exhibited in the Modified Method 0010 stack gas train front-half, back-half, and condensate sample fractions during all three test runs. Please refer to Table 5-9. The Run 1 and Run 2 breakthrough XAD resin samples were non-detect for HFPO-DA. The Run 3 breakthrough XAD resin sample exhibited positive results above the method detection limit (MDL), but below the reporting limit (RL). The field blank train (FB) front-half, back-half, and condensate sample fractions exhibited HFPO-DA levels similar to the Run 1 Method 0010 samples; the breakthrough XAD resin sample was non-detect. Positive results were exhibited in the proof blank train (PB) front-half and condensate sample fractions just above the method detection limit levels; the back-half and breakthrough XAD resin samples were non-detect. The filter media check exhibited a positive result just above the method detection limit. The deionized water blank, methanol reagent blank, and XAD-2 resin media check samples were all non-detect.

The purpose of the field blank train is to evaluate the potential field sources of contamination associated with the sampling train setup, sampling, and recovery processes. The field blank train was assembled using laboratory clean glassware not previously used to perform sampling of the thermal oxidizer emissions. The field blank train was assembled, leak checked, and setup as near the thermal oxidizer emissions sampling location as possible during Run 1. The field blank train was heated to the same temperature as used for the stack sampling train, and the impinger portion of the train was iced down and chilled water circulated through the coil condenser. The field blank train remained in place for the duration of the concurrent Run 1 sampling. Other than the ambient air during leak checks, no gas was drawn through the sampling train. The field blank train was then recovered in like manner as the other Method 0010 sampling trains.

The analysis of the proof blank train reflects possible artifacts from the sampling train recovery process. The proof blank train was assembled using same glassware used to perform the Run 1 emissions sampling after recovery of the Run 1 Method 0010 sampling train. The glassware components of the proof blank train were then immediately recovered in like manner as the other Method 0010 sampling trains. This assembly and recovery was performed in the same laboratory area where the stack gas Method 0010 sampling train assemblies and recoveries were performed. This second recovery of Run 1 sampling train is to evaluate the effectiveness of the initial sampling train breakdown and collection process.

The probability is low that the positive HFPO-DA results in the thermal oxidizer stack gas samples originated from thermal oxidizer emissions. The potential for HFPO-DA to pass through the combustion system as HFPO-DA is thermodynamically improbable. Fluoroether E-1 is the thermal decarboxylation product of HFPO-DA which occurs at approximately 200-250ºF. Incomplete combustion of HFPO-DA could possibly be exhibited as Fluoroether E-1. However, the stack gas Modified Method 18 samples were all non-detect for Fluoroether E-1 which makes the survival hypothesis seem remote. Other background HFPO-DA sources are considered probable.

The exact source of the positive HFPO-DA results in the field blank train is unclear, but perhaps point to a possible background field source. The proof blank train analyses demonstrate the sampling train recovery process is very effective; the run-to-run carryover of artifacts is negligible.

5.4 PROCESS WATER ANALYSES

The demineralized make-up water used in the scrubber system, and the HF acid and Stage 4 purge streams from the scrubber system were sampled and analyzed for the same five (5) target PFAS compounds. The analyses are summarized in Table 5-10.

The purpose for the sampling and analyses of the demineralized make-up water samples was to evaluate possible target analyte contamination introduced to the stack gas samples. The purpose of the HF acid and Stage 4 purge samples was to evaluate the possible fate of the target analytes. Positive results were reported for HFPO-DA in the make-up water during all three test runs just above the reporting limit of 2.00 ng/L. The HF acid and Stage 4 purge samples were all non-detect for HFPO-DA. Make-up water, HF acid, and Stage 4 purge samples were all non-detect for the other four (4) target compounds. These data indicate possible contribution of HFPO-DA from make-up water to the Method 0010 sampling train results.

5.5 OVERALL DATA QUALITY ASSESSMENT

A comprehensive review has been conducted of the thermal oxidizer performance test data quality indicators. Quality assurance and quality control (QA/QC) measurements indicate the data sets for this test project are representative of the processes from which they are derived, and that sufficient measurements have been performed to assess the overall precision and accuracy. The conclusion from this assessment is all the data are of sufficient quality to be used for their intended purposes.

Table 5-1. Monomer Waste Gas Method 8260B Analysis Surrogate Recoveries

Method 8260B Analysis Surrogate Recoveries		Run No.	Surrogate Recovery			
Sample	**Fraction**		**1**	**2**	**3**	**4**
T- 1812	Monomer Feed Line, MM18, Impinger #1	1	95%	93%	104%	104%
	COF2 Dilution & Re-Analysis		95%	94%	107%	103%
T- 1813	Monomer Feed Line, MM18, Impinger #2	1	95%	89%	100%	104%
T- 1814	Monomer Feed Line, MM18, Impinger #3	1	97%	90%	103%	104%
T- 1815	Monomer Feed Line, MM18, Impinger #4	1	95%	90%	103%	104%
T- 1816	Monomer Feed Line, MM18, Impinger #5	1	98%	87%	103%	106%
T- 1817	Monomer Feed Line, MM18, Impinger #6	1	95%	92%	103%	103%
T- 1818	Monomer Feed Line, MM18, Impinger #1	2	95%	89%	100%	104%
	COF2 Dilution & Re-Analysis		97%	89%	104%	104%
T- 1819	Monomer Feed Line, MM18, Impinger #2	2	97%	90%	103%	106%
	COF2 Dilution & Re-Analysis		95%	94%	104%	103%
T- 1820	Monomer Feed Line, MM18, Impinger #3	2	99%	91%	104%	104%
T- 1821	Monomer Feed Line, MM18, Impinger #4	2	97%	89%	99%	102%
T- 1822	Monomer Feed Line, MM18, Impinger #5	2	97%	89%	105%	105%
T- 1823	Monomer Feed Line, MM18, Impinger #6	2	92%	89%	105%	105%
T- 1824	Monomer Feed Line, MM18, Impinger #1	3	94%	88%	102%	103%
	COF2 Dilution & Re-Analysis		96%	94%	102%	103%
T- 1825	Monomer Feed Line, MM18, Impinger #2	3	93%	89%	103%	102%
	COF2 Dilution & Re-Analysis		96%	93%	104%	101%
T- 1826	Monomer Feed Line, MM18, Impinger #3	3	94%	90%	108%	101%
	COF2 Dilution & Re-Analysis		93%	93%	103%	103%
T- 1827	Monomer Feed Line, MM18, Impinger #4	3	96%	92%	102%	102%
	HFPO Dilution & Re-analysis		94%	94%	105%	104%
T- 1828	Monomer Feed Line, MM18, Impinger #5	3	95%	89%	103%	104%
	HFPO Dilution & Re-analysis		95%	92%	104%	101%
T- 1829	Monomer Feed Line, MM18, Impinger #6	3	96%	90%	100%	103%
	HFPO Dilution & Re-analysis		93%	93%	107%	103%

No.	Surrogate	Target
1	4-Bromofluorobenzene	57% - 152%
2	Dibromofluoromethane	62% - 134%
3	1,2-Dichloroethane-d4	70% - 160%
4	Toluene-d8	71% - 139%

Table 5-2. Monomer Waste Gas Method 537 Analysis Surrogate Recoveries

EPA Method 537 Analysis Surrogate Recoveries		Run	$^{13}C_3$ HFPO-DA
Sample	**Fraction**	**No.**	**25-150%**
T- 1812	Monomer Feed Line, MM18, Impinger #1	1	89%
T- 1813	Monomer Feed Line, MM18, Impinger #2	1	101%
T- 1814	Monomer Feed Line, MM18, Impinger #3	1	117%
T- 1815	Monomer Feed Line, MM18, Impinger #4	1	115%
T- 1816	Monomer Feed Line, MM18, Impinger #5	1	100%
T- 1817	Monomer Feed Line, MM18, Impinger #6	1	83%
T- 1818	Monomer Feed Line, MM18, Impinger #1	2	110%
T- 1819	Monomer Feed Line, MM18, Impinger #2	2	142%
T- 1820	Monomer Feed Line, MM18, Impinger #3	2	228%
T- 1821	Monomer Feed Line, MM18, Impinger #4	2	165%
T- 1822	Monomer Feed Line, MM18, Impinger #5	2	121%
T- 1823	Monomer Feed Line, MM18, Impinger #6	2	91%
T- 1824	Monomer Feed Line, MM18, Impinger #1	3	179%
T- 1825	Monomer Feed Line, MM18, Impinger #2	3	112%
T- 1826	Monomer Feed Line, MM18, Impinger #3	3	114%
T- 1827	Monomer Feed Line, MM18, Impinger #4	3	94%
T- 1828	Monomer Feed Line, MM18, Impinger #5	3	91%
T- 1829	Monomer Feed Line, MM18, Impinger #6	3	79%

Table 5-3. Polymer Waste Gas Method 8260B Analysis Surrogate Recoveries

Method 8260B Analysis Surrogate Recoveries		Run No.	Surrogate Recovery			
Sample	**Fraction**		**1**	**2**	**3**	**4**
Z- 2969	Polymer Feed Line, MM18, Impinger #1	1	102%	94%	108%	104%
	Fluoroether E-1 Dilution & Re-analysis		93%	95%	105%	103%
Z- 2970	Polymer Feed Line, MM18, Impinger #2	1	100%	94%	108%	105%
Z- 2971	Polymer Feed Line, MM18, Impinger #3	1	99%	98%	106%	106%
Z- 2972	Polymer Feed Line, MM18, Impinger #4	1	97%	93%	103%	102%
Z- 2973	Polymer Feed Line, MM18, Impinger #5	1	96%	95%	110%	102%
Z- 2974	Polymer Feed Line, MM18, Impinger #6	1	95%	95%	103%	101%
Z- 2975	Polymer Feed Line, MM18, Impinger #1	2	95%	96%	104%	105%
Z- 2976	Polymer Feed Line, MM18, Impinger #2	2	96%	95%	107%	108%
Z- 2977	Polymer Feed Line, MM18, Impinger #3	2	98%	96%	106%	102%
Z- 2978	Polymer Feed Line, MM18, Impinger #4	2	94%	95%	102%	105%
Z- 2979	Polymer Feed Line, MM18, Impinger #5	2	100%	91%	107%	104%
Z- 2980	Polymer Feed Line, MM18, Impinger #6	2	93%	91%	104%	104%
Z- 2981	Polymer Feed Line, MM18, Impinger #1	3	96%	100%	108%	103%
Z- 2982	Polymer Feed Line, MM18, Impinger #2	3	94%	97%	108%	101%
Z- 2983	Polymer Feed Line, MM18, Impinger #3	3	94%	96%	102%	100%
Z- 2984	Polymer Feed Line, MM18, Impinger #4	3	94%	92%	104%	103%
Z- 2985	Polymer Feed Line, MM18, Impinger #5	3	93%	95%	111%	103%
Z- 2986	Polymer Feed Line, MM18, Impinger #6	3	92%	94%	108%	102%

No.	Surrogate	Target		
1	4-Bromofluorobenzene	57%	-	152%
2	Dibromofluoromethane	62%	-	134%
3	1,2-Dichloroethane-d4	70%	-	160%
4	Toluene-d8	71%	-	139%

Table 5-4. Polymer Waste Gas Method 537 Analysis Surrogate Recoveries

EPA Method 537 Analysis Surrogate Recoveries		Run	$^{13}C_3$ HFPO-DA
Sample	**Fraction**	**No.**	**25-150%**
Z- 2969	Polymer Feed Line, MM18, Impinger #1	1	124%
Z- 2970	Polymer Feed Line, MM18, Impinger #2	1	102%
Z- 2971	Polymer Feed Line, MM18, Impinger #3	1	100%
Z- 2972	Polymer Feed Line, MM18, Impinger #4	1	111%
Z- 2973	Polymer Feed Line, MM18, Impinger #5	1	104%
Z- 2974	Polymer Feed Line, MM18, Impinger #6	1	97%
Z- 2975	Polymer Feed Line, MM18, Impinger #1	2	118%
Z- 2976	Polymer Feed Line, MM18, Impinger #2	2	114%
Z- 2977	Polymer Feed Line, MM18, Impinger #3	2	108%
Z- 2978	Polymer Feed Line, MM18, Impinger #4	2	95%
Z- 2979	Polymer Feed Line, MM18, Impinger #5	2	110%
Z- 2980	Polymer Feed Line, MM18, Impinger #6	2	96%
Z- 2981	Polymer Feed Line, MM18, Impinger #1	3	124%
Z- 2982	Polymer Feed Line, MM18, Impinger #2	3	94%
Z- 2983	Polymer Feed Line, MM18, Impinger #3	3	104%
Z- 2984	Polymer Feed Line, MM18, Impinger #4	3	91%
Z- 2985	Polymer Feed Line, MM18, Impinger #5	3	108%
Z- 2986	Polymer Feed Line, MM18, Impinger #6	3	84%

Table 5-5. Waste Gas Line Method 8260B QC Analysis Surrogate Recoveries

Method 8260B Analysis Surrogate Recoveries		Run No.	Surrogate Recovery	
Sample	Fraction		1	2
O- 2191	Feed Line, MM18, Impinger #1	FB	99%	102%
O- 2192	Feed Line, MM18, Impinger #2	FB	98%	99%
O- 2193	Feed Line, MM18, Impinger #3	FB	94%	102%
O- 2194	Feed Line, MM18, Impinger #4	FB	102%	100%
O- 2195	Feed Line, MM18, Impinger #5	FB	101%	99%
O- 2196	Feed Line, MM18, Impinger #6	FB	98%	100%
O- 2197	Feed Line, MM18, MeOH	RB	99%	102%
O- 2198	Feed Line, MM18, MeOH	PB	99%	104%

No.	Surrogate	Target
1	Dibromofluoromethane	50% - 100%
2	1,2-Dichloroethane-d4	50% - 100%

Table 5-6. Waste Gas Line Method 537 QC Analysis Surrogate Recoveries

EPA Method 537 Analysis Surrogate Recoveries		Run	$^{13}C_3$ HFPO-DA
Sample	**Fraction**	**No.**	**25-150%**
O- 2191	Feed Line, MM18, Impinger #1	FB	99%
O- 2192	Feed Line, MM18, Impinger #2	FB	95%
O- 2193	Feed Line, MM18, Impinger #3	FB	102%
O- 2194	Feed Line, MM18, Impinger #4	FB	90%
O- 2195	Feed Line, MM18, Impinger #5	FB	94%
O- 2196	Feed Line, MM18, Impinger #6	FB	93%
O- 2197	Feed Line, MM18, MeOH	RB	96%
O- 2198	Feed Line, MM18, MeOH	PB	99%

Table 5-7. Stack Gas Modified Method 18 Analysis Surrogate Recoveries

Method 8260B Analysis Surrogate Recoveries		Run	Surrogate Recovery	
Sample	**Fraction**	**No.**	**1**	**2**
QF- 2400	Stack Gas, MM18, Impinger #1	1	100%	101%
QF- 2401	Stack Gas, MM18, Impinger #2	1	103%	100%
QF- 2402	Stack Gas, MM18, Impinger #3	1	94%	91%
QF- 2403	Stack Gas, MM18, Impinger #4	1	93%	104%
QF- 2404	Stack Gas, MM18, Impinger #5	1	101%	99%
QF- 2405	Stack Gas, MM18, Impinger #6	1	93%	105%
QF- 2407	Stack Gas, MM18, Impinger #1	2	96%	107%
QF- 2408	Stack Gas, MM18, Impinger #2	2	102%	109%
QF- 2409	Stack Gas, MM18, Impinger #3	2	90%	105%
QF- 2410	Stack Gas, MM18, Impinger #4	2	101%	107%
QF- 2411	Stack Gas, MM18, Impinger #5	2	97%	105%
QF- 2412	Stack Gas, MM18, Impinger #6	2	101%	96%
QF- 2414	Stack Gas, MM18, Impinger #1	3	103%	110%
QF- 2415	Stack Gas, MM18, Impinger #2	3	102%	105%
QF- 2416	Stack Gas, MM18, Impinger #3	3	102%	105%
QF- 2417	Stack Gas, MM18, Impinger #4	3	102%	108%
QF- 2418	Stack Gas, MM18, Impinger #5	3	98%	107%
QF- 2419	Stack Gas, MM18, Impinger #6	3	96%	104%
TF- 1991	Stack Gas, MM18, Impinger #1	FB	101%	108%
TF- 1992	Stack Gas, MM18, Impinger #2	FB	102%	97%
TF- 1993	Stack Gas, MM18, Impinger #3	FB	96%	99%
TF- 1994	Stack Gas, MM18, Impinger #4	FB	102%	96%
TF- 1995	Stack Gas, MM18, Impinger #5	FB	104%	103%
TF- 1996	Stack Gas, MM18, Impinger #6	FB	101%	102%
TF- 1998	Stack Gas, MM18, MeOH	RB	104%	98%
TF- 1999	Stack Gas, MM18, MeOH	PB	92%	101%

No.	Surrogate	Target		
1	Dibromofluoromethane	50%	-	150%
2	1,2-Dichloroethane-d4	50%	-	150%

FB = Field Blank Train
PB = Proof Blank
RB = Reagent Blank

Table 5-8. Stack Gas Modified Method 0010 Analysis Surrogate Recoveries

EPA Method 537 Analysis Surrogate Recoveries		Run No.	Surrogate Recovery				
Sample	**Fraction**		**1**	**2**	**3**	**4**	**5**
Q- 2182 Q- 2183	Stack Gas, MM0010, Front Half Composite	1	97%	NA	NA	NA	NA
Q- 2184 Q- 2185 Q- 2187	Stack Gas, MM0010, Back Half Composite	1	97%	96%	105%	90%	92%
Q- 2186	Stack Gas, MM0010, Impingers	1	89%	92%	92%	NA	NA
Q- 2188	Stack Gas, MM0010, Breakthrough XAD	1	86%	95%	95%	NA	NA
Q- 2189 Q- 2190	Stack Gas, MM0010, Front Half Composite	2	92%	NA	NA	NA	NA
Q- 2191 Q- 2192 Q- 2194	Stack Gas, MM0010, Back Half Composite	2	99%	109%	112%	83%	86%
Q- 2193	Stack Gas, MM0010, Impingers	2	93%	98%	95%	NA	NA
Q- 2195	Stack Gas, MM0010, Breakthrough XAD	2	87%	99%	94%	NA	NA
Q- 2196 Q- 2197	Stack Gas, MM0010, Front Half Composite	3	103%	NA	NA	NA	NA
Q- 2198 Q- 2199 Q- 2201	Stack Gas, MM0010, Back Half Composite	3	91%	99%	106%	118%	115%
Q- 2200	Stack Gas, MM0010, Impingers	3	109%	98%	91%	NA	NA
Q- 2202	Stack Gas, MM0010, Breakthrough XAD	3	90%	105%	102%	NA	NA
H- 2546 H- 2547	Stack Gas, MM0010, Front Half Composite	FB	85%	NA	NA	NA	NA
H- 2548 H- 2549 H- 2551	Stack Gas, MM0010, Back Half Composite	FB	98%	112%	117%	92%	99%
H- 2550	Stack Gas, MM0010, Impingers	FB	100%	95%	99%	NA	NA
H- 2552	Stack Gas, MM0010, Breakthrough XAD	FB	101%	110%	96%	NA	NA
H- 2553 H- 2554	Stack Gas, MM0010, Front Half Composite	PB	89%	NA	NA	NA	NA
H- 2555 H- 2556 H- 2558	Stack Gas, MM0010, Back Half Composite	PB	103%	114%	119%	82%	85%
H- 2557	Stack Gas, MM0010, Impingers	PB	100%	96%	103%	NA	NA
H- 2559	Stack Gas, MM0010, Breakthrough XAD	PB	93%	99%	93%	NA	NA
H- 2560	Stack Gas XAD Resin Tube	RB	99%	110%	112%	87%	87%
H- 2561	Stack Gas MeOH/5%NH4OH	RB	88%	93%	91%	NA	NA
H- 2562	Stack Gas Filter	RB	98%	NA	NA	NA	NA
H- 2563	Stack Gas DI Water	RB	94%	93%	95%	NA	NA
H- 2564	Stack Gas XAD Resin Tube	TB	99%	108%	104%	85%	87%
H- 2565	Stack Gas MeOH/5%NH4OH	TB	96%	96%	101%	NA	NA
H- 2566	Stack Gas DI Water	TB	93%	92%	94%	NA	NA
C- 2554	Stack Gas XAD Resin Tube	MC	95%	93%	101%	NA	NA

Table 5-8. Stack Gas Modified Method 0010 Analysis Surrogate Recoveries

EPA Method 537 Analysis Surrogate Recoveries		Run	Surrogate Recovery				
Sample	**Fraction**	**No.**	**1**	**2**	**3**	**4**	**5**
C- 2555	Stack Gas Filter	MC	85%	NA	NA	NA	NA

No.	Surrogate	Target
1	$^{13}C_3$ HFPO-DA	25% - 150%
2	$^{13}C_4$ PFOA	25% - 150%
3	$^{13}C_4$ PFOS	25% - 150%
4	$^{13}C_8$ PFOA	50% - 150%
5	$^{13}C_8$ PFOS	50% - 150%

NA = Not Applicable
FB = Field Blank Train
PB = Proof Blank Train
RB = Reagent Blank
TB = Trip Blank
MC = Media Check

Table 5-9. Thermal Oxidizer Modified Method 0010 Analysis Results

Parameter	Units	Run 1	Run 2	Run 3	FB	PB
Method 0010 Front Half	ug	0.970	9.78	1.88	0.186	0.000767
Method 0010 Back Half	ug	0.0674	0.0992	4.89	0.0591	< 0.00160
Method 0010 Impingers	ug	0.0111	0.0366	1.71	0.00396	0.000111
Total	ug	1.05	9.92	8.48	0.249	0.00248
Method 0010 Breakthrough XAD	ug	< 0.00160	< 0.00160	0.0902	< 0.00160	< 0.00160

XAD Resin Reagent Blank HFPO-DA	ug	< 0.00160 ND
MeOH/5% NH4OH Reagent Blank HFPO-DA	ug	< 0.00160 ND
Filter Reagent Blank HFPO-DA	ug	< 0.00100 ND
Deionized Water Blank HFPO-DA	ug	< 0.000500 ND
XAD Resin Trip Blank HFPO-DA	ug	< 0.00160 ND
MeOH/5% NH4OH Trip Blank HFPO-DA	ug	< 0.00160 ND
Deionized Water Trip HFPO-DA	ug	< 0.000500 ND
XAD-2 Resin Media Check HFPO-DA	ug	< 0.00160 ND
Filter Media Check HFPO-DA	ug	0.000605

Table 5-10. Thermal Oxidizer Process Water Analysis Results

Demineralized Water Analyses

Compound	Units	Run 1	Run 2	Run 3	Average
Compounds by EPA 537					
HFPO-DA	ng/L	2.85	3.27	2.17	2.76
Compounds by Method 8260B					
Carbonyl Difluoride	mg/kg	< 3.82 ND	< 3.85 ND	< 3.85 ND	< 3.84 ND
Fluoroether E-1	mg/kg	< 1.25 ND	< 1.26 ND	< 1.26 ND	< 1.26 ND
HFPO-DAF	mg/kg	< 1.21 ND	< 1.22 ND	< 1.22 ND	< 1.22 ND
HFPO	mg/kg	< 1.09 ND	< 1.10 ND	< 1.10 ND	< 1.10 ND

Method 537 Sample No.	No.	X- 1642	X- 1648	X- 1654
Method 8260B Sample No.	No.	X- 1643	X- 1649	X- 1655

Stage 4 Purge Analyses

Compound	Units	Run 1	Run 2	Run 3	Average
Compounds by EPA 537					
HFPO-DA	ng/L	< 250 ND	< 250 ND	< 250 ND	< 250 ND
Compounds by Method 8260B					
Carbonyl Difluoride	mg/kg	< 3.76 ND	< 3.70 ND	< 3.66 ND	< 3.71 ND
Fluoroether E-1	mg/kg	< 1.23 ND	< 1.21 ND	< 1.20 ND	< 1.21 ND
HFPO-DAF	mg/kg	< 1.19 ND	< 1.17 ND	< 1.16 ND	< 1.17 ND
HFPO	mg/kg	< 1.07 ND	< 1.06 ND	< 1.05 ND	< 1.06 ND

Method 537 Sample No.	No.	X- 1644	X- 1650	X- 1656
Method 8260B Sample No.	No.	X- 1645	X- 1651	X- 1657

HF Acid Analyses

Compound	Units	Run 1	Run 2	Run 3	Average
Compounds by EPA 537					
HFPO-DA	ng/L	< 250 ND	< 250 ND	< 250.0 ND	< 250 ND
Compounds by Method 8260B					
Carbonyl Difluoride	mg/kg	< 3.74 ND	< 3.70 ND	< 3.82 ND	< 3.75 ND
Fluoroether E-1	mg/kg	< 1.22 ND	< 1.21 ND	< 1.25 ND	< 1.23 ND
HFPO-DAF	mg/kg	< 1.18 ND	< 1.17 ND	< 1.21 ND	< 1.19 ND
HFPO	mg/kg	< 1.07 ND	< 1.06 ND	< 1.09 ND	< 1.07 ND

Method 537 Sample No.	No.	X- 1646	X- 1652	X- 1658
Method 8260B Sample No.	No.	X- 1647	X- 1653	X- 1659

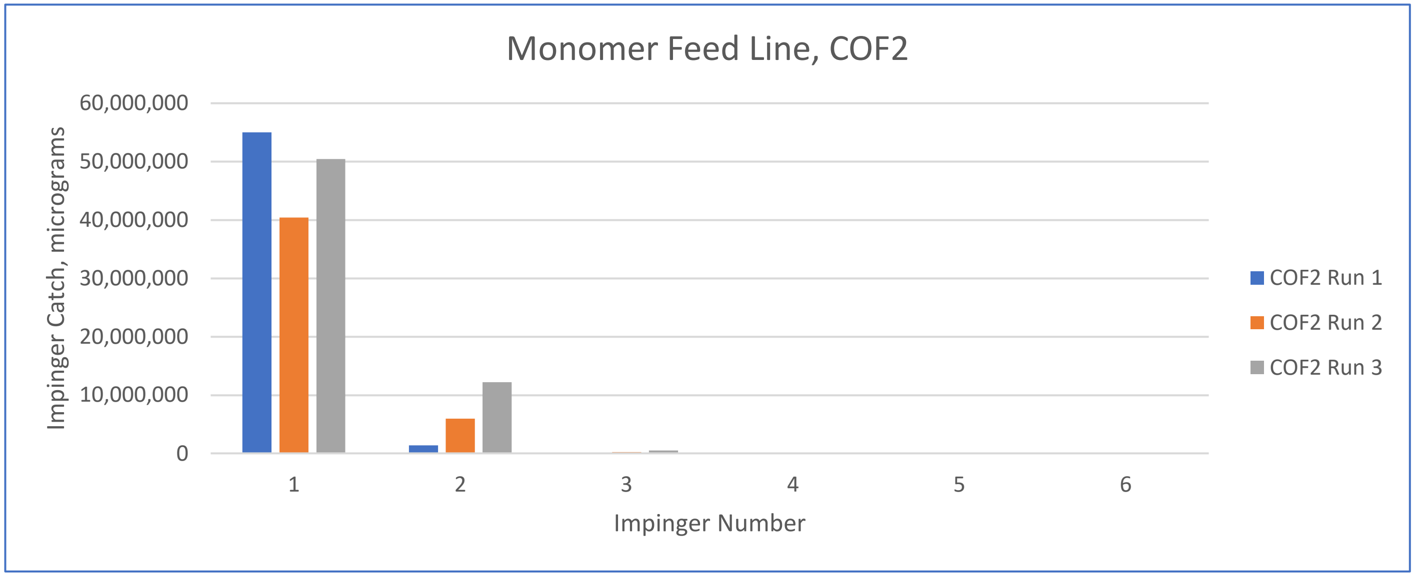


Figure 5-1. Monomer Waste Gas (Line #1) Modified Method 18 COF_2 Capture

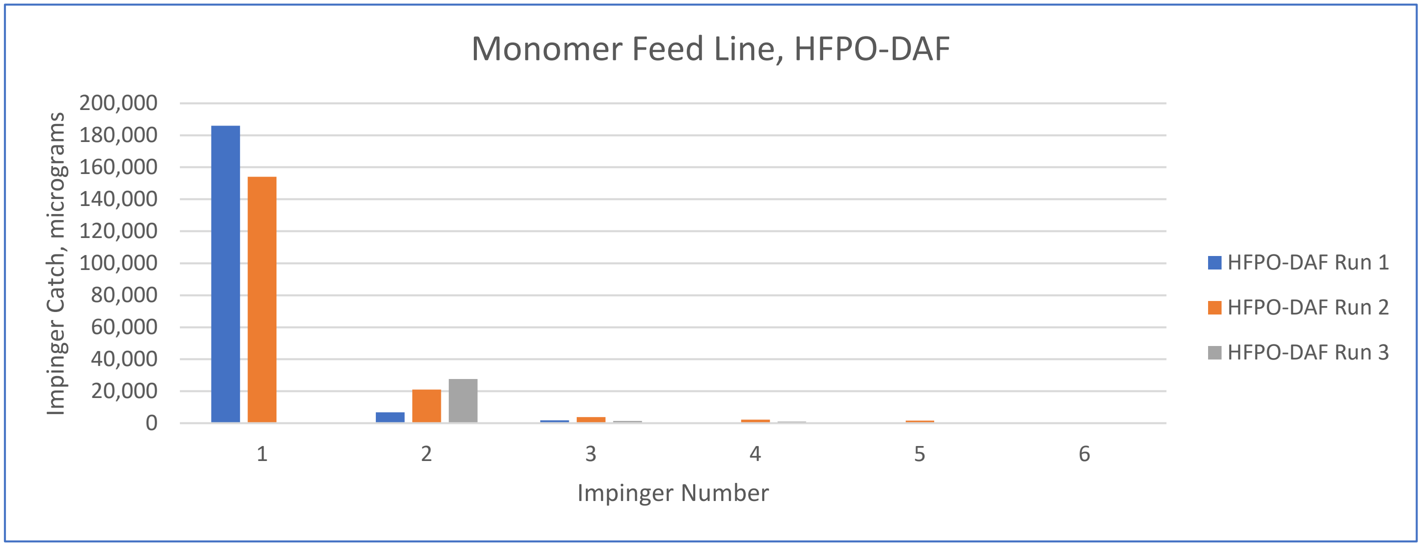


Figure 5-2. Monomer Waste Gas (Line #1) Modified Method 18 HFPO-DAF Capture

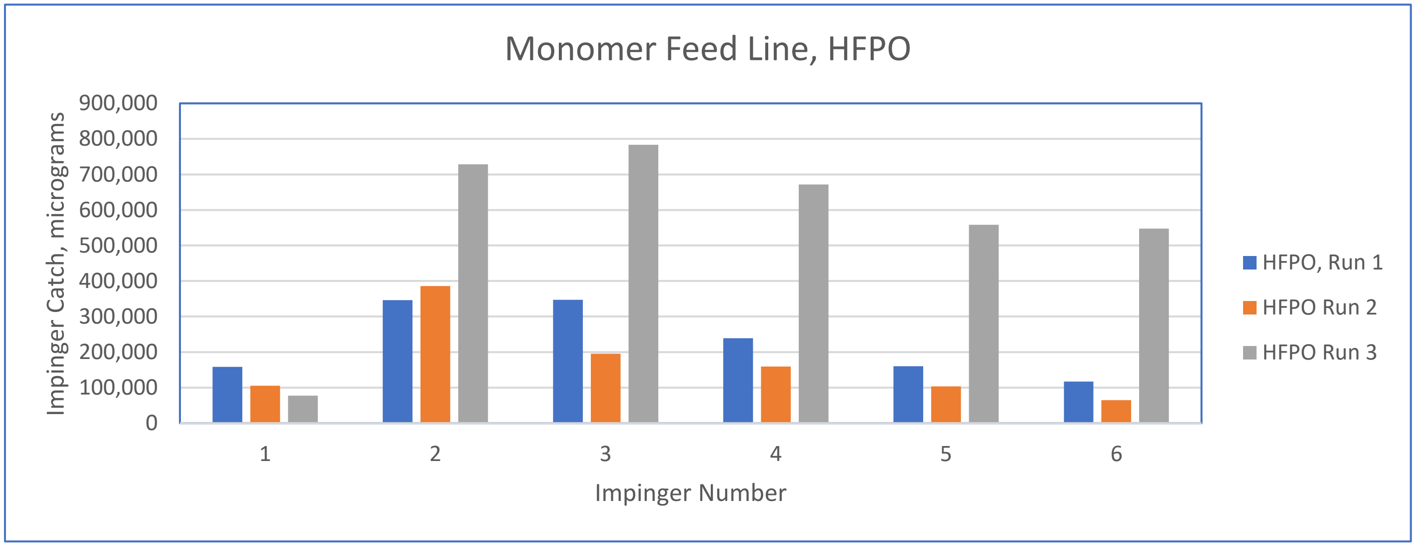


Figure 5-3. Monomer Waste Gas (Line #1) Modified Method 18 HFPO Capture

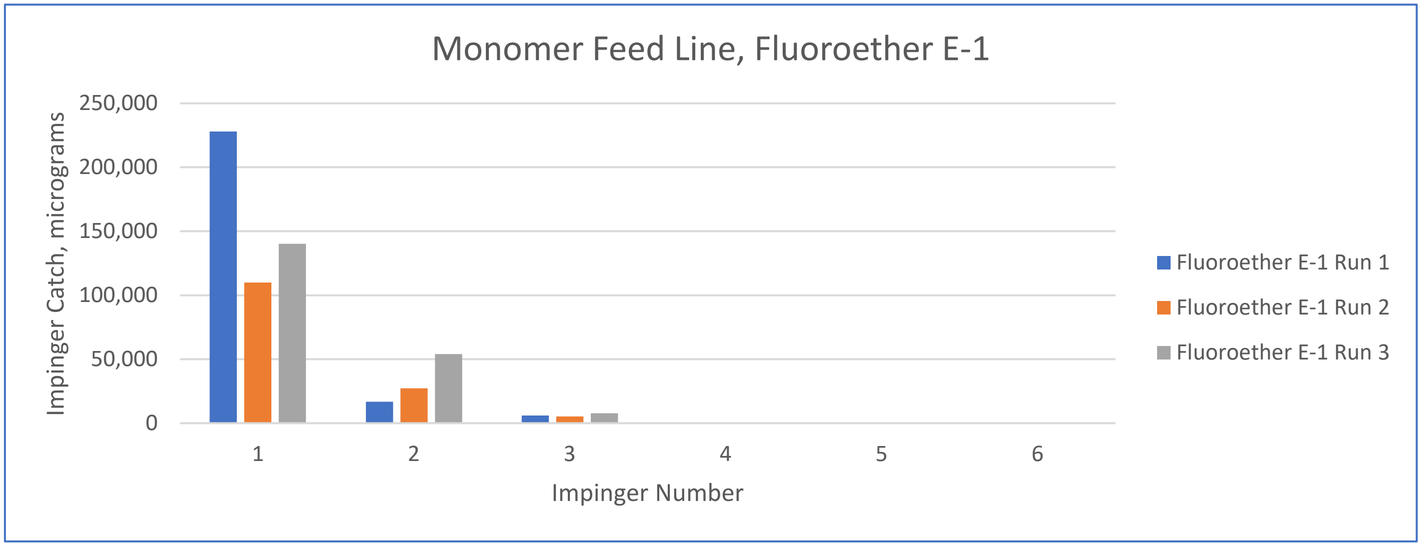


Figure 5-4. Monomer Waste Gas (Line #1) Modified Method 18 Fluoroether E-1 Capture

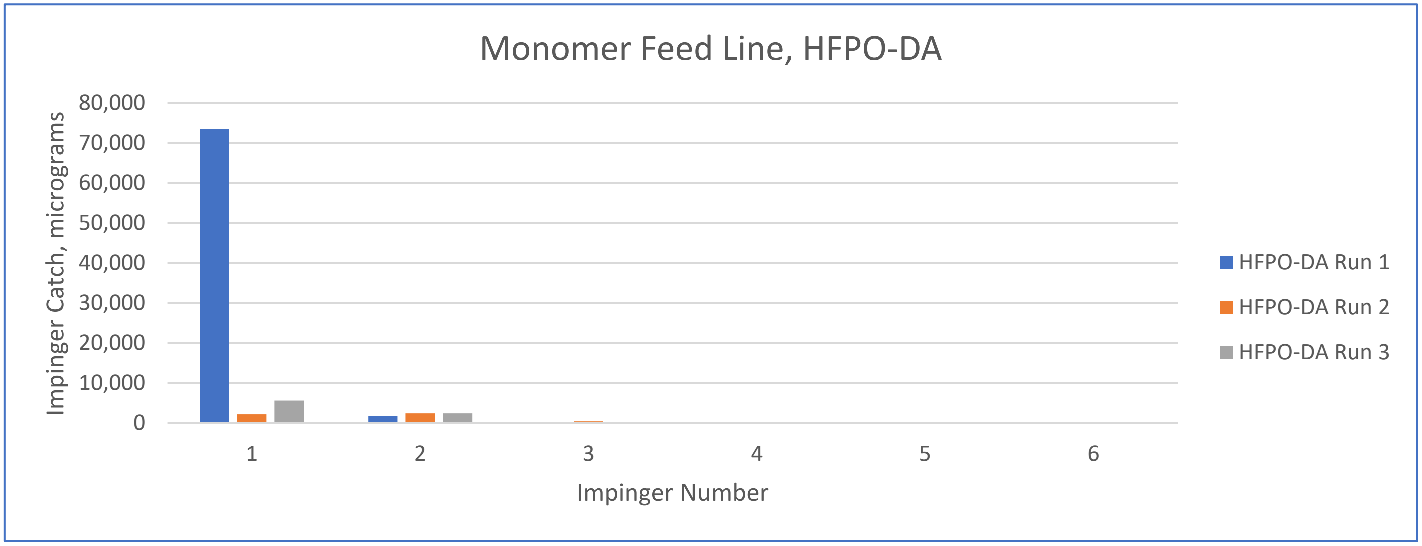


Figure 5-5. Monomer Waste Gas (Line #1) Modified Method 18 HFPO-DA Capture

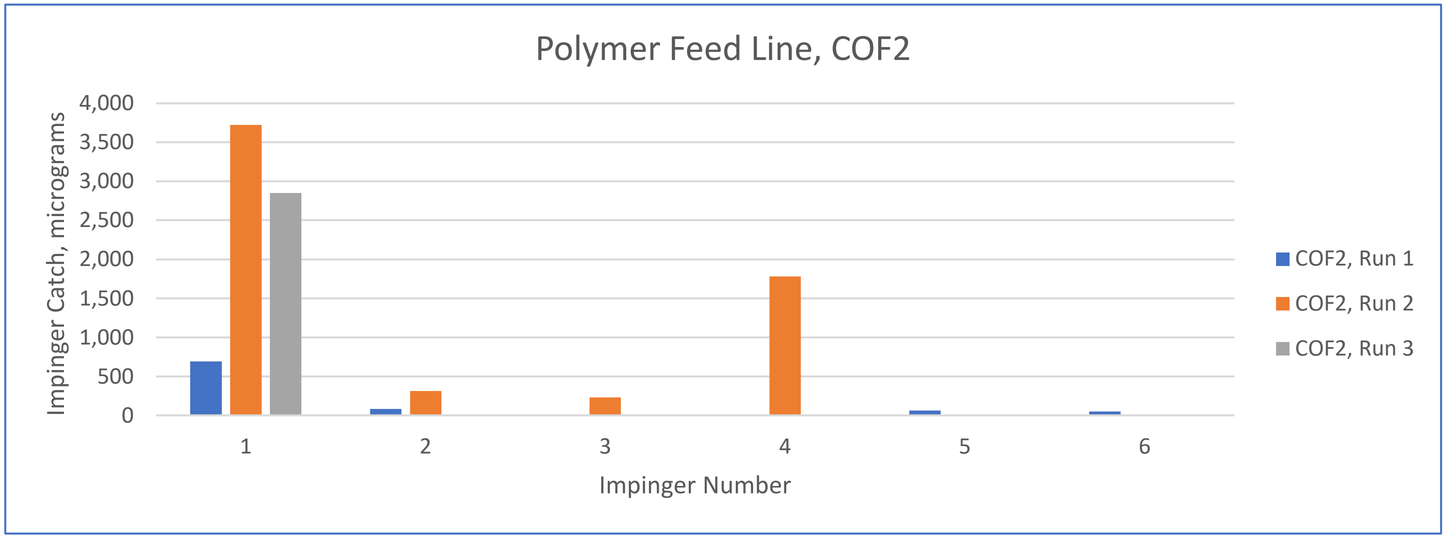


Figure 5-6. Polymer Waste Gas (Line #2) Modified Method 18 COF_2 Capture

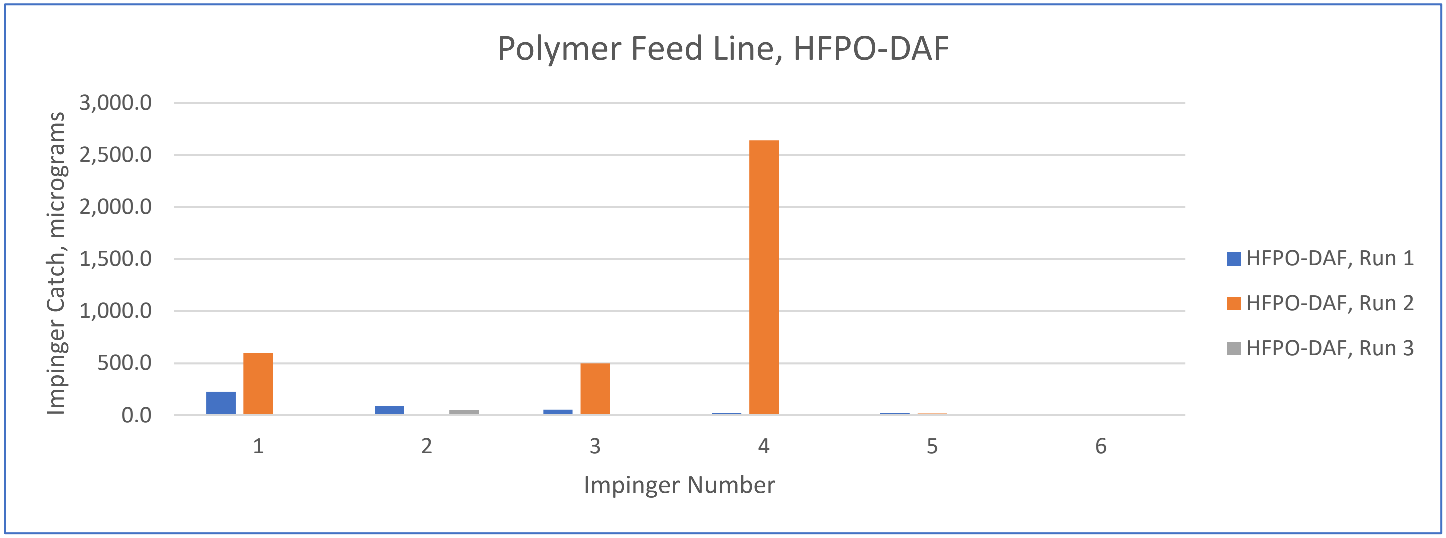


Figure 5-7. Polymer Waste Gas (Line #2) Modified Method 18 HFPO-DAF Capture

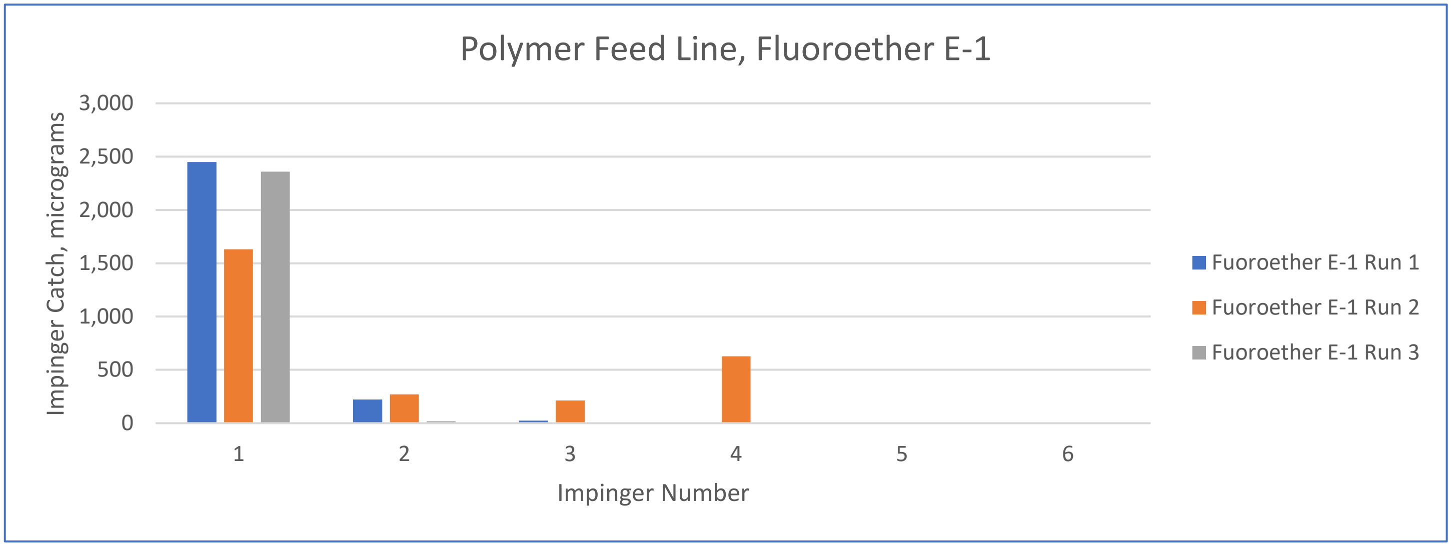


Figure 5-8. Polymer Waste Gas (Line #2) Modified Method 18 Fluoroether E-1 Capture

6.0 CONCLUSION

The Chemours thermal oxidizer is controlling PFAS emissions at an average efficiency exceeding 99.99961%, demonstrating compliance with the consent order requirement to control all PFAS at an efficiency of 99.99%.