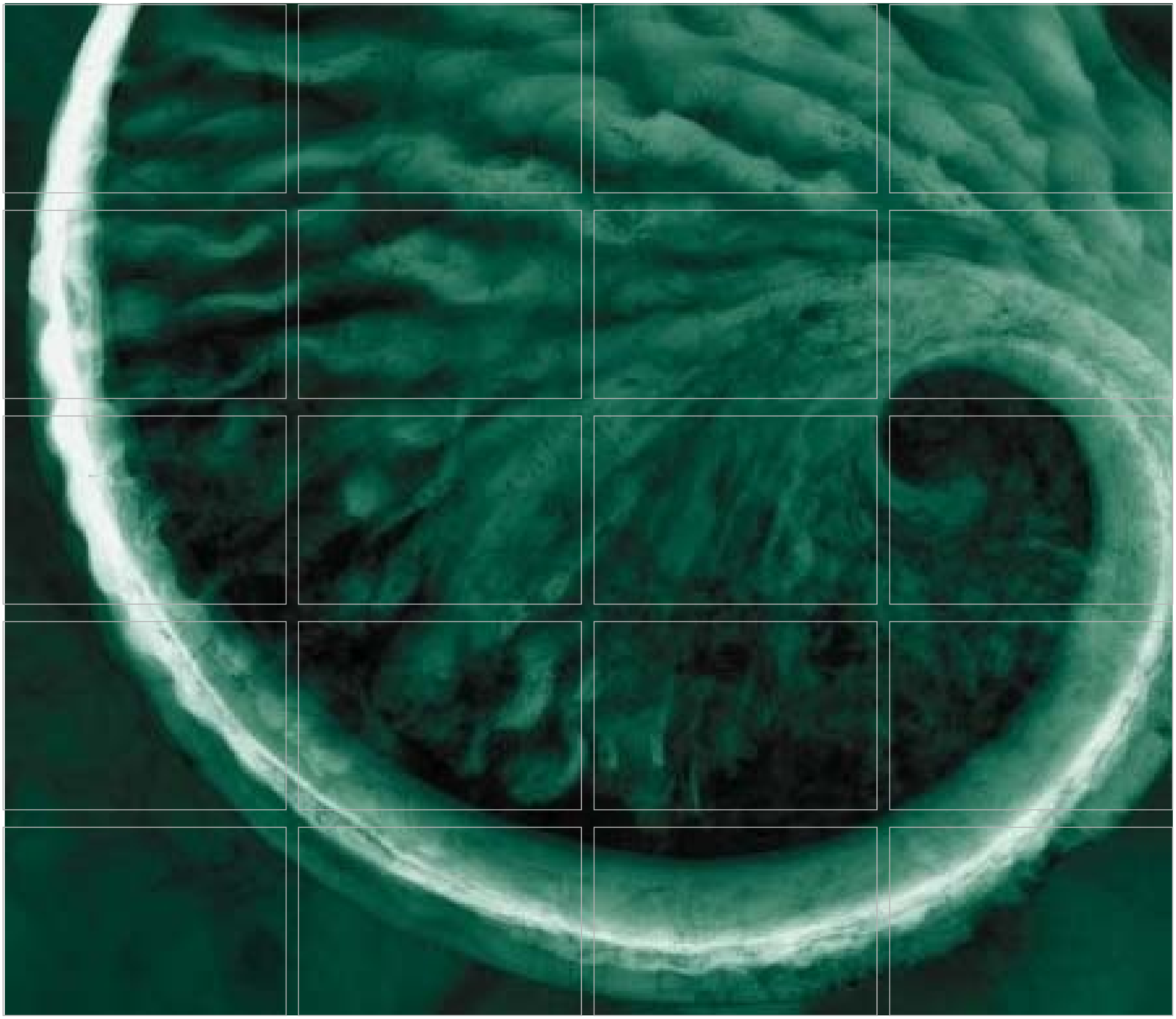

Third-Party LDAR Program Review

Prepared for:
The Chemours Company

Fayetteville Works Facility
Fayetteville, North Carolina

January 31, 2018

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The Chemours Company

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EXECUTIVE SUMMARY

The Chemours Company (Chemours) requested that ERM review the Chemours – Fayetteville Works facility's (the facility's) existing Leak Detection and Repair (LDAR) program and site procedures to identify opportunities in which the LDAR program could be enhanced to further reduce emissions from equipment component leaks from valves, connectors, and pumps. This document details ERM's review of the facility's existing LDAR program and site procedures and identifies enhancements that could lead to further fugitive emission reductions, specifically for components containing Hexafluoropropylene Oxide – Dimer Acid Fluoride (HFPO-DAF) and Hexafluoropropylene Oxide – Dimer Acid (HFPO-DA). At the facility, these constituents are used or produced in the following process areas:

- Vinyl Ethers – North Process Unit;
- Vinyl Ethers – South Process Unit;
- Polymer Processing Aid (PPA) Unit; and
- Semi-works Polymerization Operation (Semi-works).

This document is presented in three main sections: HFPO-DAF and HFPO-DA fugitive emission estimations, current facility procedures and best practices, and potential opportunities for emission reductions. Options for reducing emissions include both near-term and longer-term work practices and equipment standards.

1.0 FUGITIVE EMISSION ESTIMATIONS

In efforts to estimate the amount of fugitive HFPO-DAF and HFPO-DA emissions from equipment leaks, ERM reviewed the total number of components that contain process streams with at least 1 weight percent (wt. %) HFPO-DAF or 1 wt. % HFPO-DA provided by Chemours along with the location of those components (indoors or outdoors). The composition of HFPO-DAF and HFPO-DA in those streams, component specific emission factors, the stream service (i.e., heavy liquid, light liquid, or gas/vapor), and the maximum hours of operation, by product campaign, during the last five year period (2012-2016) were utilized in the estimation of fugitive emissions from equipment leaks. For Semi-works, the maximum hours of operation was estimated to be 500 hours per year.

The 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), were used to calculate the fugitive emissions from equipment leaks. 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) volatile organic compound (VOC) emission factors.[1] Specifically, these DuPont emission factors were based on the following criteria:

- Special techniques used to routinely locate leaks;
- Daily leak checks in process areas;
- Leak test procedures used during process startups;
- Documented startup procedure checklist used to locate routine leaks; and
- Formal procedures to accomplish timely repair.

Also, as part of this evaluation, ERM estimated the emissions of fugitive equipment leaks from components located within the confines of buildings as well as those located outdoors. For the PPA unit, the number of indoor components and the estimated emissions from indoor equipment leaks were not estimated as part of this review. Those emissions are exhausted through the PPA vent stack and have been

[1] 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.

accounted for in emission rates measured at the stack exhaust. Chemours is in the process of evaluating PPA building exhaust emissions by source testing; therefore, for purposes of this document, emissions have not been estimated for indoor equipment leaks in the PPA unit. Also, the only source of HFPO-DA emissions would be within the confines of the PPA building. Therefore, all other emissions presented in this section are HFPO-DAF. The other process units that have the potential to emit HFPO-DAF from equipment leaks (and contain process streams with HFPO-DAF concentrations of at least 1% by wt.) include Vinyl Ethers – North, Vinyl Ethers – South, and Semi-Works Polymerization Operation (Semi-works).

In accordance with the definition for heavy liquid listed in 40 CFR §52.741[2] and 40 CFR §63.161, HFPO-DA would be considered a heavy liquid due to the relatively low vapor pressure of 0.0149 psia (pounds per square inch absolute) at 20 degrees Celsius (^{o}C), except when in gas/vapor form. HFPO-DAF has a vapor pressure of 3.8 psia at 20^{o}C, which would be considered a light liquid, except when in gas/vapor form.

The stream composition data, including average concentrations of HFPO-DA and HFPO-DAF, and P&ID numbers for each applicable process stream which was used to estimate fugitive equipment leak emissions is included in Appendix A.

For those areas with potential for HFPO-DA or HFPO-DAF emissions, summary tables have been included as Tables 1-1 through 1-4, which detail the total number of components and estimated emissions of HFPO-DA or HFPO-DAF from both indoor and outdoor fugitive equipment leaks. Also included in Appendix A is a detailed calculation used to develop the tables presented within this section. The facility may consider reevaluating these estimated emissions based on results from source testing currently being conducted at the facility.

2 "Heavy liquid" means liquid with a true vapor pressure of less than 0.3 kPa (0.04 psi) at 294.3° K (70° F) established in a standard reference text or as determined by ASTM method D2879-86; or which has 0.1 Reid Vapor Pressure as determined by ASTM method D323-08; or which when distilled requires a temperature of 421.95° K (300° F) or greater to recover 10 percent of the liquid.

Table 1-1: Estimated Fugitive HFPO-DAF Emissions from Vinyl Ethers – North

Component Class	Service	Component Count		Estimated Emissions (lb/yr)	
		Indoor	Outdoor	Indoor	Outdoor
Valve	Light Liquid	250	55	163	64
Valve	Gas/Vapor	4	59	0.1	42
Connector	Light Liquid	579	136	183	79
Connector	Gas/Vapor	8	159	0.1	53
Pump	Light Liquid	5	1	12	4
			Total	***357***	***241***

Table 1-2: Estimated Fugitive HFPO-DAF Emissions from Vinyl Ethers – South

Component Class	Service	Component Count		Estimated Emissions (lb/yr)	
		Indoor	Outdoor	Indoor	Outdoor
Valve	Light Liquid	74	0	6	0
Valve	Gas/Vapor	8	16	1	2
Connector	Light Liquid	195	0	8	0
Connector	Gas/Vapor	24	43	1	3
Pump	Light Liquid	2	0	1	0
			Total	***18***	***5***

Table 1-3: Estimated Fugitive HFPO-DAF Emissions from PPA

Component Class	Service	Component Count		Estimated Emissions (lb/yr)	
		Indoor	Outdoor	Indoor	Outdoor
Valve	Light Liquid	*	9	*	18
Valve	Gas/Vapor	*	10	*	22
Connector	Light Liquid	*	13	*	13
Connector	Gas/Vapor	*	16	*	16
Pump	Light Liquid	*	0	*	0
			Total	***	***69***

**Indoor emissions from the PPA unit are currently being evaluated through source testing and therefore were not estimated as part of this evaluation.*

Table 1-4: Estimated Fugitive HFPO-DAF Emissions from Semi-Works

Component Class	Service	Component Count		Estimated Emissions (lb/yr)	
		Indoor	Outdoor	Indoor	Outdoor
Valve	Heavy Liquid	11	2	2	0.4
Valve	Gas/Vapor	0	0	0	0
Connector	Heavy Liquid	27	4	2	0.4
Connector	Gas/Vapor	0	0	0	0
Pump	Heavy Liquid	0	0	0	0
			Total	***4***	***1***

As summarized in the Table 1-5, it is estimated that Vinyl Ethers – North emits significantly higher amounts of HFPO-DA or HFPO-DAF from fugitive emission equipment leaks than any other applicable area that was included in this evaluation. Vinyl Ethers North accounts for approximately 85% of all estimated HFPO-DA and HFPO-DAF fugitive emissions from equipment leaks at the Fayetteville Works facility, excluding indoor PPA equipment leaks.

Table 1-5: Facility-Wide Summary of Estimated HFPO-DAF Emissions from Equipment Leaks (By Area)

Area	Estimated Emissions (lb/yr)		
	Indoor	Outdoor	Total
Vinyl Ethers - North	357	241	598
Vinyl Ethers - South	18	5	22
PPA	N/A	69	69
Semi-Works	4	1	5
FACILITY-WIDE	***379***	***314***	***694***

As is depicted in Figure 1-1, the majority of the equipment leak estimated emissions are from indoor components. Of those fugitive equipment leaks located in the Vinyl Ethers – North process area, approximately 60% of the fugitive emissions from equipment leaks occur inside the building.

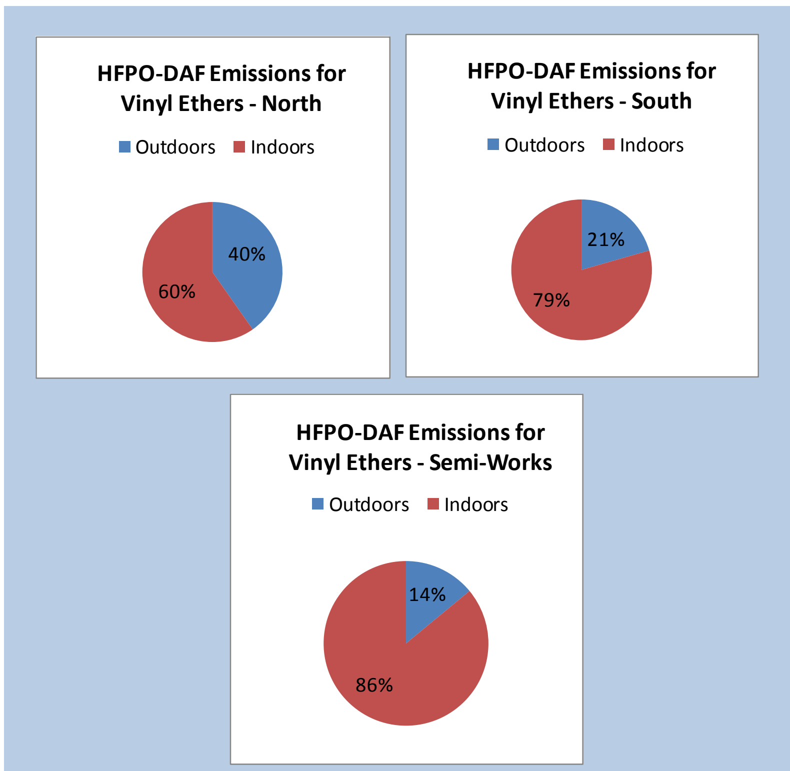

Figure 1-1: Estimated Fugitive HFPO-DAF Emissions (By Area)

The equipment leak emission estimates when compared by component type did not provide a significant outlier that would contribute to the majority of fugitive emissions, with the exception of pumps. Because the number of pumps utilized in the process units are considerably less than the number of valves and connectors, pump emissions are significantly lower. As for valves and connectors, connectors attribute slightly more than valves to the total equipment leak emission rates as detailed in Table 1-6.

Table 1-6: Summary of Estimated HFPO-DAF Emissions from Equipment Leaks (By Component Type)

Area	**Emissions (lb/yr)**		
	Indoor	**Outdoor**	**Total**
Valves	108	172	280
Connectors	135	195	330
Pumps	30	4	33

2.0 CURRENT LDAR PROCEDURES AND BEST PRACTICES

Portions of the facility, specifically those streams that are subject to 40 CFR Part 63, Subpart FFFF – "National Emission Standards for Hazardous Air Pollutants: Miscellaneous Organic Chemical Manufacturing" (MON), and contain at least 5% by weight hazardous air pollutants (HAPs), are being monitored by Team Furmanite, Inc. using flame ionization detectors (FIDs) on a routine basis to identify VOC equipment leaks. The MON-applicable components that overlap with the process streams containing HFPO-DA or HFPO-DAF are monitored and repaired in accordance with the MON requirements (e.g., approximately 20% of those components that are located within the Vinyl Ethers – North process area tower are subject to the MON LDAR requirements). Those components found to be leaking at the component-specific leak definitions in the MON undergo a first attempt at repair within 5 days of leak detection and are repaired within 15 days of leak detection. The facility's normal procedure is to repair the leaks immediately or, if the repairs cannot be made in-line, then the process is shut down for repair. Therefore, the facility does not typically utilize the delay of repair provisions in 40 CFR §63.171, which allow repair at the next process unit shutdown.

While the remaining components are not currently instrument monitored on a routine basis, the facility has implemented several procedures and best practices that would reduce fugitive emissions from equipment by promptly identifying and repairing leaks. Some examples of those best practices include pressure testing prior to process startup, use of area monitors to detect leaks, and routine audio, visual, and olfactory (AVO) leak checks. These best practices are described in more detail in the following sections.

2.1 PRESSURE TESTING

The facility also conducts pressure testing on each system (equipment and process lines) within the four process units with components in HFPO-DA or HFPO-DAF service: Vinyl Ethers – North, Vinyl Ethers – South, PPA, and Semi-works. If any part of the system is opened to the atmosphere (e.g., between campaigns or for repairs), a pressure test is performed prior to startup. The system is blocked in and pressurized with nitrogen to a set pressure that is dependent upon the area or systems being tested and their normal operating pressures. The nitrogen is then turned off and the system remains pressurized for 30 minutes. If the pressure drop exceeds a specified amount (also dependent upon the system being tested), facility personnel locate the leak using methods such as applying soap or ammonia spray solutions. This procedure is followed or repeated until the leaks have been repaired and the system can maintain the pressure drop below the specified limit for 30 minutes.

2.2 *AREA MONITORS*

Chemours – Fayetteville Works also utilizes on line air monitoring systems to aid in the detection of process leaks. These systems are installed throughout the Vinyl Ethers – North, Vinyl Ethers – South, PPA, and Semi-Works units and are utilized both indoors (inside the process towers) and in the outdoor process areas. The primary air monitoring systems utilized are an ABB FTPA9200 FT-IR 36 stream analyzer, a 12-stream Analect EVM, and a 20-stream Analect EVMs. The monitoring systems are capable of measuring acid fluorides, but do not currently have the capability to speciate for HFPO-dimer acid fluoride. The location and number of points monitored and the frequency of monitoring are based on the number of pieces of equipment in acid fluoride service and the size and physical layout of the affected process areas.

The monitoring systems are set to alarm at 0.5 parts per million by volume (ppmv), or 100 part per billion by volume (ppbv), of acid fluorides. At this alarm level, the operations personnel are required to locate and repair the leak. Leak repairs are verified using various methods that include, but are not limited to, using a soap solution to identify leaks by the formation of bubbles, pressure testing, Method 21 ("Determination of Volatile Organic Compound Leaks") instrument monitoring, or ammonia spray solution.

2.3 *INSPECTIONS AND LEAK REPAIRS*

The facility also conducts AVO leak checks while performing routine operator inspections. The facility conducts routine visual checks for leaks on process equipment in the Vinyl Ethers – North, Vinyl Ethers – South, PPA, and Semi-works units.

When visual leaks are identified on any equipment within the affected areas that potentially contain HFPO-DAF or HFPO-DA, the leaks are immediately addressed. As previously discussed, the normal procedure is to repair the leak in-line, with the process operating, if possible. If that is not effective, the process is typically shut down and the leak repaired.

Aside from the routine MON monitoring, when the facility utilizes the FID to locate or evaluate internally for leaks, the facility's internal procedures require leak repairs if the instrument reading is greater than

100 ppmv, which is significantly lower than the federal regulatory leak definitions.

3.0 OPPORTUNITIES FOR EMISSION REDUCTIONS FROM FUGITIVE LEAKS

While Chemours – Fayetteville Works is currently implementing several best practices to promptly identify and repair equipment leaks, there are opportunities for additional enhanced work practices that could further reduce equipment leak emissions of HFPO-DA and HFPO-DAF. ERM has evaluated current practices and developed a list of options for further near-term reduction of equipment leak emissions. Those practices include controlling indoor equipment leaks, enhanced pressure testing, enhanced AVO inspections, supplemental instrument monitoring, and improvements to the area monitoring program. Among the additional emission reduction options, which may be used for future (longer-term) equipment leak emission reductions, are increased connection/flange welds and replacement of existing equipment with low-leak technology for valves and connectors. Both the near-term and longer-term emission reduction opportunities are discussed in more detail throughout this section.

3.1 INDOOR FUGITIVE LEAKS

As described previously, the vast majority of fugitive HFPO-DA and HFPO-DAF emissions are present in the Vinyl Ethers – North unit, specifically during times when the unit is operating on the perfluoropropyl vinyl ether (PPVE) campaign. Of those fugitive equipment leak emissions in the Vinyl Ethers – North area, approximately 60% are from equipment located indoors. As detailed in Chemours' January 15, 2018 correspondence with North Carolina Department of Environmental Quality (NC DEQ), Chemours – Fayetteville Works is proposing to install a carbon adsorption system (CAS) to reduce VOC emissions from the building exhaust of the Vinyl Ethers – North building or tower. As a result, the CAS should provide high removal efficiency for HFPO-DAF and HFPO-DA emissions from fugitive equipment leaks.

3.2 PRESSURE TESTING

While Chemours – Fayetteville Works is currently utilizing pressure testing prior to startup of equipment that has been opened to the atmosphere, those procedures are not in accordance with federally-approved methods such as those presented in 40 CFR 63, Subpart H, "National Emission Standards for Organic Hazardous Air Pollutants for Equipment Leaks" (HON). As an alternative to routine instrument monitoring, the HON allows batch processes to be pressure tested as a means of detecting and reducing fugitive equipment leak emissions. The alternative control measures for batch process listed in 40 CFR §63.178(b) are as follows:

> *(1) Each time equipment is reconfigured for production of a different product or intermediate, the batch product-process equipment train shall be pressure-tested for leaks before organic HAP is first fed to the equipment and the equipment is placed in organic HAP service.*
>
> *(i) When the batch product-process train is reconfigured to produce a different product, pressure testing is required only for the new or disturbed equipment.*
>
> *(ii) Each batch product process that operates in organic HAP service during a calendar year shall be pressure tested at least once during that calendar year.*
>
> *(iii) Pressure testing is not required for routine seal breaks, such as changing hoses or filters, which are not part of the reconfiguration to produce a different product or intermediate.*
>
> *(2) The batch product process equipment shall be tested either using the procedures specified in §63.180(f) of this subpart for pressure or vacuum loss or with a liquid using the procedures specified in §63.180(g) of this subpart.*
>
> *(3)(i) For pressure or vacuum tests, a leak is detected if the rate of change in pressure is greater than 6.9 kilopascals (1 psig) in 1 hour or if there is visible, audible, or olfactory evidence of fluid loss.*
>
> *(ii) For pressure tests using a liquid, a leak is detected if there are indications of liquids dripping or if there is other evidence of fluid loss.*
>
> *(4)(i) If a leak is detected, it shall be repaired and the batch product-process equipment shall be retested before startup of the process.*
>
> *(ii) If a batch product-process fails the retest or the second of two consecutive pressure tests, it shall be repaired as soon as practicable, but not later than 30 calendar days after the second pressure test, provided the conditions specified in paragraph (d) of this section are met.*

To meet the requirement of 40 CFR §63.180(f), the facility could opt to pressure test for a shorter interval of time (with a minimum interval of 15 minutes) to detect a pressure loss rate up to 6.9 kPa (equivalent to 1 pound per square inch gauge (psig)) per hour. For example, if the facility chooses to continue with the current procedure of pressure testing for 30-minute intervals, the pressure change should be lowered to 3.45 kPa or less during the 30-minute tests. Allowable pressure drops under the facility's current procedures vary but are typically about 5 kPa during the 30-minute tests.

In addition to following the procedures for pressure testing, the facility should also maintain formal documentation of each test. Pressure testing records include, but are not limited to, the date of inspection, results of the inspection/pressure testing, repairs made to any equipment found to be leaking during pressure testing, and follow-up pressure testing to verify successful repair.

3.3 ENHANCED AVO INSPECTIONS

While the facility is conducting routine AVO checks during operator inspections, an option for reducing fugitive emissions from equipment leaks would include expanding the equipment subject to the AVO inspection process. The facility could consider conducting, at minimum daily AVO inspections of all outdoor equipment containing at least 1% by wt. or greater HFPO-DAF or HFPO-DA in the Vinyl Ethers – North areas and both indoors and outdoors in the Vinyl Ethers – South, PPA, and Semi-works areas. The inspection should also include a checklist of all equipment to be inspected along with information such as the date and time of the inspection, the names of the personnel conducting the inspections, and detailed descriptions of the areas or equipment inspected. Inspection results, including any leaks found and repair actions taken, would also be documented and maintained.

Finally, the facility might also consider incorporating additional enhanced AVO inspection methods such as the use of ultrasonic leak detectors to assist in detecting audio leaks. Ultrasonic leak detectors could be used as a supplement to support the AVO inspection as needed when locating smaller leaks at higher audible frequencies (hissing) than the human ear can detect.

3.4 ADDITIONAL METHOD 21 INSTRUMENT MONITORING

Certain organic HAP process streams throughout the facility are being instrument monitored using FIDs in accordance with the MON requirements. Results from the February 2017 MON monitoring of valves in Vinyl Ethers – North, while running a PPVE campaign, indicate low monitored concentrations (i.e., 11 ppmv or less). Another option to potentially reduce fugitive emissions from equipment leaks would be for the facility to institute routine instrument monitoring for all outdoor equipment on process lines with the potential to contain at least 1 wt. % HFPO-DA or HFPO-DAF. The facility could conduct quarterly Method 21 monitoring of these additional valves and connectors. The facility could also consider a lower internal leak definition and/or shorter initial repair attempts and final repair timelines, with no option for delay of repair.

A preliminary evaluation of the response factors for HFPO-DA and HFPO-DAF suggests that the ThermoFisher TVA-1000B FID currently used for the facility's LDAR program may respond to both components and thus may be used for Method 21 instrument monitoring on the applicable process streams. Relative response factors for instruments used to measure various organic compounds in fugitive emissions from industrial processes are required by both federal rules and EPA Method 21. The response factors vary depending on the analyzer and molecular structure of the compound being analyzed. Organic compound response factors for different FID instruments have been published, but many compound response factors have not yet been experimentally determined. For the case when the relative response factor of a particular compound has not or cannot be experimentally determined as with HFPO-DA and HFPO-DAF, the effective carbon number (ECN) of compounds can be used to calculate the relative response factor following procedures found in the *Journal of Chromatographic Science*.[3]

The ECN of each organic compound can be determined by examining the functional groups within a compound. The contributions of different functional groups to ECN compiled in the *Journal of Chromatographic Science* were used to calculate an ECN for each of the compounds analyzed. The ECN is calculated by taking the sum of the contributions made by the various atoms comprising the molecule and then correcting for the presence of any functional groups. For example, methanol would have an ECN of 0.5, having one aliphatic carbon (1x1) and one primary alcohol oxygen (-0.5). A single halogen on a carbon has a negligible effect on the relative molar response; therefore, a compound such as methyl bromide would have the same ECN as methane (i.e., ECN of 1).
Once the ECN is determined for each compound, the relative weight response factor can be determined by:

---

3 *Calculation of Flame Ionization Detector Relative Response Factors Using the Effective Carbon Number Concept*. *Journal of Chromatographic Science*, Volume 23, Issue 8, 1 August 1985, Pages 333–340. James T. Scanlon and Donald E. Willis, August 1985.

$$RF_{(relative\text{-}weight)} = \frac{MW_{component} \times ECN_{reference}}{MW_{reference} \times ECN_{compound}}$$

Since the FID at Chemours is calibrated with methane, the reference compound used was methane (ECN=1, MW=16). The response factors for HFPO-DA and HFPO-DAF were calculated to be 5.2 and 6.9, respectively.[4] EPA Method 21, Section 8.1.1.2 states that "the instrument response factors for each of the individual VOC to be measured shall be less than 10 unless otherwise specified in the applicable regulation."

The technical article does, however, indicate that anomalies have been identified in the analysis of perfluorinated compounds. So while the calculated response factors for HFPO-DA and HFPO-DAF appears to be less than 10, it is recommended that the facility conduct an experimental evaluation using the TVA-1000B FID to confirm the response of the instrument to HFPO-DA and HFPO-DAF.

3.5 ENHANCED AREA MONITORING

Currently the facility utilizes area monitors to detect leaks of acid fluorides at both indoor and in outdoor locations. The facility should consider increasing the amount of channels to allow for more frequent monitoring (i.e., shorter intervals between sample times). The facility could also consider increasing the number of area monitoring sampling locations, specifically near those streams with the potential to include 1% by wt. of HFPO-DA or HFPO-DAF.

The facility could also consider lowering the alarm thresholds for acid fluorides in efforts to detect smaller leaks that may not currently be detectable. In order to assign a new threshold alarm limit for acid fluoride, the facility would need to evaluate the capabilities of the area monitoring equipment (detection limits/capabilities) and evaluate area monitoring concentration trends to determine typical background levels and assess the data for indications of small leaks that were below the alarm threshold of 0.5 ppmv.

4 HFPO-DAF: ECN = Aliphatic C (1x5) + Carbonyl C (1x0) + Ether O (1x-1) = 4; MW = 332.04 HFPO-DA: ECN = Aliphatic C (1x5) + Carboxyl C (1x0) + Ether O (2x-1) = 3; MW = 330.053

3.6 REPLACEMENT OR IMPROVEMENT OPTIONS FOR VALVES

Enhanced LDAR programs at SOCMI facilities commonly include requirements for equipment replacement and improvement programs to replace valves and connectors leaking at concentrations lower than federal leak definitions. Low-leak technology, also called low-emission or low-E equipment, is defined as commercially available, certified low-leaking components or certified low-leaking valve packing or gasket material. The component, valve packing or gasket material is guaranteed not to leak above 100 ppmv for five years. Low-leak technology is also commonly required for new installed valves and connectors at SOCMI facilities. If replacing or repacking an existing valve does not require a process unit shutdown, facilities are required to replace or repack existing valves with low-leak technology within one month after the triggering leak.

The facility should consider installing low-leak technology at the time of replacement for the process units that handle HFPO-DA and/or HAPO-DAF at concentrations greater than 1% by wt. Since the facility operates batch process units, it should be feasible to replace leaking or repeat leaking equipment with low-leak technology between batches.

3.7 REPLACEMENT OR IMPROVEMENT OPTIONS FOR CONNECTORS

As detailed in the fugitive emission calculations section of this document, fugitive equipment leak emissions are generally proportional to the number of components. Connectors that are welded together around the circumference of the connection such that the flanges are no longer capable of being disassembled by unbolting the flanges do not have the potential for leakage. According to the DuPont emission factors, a connector (screwed or flanged) contributes half the emissions of a valve. Connectors generally outnumber valves by a factor of three to four, depending on the facility. Consequently, the equivalent emissions from one valve can be eliminated by reducing a pair of connectors through use of welded pipe, or by welding connectors.

In addition to welding, there are other options for reduction of emissions from connectors, including improved gasket seals. Good engineering judgment in consideration of the service and operating conditions for the connector is also required in the process of installing new connectors. For connectors, the replacement or improvement options presented in Table 3-1 could reduce emissions from equipment leaks, particularly for components that are not currently monitored.

Table 3-1: Connector Replacement or Improvement Options

Connector Type	Replacement or Improvement Option Description
Flanged	Gasket replacement or gasket improvement
Threaded	Gasket replacement or gasket improvement
Compression	Replacement of the connector
CamLock	Gasket replacement or gasket improvement
Quick Connect	Replacement or improvement of the gasket, if applicable, or replacement of the connector is there is no gasket
Any type (including any of the above types)	Elimination (e.g., through welding, pipe replacement, etc.) without the addition of another connector

Appendix A
Equipment Leak Emission Calculations

			HFPO-Dimer	OUTSIDE COMPONENT COUNT						INSIDE COMPONENT COUNT						HFPO-Dimer Emissions (lb/yr)			OUTDOOR EMISSIONS						INDOOR EMISSIONS					
DWG Name	DWG #	DWG Title	Composition	# of valves		# of connectors		# of pumps		# of valves		# of connectors		# of pumps		Outside	Inside	Total	valves		connectors		pumps		valves		connectors		pumps	
			(%)	LIQUID	VAPOR	LIQUID	VAPOR	LIQUID	VAPOR	LIQUID	VAPOR	LIQUID	VAPOR	LIQUID	VAPOR	*3,240 Hr/Yr for VEN*			LIQUID	VAPOR	LIQUID	VAPOR	LIQUID	VAPOR	LIQUID	VAPOR	LIQUID	VAPOR	LIQUID	VAPOR
VEN				55	59	136	159	1	0	250	4	579	8	5	0				**64**	**42**	**79**	**53**	**4**	**0**	**163**	**0**	**183**	**0**	**12**	**0**
Emissions (lb/yr)																														
W 553416	553416	VE-N MFG CONDENSATION RX P&I SH 37	20.0%	0	0	0	0	0	0	33	0	78	0	1	0	0.0	17.5	17.5	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	9.1	0.0	0.7	0
W 553417	553417	VE-N MFG STRIPPER FD DECANTER SOR P&I SH38	60.0%	0	0	0	0	0	0	15	0	34	0	0	0	0.0	22.4	22.4	0.0	0.0	0.0	0.0	0.0	0.0	10.5	0.0	11.9	0.0	0.0	0
W 553418	553418	VE-N MFG STRIPPER P&I DIAG SH39	90.0%	0	0	0	0	0	0	38	0	84	0	1	0	0.0	87.3	87.3	0.0	0.0	0.0	0.0	0.0	0.0	39.9	0.0	44.1	0.0	3.4	0
W 553418	553418	VE-N MFG STRIPPER P&I DIAG SH39	1.0%	0	7	0	22	0	0	0	0	0	0	0	0	0.217	0.0	0.2	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
W 553419	553419	VE-N MFG A/F COL DECANTER P&I SH40	99.0%	0	0	0	0	0	0	30	0	62	0	0	0	0.0	70.4	70.4	0.0	0.0	0.0	0.0	0.0	0.0	34.6	0.0	35.8	0.0	0.0	0
W 553419A	553419A	VE-N MFG MID-POINT RECEIVER P&I DIAG SH40A	99.0%	10	6	26	20	0	0	17	0	41	0	1	0	45.6	47.0	92.6	11.5	7.5	15.0	11.5	0.0	0.0	19.6	0.0	23.7	0.0	3.7	0
W 553420	*553420*	*VE-N MFG A/F COL P&I DIAG SH41*	99.0%	4	0	12	1	0	0	0	0	0	0	0	0	12.1	0.0	12.1	4.6	0.0	6.9	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
W 553420	*553420*	*VE-N MFG A/F COL P&I DIAG SH41*	90.0%	0	0	0	0	0	0	6	0	14	0	0	0	0.0	13.6	13.6	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	7.3	0.0	0.0	0
W 553420	*553420*	*VE-N MFG A/F COL P&I DIAG SH41*	1.0%	0	0	0	0	0	0	15	0	51	0	1	0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.3	0.0	0.0	0
W 553421	553421	VE-N MFG A/F STORAGE TANKS P&I DIAG SH42	99.0%	9	0	20	0	0	0	29	0	68	0	1	0	21.9	76.4	98.4	10.4	0.0	11.5	0.0	0.0	0.0	33.5	0.0	39.3	0.0	3.7	0
W 553422	553422	VE-N MFG AGITATED BED RX P&I SH43	99.0%	1	8	3	29	0	0	0	0	0	0	0	0	29.6	0.0	29.6	1.2	10.0	1.7	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
W556011	556011	HFPO-VE MFG WASTE GAS SCRUBBER FEED	50.0%	0	1	0	2	0	0	0	0	0	0	0	0	1.2	0.0	1.2	0.0	0.6	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
W1207804	*1207804*	*VE-N RX DECANTER P&I*	20.0%	0	0	0	0	0	0	26	0	62	0	0	0	0.0	13.3	13.3	0.0	0.0	0.0	0.0	0.0	0.0	6.1	0.0	7.2	0.0	0.0	0
W1207804	*1207804*	*VE-N RX DECANTER P&I*	60.0%	0	0	0	0	0	0	3	0	6	0	0	0	0.0	4.2	4.2	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	2.1	0.0	0.0	0
W1338892	1338892	VE-N A/F COLUMN OVHD CONDENSER & RECEIVER P&I	50.0%	0	11		23	0	0	0	0	0	0	0	0	13.7	0.0	13.7	0.0	6.9	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
W1338892	1338892	VE-N A/F COLUMN OVHD CONDENSER & RECEIVER P&I	99.0%	24	0	58	0	1	0	0	0	0	0	0	0	64.9	0.0	64.9	27.7	0.0	33.5	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0
W1339121	1339121	VE-N STRIPPER OVHD CONDENSERS P&I	1.0%	0	4	0	13	0	0	0	0	0	0	0	0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
W1339132	1339132	VE-N STRIPPER OVHD RECEIVER P&I	1.0%	0	9	0	20	0	0	0	4	0	8	0	0	0.2	0.1	0.3	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0
W1339182	1339182	VE-N A/F COLUMN TAILS DECANTER P&I	1.0%	0	0	0	0	0	0	30	0	63	0	0	0	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.4	0.0	0.0	0
W 1591480	1591480	VE-N CONDENSATION VENT CONDENSER & REACTOR CO	20.0%	0	0	0	0	0	0	8	0	16	0	0	0	0.0	3.7	3.7	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	1.9	0.0	0.0	0
W1730584	1730584	DAF ISO	99.0%	7	13	17	29	0	0	0	0	0	0	0	0	50.9	0.0	50.9	8.1	16.3	9.8	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
VES				0	16	0	43	0	0	74	8	195	24	2	0	*331 Hr/Yr for VES*			0.0	2.0	0.0	2.5	0.0	0.0	6.4	1.0	8.5	1.3	0.5	18
W1297394	1297394	VE-S CONDENSATION RX P&I DIAG SH6	20.0%	0	0	0	0	0	0	14	0	34	0	1	0	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.4	0.0	0.1	0
W1297395	1297395	VE-S RX DECANTER P&I SH7	20.0%	0	0	0	0	0	0	4	0	12	0	0	0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0
W1297395	1297395	VE-S RX DECANTER P&I SH7	60.0%	0	0	0	0	0	0	6	0	17	0	0	0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.6	0.0	0.0	0
W1297396	1297396	VE-S STRIPPER COLUMN P&I DIAG SH8	90.0%	0	0	0	0	0	0	8	5	20	14	0	0	0.0	3.3	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.6	1.1	0.8	0.0	0
W1297396	1297396	VE-S STRIPPER COLUMN P&I DIAG SH8	60.0%	0	0	0	0	0	0	1	0	2	0	0	0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0
W1297397	1297397	VE-S A/F COLUMN P&I DIAG SH9	100.0%	0	0	0	1	0	0	6	0	15	0	0	0	0.06	1.6	1.7	0.0	0.0	0.0	0.1	0.0	0.0	0.7	0.0	0.9	0.0	0.0	0
W1297397	1297397	VE-S A/F COLUMN P&I DIAG SH9	90.0%	0	0	0	0	0	0	1	0	3	0	0	0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0
W1297398	1297398	VE-S A/F O/H COND & RCVR P&I DIAG SH10	99.0%	0	0	0	0	0	0	16	3	46	8	1	0	0.0	5.8	5.8	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.4	2.7	0.5	0.4	0
W1297399	1297399	VE-S A/F O/H COOLER & DECANTER P&I DIAG SH12	99.0%	0	0	0	0	0	0	16	0	40	2	0	0	0.0	4.4	4.4	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	2.4	0.1	0.0	0
W1297400	1297400	VE-S A/F SUPERHEATERS P&I DIAG SH14	99.0%	0	6	0	18	0	0	0	0	0	0	0	0	1.8	0.0	1.8	0.0	0.8	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
W1297401	1297401	VE-S AGITATED BED RX WEST P&I DIAG SH15	99.0%	0	2	0	6	0	0	0	0	0	0	0	0	0.6	0.0	0.6	0.0	0.3	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
W1297403	1297403	VE-S AGITATED BED RX EAST P&I DIAG SH17	99.0%	0	2	0	6	0	0	0	0	0	0	0	0	0.6	0.0	0.6	0.0	0.3	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
W1297416	1297416	VE-S WGS KO & VENT SYS P&I DIAG SH31	99.0%	0	6	0	12	0	0	0	0	0	0	0	0	1.5	0.0	1.5	0.0	0.8	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
W1587456	1587456	VE-S CONDENSATION REACTOR COOLER	20.0%	0	0	0	0	0	0	2	0	6	0	0	0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0
PPA				9	10	13	16	0	0	0	0	0	0	0	0	*5,544 Hr/Yr for PPA*														
W1730585	1730585	DAF ISO - UNLOADING AND FEED	100.0%	9	10	13	16	0	0							68.5	0.0	68.5	18.0	21.6	13.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Semiworks				2	0	4	0	0	0	11	0	27	0	0	0	*500 Hr/Yr for Semi-Works*														
W1570411	1570411	DP Reactor	100.0%	2	0	4	0	0	0	11	0	27	0	0	0	0.7	4.4	5.1	0.4	0.0	0.4	0.0	0.0	0.0	2.0	0.0	2.4	0.0	0.0	0