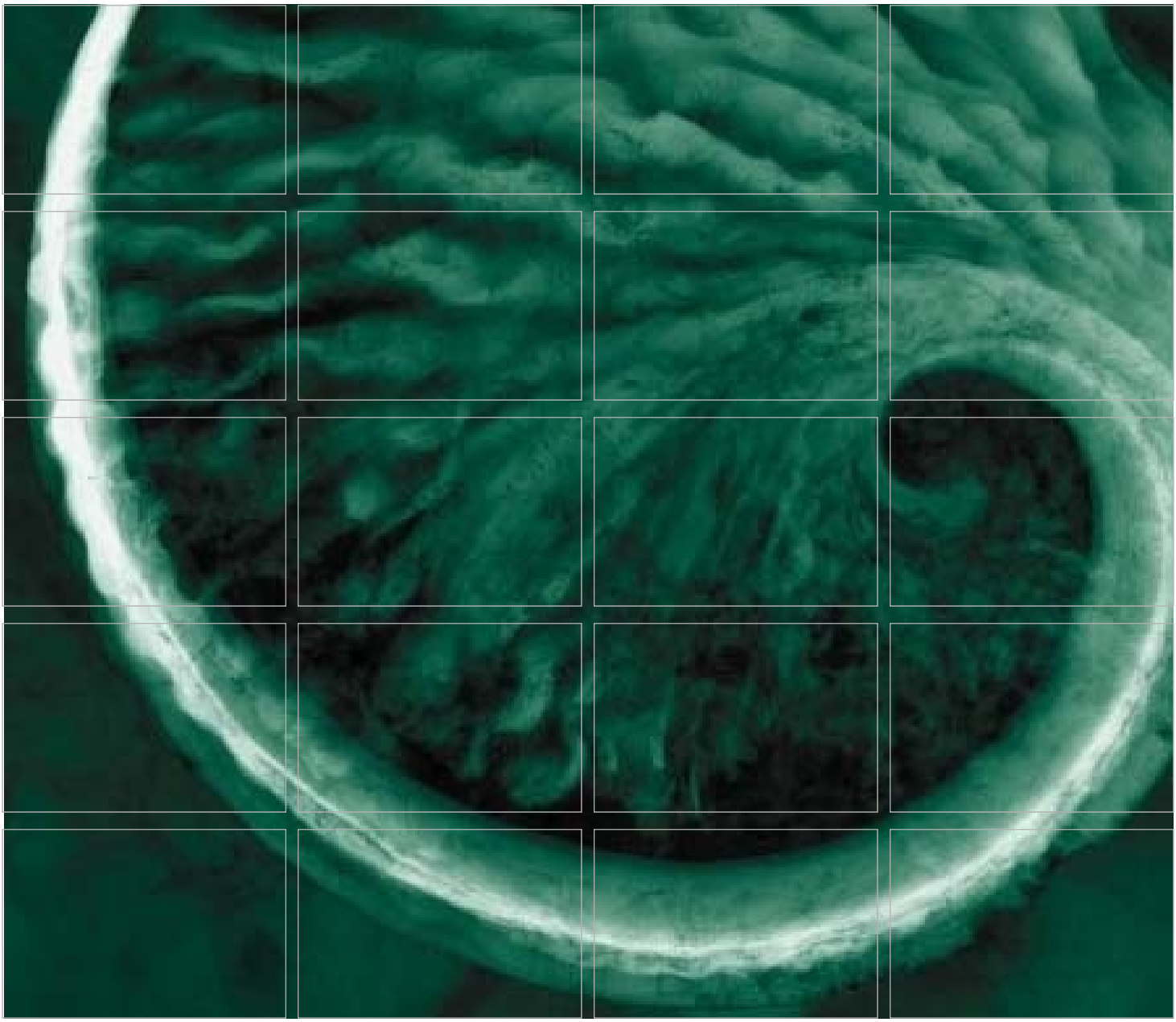

HFPO-DA Baseline Emission Estimates

Fayetteville Works Facility
Fayetteville, North Carolina

Revised May 18, 2018
www.erm.com

Prepared for:
The Chemours Company

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ERM

The Chemours Company

HFPO-DA Baseline Emission Estimates

April 27, 2018; Revised May 18, 2018

Project No. 0422611
Fayetteville Works Facility
Fayetteville, North Carolina

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The Chemours Company (Chemours) requested that ERM conduct a review of Chemours Company – Fayetteville Works facility's (the facility's) baseline emissions of Hexafluoropropylene Oxide – Dimer Acid Fluoride (HFPO-DAF). ERM utilized best available data, including source test results, process data, and engineering knowledge to estimate emissions. We estimated baseline emissions using calendar year 2017 operating hours and production data. It is important to note that source tests would have been performed for the dimer acid anion, therefore, results from testing would include emissions of the following three dimer acid compounds: HFPO Dimer Acid Fluoride, HFPO Dimer Acid Ammonium Salt, and HFPO Dimer Acid (HFPO-DA). For purposes of this report, the results will be expressed as HFPO – Dimer Acid.

Calendar year 2017 emissions were estimated for indoor equipment emissions, outdoor equipment emissions, as well as process emissions from each applicable process unit:

- Vinyl Ethers – North Process Unit (VE-North),
- Vinyl Ethers – South Process Unit (VE-South),
- Polymer Processing Aid (PPA) Unit,
- Semi-works Polymerization Unit (Semi-works), and
- Polymers Process Unit (Polymers).

A summary of the emissions by process unit are detailed in Table 1. The following sections describe in detail the methodologies used to estimate the HFPO-DA emissions summarized in this report.

Table 1: Facility-Wide 2017 Baseline HFPO-DA Emissions Summary

Process Unit	Indoor Equipment Emissions (lb/yr)	Outdoor Equipment Emissions (lb/yr)	Process Emissions (lb/yr)
VE-North	2.5	1.7	1,486
VE-South	1.6	0.4	30
PPA	31.2	1.0	639
Semi-works	0.15	0	0.35
Polymers	0	0	4.8

1.0 PROJECT TEAM/EXPERIENCE

Donald "Deever" Bradley III, P.E., Kevin Eldridge, QEP, GHG-IQ, and Christy Richardson, P.E. developed the emission estimations presented here and prepared this report. Professional Profiles are included in Appendix A.

Mr. Bradley is a Partner with ERM based in Houston, Texas, and served as the technical lead on this project. He has 24 years of environmental consulting experience for industrial and government clients in 40 states, Puerto Rico, Canada, and Brazil. His project experience includes air quality permitting and compliance, auditing, environmental due diligence, and litigation support for various industries, including petroleum refining, chemical and pharmaceutical manufacturing, oil and gas production, and pipelines. Mr. Bradley is ERM's subject matter expert for LDAR, with compliance experience developing LDAR programs, conducting third-party audits, and responding to state and federal enforcement actions and investigations of civil and criminal violations. He regularly trains and presents to various industries on LDAR-related issues.

Mr. Eldridge served as the project manager on the emissions review task. He is a Principal Consultant in ERM's Raleigh, North Carolina office with over 30 years of experience in providing air quality services. His experience is in the environmental consulting field, including management of emission inventory programs, air quality permitting, regulatory analysis and development, risk management planning, and dispersion modeling, as well as other multi-media environmental projects. Project management experience includes direction and supervision of engineers, meteorologists, and other scientists on air quality projects, including interaction with state regulators, client interface, budget, schedule development and monitoring, and quality assurance/quality control (QA/QC) of deliverables. Mr. Eldridge has provided air quality services in over 35 states with a vast majority of his experience in North Carolina. His experience includes chemical manufacturing, upstream and mid-stream oil and gas, manufacturing, power,

Mrs. Richardson is a senior consultant based in Raleigh, North Carolina where she focuses on air quality permitting and compliance for various manufacturing facilities. Mrs. Richardson has over 15 years of experience in providing air quality services to a wide-range of industrial clients. Mrs. Richardson has prepared numerous air emissions inventories, air permit applications and compliance reports for a wide variety of facilities, specializing in chemical manufacturing, wood products facilities, oil and gas industry, and other various manufacturing operations. Her experience includes serving as an environmental engineer for a chemical plant located in Wilmington, North Carolina. Her expertise also includes compliance auditing, regulatory applicability determination, and compliance program implementation. Mrs. Richardson has extensive experience with LDAR programs including third party compliance auditing, investigative reviews, and program implementation.

2. 0 EQUIPMENT EMISSION ESTIMATES

To estimate fugitive emissions of HFPO-DA from the facility, best available data has been utilized including component monitoring data, fugitive equipment emission ratios, stream compositions, and source test data. This section breaks down the methodologies used to estimate the 2017 fugitive emissions resulting from equipment leaks into three main categories: EPA Method 21 monitoring data, equipment emission ratios, and stack test data. Depending on the data available for each process unit, the most applicable (best available) data was utilized to estimate emissions by unit for calendar year 2017.

2.1 EPA METHOD 21 MONITORING DATA

In addition to the facility's normal fugitive emissions monitoring of equipment subject to the Miscellaneous Organic NESHAP (MON), in April 2018, Chemours retained Team, Inc. (Team) to conduct instrument monitoring on valves and connectors for specified streams containing at least 1% by weight or greater HFPO-DA or HFPO-DAF. EPA Method 21 monitoring was conducted using flame ionization detectors (FIDs) to identify volatile organic compound (VOC) leaks from these specific fugitive piping components. The areas monitored were:

- VE-North: Outdoor components monitored during a perfluoropropyl vinyl ether (PPVE) campaign,
- PPA: Outdoor components, and
- Semi-works: Indoor components during a dimer acid peroxide (DP) synthesis campaign (This area does not have any components located outdoors, which contain at least 1% by weight HFPO-DA or HFPO-DAF.)

Instead of emission factors, the monitoring data for the components associated with these areas was used to estimate emissions. Previously Chemours calculated the fugitive emissions from equipment leaks using emission factors developed by DuPont, as described in the September 26, 1989 letter from DuPont De Nemours & Company (DuPont) to Mr. Leslie Evans of the U.S. Environmental Protection Agency (US EPA). These factors were developed from company leak testing along with procedures and practices for leak reductions from processes involving toxic or extremely hazardous chemicals as an alternative to the EPA's Synthetic Organic Chemical Manufacturing Industry (SOCMI) VOC emission factors.[i]

Where monitoring data is available, EPA provides guidance on calculating mass emission rates from equipment leaks using concentration (monitoring) data obtained using Method 21 monitoring. The procedures for estimating emission rates using the concentration (monitoring or screening) data is also detailed in

[i] Protocol for Equipment Leak Emission Estimates. EPA-453/R-95-017, United States Environmental Protection Agency, Office of Air Quality, Planning and Standards, November 1995.

the EPA's Protocol for Equipment Leak Emission Estimates.[ii] The EPA Correlation Approach, as this methodology is called, can be used to estimate mass emission rates from equipment leaks by using a correlation equation to predict mass emission rates as a function of the screening (or monitoring) value for a particular equipment type. Table 2 lists correlation equations, which predict total organic compound emission rates, that EPA developed for SOCMI.

Table 2: ***SOCMI Leak Rates / Screening Value Correlations***

Equipment Type	Correlation[a]
Gas Valves	Leak Rate (kg/hr) = 1.87E-06 x $(SV)^{0.873}$
Light Liquid Valves	Leak Rate (kg/hr) = 6.41E-06 x $(SV)^{0.797}$
Connectors	Leak Rate (kg/hr) = 3.05E-06 x $(SV)^{0.885}$

[a] (SV) = Screening value, in ppm

These correlation equations may be utilized when estimating emissions from any non-zero screening values. EPA's "default-zero" leak rates were conservatively used to estimate mass emission rates associated with screening values of zero, or in instances with screening values less than or equal to background or ambient concentrations. These default-zero emission rates were developed because EPA determined that zero screening values are not indicative of zero mass emission rates. The default zero emission rates for SOCMI total organic compounds are listed in the table below.

Table 3: ***SOCMI Default-Zero Values***

Equipment Type	Default-Zero Emission Rate (kg/hr/source)
Gas Valves	6.6E-07
Light Liquid Valves	4.9E-07
Connectors	6.1E-07

Using Team's April 2018 monitoring data for these components as representative of normal operations during calendar year 2017, the equipment type, and the HFPO-DA or HFPO-DAF concentration of the associated stream, the hourly emissions rates associated with each of the areas monitored were calculated. In accordance with Type I monitoring under EPA Method 21, background concentrations were not included; the maximum reading observed at the component leak interfaces, minus the background concentration, was used to generate the emission estimate for each component. The facility's in-house laboratory confirmed that the monitoring instrument was able to measure the concentration of HFPO-DAF in a known standard, so a response factor of 1 was used for the emission estimates (i.e., they were not adjusted to compensate for the instrument's ability to measure the target compound). Example calculations for a component with a screening value greater than zero (Correlation Equations) and a component with a screening value, or net screening value of zero, (Default-Zero Emission rates) are provided in the following figures for reference:

[ii] Protocol for Equipment Leak Emission Estimates. EPA-453/R-95-017, United States Environmental Protection Agency, Office of Air Quality, Planning and Standards, November 1995.

Example Calculation Using Correlation Equations

Tag 0078, Valve, Light Liquid Service, 99% by weight HFPO-DA

$$ER\left(\frac{lb\ HFPO-DA}{hr}\right) = 6.41E-06 \times (SV)^{0.797}\frac{kg\ TOC}{hr} \times 2.2046\frac{lb}{kg} \times Wt\%_{HFPO-DA}$$

$$ER_{0078}\left(\frac{lb\ HFPO-DA}{hr}\right) = 6.41E-06 \times 1\ ppm^{0.797} \times 2.2046 \times 0.99$$

$$= 1.399E-05\ \frac{lb\ HFPO-DA}{hr}$$

Where
ER = Emission rate of HFPO-DA (lb/hr)
SV = Screening Value (ppm)
TOC = Total Organic Carbon
$Wt\%_{HFPO\text{-}DA}$ = Weight percent of HFPO-DA or HFPO-DAF in the associated process stream

Example Calculation Using Default-Zero Emission Rates

Tag 0001, Valve, Light Liquid Service, 99% by weight HFPO-DA

$$ER\left(\frac{lb\ HFPO-DA}{hr}\right) = 4.9E-07\left(\frac{kg\ TOC}{hr}\right) \times 2.2046\frac{lb}{kg} \times Wt\%_{HFPO-DA}$$

$$ER_{0001}\left(\frac{lb\ HFPO-DA}{hr}\right) = 4.9E-07 \times 2.2046 \times 0.99$$

$$= 1.069E-06\frac{lb\ HFPO-DA}{hr}$$

Where
ER = Emission rate of HFPO-DA (lb/hr)
TOC = Total Organic Carbon
$Wt\%_{HFPO\text{-}DA}$ = Weight percent of HFPO-DA or HFPO-DAF in the associated process stream

This EPA correlation approach was used to calculate annualized emissions from the three process areas monitoring during Team's Method 21 monitoring efforts. A summary of the annual emissions and the hours of operation for each of the areas are included in Table 4.

Table 4: ***Annual Equipment Emissions from Monitoring Data***

Process Unit	Area Monitored	Assumed Annual Hours of Operation	2017 Annual Emissions (lb/yr)
VE-North	Outdoor Equipment	8,760	1.65
PPA	Outdoor Equipment	8,760	1.04
Semi-works	Indoor Equipment	345	0.15

Note that VE-North and PPA did not operate for 8,760 hours during 2017. However, since the equipment would not have been de-inventoried every time the process was down, the emission estimates for those process units assume the equipment was in VOC service for 8,760 hours during 2017.

2.2 SOURCE TEST DATA

On January 25, 2018, Chemours conducted a source test to determine the amount of HFPO Dimer anion (referred to as HFPO-DA throughout this report) present in the building exhaust from the PPA process unit. The building exhaust would include any fugitive losses from equipment located indoors. Therefore, the indoor equipment emissions were calculated using the emission rate obtained from the stack test and multiplying by the total hours of operation during 2017. The annual emissions were calculated as follows:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 0.0058\frac{lb\ HFPO-DA}{hr} \times 5{,}381\ hr = 31.2\ lb\ HFPO-DA$$

2.3 FUGITIVE EQUIPMENT EMISSION RATIOS AND COMPONENT COUNT DATA

Since stack test data was not available for the building exhaust from the VE-North tower, the indoor equipment emissions were calculated using the actual monitoring data for outdoor equipment and the ratio of estimated emissions from indoor to outdoor components located in the VE-North process unit as detailed in ERM's LDAR Program Review Report. It is estimated that 40% of the VE–North equipment emissions are associated with outdoor components and 60% of the VE-North equipment emissions are associated with components located indoors. Therefore, the emissions estimated from monitoring of the outdoor equipment were scaled up accordingly. The annual indoor VE-North emissions were calculated as follows:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 1.65\frac{lb\ HFPO-DA}{yr} \times \frac{60\%\ indoors}{40\%\ outdoors} = 2.5\ lb\ HFPO-DA$$

Since actual monitoring data could not be obtained for the VE-South process unit, during a PPVE campaign, the VE-North outdoor emission rates estimated

from actual monitoring data were scaled down based on the ratio of VE-North to VE-South component counts. It was estimated that VE-South outdoor equipment leak emission rates would be approximately 25% of that from VE-North (i.e., 59 VE-South components and 232 VE-North components). Therefore, the annual outdoor equipment emissions for VE-South were estimated as follows:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 1.65\frac{lb\ HFPO-DA}{yr} \times \frac{59\ VE-S}{232\ VE-N} = 0.42\ lb\ HFPO-DA$$

The indoor equipment emissions in VE-South process unit were calculated using the estimated outdoor equipment emissions and the ratio of equipment emissions from indoor and outdoor components located in the VE-South process unit. As detailed in ERM's LDAR Program Review Report, 21% of the VE-South equipment emissions are from components (containing at least 1% by weight HFPO-DA or HFPO-DAF) located outdoors and the remaining 79% of the VE-South equipment emissions are from components located indoors. Therefore, the emissions estimated from monitoring of the outdoor equipment were scaled up accordingly. The annual indoor VE-South emissions were calculated as follows:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 0.42\frac{lb\ HFPO-DA}{yr} \times \frac{79\%\ indoors}{21\%\ outdoors} = 1.6\ lb\ HFPO-DA$$

It should be noted that the VE-South estimates are conservative in that they assume the same annual hours of operation as VE-North; however, VE-South only operated on PPVE campaign for 528 hours during 2017.

2.4 *SUMMARY*

There are no outdoor components located in the Semi-works process unit, and no components located in the Polymers process unit, containing more than 1% by weight HFPO-DA or HFPO-DAF. Therefore, equipment emissions of HFPO-DA were not quantified from those areas. A summary of the equipment emissions, from indoor and outdoor equipment, is included in the following table.

Table 5: ***Annual HFPO-DA Equipment Emissions Summary***

Process Unit	Indoor Emissions (lb/yr)	Outdoor Emissions (lb/yr)
VE-North	2.5	1.7
VE-South	1.6	0.4
PPA	31.2	1.0
Semi-works	0.15	0
Polymers	0	0

3.0 PROCESS EMISSIONS

Best available data, including source test results and production data, was used to calculate process emissions of HFPO-DA from the facility. This section breaks down the methodologies used to determine the 2017 process emissions resulting from each applicable process unit and associated campaign: Vinyl Ethers – North, Vinyl Ethers – South, PPA, Semi-works, and Polymers. Depending on the data available for each process unit, the most applicable (best available) data was utilized to estimate emissions by unit for calendar year 2017.

3.1 VINYL ETHERS – NORTH

During the first quarter of 2018, source testing was performed on the Division Stack (ID No. NEP-HDR1) for various scenarios for the HFPO Dimer anion. On January 22-23, 2018, testing was performed while the unit was producing Perfluoropropyl Vinyl Ether (PPVE). On March 19, 2018, testing was performed while the unit was producing Perfluoro-2-(2-Fluorosulfonylethoxy) Propyl Vinyl Ether (PSEPVE). The unit also produces Propanoic Acid, 3-[1-[Difluoro [(Trifluoroethenyl oxy] Methyl]-1,2,2,2-Tetrafluoroethoxy] -2,2,3,3-Tetrafluoro-, Methyl Ester (EVE). Source testing was not conducted while producing EVE; however, this product is expected to result in similar emissions as the PSEPVE campaigns.

3.1.1 PPVE Campaigns

The stack testing conducted on January 22-23, 2018 while producing PPVE showed an average emission rate (from three test runs) of 0.296 lb/hr of HFPO-DA. These emission rates include the post-control process vent, maintenance activities, and indoor equipment emissions. To calculate process emissions, the emission rate was multiplied by the hours of operation while producing PPVE as follows:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 0.296\ \frac{lb\ HFPO-DA}{hr} \times 4{,}176\ \frac{hr}{yr} = 1{,}236\ \frac{lb}{yr}$$

3.1.2 PSEPVE Campaigns

The source testing conducted on March 19, 2018 while producing PSEPVE showed an emission rate of 0.103 lb/hr of HFPO-DA. Only the results from Run 1 were utilized to obtain the emission rate since it was later realized that the process was not fully operational during Runs 2 and 3 (conducted on March 20, 2018). These emissions consist of post-control process vent, maintenance activities, and indoor equipment emissions. Process emissions were calculated by multiplying the measured rate by the hours of operation while producing PSEPVE, as follows:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 0.103\ \frac{lb\ HFPO-DA}{hr} \times 1{,}968\ \frac{hr}{yr} = 203\ \frac{lb}{yr}$$

3.1.3 *EVE Campaigns*

Since source testing was not conducted while producing EVE, emissions were assumed to be equivalent to those determined during the PSEPVE stack testing. Using the emission rate from the PSEPVE stack test results and the hours of operation while producing EVE, annual emissions were calculated as follows:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 0.103\ \frac{lb\ HFPO-DA}{hr} \times 480\ \frac{hr}{yr} = 49\ \frac{lb}{yr}$$

3.1.4 *Summary*

Since the source test results included the indoor equipment leaks in the building exhaust emissions, those fugitive emissions were subtracted from the total emissions calculated using source test data. After subtracting the indoor equipment emission rate (2.5 lb of HFPO-DA per year) from the total VE-North emissions calculated in this section, the total HFPO-DA process emissions for 2017 were determined as follows:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 1{,}236 + 203 + 49 - 2.5 = 1{,}486\ \frac{lb\ HFPO-DA}{hr}$$

3.2 *VINYL ETHERS – SOUTH*

On February 26-27, 2018, source testing was performed on the Vinyl Ethers South Stack (ID No. NEP-Hdr2) during the Perfluoromethyl vinyl ether (PMVE) / Perfluoroethyl vinyl ether (PEVE) campaigns. While source testing was not conducting when producing PPVE at the VE-South unit, it was assumed that the emission rate (per kilogram of product) would be the same as that obtained for the VE-North unit.

3.2.1 *PMVE/PEVE Campaigns*

The source testing conducted on February 26-27, 2018 while producing PMVE/PEVE showed an emission rate of 0.00106 lb/hr of HFPO-DA. This emission rate was calculated using the average of the three test runs, including one run that was aborted due to a failed post-test leak check. These emissions included the post-control process emissions and the indoor equipment emissions. To calculate process emissions, the emission rate was multiplied by the hours of operation while producing PMVE/PEVE as follows:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 0.00106\ \frac{lb\ HFPO-DA}{hr} \times 7{,}128\ \frac{hr}{yr} = 7.6\ \frac{lb}{yr}$$

3.2.2 *PPVE Campaigns*

Based on VE-North stack test data, control efficiency of 99.1% for the VE–North scrubber, and PPVE production in the VE–North process unit, it was estimated that 0.8299 lb of HFPO-DA would be emitted (pre-controls) for every kilogram of PPVE produced. The production-based emission factor, along with PPVE production in VE–South, was used to calculate annual emissions of HFPO-DA from VE–South during PPVE campaigns. The VE–South waste gas scrubber control efficiency of 99.8% was used and was based on 2013 scrubber efficiency testing performed at the site. This emission rate also includes indoor equipment emissions. The emission calculation was:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 0.8299\ \frac{lb\ HFPO-DA}{kg\ PPVE\ produced} \times 14{,}127\ \frac{kg\ PPVE}{yr} \times (1-0.998) = 23\ \frac{lb}{yr}$$

3.2.3 *Isotainer Filling and Decontamination*

Additional HFPO-DA emissions occur when the isotainers returned from the PPA area are refilled. One isotainer per month is typically returned for refilling during which it is vented through the VE-South scrubber. During 2017, 11 isotainers were returned for filling. In order to determine emissions associated with each isotainer filling, the headspace concentration of HFPO-DA in the isotainers was multiplied by the volume of vapor displaced when the isotainer was refilled. The emissions are vented through the VE-South scrubber, which has a control efficiency of 99.8%. An example calculation is as follows:

$$ER\left(\frac{lb\ HFPO-DA}{month\ January}\right) = 0.000835\ \frac{lb\ HFPO-DA}{L\ vapor} \times 5{,}926.9\ \frac{L\ vapor}{month\ January} \times (1 - 0.998) = 0.01\ \frac{lb}{month\ January}$$

The annual emissions from isotainer loading was less than 0.1 lb/yr.

HFPO-DA emissions also occur when an isotainer has to be decontaminated via pressure venting. One HFPO-DAF isotainer was decontaminated during 2017. The total liquid heel in the isotainer along with the headspace concentration and volume of the isotainer were used to calculate annual emissions from isotainer decontamination. The emission calculation was:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = \left[\left(0.001123\ \frac{lb\ HFPO-DA}{L\ vapor} \times 14{,}600\ \frac{L\ vapor}{ISO}\right) + 219\ lb\ (in\ liquid\ heel)\right] \times (1-0.998)\ = 0.47\ \frac{lb}{yr}$$

The total HFPO-DA emissions for 2017 from isotainer filling and decontamination are less than 0.6 lb/yr.

3.2.4 Summary

Since the source test results would have included the indoor equipment leaks in the building exhaust emissions, those fugitive emissions were subtracted from the total emissions calculated using source test data. After subtracting the indoor equipment emission rate (1.6 lb of HFPO-DA per year) from the total VE–South emissions calculated in this section, the total HFPO-DA process emissions for 2017 for VE – South were calculated as:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 7.6 + 23 + 0.6 - 1.6 = 30\,\frac{lb\ HFPO-DA}{hr}$$

3.3 PPA

During the first quarter of 2018, stack testing was performed on the PPA Stack (ID No. ACD-A1) for various scenarios for the HFPO Dimer anion. During testing, it was determined that emissions during the hydrolysis portion of the process were significantly higher than those emissions during normal operation of the process. The source testing conducted on January 24-25, 2018 showed an emission rate of 0.0255 lb/hr of HFPO-DA during the non-hydrolysis (or vaporization) phase of the process. The source testing conducted on March 1-2, 2018 during the hydrolysis portion of the process showed an emission rate of 1.58 lb/hr of HFPO-DA. These emissions would be the combination of the post-control process emissions and the indoor equipment emissions.

In order to calculate process emissions, the emission rate was multiplied by the hours of operation during the applicable portion of the process. The emission calculation is as follows:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 0.0255\ \frac{lb\ HFPO-DA}{hr} \times 5{,}381\ \frac{hr}{yr} + 1.58\,\frac{lb\ HFPO-DA}{hr} \times 337\,\frac{hr}{yr}\ = 670\ \frac{lb}{yr}$$

Since the source test results include the indoor equipment leaks in the building exhaust emissions, those fugitive emissions were subtracted from the total emissions calculated using stack test data. After subtracting the indoor equipment emission rate (31.2 lb of HFPO-DA per year) from the total PPA emissions calculated in this section, the total HFPO-DA process emissions for 2017 were determined as follows:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 670 - 31.2 = 639\ \frac{lb\ HFPO-DA}{hr}$$

3.4 SEMI-WORKS

During 2018, source testing was performed at the Semi-works stack during a dimer acid peroxide (DP) synthesis campaign for the HFPO Dimer anion. The stack testing conducted on March 23, 2018 showed an average emission rate of 0.00155 lb/hr of HFPO-DA.

Process emissions were calculated by multiplying the emission rate by the hours of operation while producing DP, as follows:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 0.00155\ \frac{lb\ HFPO-DA}{hr} \times 345\ \frac{hr}{yr} = 0.5\ \frac{lb}{yr}$$

Since the source test results included the indoor equipment leaks in the building exhaust emissions, those fugitive emissions were subtracted from the total emissions calculated using stack test data. After subtracting the indoor equipment emission rate (0.15 lb of HFPO-DA per year) from the total Semi-works emissions calculated in this section, the total HFPO-DA process emissions for 2017 were determined as follows:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 0.5 - 0.15 = 0.35\ \frac{lb\ HFPO-DA}{yr}$$

3.5 POLYMERS

During 2018, source testing was performed on the Polymers stack for the HFPO Dimer anion. The Resins stack testing shows two different scenarios: 1) Recycle Still and Polymerization and 2) Polymerization and Line 4 Extrusion. There is no way to determine the emission contribution from each of the three operations since two are always combined.

The average emission rate determined during the March 21-22, 2018 stack testing for the Recycle Still was 0.000477 lb/hr HFPO-DA. The average emission rate for the Line 4 Extrusion was 0.000507 lb/hr HFPO-DA. The highest emission rate for the Polymers process, which is the combined emission rates of the Recycle Still and the Line 4 Extrusion, is 0.000984 lb/hr DA. To calculate process emissions, the emission rate was multiplied by the hours of operation of the Polymers unit as follows:

$$ER\left(\frac{lb\ HFPO-DA}{yr}\right) = 0.000984\ \frac{lb\ HFPO-DA}{hr} \times 4{,}873\ \frac{hr}{yr} = 4.8\ \frac{lb}{yr}$$

3.6 SUMMARY

As discussed in detail throughout this section, source test data along with operational hours and/or production data were utilized to determine stack emissions of HFPO-DA from each of the applicable process units. A summary table of the source test dates, emission rates, and 2017 hours of operation by process unit and campaign or process step is provided below.

Table 6: Source Test Data Summary

Process Unit	Campaign / Process Step	Source Test Date	Emission Rate (lb/hr)	Hours of Operation (hr/yr)
VE-North	PPVE	1/22/18 – 1/23/18	0.296	4,176
	PSEPVE	3/19/18	0.103	1,968
	EVE	n/a	Assumed = PSEPVE	480
VE-South	PMVE/PEVE	2/26/18 – 2/27/18	0.00106	7,128
	PPVE	n/a	Assumed = VE-North (lb/kg basis)	
PPA	Vaporization	1/24/18 – 1/25/18	0.0255	5,381
	Hydrolysis	3/1/18 – 3/2/18	1.58	337
Semi-works	DP Synthesis	1/23/18	0.00155	345
Polymers	Recycle + Extrusion	1/21/18 – 1/22/18	0.000984	4,873

As described throughout this section, the raw data presented in Table 6 above was used to determine the source emissions. After subtracting the indoor equipment emissions, process emissions were estimated and are summarized from each process unit during 2017 in the following table.

Table 7: Annual HFPO-DA Process Emissions Summary

Process Unit	Process Emissions (lb/yr)
VE-North	1,486
VE-South	30
PPA	639
Semi-works	0.35
Polymers	4.8

Professional Profiles

Appendix A

April 27, 2018
Project No. 0422611

Environmental Resources Management
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Donald D. Bradley III, PE

Partner

Mr. Deever Bradley is a Partner with ERM based in Houston, Texas. He has 24 years of environmental consulting experience for industrial and government clients in 40 states, Puerto Rico, and Brazil. His project experience includes air quality permitting and compliance, auditing, environmental due diligence, and litigation support for various industries, including petroleum refining, chemical and pharmaceutical manufacturing, oil and gas production, and pipelines. Deever is ERM's subject matter expert for LDAR, with compliance experience developing LDAR programs, conducting third-party audits, and responding to state and federal enforcement actions and investigations of civil and criminal violations. He regularly trains and presents to various industries on LDAR-related issues.

Experience: Over 24 years of experience primarily in oil & gas, chemical, power, and manufacturing sectors

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Education

- B.S. Chemical Engineering, Cornell University, 1993

Professional Affiliations and Registrations

- Registered Professional Engineer in Texas
- Air & Waste Management Association Gulf Coast Chapter Director/Treasurer (2001 – 2007)
- ERM Foundation Board of Directors (2002–2012)
- LDAR University Lecturer (2009) and ISA LDAR Symposium Trainer (2008, 2010, 2012-2017)

Languages

- English, native speaker

Fields of Competence

- Air quality permitting, monitoring and control
- Air pollution control technology analyses
- Atmospheric dispersion modeling
- Benzene Waste Operations NESHAP compliance
- Environmental compliance auditing
- Expert testimony and technical litigation support
- Environmental training
- Fugitive emissions estimation and measurement
- Greenhouse gas PSD permitting
- Leak detection and repair (LDAR) compliance
  - Third-party auditing and data analysis
  - Commercial LDAR database software
  - Field instruction and compliance training
  - State and federal program implementation
- LDAR regulations and applicability analyses
  - Texas Regulation 115 and HRVOC rules as well as the 28-series permit special conditions
  - TX, CA, LA, IL, KY, MI, OH, OK, PA, NJ rules
  - Federal NSPS, NESHAP, and MACT rules
- LDAR applicability and program implementation
- Optical gas imaging surveys (aka Smart LDAR)

Key Projects

Deever has extensive experience with LDAR program compliance, including extensive auditing, implementation, and compliance support for federal and state regulations and permitting requirements.

Third-Party LDAR Program Audits
Lead auditor or technical consultant for 250 initial or biennial third-party LDAR program audits or program reviews to evaluate applicability and implementation of LDAR provisions at chemical manufacturing plants, natural gas processing plants, petroleum refineries, oil & gas facilities, pharmaceutical plants, and terminals, including comparative monitoring, in accordance with global Consent Decrees or to evaluate baseline compliance with respect to existing rules as well as anticipated future enhanced program requirements. Audited compliance with applicable state and federal LDAR requirements and permit conditions as well as enhanced LDAR CD provisions and site procedures. Audits generally consisted of comparative monitoring, tagging reviews, and observation of technicians' calibration and monitoring techniques as well as records reviews, including forensic database analysis, and assessing the effectiveness of data management systems. Identified corrective actions and best practices that improved compliance performance, which supported the termination of CDs for more than 20 facilities.

Refinery-wide Re-Tagging Project Support
Managed the refinery-wide re-evaluation of LDAR applicability, interpreting P&IDs to identify subject fugitive equipment. Developed and executed a process to obtain, assess, document, and review LDAR speciation data and identify component service on more than 1,500 P&IDs for 33 process units for the LDAR contractor to re-tag components refinery. Technical advisor for a separate refinery-wide tagging audit and subsequent stream speciation evaluation and component tagging effort, with DTM Method 21 monitoring, for a major U.S. refinery.

LDAR Expert Witness Support
Litigation Expert Witness for plaintiff in pending lawsuit alleging contractor responsibility for LDAR enforcement-related costs associated with a Consent Decree. Provided expert report, rebuttal report, and deposition testimony regarding the nature of LDAR regulations and enhanced requirements, the contractor's responsibilities, EPA's enforcement initiative and actions, and the resulting penalties and injunctive relief under its penalty policy. *INEOS USA LLC v. Furmanite America, Inc., A Division of Furmanite, Inc. and Todd Grant*, No. CV2009 0371, in the Court of Common Pleas of Allen County, Ohio.

LDAR Patent Litigation Support
Provided technical analysis, expert opinions, and declaration in the *inter partes* review by the U.S. Patent and Trademark Office regarding (a) the disclosures of U.S. Patent Nos. 7,657,384 and 8,386,164; (b) the indefiniteness of certain claim terms or phrases of the asserted claims of the Patents; and (c) the construction or meaning of certain claim terms or phrases of the asserted claims of the Patents. Case 3:14-cv-00012, *LDARtools, Inc. v. Inspectionlogic Corporation*, in the United States District Court for the Southern District of Texas.

LDAR Comprehensive Assessment
Led a three-consultant team of LDAR subject matter experts in performing a three-month, on-site comprehensive environmental assessment (CEA) to review compliance with applicable state and federal regulatory requirements and identify deficiencies and recommend improvements to the LDAR program to enhance long-term compliance sustainability at a major U.S. refining complex. Conducted a broader assurance review of the transformed LDAR program, policies, procedures, and practices two years after the CEA to evaluate program performance.

Third-Party HRVOC LDAR Audits
Partner-in-Charge for 150 third-party HRVOC LDAR audits for industrial facilities in the Houston-Galveston-Brazoria nonattainment area, which included analysis of monitoring data for abnormal

data patterns, field reviewing open leaks, and a statistical Method 21 compliance review based on comparative monitoring a random subset of valves.

LDAR Enforcement Support
Assisted chemical, refining, and pharmaceutical facilities across multiple EPA Regions, states, and local programs to evaluate, respond, and negotiate lower fines in response to NOVs and FOVs for alleged noncompliance with equipment standards, LDAR monitoring requirements, and fugitive emission limits and related to their implementation of several aspects of the HON/MON NESHAP and Pharmaceutical and Refinery MACT rules.

LDAR Management Systems Assessment
Conducted a third-party management systems assessment for a national LDAR services provider to review its operations pursuant to an Agreed Order. Visited branch offices and interviewed a range of staff members to benchmark software systems and equipment against competitors and evaluate how effectively its company policies and procedures, organizational structure, job responsibilities and compliance accountability, training programs, and processes for identifying and communicating regulatory changes implemented at the branch level to promote and ensure compliance with applicable federal and state regulations. Presented assessment results to the CEO and executive team.

LDAR Training Seminars
Developed and provided internal training seminars to keep refinery LDAR coordinators, supervisors, technicians, and corporate staff updated on rule requirements, enforcement initiatives, industry best practices, rule developments, and lessons learned from LDAR compliance projects and audits.

NEIC LDAR Enforcement Support
Responded to NEIC and DOJ over alleged violations of LDAR requirements under NSPS Subparts VV, GGG, QQQ, and NESHAP Subpart FF for a U.S. refinery. Assisted in identifying applicable LDAR requirements and preparing a refinery-wide Program Plan. Identified and documented subject components on refinery P&IDs, field-verified process lines, and tagged applicable fugitive components. Conducted a limited compliance review of the applicable LDAR, BWON, and PSD rules to facilitate settlement in an ongoing EPA enforcement action.

LDAR Regulatory Evaluation Support
Conducted regulatory applicability assessments of LDAR requirements for oil & gas and chemical manufacturing sites. Identified and re/tagged subject equipment and performed component monitoring using both an infrared camera and conventional Method 21 instrument methods. Prepared LDAR plans to identify applicable requirements, LDAR-related permit conditions, tagging and management of change, monitoring, recordkeeping, and reporting requirements and populated the LDAR database.

Fugitive Emissions Reduction Evaluation
Led a three-person team to review existing LDAR program and identify opportunities to further reduce near- and long-term fugitive emissions from sources outside of building structure. Developed an implementation plan and identified the expected emission reduction opportunity for the site to present to regulators requesting information in response to public complaints regarding chemicals detected.

Midstream LDAR Program Support
As part of a post-merger integration for dozens of midstream oil and gas assets, evaluated LDAR program records and policies to identify gaps in fugitive component inventories with air quality authorizations. Prepared white papers to outline regulatory compliance positions and recommend corrective actions to reduce fugitive emissions and enhance the LDAR program.

LDAR Program Return on Investment Study
Used aggregated emissions monitoring data and internal and contractor costs to develop a cost model to calculate the returns based. Variables such as

labor, commodity costs, and leak rates as well as potential fines and repair costs were also factored into the model to evaluate future scenarios. Prepared slides for presentation to the Board of Directors.

LDAR Regulatory Advocacy Support
Assisted the American Chemistry Council in support of advocacy efforts for EPA's proposed Uniform LDAR Standards review. Reviewed rule precedents and developed written comments for submission. For the American Petroleum Institute, supported review and reconsideration of the final NSPS Subpart OOOOa rule. Collect and analyzed fugitive emissions data for onshore production well sites and gathering and boosting facilities and suggested regulatory changes to reduce the regulatory burden.

LDAR Compliance Support
Prepared a LDAR program plans and procedures, developed audit protocols, and implemented enhanced LDAR provisions in accordance with applicable rules or in response to enforcement actions. Advised clients on agency and third-party audit interpretations of state and federal LDAR rules. Reviewed applicability and exemption determinations and supporting documentation and conducted field "spot checks" and detailed reviews of LDAR components in process units to assess proper component tagging and identification in facility LDAR software programs. Assisted EHS staff in specifying, selecting, and implementing LDAR database software, monitoring instrument, and dataloggers. Provided third-party QA/QC support of LDAR contractor monitoring and compliance data. Conducted forensic review of LDAR data following ownership transfer to identify compliance issues in furtherance of settlement negotiations.

Key Industry Sectors

- Oil & gas
- Chemical
- Power
- Manufacturing

Publications & Presentations

- "A Disservice to VOC Service" AWMA Gulf Coast Chapter Annual Conference and Exhibition. March 2018
- "It's Just Calibration…How Hard Could it Be?" 4C Conference. February 2017.
- "Have Consent Decree Audits Improved Refinery LDAR Programs?" AFPM Environmental Conference. October 2016
- "Trust, but Verify: Evaluating LDAR Technician Monitoring Data" 4C Conference. February 2017.
- "Comparing Potential and Actual Fugitive Emission Estimation Methodologies – from the AID to the ICR, and Beyond", LBT Conference, February 2012
- "Estimating Source Emissions – Leak Detection and Repair." Environmental Science Deskbook, Thomson Reuters/West. June 2008.
- Abshire, C.S., Sheffield, C.K., and D.D. Bradley III. "Refinery Leak Detection and Repair – Challenges and Solutions." (ENV-07-115). NPRA Environmental Conference, September 2007
- Hampton, S.P. and D.D. Bradley III, "Refinery Air Quality Enforcement Issues", *Hydrocarbon Processing*, August 1999.

ISA Fugitive Emissions and LDAR Symposium

- Conference Chair (2014-2018)
- Technical Course: "LDAR Best Practices – Advanced Edition" (2013, 2016)
- Technical Course: "Audit-Proofing Your LDAR Program" (2008, 2010-17)
- LDAR Expert Panel Member (2006-2018)
- "Appendix VI: EPA's New Penalty Policy" September 2013
- "Insulation and Other Valve Obstructions—Are You Really Performing Method 21?" May 2012
- "The Calibration Trap – How to Violate Regulations without Leaving the LDAR Building" May 2011
- "Compliant & Cost Effective Repairs" May 2009
- "How Safe is Unsafe to Monitor?" June 2007
- "Pharmaceutical MACT LDAR Challenges" June 2006.
- "Understanding UTMs, DTMs, and Inaccessible Fugitive Components" May 2004

Kevin Eldridge, QEP, GHG-IQ

Principal Consultant

Mr. Eldridge is a Principal Consultant in ERM's Raleigh, North Carolina office. His experience is in the environmental consulting field, including management of air quality permitting, regulatory analysis, dispersion modeling, and emissions inventory programs as well as other multi-media environmental projects. Project management experience includes direction and supervision of engineers, meteorologists, and other scientists on air quality projects, including interaction with state regulators, client interface, budget, schedule development and monitoring, and quality assurance/quality control (QA/QC) of deliverables. Mr. Eldridge's experience also includes developing Risk Management Plans for natural gas processing plants, chemical manufacturing, hydrogen storage and general manufacturing processes.

Experience: 30 + years' experience in environmental consulting field.

Email: kevin.eldridge@erm.com

LinkedIn: https://www.linkedin.com/in/kevin-eldridge-b884228/

Education

- M.S. Atmospheric Sciences, North Carolina State University; 1984
- B.S., Meteorology, State University of New York; 1978

Professional Affiliations and Registrations

- Certified Greenhouse Gas Inventory Quantifier (GHG-IQ), GSA America, Inc. (No. 0019B)
- Qualified Environmental Professional (QEP), Air and Waste & Management Association (No. 2950110; 1995)
- North Carolina State University School of Physical and Mathematical Sciences (PAMS), Board of Directors (2008-2010)
- Air & Waste Management Association
- Carolina Air Pollution Control Association
- North Carolina Manufacturers A

Languages

- English, native speaker

Fields of Competence

- Stationary Source Air Quality Dispersion Modelling
- Emission inventories
- Air Permitting including:
  - Prevention of Significant Deterioration
  - Title V
  - Synthetic minor
  - State construction
  - Permit Negotiation
- Compliance
- Regulatory Analysis
- Risk Management Programs
- Greenhouse Gas Reporting
- Litigation & Expert Witness
- Mobile Source Emissions and Modelling
- Environmental Auditing

Key Industry Sectors

- Chemical Manufacturing
- Power Generation including Biomass
- Landfills
- General Manufacturing
- Pulp & Paper
- Forest Products
- Upstream and Midstream Oil & Gas Operations
- Ports
- Automotive Support Facilities

Key Projects

Air Quality Emission Inventories, North Carolina
Completed an emission inventory for two chemical processing facilities in Durham and Greensboro, North Carolina. The emission inventory was entered into the North Carolina AERO online emission inventory system.

Air Quality Permitting, North Carolina
Developed a permit application for a rubber manufacturing extrusion and curing facility located in North Carolina. The application was for the modification of air pollution control devices located at the facility. Also updated the emission inventory for the facility.

Air Quality Modeling, North Carolina
Evaluated emissions of North Carolina regulated air toxic emissions from this automobile parts manufacturing facility located in Fayetteville, North Carolina. Used AERMOD to determine off-site impacts associated with emissions from the facility.

Particulate Monitoring, North Carolina
Led a team to conduct personnel particulate sampling for two chemical processing facilities located in Durham and Greensboro, North Carolina.

Environmental Audit, North Carolina
Participated in a complete environmental audit for an automotive manufacturing facility located in Advance, North Carolina. The audit reviewed compliance with: Air Quality/Air Pollution Control; Chemical Use and Storage; Spill Prevention Control and Countermeasure Planning; Environmental Noise; Odors; Waste Management; and Water Management. Provided a report that identified areas where the facilities were not meeting current regulatory requirements and provided listings of Best Management Practices (BMPS). Also evaluated compliance with the company's corporate standards.

Environmental Audit, North Carolina and South Carolina
Participated in a complete environmental audit for two manufacturing facilities located in Gastonia, North Carolina and Dillon, South Carolina. During the audit, he reviewed compliance with Air Quality/Air Pollution Control; Chemical Use and Storage; Spill Prevention and Emergency Response; Storage Tanks Limited Transportation Regulations; Environmental Noise; Hazardous Materials Management; and Water Management. Provided a report that identified areas where the facilities were not meeting current regulatory requirements and provided listings of Best Management Practices (BMPS). BMPs are optional suggestions for improvement that are tracked to completion in the company's informational management system. Also evaluated compliance with the company's Global standards.

Air Quality Permitting, South Carolina
Assisted a building products manufacturing facility with permitting new and modified operations at its Swansea, South Carolina facility. Calculated air quality emissions from the various modified sources. Conducted air quality modeling for air toxics using AERMOD.

Air Quality Permit Application, Utah
Provided air quality permit support for a natural gas processing plant located in a remote area of southern Utah. The permit application allowed for the operation of a flare at the facility.

Air Quality Permit Application, Utah
Assisted a trans-loading facility located in Salt Lake City, Utah, that loads crude oil, solids, propane and sulfuric acid into railcars to obtain the appropriate air quality permits. Developed the emission rates and completed the Notice of Intent application for the operations.

Air Quality Permitting, Tennessee
Developed emission estimates and updated the permit application for this gasoline bulk terminal located in Nashville, Tennessee.

Air Quality Permitting and Emission Inventory, Oklahoma
Developed an air quality permit application for an 80 MMBtu/hr natural gas boiler to be located at a facility that manufactures burners, flares and pilots for oil and gas industries. Also developed the annual inventory for the facility.

Air Quality Toxics Dispersion Modelling, North Carolina
Led a team to conduct an air toxics modelling analysis for formaldehyde and phenol emissions from an automotive parts manufacturing facility located in Fayetteville, North Carolina.

Air Quality Permitting and Modeling, North Carolina
Evaluated emissions of toluene diisocyanate emissions from a polyurethane foam manufacturing facility located in Mt. Airy, North Carolina. Used AERMOD to determine off-site impacts associated with emissions of toluene diisocyanate from the facility. Developed a permit application to allow for a more flexible operation of the facility, based on the air quality modeling results.

Tier II and TRI Reporting, North Carolina
Assisted a polyurethane foam manufacturing facility located in Mount Airy, North Carolina, with its annual Tier II and TRI reporting.

Greenhouse Gas Reporting, Colorado
Conducted an emission inventory of this upstream oil and gas operation facility located in Colorado. Emissions were uploaded into the Environmental Protection Agency's e-GGRT system.

Key Projects Prior to Joining ERM

Air Quality Permitting and Emission Inventories, North Carolina and Mississippi
Mr. Eldridge has developed numerous air quality permit applications and emission inventories for this resin manufacturing facility located in North Carolina and Mississippi for the past twenty years. The operations include manufacturing reactors, storage tanks, boilers, internal combustion engines, loading and unloading of raw materials and final products and flaking operations.

Air Permitting and Modelling, North Carolina
Developed permit application for new emergency generator at the international airport near Raleigh, North Carolina. He developed emission estimates for a wide-variety of emergency generators and boilers operated at the airport. He conducted an air quality modelling analysis for evaluation of emissions to demonstrate compliance with air toxics regulations.

Air Quality Modeling, North Carolina
Evaluated the emissions and conducted air quality dispersion modeling for a scrap metal crushing facility. Used AERMOD to evaluate the impacts of acrolein, benzene, hexanes, xylenes, polychlorinated byphenyls, and cadmium for comparison to health based standards acceptable to the North Carolina Division of Air Quality.

Air Quality Modeling and Permitting, North Carolina
Managed a project to evaluate criteria and air toxic pollutant impacts associated with a permit modification for this a chemical manufacturing facility located in North Carolina. The modeling was conducted using AERMOD.

Environmental Support, North Carolina
Providing general environmental support to a polyurethane foam manufacturing facility located in Mt. Airy, North Carolina for the past five years. The support includes air permitting, Tier II and TRI

reporting, spill reporting, stormwater and RMP preparation and documentation.

PSD Permit Application for Biomass Facility, Michigan
Developed a PSD permit application for a new biomass power plant to be located in Marquette, Michigan. The application tasks included:

- Calculating emissions of criteria pollutants and air toxics;
- Conducting a BACT analysis to evaluate control technologies;
- Conducting air quality dispersion modelling using AERMOD to evaluate ambient impacts of criteria and air toxic pollutants;
- Negotiating permit conditions with the state regulator; and
- Developing the acid rain permit application.

Air Quality Permitting and Modeling Services, Texas
Managed the development of a permit application for a new foam lamination facility to be located in Hidalgo, Texas. Developed emission rates based on previous testing conducted at other facilities. Led the air quality modeling analysis using AERMOD that determined off-site impacts of toluene diisocyanate for comparison to the Texas Commission on Environmental Quality Effects Screening Levels.

Air Permitting, Emission Inventory and Risk Management Plan, Mississippi
Developed the air permit application for a new process located at a resin manufacturing company located in Hattiesburg, Mississippi. He developed potential-to-emit and actual emission inventory. Emission sources included boilers, process heaters, emergency generators, chemical reactors, fugitive leaks, flaking operations, storage tanks, and loading and unloading of raw material and final product. As part of this project, he also developed a Risk Management Plan for the new process as it involved the storage of a regulated chemical in excess of threshold amounts. Both a worst case and an alternative case explosion scenario were assessed. A Risk Management Plan was then developed in compliance with the Program 3 requirements for a Risk Management Program. Also entered the data into the EPA CDX system.

Title V Permit Renewal Applications, Numerous States
Managed a team that prepared Title V permit renewal applications for multiple compressor stations located in Kentucky, Tennessee, Minnesota, Wisconsin, Iowa, Illinois, and Missouri. The team conducted site visits of each facility to gather information for the permit renewal application packages. Prepared the applicable renewal application documents, using state-specific Title V software; reviewed applicable State air regulations to ensure latest revisions are being followed; updated the Title V emission calculations; and incorporated comments on draft documents.

Preparation of Air Quality Permit Applications and Regulatory Analysis, Alaska
Provided assistance with developing air quality Title 1, Title V and PSD permit applications and negotiations, evaluating emissions, conducting air quality dispersion modelling, and evaluating permitting applicability for various activities at an oil production facility in Alaska. He also provided assistance with identifying the applicable requirements of 40 CFR 63 Subpart ZZZZ, testing requirements, and control evaluations for over ten facilities located throughout Alaska for over 100 internal combustion engines. He also developed a PSD permit application that included air quality dispersion modelling utilizing AERMOD to evaluate impacts of criteria pollutants.

PSD Permit Application, Michigan
Developed a PSD application to convert the existing coal, oil, and gas-fired boiler to burn other fuels for this facility located in L'Anse, Michigan. The facility was permitted to burn wood waste, tire-derived fuels, bark, wood fines, railroad ties, and a mixture of paper

sludge and residual ash from a local paper mill. He calculated emissions of criteria pollutants and air toxics. He led a team that conducted a BACT analysis to evaluate control technologies. He conducted air quality dispersion modelling using AERMOD to evaluate ambient impacts of criteria and air toxic pollutants. He conducted an analysis of the impacts of the project on endangered species. He also negotiated permit conditions with the state regulators and assisted with the response to public comments.

Compliance Support, Utah, Colorado

Provided compliance support for the past three years for a Natural Gas Processing Plant located in a remote area of southern Utah. The facility processes up to 40 million standard cubic feet per day natural gas. The pipeline system that feeds the plant transverses Colorado and Utah and consists of four gas compressor stations and 262 miles of gas gathering lines. Provided assistance with the following activities at the plant:

- Preparing air quality Notice of Intent permit applications;
- Updating potential to emit emission inventories and compiling the annual actual air emission inventory for submittal to the state;
- Assisting with the preparation of annual compliance reports;
- Preparing the Title V renewal application;
- Evaluating and assisting with submittals of stack test reports;
- Assisting with the preparation and updating the Risk Management Plans;
- Preparing Greenhouse Gas emission inventories for submittal to EPA through the e-GGRT system;
- Preparing and updating the Greenhouse Gas Management Plan; and
- Providing Method 22 Visual Observation training to field staff.
- Air Quality Permitting and Regulatory Analysis

Air Quality Permitting and Modelling, Biomass Briquette Production Facilities, South Carolina and Georgia

Developed permit applications for two facilities located in South Carolina and Georgia. The operations process green wood chips that are received or chipped on site, stockpiled, dried, treated in a reactor, ground, mixed in a paddle blender and formed into briquettes that are dried, cooled and stored for ultimate sale to the power production industry overseas. Led a team that developed the air quality permit application and conducted air quality modelling utilizing AERMOD to demonstrate compliance with the state air toxic standard for formaldehyde.

Expert Witness, Texas

Served as an expert witness in a trial associated with alleged household contaminations in Gilmer, Texas. He developed information to assess the nature and extent of the air impacts likely associated with the burning of chromated copper arsenate -treated wood in an industrial boiler. He conducted the following activities:

- Reviewed, commented, and rebutted information provided by the plaintiff's expert witness with regard to impacts associated with the facility.
- Calculated of emissions of air pollutants.
- Conducted dispersion modelling of the site for air pollutant emissions.
- Compared the calculated concentrations to appropriate state and federal air quality standards.
- Presented its findings in depositions, hearings, and in court.
- The case was settled out of court.

Cited as: Homer Abron, Jr. et al. v. Dean Lumber Co. Inc. et al., United States District Court, Eastern District: Marshall Division, Texas, Civil Action No. 2: CV-0197-DF/HWM. Deposition, 5 November 2002.

GHG Emission Evaluation, Worldwide
Provided GHG evaluation services for a worldwide inventory of GHGs. The inventory included hundreds of facilities located throughout the world that provide a variety of products and services. He evaluated and reviewed raw data sources, emission factors, and methodologies to ensure the inventory complied with the Climate Registries methodologies. The inventory included Scope 1, 2 and 3 emission sources.

Mobile Source Emission Inventory, Numerous States
Led a team that conducted a mobile source emission inventory for 12 Air Force bases located in the southern and western United States. He evaluated emissions associated with aircraft operations (including transient aircraft), aerospace ground equipment, government-owned vehicles, privately owned vehicles, non-road vehicles, and mobile refueling operations. He used a variety of techniques for estimating emissions from these operations including models such as Mobile 6, NonRoad, and EDMS.

Port-Owned and Port-Wide Emission Inventory, Washington
Managed the development of the GHG and criteria pollutant emission inventory for the Port-owned and Port-wide emissions of criteria and hazardous air pollutants for the Port of Vancouver, Washington. Marine side emissions were evaluated from diesel engines operating on oceangoing vessels, tugs and tows, dredges, and other vessels operating within a port area. Land-based emission sources included cargo handling equipment such as terminal tractors, cranes, container handlers, and forklifts, as well as heavy duty trucks and locomotives operating within a port area. The inventory also included emissions from Port tenant operations. Methodologies employed EPA's guidance documents for port emission inventories. EPA models including NONROAD and MOBILE 6.2 were used to calculate specific emission factors for landside emission sources. World Resources Institute /International Panel on Climate Change emission factors and methodologies were used to develop GHG emission factors for the various source categories.

Environmental Compliance Assessment, Power Plants, Numerous States
Led a team of scientist and engineers that completed a comprehensive environmental assessments of approximately twenty power plants located in New York, Maryland, Montana, Pennsylvania, Massachusetts, Maine, Wisconsin, and New Jersey. The client was evaluating these power facilities for possible purchase. The plants combusted natural gas, coal, oil and biomass and ranged in size from 20 to 800 MW. The evaluations included analyses of all environmental programs with an emphasis on air and water quality requirements and compliance. These evaluations typically included an initial site visit and evaluation of compliance status and future compliance issues that might have large cost impacts on the facilities future operations. Initial evaluations were based on interviews with staff and documentation provided by the facility as well as information available through the internet and from regulatory agencies. Also evaluated requirements for other miscellaneous environmental programs such as the Risk Management Program, hazardous waste management and TRI reporting.

Due Diligence, New Mexico
Conducted a due diligence environmental compliance evaluation for the San Juan River Natural Gas Processing plant located in northern New Mexico. The pipeline associated with the gas plant traverses Utah, New Mexico and Colorado and consisted of 3 supporting compressor stations and 224 miles of gas gathering lines.

Environmental Compliance and Due Diligence, Several States
Led a team of scientist and engineers to evaluate environmental compliance for 20 sites in North Carolina, Pennsylvania, Virginia, Florida and

Maryland. The sites produced energy for sale to the electric grid by combusting landfill gases. The first phase of the project was to conduct an Environmental Site Assessment at each site. The second phase was the evaluation of all environmental programs including, stormwater, SPCC, NPDES permitting, air quality, storage tank permitting, Tier II and TRI reporting and hazardous waste generation.

PSD Permitting and Modeling, Texas
Conducted PSD and air toxics air quality modeling for this proposed condensate splitter to be located in Texas. Modeling was conducted using AERMOD. Evaluated impacts of CO, NO_2, SO_2, PM_{10}, and $PM_{2.5}$ as well as impacts of state listed air toxics.

Litigation Consultant, Expert Witness, Texas
Provided litigation support for a trial associated with potential air quality impacts on the community in Somerville, TX. Developed information to assess the nature and extent of the multi-pathway air impacts likely associated with a wood treatment facility. Conducted the following activities: Review, comment, and rebuttal of information provided by the plaintiff's expert witness with regard to impacts associated with the facility; Calculation of emissions of air pollutants; Conducted dispersion modeling of the site for air pollutant emissions; Compared the calculated concentrations to appropriate state and federal air quality standards.

Expert Witness, Georgia
Served as Project Manager and expert witness in a trial associated with the construction of a rail facility in Georgia. Developed information to assess the nature and extent of the air impacts likely associated with the proposed facility. Developed the following information: Calculation of emissions of air pollutants including fugitive dust and HAPs; Verification of emission calculations included in the facility's report; Verified input/output data for the mobile source emission models used; Conducted dispersion modeling of the site for air pollutant emissions. Used EPA-recommended air dispersion models to conduct the analyses. Worked with traffic engineers to model off-site intersections; Compared the calculated concentrations to appropriate state and federal air quality standards; and. Presented findings to a jury during the court trial.

Air Quality Permitting and Regulatory Analysis, Utah and Colorado
Assisted with preparation of regulatory applicability memorandums for various regulations affecting the operations in Utah and Colorado. The operations include one main gas processing plant, four compressor stations and over 100 well sites. This included the evaluation of 40 CFR 63 Subpart ZZZZ, 40 CFR 60 Subpart OOOO, and 40 CFR 63 Subpart HH. In addition: Provided assistance with the following activities for the Lisbon facility: Prepared air quality Notice of Intent permit applications; Updated potential to emit emission inventories; Compiling the annual actual emission inventory for submittal to the Utah Department of Air Quality; Assisted with preparing annual and semi-annual compliance reports; Evaluated and assisting with submittals of stack test reports; Evaluated applicability of New Source Performance Standards; Assisted with preparing and updating the Risk Management Plan for the facility; Prepared and updating the Title V renewal permit application; and Provided Method 22 Visual Observation training to field staff.

Air Quality Permitting, Texas
Led a team that prepared over 100 permit by rule (PBR) permit applications for compressor stations and well field operations located in several counties in Texas. Emission were calculated based on engine specifications and emission factors. Startup, shutdown and maintenance emissions were also included in the permit applications.

Preparation of Title V Permits, Alaska
Reviewed numerous Title V permit renewal applications submitted by Marathon Oil Company gas production facilities located on the Kenai Peninsula. Prepared the draft Title V permits for

review by ADEC staff and approval. Also managed the preparation of the Title V permits for the Anchorage Landfill and two Chugach Electric Generating facilities.

Worldwide Greenhouse Gas Emission Inventory, Worldwide
A global provider of offshore drilling services to the petroleum industry operates offshore drilling equipment in six continents. As part of United Kingdom requirements, the company was required to report their worldwide emissions of GHGs. Assisted with development of their GHG inventory by providing guidance on emission factor selection and intensity determinations.

Air Quality Review, Alabama
Conducted a regulatory review of the operations of at an upstream oil and gas facility located in Tuscaloosa County, Alabama. The facility operates approximately 500 coal bed methane wells, 7 compressor stations, 3 water treatment plants, and over 150 miles of intrastate gathering pipelines. The analysis included evaluating permitting requirements, GHG reporting requirements and the applicability of a variety of air quality regulations to the operations.

Title V Permitting, Numerous Locations
Led a team the provided Title V permit renewal applications for eight compressor stations located in Kentucky, Tennessee, Minnesota, Wisconsin, Iowa, Illinois and Missouri. Prepared applicable renewal application documents, using state-specific Title V software (where applicable) and/or forms. Updated the Title V emission calculation spreadsheets; incorporated TransCanada comments on draft documents; coordinated with TransCanada Air Group contact; responsible for answering questions from the state after submittal of applications.

Air Quality Due Diligence, Utah, New Mexico, Colorado, and Texas
Conducted a regulatory review of the operations of a natural gas processing plant in New Mexico and three compressor stations located in Utah, New Mexico, Texas and Colorado. The analysis included evaluating permitting requirements, GHG reporting requirements and the applicability of a variety of air quality regulations.

Air Quality Compliance Assistance and Permitting, New Mexico
Lead a team providing compliance reporting and permit support for the San Juan River Gas plant located in Farmville, New Mexico and three supporting compression stations located in New Mexico and Utah. Compliance includes developing semi-annual and annual compliance reports, emission inventories and developing and submitting the GHG emission through EPA e-GGRT system. Weston is also currently providing New Source Review and Title V permitting support for operational changes at the facility.

Air Quality Permitting Support, Pennsylvania, West Virginia, Kansas, Oklahoma and Arkansas
Provided permitting evaluation and support for over 30 oil and gas support operations located in Pennsylvania, West Virginia, Arkansas, Kansas, and New Mexico. Led a team that evaluated the permitting requirements in each of these states and developed emission estimates for each facility.

Greenhouse Gas Reporting, United States
Developed the GHG emission inventories for 2014 and 2015 for this oil and gas import/export operation as required under 40 CFR Part 98 Subpart MM. Mr. Also developed the required Monitoring Plan for these operations.

Other Environmental Projects, Numerous States
Mr. Eldridge leads other non-air related environmental projects such as Spill Prevention Control and Countermeasure Plan development, Stormwater Pollution Prevention plan development, and soil and surface water sampling and analyses. He recently led a team of experts conducting due diligence for over twenty power plants located in the eastern United States. The due diligence covered all environmental aspects including: air; water;

wastewater; hazardous waste; risk management; RCRA and environmental permitting. In addition, he managed the Phase I environmental site assessments that were conducted at the sites.

Publications

- Eldridge, K. and D. Pittman. 2017. "Updating the 20D Tool for the Cumulative Impact Analysis." Publication and presentation at the 2017 Guideline on Air Quality Models: The Changes conference in Chapel Hill, NC, December 2017.
- Cudney-Black, J. and K. Eldridge. 2015. "Climate Change and Social Change – A Comparison of Regulatory Reform and Socio-Cultural Response to Climate Change Policy in Europe and the United States." Publication and Presentation at the 108th Air and Waste Management Association Annual Conference.
- Eldridge, K. 2012. "Applicability and Compliance – 40 CFR 63 Subpart ZZZZ at Multiple Facilities." Publication and Presentation at the 105th Air and Waste Management Association Annual Conference.
- Davis, J. and K. Eldridge. 2012. "Employee Empowerment and the Reduction of Community Exposure to Accidentally Released Chemicals and Other Hazards." Publication and Presentation at the 105th Air and Waste Management Association Annual Conference.
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Christy Richardson, PE

Senior Consultant

Christy is a senior consultant based in Raleigh, North Carolina where she focuses on air quality permitting and compliance for various manufacturing facilities. Mrs. Richardson has prepared numerous air permit applications and compliance reports for a wide variety of facilities, specializing in chemical manufacturing, wood products facilities, oil and gas industry, and other various manufacturing operations. Her expertise also includes compliance auditing, regulatory applicability determination, and compliance program implementation. Mrs. Richardson has extensive experience with Leak Detection and Repair, through third party compliance auditing, investigative reviews, and program implementation.

Experience: 13 years' experience in air quality.

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Education

- Bachelor of Science, Chemical Engineering, North Carolina State University, Raleigh, NC

Professional Affiliations and Registrations

- P.E.

Fields of Competence

- Environmental Compliance Auditing, Investigations, and Assessments
- Air Quality Permitting
- Leak Detection and Repair (LDAR)
- Environmental / Regulatory Compliance Support
- Regulatory Communication and Negotiation
- NSPS / MACT Applicability, Implementation, and Compliance
- Emissions Estimations and Inventories
- Environmental Management
- Applicability Determinations
- Environmental Plan Development (SPCC, SWPPP)

Key Industry Sectors

- Chemical Manufacturing
- Wood Products Manufacturing
- Miscellaneous Manufacturing

Key Projects

Compliance Auditing.
Led and managed third-party LDAR program audits, including comparative monitoring, records reviews, and data analyses, at chemical plants and refineries in support of Consent Decree requirements, or under state audit privilege provisions. Evaluated compliance with applicable state, federal, and enhanced LDAR requirements and audited for Method 21 compliance. Provided corrective actions to address audit findings. Conducted general air compliance auditing at chemical manufacturing and wood products facilities, including applicability reviews and regulatory compliance with HON, MON, PCWP MACT, RICE MACT and various NSPS regulations.

Title V Permit Applications
Assisted with numerous Title V Permit applications, including installation of large natural-gas fired boilers, production rate increases, decommissioning (varying operational scenarios), and other various process modifications. Also assisted with numerous permit renewal applications, including re-evaluation of applicable requirements, facility-wide potential emission calculations, and permit language enhancements.

MON / HON / OLD Compliance Assurance.
Reviewed facility regulatory applicability, ensured compliance with HON, MON, and OLD monitoring, recordkeeping and reporting requirements, and developed environmental improvement strategies. Ensured management and operations personnel where knowledgeable on compliance requirements through training, involvement, and reasonable inquiries. Assisted the facility with project reviews to determine regulatory applicability of proposed changes.

Boiler MACT Information Collection Request (ICR).
Assisted facility with source testing, data review, and data submittal for a residual fuel oil-fired boiler in response to EPA's Section 114 Information Collection Request.

MON Applicability Tool.
Developed a tool for evaluating applicability of MON requirements to sources at resin manufacturing facilities. The applicability tool included flow charts and regulatory citations and descriptions for all applicable requirements.

Onsite Environmental Management Support.
Acted as environmental manager for wood products facilities in North and South Carolina fulfilling all duties of the site environmental manager. Ensured compliance with the PSD permit requirements, stack testing requirements, NESHAP requirements, and NPDES stormwater requirements. Reviewed and implemented Stormwater Pollution Prevention Plans (SWPPP) and Spill Prevention and Control Countermeasure (SPCC) plans. Developed and submitted various environmental reports and regulatory responses, including air emission inventory, compliance certifications, greenhouse gas inventory, and Tier II reporting. Assisted with various air permitting modifications and project reviews.

Boiler MACT Applicability Review and Implementation.
Oversaw Boiler MACT implementation for all US composite panel mills for a large wood products company. Provided site-specific applicability determinations and applicability and compliance tools for each site. Collaborated with the sites to develop monitoring and recordkeeping strategies specific to their operation and capabilities. Ensured completion of initial tune-ups, energy assessments, and compliance demonstrations. Developed reporting tools for Initial Notifications, Notification of Compliance Status and Compliance Reports.

LDAR Plan Development and Program Implementation.
Assisted an advanced wastewater treatment plant with the development of a state-required LDAR plan and initial implementation of the program. Oversaw component identification, field tagging, and initial Method 21 monitoring. Developed LDAR software training tools for site personnel. Developed quality assurance (QA) plans to assist facilities with routine reviews of LDAR database and records to ensure continual compliance with site-specific regulations. Ensured plans were detailed and descriptive, providing step-by-step instructions and LDAR software guidance.

LDAR Investigative Data Review.
Reviewed LDAR monitoring data for anomalies or abnormal data trends. Evaluated thousands of monitoring events, using various tools and search approaches, to identify repeat leakers, abnormal data or monitoring trends, and inadequate leak records.

SOC Implementation and General Support.
Oversaw the implementation of manufacturing facility's Special Order by Consent. Assisted the facility with development of a plan for compliance and consistently tracked progress of the project. As part of the implementation, the site installed thermal oxidizers to control PM, VOC, and VE. Developed compliance tools for the site to demonstrate continuous compliance. Developed emission calculations, reports, and notifications and oversaw numerous stack tests.

Greenfield Facility PSD/Title V Permitting.
Assisted with development and review of emission estimates for a greenfield wood products facility in North Carolina. Conducted regulatory review for both State and Federal regulations. Assisted with development of the initial PSD permit application narrative, emission calculations, and application forms.