Accidental Releases to Atmosphere

For 2005 there were no accidental releases from the Tinting Process.

Emission Summary

A. VOC Emissions by Compound and Source

Butacite® Compound	CAS Chemical Name	CAS No.	Point Source Emissions (lbs)	Fugitive Emissions (lbs)	Equipment Emissions (lbs)	Accidental Emissions (lbs)	Total VOC Emissions (lbs)
DMF	Dimethylformamide	68-12-2	1,338.5	0	0	0	1,338.5
	Total VOC Emissions in 2005		**1,338.5**	**0**	**0**	**0**	**1,338.5**
					Total VOC (Tons)		**0.67**

B. Hazardous Air Pollutant Summary

Butacite® Compound	CAS Chemical Name	CAS No.	Point Source Emissions (lbs)	Fugitive Emissions (lbs)	Equipment Emissions (lbs)	Accidental Emissions (lbs)	Total Emissions (lbs)
DMF	Dimethylformamide	68-12-2	1,339	0.0	0	0	1,338.5

2005 Air Emissions Inventory Supporting Documentation

Emission Source ID No.: BS-Insig B8.1

Emission Source Description: Butacite Extrusion Process - Line 3

Process and Emission Description:

The Butacite Line 3 Extrusion Process is a continuous process in which polyvinyl butyral (PVB) resin is extruded into a plastic sheet using three separate mechanical extruders. To remove the resin's entrained water, a vacuum is pulled on the extruders using a series of steam venturi jets. Following each steam jet, the exhaust stream passes through water-cooled condensers to remove the water vapor so that the following steam jet can achieve the necessary secondary vacuum to achieve the required overall vacuum at the extruder so as to produce saleable product.

Air emissions from the Butacite Line 3 Extrusion Process are assumed to be completely (100%) captured. The emissions of Volatile Organic Compounds (VOC) are assumed to be totally the 3GO plasticizer used to manufacture Butacite PVB sheeting. Because the potential VOC emissions are well less than the 40 ton per year NSR/PSD significant emission rate, the final condenser, which exists to remove water and other condensable compounds from the atmospheric discharge, can be treated as having a control efficiency of 0%.

Basis and Assumptions:

The assumption is that all VOC emissions from the Line 3 extrusion process are comprised of the 3GO plasticizer.

Information Inputs and Source of Inputs:

Information Inputs	Source of Inputs
Butacite Line 3 Extrusion Process total throughput pounds for the year	Butacite Production Support (BPS) System annual report.

Point Source Emissions Determination:

Determination of point source VOC emissions are given in the following pages.

Equipment Emissions and Fugitive Emissions Determination:

Since the Butacite extruders operate under a vacuum, there are no non-point source (fugitive) emissions nor equipment emissions associated with this process.

Point Source Emission Determination - Line 3 Extrusion Process

Triethylene glycol di-2-ethylhexanoate (3GO) **CAS No. 94-28-0**

Emission Estimation Approach:

Emissions from the Butacite® extruders are calculated using a mass balance approach. Based on the vapor pressure exerted by organic material in the extruder and the flow rate out of the extruder, material flowrates throughout the entire extruder process are calculated. There are a total of 3 extruders in the Line 3 extruder operation.

The extruder process consists of the extruder unit followed by a knock-out pot, and the steam jet vacuum system. Material flowrates into and out of each of these process steps are calculated below.

General Steps for Quantifying Emissions:

The primary purpose of the extruders is to remove water from the extruder feed material. This is accomplished by heating the feed material and operating the extruders under vacuum conditions. A vacuum is pulled on each extruder via a 2-stage steam jet vacuum system. The vacuum jet system consists of a 1st condenser followed by the 1st vacuum jet, 2nd condenser, 2nd vacuum jet, and lastly a final condenser. The purpose of the first condenser is to remove condensable substances so as to maximize efficiency of the steam jet. The purpose of the 2nd condenser is to condense steam injected into the 1st vacuum jet in order to maximize efficiency of the 2nd vacuum jet. The purpose of the final condenser is to condense the steam that is injected into the 2nd vacuum jet. The general steps for quantifying emissions are as follows:

STEP 1: Estimate the VOC's vented from the extruder unit based on the water and noncondensables that are vented, the total system pressure, and the approximate vapor pressure of organics.

STEP 2: Calculate the amount of VOC that passes through the first condenser based on the temperature out of the first condenser, the noncondensable flow, and the system pressure.

STEP 3: Calculate the amount of VOC that passes through the second condenser based on the temperature of the second condenser, the noncondensable flow, and the system pressure.

STEP 4: Calculate the amount of VOC that passes through the final condenser based on the temperature of the final condenser, the noncondensable flow, and the atmospheric pressure.

For Steps 1 and 2, the VOC flowrates are calculated on a per extruder basis. For Steps 3 and 4, the VOC flowrates are calculated per extruder and for all three extruders combined.

Moles of VOC emitted from the extruder are determined by subtracting the non-organic moles in the off-gas (10.46 lb-mole/hr/extruder) from the total moles in the off-gas (10.85 lb-mole/hr/extruder).

$$\frac{10.85 \text{ lb-mole}}{\text{hr - extruder}} - \frac{10.46 \text{ lb-mole}}{\text{hr - extruder}} = \frac{0.39 \text{ lb-mole VOC}}{\text{hr - extruder}}$$

The mass of VOC emitted from each extruder is determined by number of moles emitted from an extruder per hour (0.39 lb-mole VOC) by the molecular weight of the organic, which is assumed to be 3GO with a molecular weight of 402.6 lb / lb-mole.

$$\frac{0.39 \text{ lb-mole VOC}}{\text{hr - extruder}} \times \frac{402.6 \text{ lb}}{\text{lb-mole}} = \frac{156.3 \text{ lb VOC}}{\text{hr - extruder}}$$

STEP 2: VOC's passing through the first condenser:

Note: Much of the VOC in the extruder off-gas is expected to be captured in the knock-out pot. However, for the purposes of these calculations, it is assumed that all of the VOC enters into the 1st condenser.

All of the noncondensables pass through the first condenser. Most of the water and most of the VOC are condensed. The vapor pressure of water and VOC at the condenser outlet are used to calculate their overall mole fraction. Based on this and the known moles of noncondensables passing through the condenser, the mass of VOC and water passing through the condenser is calculated.

Mole fraction of Water

Calculated as the vapor pressure of water (42.2 mmHg at 35 deg. C) divided by the system pressure (90 mmHg).

$$\frac{42.2 \text{ mmHg}}{90 \text{ mmHg}} = 46.9\% \text{ water}$$

Mole fraction of VOC

Calculated as the vapor pressure of the VOC (0.26 mmHg at 35 deg. C) divided by the system pressure (90 mmHg).

$$\frac{0.26 \text{ mmHg}}{90 \text{ mmHg}} = 0.29\% \text{ VOC as 3GO}$$

Mole fraction of noncondensables

Calculated as 100% minus the mole fraction of the water and VOC.

100% minus 46.9% water minus 0.29% VOC = 52.8% noncondensable gases

Total Moles

Calculated as the lb-moles of noncondensables (0.71 lb-moles per hour per extruder) divided by the noncondensable mole fraction (52.8% noncondensables).

$$\frac{0.71 \text{ lb-moles per hour per extruder}}{52.8\%} = 1.352 \frac{\text{lb-moles}}{\text{hour - extruder}}$$

Mass of VOC in condenser outlet

Calculated as the mole fraction of VOC (0.29%) times the total moles of gas (1.352 lb-moles per hour per extruder) times the VOC molecular weight o: 402.6 .

$$1.352 \frac{\text{lb-moles}}{\text{hour - extruder}} \times 0.29\% \text{ VOC} \times 402.6 \frac{\text{lb}}{\text{lb-mole}} = 1.57 \frac{\text{lb VOC}}{\text{hour - extruder}}$$

STEP 3: VOC's passing through the second condenser:

In general the same approach used in Step 2 is applied here with the only difference being that the system pressure is slightly higher which results in a slightly lower VOC mole fraction.

Mole fraction of Water

Calculated as the vapor pressure of water (42.2 mmHg at 35 deg. C) divided by the system pressure (225 mmHg).

$$\frac{42.2 \text{ mmHg}}{225 \text{ mmHg}} = 18.8\% \text{ water}$$

Mole fraction of VOC

Calculated as the vapor pressure of the VOC (0.26 mmHg at 35 deg. C) divided by the system pressure (225 mmHg).

$$\frac{0.3 \text{ mmHg}}{225 \text{ mmHg}} = 0.12\% \text{ VOC as 3GO}$$

STEP 4: VOC's passing through the final condenser:
In general the same approach used in Steps 2 and 3 is applied here with the only difference being that the system pressure is atmospheric at the condenser outlet which results in a lower VOC mole fraction.

Mole fraction of Water

Calculated as the vapor pressure of water (42.2 mmHg at 35 deg. C) divided by condenser's atmospheric pressure (760 mmHg).

$$\frac{42.2 \text{ mmHg}}{760 \text{ mmHg}} = 5.6\% \text{ water}$$

Mole fraction of VOC

Calculated as the vapor pressure of the VOC (0.26 mmHg at 35 deg. C) divided by the system pressure (760 mmHg).

$$\frac{0.26 \text{ mmHg}}{760 \text{ mmHg}} = 0.03\% \text{ VOC as 3GO}$$

Mole fraction of noncondensables

Calculated as 100% minus the mole fractions of water and VOC

100% minus 5.6% water minus 0.03% VOC = 94.4% noncondensable

Total Moles

Calculated as the lb-mole of noncondensables (0.71 lb-moles per hour per extruder) divided by the noncondensable mole fraction (94.4% noncondensables).

$$\frac{0.71 \text{ lb-moles per hour per extruder}}{94.4\%} = 0.76 \frac{\text{lb-moles}}{\text{hour - extruder}}$$

Butacite Extrusion Process (Line 3) - Emission Summary

A. VOC Emissions by Compound and Source

Butacite® Compound	CAS Chemical Name	CAS No.	Point Source Emissions (lbs)	Fugitive Emissions (lbs)	Equipment Emissions (lbs)	Accidental Emissions (lbs)	Total VOC Emissions (lbs)
3GO	Triethylene glycol di-2-ethylhexanoate	94-28-0	2,339.4	0	0	0	2,339.4
	Total VOC Emissions in 2005		**2,339.4**	**0**	**0**	**0**	**2,339.4**
					Total VOC (Tons)		**1.17**

2005 Air Emissions Inventory Supporting Documentation

Emission Source ID No.: BS-Insig B8.2

Emission Source Description: Butacite Extrusion Process - Line 4

Process and Emission Description:

The Butacite Line 4 Extrusion Process is a continuous process in which polyvinyl butyral (PVB) resin is extruded into a plastic sheet using three separate mechanical extruders. To remove the resin's entrained water, a vacuum is pulled on the extruders using a series of steam venturi jets. Following each steam jet, the exhaust stream passes through water-cooled condensers to remove the water vapor so that the following steam jet can achieve the necessary secondary vacuum to achieve the required overall vacuum at the extruder so as to produce saleable product.

Air emissions from the Butacite Line 4 Extrusion Process are assumed to be completely (100%) captured. The emissions of Volatile Organic Compounds (VOC) are assumed to be totally the 3GO plasticizer used to manufacture Butacite PVB sheeting. Because the potential VOC emissions are well less than the 40 ton per year NSR/PSD significant emission rate, the final condenser, which exists to remove water and other condensable compounds from the atmospheric discharge, can be treated as having a control efficiency of 0%.

Basis and Assumptions:

The assumption is that all VOC emissions from the Line 4 extrusion process are comprised of the 3GO plasticizer.

Information Inputs and Source of Inputs:

Information Inputs	Source of Inputs
Butacite Line 4 Extrusion Process total throughput pounds for the year	Butacite Production Support (BPS) System annual report.

Point Source Emissions Determination:

Determination of point source VOC emissions are given in the following pages.

Equipment Emissions and Fugitive Emissions Determination:

Since the Butacite extruders operate under a vacuum, there are no non-point source (fugitive) emissions nor equipment emissions associated with this process.

Point Source Emission Determination - Line 4 Extrusion Process

Triethylene glycol di-2-ethylhexanoate (3GO) **CAS No. 94-28-0**

Emission Estimation Approach:

Emissions from the Butacite® extruders are calculated using a mass balance approach. Based on the vapor pressure exerted by organic material in the extruder and the flow rate out of the extruder, material flowrates throughout the entire extruder process are calculated. There are a total of 3 extruders in the Line 4 extruder operation.

The extruder process consists of the extruder unit followed by a knock-out pot, and the steam jet vacuum system. Material flowrates into and out of each of these process steps are calculated below.

General Steps for Quantifying Emissions:

The primary purpose of the extruders is to remove water from the extruder feed material. This is accomplished by heating the feed material and operating the extruders under vacuum conditions. A vacuum is pulled on each extruder via a 2-stage steam jet vacuum system. The vacuum jet system consists of a 1st condenser followed by the 1st vacuum jet, 2nd condenser, 2nd vacuum jet, and lastly a final condenser. The purpose of the first condenser is to remove condensable substances so as to maximize efficiency of the steam jet. The purpose of the 2nd condenser is to condense steam injected into the 1st vacuum jet in order to maximize efficiency of the 2nd vacuum jet. The purpose of the final condenser is to condense the steam that is injected into the 2nd vacuum jet. The general steps for quantifying emissions are as follows:

STEP 1: Estimate the VOC's vented from the extruder unit based on the water and noncondensables that are vented, the total system pressure, and the approximate vapor pressure of organics.

STEP 2: Calculate the amount of VOC that passes through the first condenser based on the temperature out of the first condenser, the noncondensable flow, and the system pressure.

STEP 3: Calculate the amount of VOC that passes through the second condenser based on the temperature of the second condenser, the noncondensable flow, and the system pressure.

STEP 4: Calculate the amount of VOC that passes through the final condenser based on the temperature of the final condenser, the noncondensable flow, and the atmospheric pressure.

For Steps 1 and 2, the VOC flowrates are calculated on a per extruder basis. For Steps 3 and 4, the VOC flowrates are calculated per extruder and for all three extruders combined.

Moles of VOC emitted from the extruder are determined by subtracting the non-organic moles in the off-gas (10.46 lb-mole/hr/extruder) from the total moles in the off-gas (10.85 lb-mole/hr/extruder).

$$\frac{10.85 \text{ lb-mole}}{\text{hr - extruder}} - \frac{10.46 \text{ lb-mole}}{\text{hr - extruder}} = \frac{0.39 \text{ lb-mole VOC}}{\text{hr - extruder}}$$

The mass of VOC emitted from each extruder is determined by number of moles emitted from an extruder per hour (0.39 lb-mole VOC) by the molecular weight of the organic, which is assumed to be 3GO with a molecular weight of 402.6 lb / lb-mole.

$$\frac{0.39 \text{ lb-mole VOC}}{\text{hr - extruder}} \times \frac{402.6 \text{ lb}}{\text{lb-mole}} = \frac{156.3 \text{ lb VOC}}{\text{hr - extruder}}$$

STEP 2: VOC's passing through the first condenser:

Note: Much of the VOC in the extruder off-gas is expected to be captured in the knock-out pot. However, for the purposes of these calculations, it is assumed that all of the VOC enters into the 1st condenser.

All of the noncondensables pass through the first condenser. Most of the water and most of the VOC are condensed. The vapor pressure of water and VOC at the condenser outlet are used to calculate their overall mole fraction. Based on this and the known moles of noncondensables passing through the condenser, the mass of VOC and water passing through the condenser is calculated.

Mole fraction of Water

Calculated as the vapor pressure of water (42.2 mmHg at 35 deg. C) divided by the system pressure (90 mmHg).

$$\frac{42.2 \text{ mmHg}}{90 \text{ mmHg}} = 46.9\% \text{ water}$$

Mole fraction of VOC

Calculated as the vapor pressure of the VOC (0.26 mmHg at 35 deg. C) divided by the system pressure (90 mmHg).

$$\frac{0.26 \text{ mmHg}}{90 \text{ mmHg}} = 0.29\% \text{ VOC as 3GO}$$

Mole fraction of noncondensables

Calculated as 100% minus the mole fraction of the water and VOC.

100% minus 46.9% water minus 0.29% VOC = 52.8% noncondensable gases

Total Moles

Calculated as the lb-moles of noncondensables (0.71 lb-moles per hour per extruder) divided by the noncondensable mole fraction (52.8% noncondensables).

$$\frac{0.71 \text{ lb-moles per hour per extruder}}{52.8\%} = 1.352 \frac{\text{lb-moles}}{\text{hour - extruder}}$$

Mass of VOC in condenser outlet

Calculated as the mole fraction of VOC (0.29%) times the total moles of gas (1.352 lb-moles per hour per extruder) times the VOC molecular weight o: 402.6 .

$$1.352 \frac{\text{lb-moles}}{\text{hour - extruder}} \times 0.29\% \text{ VOC} \times 402.6 \frac{\text{lb}}{\text{lb-mole}} = 1.57 \frac{\text{lb VOC}}{\text{hour - extruder}}$$

STEP 3: VOC's passing through the second condenser:

In general the same approach used in Step 2 is applied here with the only difference being that the system pressure is slightly higher which results in a slightly lower VOC mole fraction.

Mole fraction of Water

Calculated as the vapor pressure of water (42.2 mmHg at 35 deg. C) divided by the system pressure (225 mmHg).

$$\frac{42.2 \text{ mmHg}}{225 \text{ mmHg}} = 18.8\% \text{ water}$$

Mole fraction of VOC

Calculated as the vapor pressure of the VOC (0.26 mmHg at 35 deg. C) divided by the system pressure (225 mmHg).

$$\frac{0.3 \text{ mmHg}}{225 \text{ mmHg}} = 0.12\% \text{ VOC as 3GO}$$

Mole fraction of noncondensables

Calculated as 100% minus mole fraction of water and VOC

100% minus 18.8% water minus 0.12% VOC = 81.1% noncondensable gases

Total Moles

Calculated as the lb-mole of noncondensables (0.71 lb-moles per hour per extruder) divided by the noncondensable mole fraction (81.1% noncondensables).

$$\frac{0.71 \text{ lb-moles per hour per extruder}}{81.1\%} = 0.88 \frac{\text{lb-moles}}{\text{hour - extruder}}$$

Mass of VOC in condenser outlet

Calculated as the mole fraction of VOC (0.12%) times the total moles of gas (0.88 lb-moles per hour per extruder) times the VOC molecular weight of 402.6 .

$$0.88 \frac{\text{lb-moles}}{\text{hour - extruder}} \times 0.12\% \text{ VOC} \times 402.6 \frac{\text{lb}}{\text{lb-mole}} = 0.41 \frac{\text{lb VOC}}{\text{hour - extruder}}$$

Total Potential Emissions before the final condenser

Calculated by using the VOC emission rate of 0.41 lb. VOC per hour per extruder multiplied by 3 extruders and multiplied by 8,760 hours per year.

$$0.41 \frac{\text{lb VOC}}{\text{hour - extruder}} \times 3 \text{ extruders} \times \frac{8{,}760 \text{ hours}}{\text{year}} = \mathbf{10{,}764} \frac{\textbf{lb VOC}}{\textbf{year}}$$

STEP 4: VOC's passing through the final condenser:
In general the same approach used in Steps 2 and 3 is applied here with the only difference being that the system pressure is atmospheric at the condenser outlet which results in a lower VOC mole fraction.

Mole fraction of Water

Calculated as the vapor pressure of water (42.2 mmHg at 35 deg. C) divided by condenser's atmospheric pressure (760 mmHg).

$$\frac{42.2 \text{ mmHg}}{760 \text{ mmHg}} = 5.6\% \text{ water}$$

Mole fraction of VOC

Calculated as the vapor pressure of the VOC (0.26 mmHg at 35 deg. C) divided by the system pressure (760 mmHg).

$$\frac{0.26 \text{ mmHg}}{760 \text{ mmHg}} = 0.03\% \text{ VOC as 3GO}$$

Mole fraction of noncondensables

Calculated as 100% minus the mole fractions of water and VOC

100% minus 5.6% water minus 0.03% VOC = 94.4% noncondensable

Total Moles

Calculated as the lb-mole of noncondensables (0.71 lb-moles per hour per extruder) divided by the noncondensable mole fraction (94.4% noncondensables).

$$\frac{0.71 \text{ lb-moles per hour per extruder}}{94.4\%} = 0.76 \ \frac{\text{lb-moles}}{\text{hour - extruder}}$$

Butacite Extrusion Process (Line 4) - Emission Summary

A. VOC Emissions by Compound and Source

Butacite® Compound	CAS Chemical Name	CAS No.	Point Source Emissions (lbs)	Fugitive Emissions (lbs)	Equipment Emissions (lbs)	Accidental Emissions (lbs)	Total VOC Emissions (lbs)
3GO	Triethylene glycol di-2-ethylhexanoate	94-28-0	2,477.5	0	0	0	2,477.5
	Total VOC Emissions in 2005		**2,477.5**	**0**	**0**	**0**	**2,477.5**
					Total VOC (Tons)		**1.24**

Emission Summary

A. VOC Compound Summary

Nafion® Compound	CAS Chemical Name	CAS No.	Point Source and Non-point Source Emissions (lbs)	Accidental Emissions	Total Emissions (lbs)
COF2	Carbonyl Fluoride	353-50-4	1,855		1,855.36
PAF	Trifluoroacetyl Fluoride	354-34-7	1,795		1,795.18
A/F Solvent (TFF)	Perfluoro-3,5,7,9,11-pentaoxadodecanoyl fluoride	690-43	486		486.26
A/F Solvent (TAF)	Trifluoromethyl ester of carbonofluoridic acid	3299-24-9	486		486.26
HFP	Hexafluoroproplyene	116-15-4	42,016	5	42,020.55
HFPO	Hexafluoroproplyene Epoxide	428-59-1	41,509	952	42,461.18
Benzene	Benzene	71-43-2	1		1.24
Toluene	Methylbenzene	108-88-3	10,356		10,356.00
				Total VOC Emissions (lbs)	**99,462**
				Total VOC Emissions (tons)	**49.73**

B. VOC Control Efficiency

VOCs Generated			VOCs Emitted from Stack		
Point Source Generated (lbs)	Equipment Emissions Inside Buildings (lbs)	Total VOC Generated	Point Source Emissions (lbs)	Non-point Source Emissions (lbs)	Total VOC Emitted (lbs)
859,423	3,420	862,843	59,576	2,183	61,759

862,843 lb VOC generated
\- 61,759 lb VOC emitted
801,084 lb VOC removed in control device

801,084 lb VOC removed in control device
862,843 lb VOC generated
= **92.84% VOC control efficiency**

C. Toxic Air Pollutant Summary

Nafion® Compound	CAS Chemical Name	CAS No.	Point Source Emissions (lbs)	Non-point Source Emissions (lbs)	Accidental Emissions	Total Emissions (lbs)
HF	Hydrogen Fluoride	7664-39-3	1,200.54	153.64		1,354.19
Benzene	Benzene	71-43-2		1.24		1.24
Toluene	Methylbenzene	108-88-3		10,356.00		10,356.00

D. HF Control Efficiency

Total Emissions (tons) **55.59**

$$\frac{1{,}201 \text{ lb HF emitted from Point Sources}}{(100\%-99.6\%) \text{ Stack Efficiency}}$$

= 300,135 lb HF sent to control device from Point Sources

300,135 lb HF sent to control device from Point Sources
\- 1,354 lb HF emitted
= 298,781 lb HF removed in control device

300,135 lb HF sent to control device from Point Sources
\+ 154 lb HF from Non-point Sources inside buildings
= 300,289 lb HF generated

$$\frac{298{,}781 \text{ lb HF removed in control device}}{300{,}289 \text{ lb HF generated}}$$

= **99.50% HF control efficiency**

After-control emissions utilizing the 99.6% control efficient Waste Gas Scrubber (WGS):

<u>VOC Emissions</u>		146,190 kg COF_2		
Waste Gas Scrubber	x	(100%-99.6%)		
	=	585 kg COF_2	=	585 kg VOC
			=	**1289 lb. VOC**
<u>HF Equivalent Emissions</u>		585 kg COF_2		
	x	0.606 kg HF/kg COF_2		
	=	354 kg HF	=	**781 lb. HF**

F. Perfluoromethylcyclopropane (PMCP) **CAS No. 379-16-8**
Oxygen (O_2) **CAS No. 7782-44-7**
Fluoroform (CF_3H) **CAS No. 75-46-7**
Carbon Dioxide (CO_2) **CAS No. 124-38-9**

PMCP, O_2, CF_3H, and CO_2 are not VOCs nor do they have potential to make HF. Since they are not reportable emissions, the calculations are not shown here.

G. Point Source Summary

Nafion Compound Name		Before Control VOC Generated		After Control Stack Emissions		
		kg/yr VOC	lb/yr VOC	lb/yr VOC	VOC ton/yr	lb/yr HF
A.	COF2	146,190	322,290	1,289	1	781
B.	PAF	141,448	311,836	1,247	1	215
C.	Acid Fluoride Solvent (TFF)	38,314	84,466	338	0	204.8
	Acid Fluoride Solvent (TAF)	38,314	84,466	338	0	
D.	HFP	12,747	28,103	28,103	14	
E.	HFPO	12,819	28,261	28,261	14	
	Total	389,832	859,423	**59,576**	**30**	**1,201**

Non-point Source Emission Determination:

Non-point source emissions include equipment emissions and maintenance emissions. Equipment emissions are due to leaks from valves, flanges, and pumps. If these leaks occur outside of a building, they are considered fugitive emissions. Maintenance emissions are due to opening up vessels for maintenance and though some of this equipment is located indoors, to be conservative it will be assumed that all maintenance emissions are fugitive emissions.

I. Equipment Emissions

Equipment Emissions are a function of the number of emission points in the plant (valves, flanges, pump seals). For the equipment emission calculations the inventory shown below is conservative and based on plant and process diagrams. Note that the calculations below include equipment emissions (EE) inside buildings (which become stack emissions or SE) as well as equipment emissions outside buildings (fugitive emissions or FE).

A. Equipment Emissions Inside Buildings (Stack Emissions)

1. Equipment Emissions from Reactor, Distillation Column, #1 Recycle Tank:
Emissions are vented from equipment located in the barricade and are vented through the barricade scrubber. Barricade scrubber is 95% efficient for control of acid fluorides. From Flowsheet W1208078:

Material	VOC	HF	Average Vessel Contents (kg/hr)				% of contents	% VOC	% HF	HF Potential	% overall HF Potential			
			Line 6	Line 6	Line 4	Total					0.606	0.172	0.11	0.081
O2			2.4	2.4		4.8	0.1%							
COF2	x	x	33.7	33.7		67.4	1.4%	1.4%	1.4%	0.606	1.4%			
PAF	x	x	25.5	25.5		51	1.0%	1.0%	1.0%	0.172		1.0%		
HFP	x		76.4	76.4		152.8	3.1%	3.1%						
HFPO	x		100.1	100.1		200.2	4.1%	4.1%						
HFA	x		1	1		2	0.0%	0.0%						
PMFF	x	x	9.6	9.6		19.2	0.4%	0.4%	0.4%	0.606	0.4%			
PMAF	x	x	18.4	18.4	14.5	51.3	1.1%	1.1%	1.1%	0.11			1.1%	
PMCP			86.6	86.6	80.5	253.7	5.2%							
TFF	x	x	50.3	50.3	50	150.6	3.1%	3.1%	3.1%	0.081				3.1%
TAF	x	x	500	500	495.9	1495.9	30.6%	30.6%	30.6%	0.606	30.6%			
TAF	x	x	335	335	332	1002	20.5%	20.5%	20.5%	0.606	20.5%			
TAF	x	x	479	479	476.3	1434.3	29.4%	29.4%	29.4%	0.606	29.4%			
Total						4885.2		94.7%	87.4%		82.3%	1.0%	1.1%	3.1%

Average HF Potential **0.504**

Assume that: 95% of process materials are VOCs;
88% are acid fluorides with 95% controlled in the barricade scrubber;
7% are non-acid fluorides with 0% controlled in the barricade scrubber.
100% of the liquid is 0.504 weight fraction HF.

Barricade:

Valve emissions:	119 valves x 0.00039 lb/hr/valve	=	0.046 lb/hr EE
Flange emissions:	248 flanges x 0.00018 lb/hr/flange	=	0.045 lb/hr EE
Pump emissions:	1 pump x 0.00115 lb/hr/pump	=	0.001 lb/hr EE
Total equipment emission rate		=	0.092 lb/hr EE

Barricade VOC:

From acid fluorides:
0.092 lb. EE/hr
x 8760 hr/year
x 0.880 lb. A/F VOC/lb. EE
= 710.751 lb/yr VOC generated

710.751 lb VOC generated
x (100%-95%) scrubber efficiency
= 35.538 lb/yr VOC emitted

From non-acid fluorides: 0.092 lb. EE/hr
x 8760 hr/year
x 0.070 lb. Non-A/F VOC/lb. EE
= 56.537 lb/yr VOC

Total Barricade VOC Emissions:
35.538 lb/yr VOC
\+ 56.537 lb/yr VOC
= **92.075 lb/yr VOC**

Barricade HF: 0.092 lb. EE/hr
x 8760 hr/year
x 0.504 lb. HF/lb. EE
x (100%-95%) scrubber efficiency
= **20.353 lb/yr HF**

2. Fugitive Emissions From Distillation System #1

Emissions are vented from equipment located in tower and are vented through stack.
From W1208078 HFPO Flowsheet:

Material	VOC	HF	Average Vessel Contents Line 8 (kg/hr)	% of contents	% VOC	% HF	HF Potential	% overall HF Potential 0.606	0.172	0.11
O2			2.4	0.93%						
COF2	x	x	33.7	13.09%	13.1%	13.1%	0.606	13.1%		
PAF	x	x	25.5	9.91%	9.9%	9.9%	0.172		9.9%	
HFP	x		76.4	29.68%	29.7%					
HFPO	x		99.9	38.81%	38.8%					
HFA	x		1	0.39%	0.4%					
PMFF	x	x	9.6	3.73%	3.7%	3.7%	0.606	3.7%		
PMAF	x	x	3.8	1.48%	1.5%	1.5%	0.110			1.5%
PMCP			5.1	1.98%						
TFF	x	x								
TAF	x	x								
TAF	x	x								
TAF	x	x								
Total			257.4		94.7%	87.4%		82.3%	1.0%	1.5%
								Average HF Potential		0.121

Assume that : 95 wt. % of the process material are VOCs;
100% of the liquid is 0.121 weight fraction HF.

Valve emissions:	60 valves x 0.00039 lb/hr/valve	=	0.023 lb/hr EE
Flange emissions:	120 flanges x 0.00018 lb/hr/flange	=	0.022 lb/hr EE
Total equipment emission rate		=	0.045 lb/hr EE

VOC: 0.045 lb. EE/hr
x 8760 hr/year
x 0.950 lb. VOC/lb. EE
= **374.490 lb/yr VOC**

HF: 0.045 lb. EE/hr
x 8760 hr/year
x 0.121 lb. HF/lb. EE
= **47.698 lb/yr HF**

3. Equipment Emissions From Scrubber, Dryers, and Stripper Column

Emissions are vented from equipment located in tower and are vented through stack.
From W1208078 HFPO Flowsheet:

Material	VOC	HF	Average Vessel Contents (kg/hr)				% of contents	% VOC	% HF	HF Potential	% overall HF Potential		
			Line 6	Line 11	Line 12	Total					0.606	0.172	0.11
O2													
COF2													
PAF	x	x	6.5			6.5	0.68%	0.68%	0.68%	0.172	0.68%		
HFP	x		75.8	75.8	75.8	227.4	23.90%	23.90%					
HFPO	x		99.6	96.7	96.7	293	30.79%	30.79%					
HFA	x		1			1	0.11%	0.11%					
PMFF	x	x	9.6			9.6	1.01%	1.01%	1.01%	0.606		1.01%	
PMAF	x	x	3.8			3.8	0.40%	0.40%	0.40%	0.11			0.40%
PMCP			5.1		5.1	10.2	1.07%						
Water			360			360							
KOH			40			40							
Total						951.5		56.9%	2.1%		0.7%	1.0%	0.4%

Average HF Potential **0.008**

Assume that : 57 wt. % of the process material are VOCs;
100% of the liquid is 0.008 weight fraction HF.

Valve emissions:	171 valves x 0.00039 lb/hr/valve	=	0.067 lb/hr EE
Flange emissions:	312 flanges x 0.00018 lb/hr/flange	=	0.056 lb/hr EE
Pump emissions:	2 pumps x 0.00115 lb/hr/pump	=	0.002 lb/hr EE
Total equipment emission rate		=	0.125 lb/hr EE

VOC:	0.125 lb. EE/hr	HF:		0.125 lb. EE/hr
x	8760 hr/year		x	8760 hr/year
x	0.570 lb. VOC/lb. EE		x	0.008 lb. HF/lb. EE
	624.899 lb/yr VOC		=	**8.771 lb/yr HF**

B. Equipment Emissions Outside Buildings (Fugitive Emissions)

1. Fugitive Emissions From Distillation System #2

From W1208078 HFPO Flowsheet:

Material	VOC	HF	Average Vessel Contents (kg/hr)			% of contents	% VOC	% HF
			Line 18	Line 23	Total			
O2								
COF2	x	x						
PAF	x	x						
HFP	x		74.5	73.8	148.3	3.18%	3.18%	
HFPO	x		95.8	7.7	103.5	2.22%	2.22%	
HFA	x							
PMFF	x	x						
PMAF	x	x						
PMCP			5.1	5.1	10.2	0.22%		
Toluene	x		2200	2200	4400	94.38%	94.38%	
Total					4662		99.78%	0.00%

Assume that : 100 wt. % of the process material are VOCs (most of the mass is toluene)
0 wt. % of the liquid is HF.

Valve emissions:	155 valves x 0.00039 lb/hr/valve	=	0.060 lb/hr FE
Flange emissions:	300 flanges x 0.00018 lb/hr/flange	=	0.054 lb/hr FE
Pump emissions:	1 pump x 0.00115 lb/hr/pump	=	0.001 lb/hr FE
Total fugitive emission rate		=	0.116 lb/hr FE

VOC:	0.116 lb. FE/hr	HF:		0.116 lb. FE/hr
x	8760 hr/year		x	8760 hr/year
x	1.00 lb. VOC/lb. FE		x	0.0 lb. HF/lb. FE
=	**1012.66 lb/yr VOC** (assume all is toluene)		=	**0.00 lb/yr HF**

5. Total Equipment Emissions

Emission Source		Inside Emissions (Stack Emissions)		Outside Emissions (Fugitive Emissions)	
		lb VOC	lb HF	lb VOC	lb HF
A-1	Reactor, Distillation Columns, #1 Recycle Tank	92.07	20.35		
A-2	Distillation System #1	374.49	47.70		
A-3	Scrubbing, Dryers, Stripper Column	624.90	8.771		
B-1	Distillation System #2			1013	
B-2	HFP Storage and Feed			622.84	
B-4	Toluene System			10356.00	
	Total	1091.46	76.82	11991.49	0.00

In order to be conservative, the calculated values will be multiplied by a factor of 2.

	Inside Emissions (Stack Emissions)		Outside Emissions (Fugitive Emissions)	
	lb/yr VOC	lb/yr HF	lb/yr VOC	lb/yr HF
Conservative amount (total x 2)	2,183	154	23,983	0

Total HF emissions:
154 lbs HF from outside building
\+ 0 lbs HF from inside building
= **154 lbs HF**

Total VOCs generated inside building:
710.75 lb from Reactor, Distil'n Column, #1 Recycle Tank
\+ 374.49 lb from Scrubber, Dryers, Stripper Column
\+ 624.90 lb from Scrubber, Dryers, Stripper Column
= 1710.14 lb VOC generated (before control device)

Conservative amount (total x 2) 3420 lb VOC generated (before control device)

II. Maintenance Emissions

Background

During preparation of equipment for maintenance, a vessel is first de-inventoried of liquid (to another process vessel), then de-pressurized (to a vacuum), then nitrogen is used for a series of pressurize/vent-down cycles until a vessel is fume free. For the purpose of estimating emissions from vessel preparation, the plant can be broken down into three sections: HFP Storage and Feed, HFPO Distillation system #2, and everything else. Below are the definitions, assumptions, and calculations of maintenance emissions for each section.

A. HFP Storage and Feed

The HFP Storage section consists of the two HFP Storage Tanks and the associated equipment to transfer HFP into the tanks. When maintenance clearing is required for these tanks (scheduled once per year), the liquid inventory is transferred to the other tank, the vapors are compressed into the tank (down to 10 psig), and then the residue is evacuated to the Nafion® Division Waste Gas Scrubber. The emissions to the atmosphere, therefore, are the HFP vapors remaining at 10 psig.

Calculations:

PV = nRT

Tank Volume = 3000 gal =	401 ft^3
Contents =	100 % HFP (MW=150 lb/lbmol)
Tank pressure = 10 psig =	24.7 psia
Tank temperature = ambient = 77 deg F =	537 R
R =	10.73 psia-ft^3/lbmol/R

n = PV/RT

$$n = \frac{24.7 \text{ psia}}{10.7 \text{ psia-ft}^3/\text{lbmol/R}} \times \frac{401 \text{ ft}^3}{537 \text{ R}} = 1.72 \text{ lbmol HFP}$$

$$1.72 \text{ lbmol HFP} \times \frac{150 \text{ lb HFP}}{\text{lbmol HFP}} = 258 \text{ lb HFP} = 258 \text{ lb VOC per cleaning}$$

Clearings/year: Each tank scheduled once per year; two tanks is two clearings/year scheduled; to be conservative, assume one extra clearing a year, so three clearings performed per year.

258 lb HFP
x 3 clearings/year
= 774 lb/yr HFP

VOC from HFP Storage Tank =

258 lb VOC per cleaning
x 3 clearings/year
= **774 lb/yr VOC**

B. Distillation System #2

When maintenance clearing is required for the column and tanks (scheduled once per year), the liquid inventory is transferred to the other tank, the vapors are compressed into the tank (down to 10 psig), and then the residue is evacuated to the Nafion® Division Waste Gas Scrubber. For the purposes of these calculations, the average operating pressure and total volume are used.

Calculations:

PV = nRT

Tank Volume = 3300 gal =	441 ft^3
Contents =	50 % HFP (MW=150 lb/lbmol)
(Conservative approximation based off of vessel contents and volatility of compounds)	40 % HFPO (MW=166 lb/lbmol) 10 % Toluene (MW=92 lb/lbmol)
Average system pressure = 20 psig =	34.7 psia
Average system temperature = 30 deg F =	490 R
R =	10.73 psia-ft^3/lbmol/R

n = PV/RT

$$n = \frac{34.7 \text{ psia}}{10.7 \text{ psia-ft}^3\text{/lbmol/R}} \times \frac{441 \text{ ft}^3}{490 \text{ R}} = 2.91 \text{ lbmol material}$$

$$2.91 \text{ lbmol material} \times 50\% \text{ HFP} \times \frac{150 \text{ lb HFP}}{\text{lbmol HFP}} = 218 \text{ lb HFP}$$

$$2.91 \text{ lbmol material} \times 40\% \text{ HFPO} \times \frac{166 \text{ lb HFPO}}{\text{lbmol HFPO}} = 193 \text{ lb HFPO}$$

$$2.91 \text{ lbmol material} \times 10\% \text{ Toluene} \times \frac{92 \text{ lb Toluene}}{\text{lbmol Toluene}} = 27 \text{ lb Toluene}$$

As stated previously, toluene amounts are calculated by mass balance. The amount vented calculated by mass balance will be used for toluene and VOC emisssions.

Total VOC per cleaning:

218 lb HFP
+ 193 lb HFPO
= 412 lb VOC

Clearings/year: Each tank scheduled once per year; to be conservative, assume one extra clearing a year, so two clearings per year.

218 lb HFP
x 2 clearings/year
= 437 lb/yr HFP

193 lb HFPO
x 2 clearings/year
= 387 lb/yr HFPO

VOC from Distillation system #2 =

412 lb VOC
x 2 clearings/year
= **823 lb/yr VOC**

C. "Rest of the Process"

The rest of the HFPO process contains HFP, HFPO, and both low and high vapor pressure acid fluorides (acid fluorides are organic compounds which release HF when exposed to the atmosphere). The calculations below do not include the low-pressure acid fluorides because at temperatures at which the vessels are prepared for maintenance the concentration of the low vapor pressure acid fluorides is very low. The high vapor pressure acid fluorides are not included because they are assumed to go to the WGS during decontamination. Though some of the process is located inside buildings, to be conservative it will be assumed that all emissions are fugitive emissions.

Assume that: Pressure is vapor pressure of HFP/HFPO at ambient temperature (HFP and HFPO have the same vapor pressures)
Composition HFP to HFPO of vapor space in equipment is equivilant to ratio in line 11 of HFPO Flowsheet W130878 :
44 wt% HFP
56 wt% HFPO

Calculations:

PV = nRT

Tank Volume = 1100 gal =	$147\ ft^3$		
Contents =	44 wt% HFP (MW=150 lb/lbmol)	=	47 mol% HFP
	56 wt% HFPO (MW=166 lb/lbmol)	=	53 mol% HFPO
Average system pressure	100 psia		
Average system temperature = 77 deg F =	537 R		
R =	$10.73\ psia\text{-}ft^3/lbmol/R$		

n = PV/RT

$$n = \frac{100\ psia}{10.7\ psia\text{-}ft^3/lbmol/R} \times \frac{147\ ft^3}{537\ R} = 2.55\ lbmol\ material$$

$$2.55\ lbmol\ material \times 47\ \%\ HFP \times \frac{150\ lb\ HFP}{lbmol\ HFP} = 180\ lb\ HFP$$

$$2.55\ lbmol\ material \times 53\ \%\ HFPO \times \frac{166\ lb\ HFPO}{lbmol\ HFPO} = 224.5\ lb\ HFPO$$

Total VOC per cleaning:
179.9 lb HFP
\+ 224.5 lb HFPO
= 404.3 lb VOC

Clearings/year: Each tank scheduled once per year; to be conservative, assume one extra clearing per year, so two clearings per year.

180 lb HFP	224.5 lb HFPO
x 2 clearings/year	x 2 clearings/year
= **360 lb/yr HFP**	= **449 lb/yr HFPO**

VOC from "Rest of the Process" =
404.3 lb VOC
x 2 clearings/year
= **808.6 lb/yr VOC**

D. Total fugitive Emissions from Maintenance Work

Source		lb/yr HFP	lb/yr HFPO	lb/yr VOC
II-A	HFP Storage and Feed	774		774
II-B	Distillation System #2	437	387	823
II-C	"Rest of the System"	360	449	809
	Total	**1,570**	**835**	**2,406**

III. Non-Process Point Source and Non-Point Source VOC Emission Summary

Nafion® Compound	Non-Process Point-Source Equip. Emissions (lb)	Fugitive Emissions		Total Non-Process Emissions (lb)
		Outside Emissions (lb)	Maintenance Emissions (lb)	
COF2	47	519		566
PAF	46	502		548
TFF	12	136		148
TAF	12	136		148
HFP	1,030	11,313	1,570	13,913
HFPO	1,036	11,377	835	13,248
Benzene		1		1
Toluene		10,356		10,356
Total	2,183	34,340	2,406	38,929

Note: Speciated emissions (except for benzene, toluene, and maintenance emissions) were estimated by assuming that each compound's emission concentration was equal to the compound's stack emissions fraction of the total stack emissions.

For example:
1,247 lb. [the stack emission of PAF]
59,576 lb. [with the total stack emission of VOCs]
23,983 lb. [the total outside fugitive emission (minus benzene & toluene)]

$$\frac{1{,}247 \text{ lbs PAF}}{59{,}576 \text{ lbs VOC}} \times 23{,}983 \text{ lb fugitive VOC} = 502 \text{ lb fugitive PAF emissions}$$

Accidental Releases to Atmosphere

A. IR-2005-074 Date: 3/21/2003

Material Released: Hexafluoroproplyene Epoxide (HFPO) CAS No. 428-59-1
Quantity Released: 952 lbs

HFPO is a VOC without the potential to form HF.

Quantity VOC Released:

952.0 lbs HFPO
= **952.0 lb VOC**

B. IR-2005-168 Date: 6/30/2004

Material Released: Hexafluoroproplyene (HFP) CAS No. 116-15-4
Quantity Released: 5 lbs

HFP is a VOC without the potential to form HF.

Quantity VOC Released:

5.0 lbs HFP
= **5.0 lb VOC**

E. Total Emissions from Accidental Releases

Source		lb DCM	lb HFP	lb HFPO	lb COF2	lb PAF	lb HFA	lb/yr VOC	lb/yr HF
A.	IR-2005-074	0.0	0	952.0	0	0	0	952.0	0
B.	IR-2005-168	0.0	5.0	0.0	0	0	0	5.0	0
	Total	**0**	**5**	**952**	**0**	**0**	**0**	**957**	**0**

2005 **Emission Summary**

A. VOC Emissions Summary

Nafion® Compound	CAS Chemical Name	CAS No.	EVE Process Emissions (lbs)	PPVE Process Emissions (lbs)	PSEPVE Process Emissions (lbs)	Accidental Releases (lbs)	Total Vinyl Ethers North Emissions (lbs)
HFP	Hexafluoroproplyene	116-15-4	611	6,586	9,393		16,589
HFPO	Hexafluoropropylene oxide	428-59-1	450	13,019	1,536		15,005
HFPO-Dimer	Perfluoro-2-Propoxy Propionyl Fluoride	2062-98-8	1	0	0		1
EVE	Propanoic Acid, 3-[1-[Difluoro [(Trifluoroethenyl oxy] Methyl]-1,2,2,2-Tetrafluoroethoxy] -2,2,3,3-Tetrafluoro , Methyl Ester	63863-43-4	7	0	0		7
PPVE	Perfluoropropyl vinyl ether	1623-05-8	0	4,284	0	0.1	4,284
PSEPVE	Perfluoro-2-(2-Fluorosulfonylethoxy) Propyl Vinyl Ether	16090-14-5	0	0	20.3		20
PPF	Perfluoropropionyl fluoride	422-61-7	0	59	0.4	18	77
TFE	Tetrafluoroethylene	116-14-3	334	11,736	27		12,098
C4	Perfluoro-2-butene	360-89-4	0	314	1,401		1,715
C5	Perfluoropentene	376-87-4	0	32	0		32
Glycol Ethers	Unlisted	GLYET	268	0	3,250		3,518
AN	Acetonitrile	75-05-8	0	6,676			6,676
ADN	Adiponitrile	111-69-3	2,536	0			2,536
DA	Tetrafluoro-2[Hexafluoro-2-(Tetrafluoro-2-{Fluorosulfonyl}Ethoxy) Propoxy Propionyl Fluoride	4089-58-1	0	0	0.158	163	163
Hydro-PSEPVE	Tetrafluoro-2-[Trifluoro-2-(1,2,2,2-Tetra-fluoroethoxy)-1-(Trifluoromethyl) Ethoxy]-Ethane Sulfonyl Fluoride	755-02-9	0	0	1.356		1
MA	Tetrafluoro-2-[Tetrafluoro-2-(Fluorosulfonyl)Ethoxy]-Propanoyl Fluoride	4089-57-0	0	0	0.005	141	141
HFPO Trimer	Perfluoro-2,5-Dimethyl-3,6-Dioxanonanoyl	2641-34-1	0	0	0.015	115	115
Iso-PSEPVE	Perfluoro-1-Methyl-2-(2 Fluorosulfonyl Ethoxy) Ethyl Vinyl Ether	34805-58-8	0	0	4.067		4
		Total VOC Emissions (lbs)	**4,206**	**42,706**	**15,634**	**437**	**62,983**
		Total VOC Emissions (tons)	**2.1**	**21.4**	**7.8**	**0.2**	**31.5**

Note: Actual Values for AN and Glycol ethers is not avialable until waste shipments are made, so these numbers can be positive or negative depending on what month the waste shipment went out. Full balance will be done at the end of the year.

B. VOC Control Device Efficiency

VOCs Generated				
Point Source Generated (lbs)	**Equipment Emissions (lbs)**	**Maintanence Emissions (lbs)**	**Accidental Releases (lbs)**	**Total VOC Generated (lbs)**
64,990	11,234	671	437	77,331

VOCs After Control
Total VOC Emitted (lbs)
56,307

77,331 lb VOC generated
56,307 lb VOC emitted
21,024 lb VOC removed in control device

21,024 lb VOC removed in control device
77,331 lb VOC generated
= **27.19% VOC control efficiency**

C. Toxic Air Pollutant and Hazardous Air Pollutant Summary (TAPS/HAPS)

Nafion® Compound	CAS Chemical Name	CAS No.	EVE Emissions (lbs)	PPVE Emissions (lbs)	PSEPVE Emissions (lbs)	Accidental Releases (lbs)	Total Emissions (lbs)
HF	Hydrogen Fluoride	7664-39-3	0.06	7.1	11.4	21	39.87
Glycol Ethers	Unlisted- DiGlyme (only)	111-96-6			3,250		3,250
Acetonitrile	Acetonitrile	75-05-8		6,676			6,676

D. Carbon Monoxide (CO) Emissions Summary

Nafion® Compound	CAS Chemical Name	CAS No.	EVE Emissions (lbs)	PPVE Emissions (lbs)	PSEPVE Emissions (lbs)	Total Emissions (lbs)	Total Emissions (tons)
CO	Carbon Monoxide	630-08-0	1,070	6,537	3,712	11,319	5.7

Report Created By: Amy S. Martin
Report Created: 3/28/2006

2005 AIR EMISSIONS INVENTORY SUPPORTING DOCUMENTATION

Emission Source ID No: NS-B

Emission Source Description: VE-North EVE Manufacturing Process

Process & Emission Description: The VE-North EVE manufacturing process is a continuous chemical reaction. All emissions from the process are vented through the Nafion Division Waste Gas Scrubber (Control Device ID No. NCD-Hdr) which has a documented control efficiency of 99.6% for all acid fluoride compounds. Some emitted compounds are assumed to pass completely through the scrubber, so the control efficiency for those compounds is assumed to be 0%. The control of emissions of specific compounds will be addressed and detailed in the following pages.

The EVE process in VE-North emits compounds in the acid fluoride family. In the presence of water (such as in atmospheric moisture), these acid fluorides can eventually hydrolyze to hydrogen fluoride. For the purpose of this emissions inventory, a conservative approach will be taken and the acid fluorides will be reported both as a VOC and as the equivalent quantity of hydrogen fluoride.

Basis and Assumptions:

- The EVE process flowsheet is the basis for relative concentrations of before-control emissions of gaseous wastes.

- Calculations of point source emissions are based on actual vent flow totals taken from the IP21 Historian.

- All emission determination calculations are available on the EXCEL spreadsheet found at : S:/Everyone/martinas/VEN Air Emissions 2005 Annual Summary.xls.

Point Source Emission Determination

A. Hexafluoropropylene (HFP) **CAS No. 116-15-4**

HF Potential:

HFP is a VOC without the potential to form HF

Quantity Released

HFP is a byproduct present in the HFPO feed. It is an inert in VE-North that is vented to the WGS.

HFP vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0.17 kg HFP}{0.50 kg CondRxVentFlo}$

Vented from the Crude Receiver $\frac{0\ kg\ HFP}{15.91\ kg\ Crude Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0\ kg\ HFP}{0.14\ kg\ Foreshots Receiver Vent}$

HFP vented based on 756 kg total Condensation Reactor vent stream (22266FG).
HFP vented based on 13,120 kg total Crude Receiver vent stream (22701FG).
HFP vented based on 91 kg total Foreshots Receiver vent stream (22826FG).

HFP vented from Condensation Reactor:

$\frac{0.17 \text{ kg HFP}}{0.50 \text{ kg CndRx}}$ x 756 kg CndRx = 264 kg HFP

HFP vented from Crude Receiver

$\frac{0.00 \text{ kg HFP}}{15.91 \text{ kg CrRec}}$ x 13,120 kg CrRec = 0 kg HFP

HFP vented from Foreshots Receiver

$\frac{0.00 \text{ kg HFP}}{0.14 \text{ kg FsRec}}$ x 91 kg FsRec = 0 kg HFP

VOC Emissions

		264 kg from Condensation Reactor		
	+	0 kg from Crude Receiver		
	+	0 kg from Foreshots Receiver		
	=	**264** kg HFP	=	264 kg VOC
				580 lb VOC

B. Hexafluoropropylene oxide (HFPO) **CAS No. 428-59-1**

HF Potential:

HFPO is a VOC without the potential to form HF

Quantity Released

HFPO is a byproduct present in the HFPO feed. It is an inert in VE-North that is vented to the WGS.

HFPO vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0.13\ kg\ HFPO}{0.50\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0\ kg\ HFPO}{15.91\ kg\ Crude\ Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0\ kg\ HFPO}{0.14\ kg\ Foreshots\ Receiver\ Vent}$

HFPO vented based on	756 kg total Condensation Reactor vent stream (22266FG).
HFPO vented based on	13,120 kg total Crude Receiver vent stream (22701FG).
HFPO vented based on	91 kg total Foreshots Receiver vent stream (22826FG).

HFPO vented from Condensation Reactor:

$\frac{0.13\ kg\ HFPO}{0.50\ kg\ CndRx}$ x 756 kg CndRx = 194 kg HFPO

HFPO vented from Crude Receiver

$\frac{0.00\ kg\ HFPO}{15.91\ kg\ CrRec}$ x 13,120 kg CrRec = 0 kg HFPO

HFPO vented from Foreshots Receiver

$\frac{0.00\ kg\ HFPO}{0.14\ kg\ FsRec}$ x 91 kg FsRec = 0 kg HFPO

VOC Emissions				
		194 kg from Condensation Reactor		
	+	0 kg from Crude Receiver		
	+	0 kg from Foreshots Receiver		
	=	194 kg HFPO	=	194 kg VOC
				427 lb VOC

C. Perfluoro-2-Propoxy Propionyl Fluoride (HFPO Dimer) **CAS No. 2062-98-8**

HF Potential:

Each mole of HFPO Dimer (MW = 332) can generate 1 mole of HF (MW = 20).

$$1\,kg\,Dimer \frac{1\,mole\,Dimer}{332g\,Dimer} \cdot \frac{20g\,HF}{1\,mole\,HF} \cdot \frac{1\,mole\,HF}{1\,mole\,Dimer} = 0.06\,kg\,HF$$

Therefore, each 1 kg of HFPO Dimer generates 0.060 kg of HF

Quantity Released

Before-control HFPO Dimer vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0.05\ kg\ HFPO Dimer}{0.50\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0\ kg\ HFPO\ Dimer}{15.91\ kg\ Crude Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0\ kg\ HFPO Dimer}{0.14\ kg\ Foreshots Receiver Vent}$

HFPO Dimer vented based on 756 kg total Condensation Reactor vent stream (22266FG).
HFPO Dimer vented based on 13,120 kg total Crude Receiver vent stream (22701FG).
HFPO Dimer vented based on 91 kg total Foreshots Receiver vent stream (22826FG).

Before control HFPO Dimer vented from Condensation Reactor:

$\frac{0.05\ kg\ HFPO\ Dimer}{0.50\ kg\ CndRx}$ x 756 kg CndRx = 76 kg HFPO Dimer

HFPO Dimer vented from Crude Receiver

$\frac{0.00\ kg\ HFPO\ Dimer}{15.91\ kg\ CrRec}$ x 13,120 kg CrRec = 0 kg HFPO Dimer

HFPO Dimer vented from Foreshots Receiver

$\frac{0.00\ kg\ HFPO\ Dimer}{0.14\ kg\ FsRec}$ x 91 kg FsRec = 0 kg HFPO Dimer

Total before-control HFPO Dimer vented = 76 kg HFPO Dimer

After-control emissions utilizing the 99.6% control efficient Waste Gas Scrubber (WGS):

VOC Emissions

Waste Gas Scrubber

	76 kg Dimer	
x	(100%-99.6%)	
=	0.31 kg Dimer	0.31 kg VOC
	=	**0.67 lb. VOC**

HF Equivalent Emissions

	0 kg Dimer	
x	0.060 kg HF/kg Dimer	
=	0.02 kg HF	**0.04 lb. HF**

D. Tetrafluoroethylene (TFE) **CAS No. 116-14-3**

HF Potential:

TFE is a VOC without the potential to form HF

Quantity Released

TFE is a byproduct present in the TFE feed. It is an inert in VE-North that is vented to the WGS.

TFE vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0 \ kg \ TFE}{0.50 \ kg \ Cond \ Rx \ Vent \ Flow}$

Vented from the Crude Receiver $\frac{0.18 \ kg \ TFE}{15.91 \ kg \ Crude Receiver \ Vent}$

Vented from the Foreshots Receiver $\frac{0 \ kg \ TFE}{0.14 \ kg \ Foreshots Receiver Vent}$

TFE vented based on 756 kg total Condensation Reactor vent stream (22266FG).
TFE vented based on 13,120 kg total Crude Receiver vent stream (22701FG).
TFE vented based on 91 kg total Foreshots Receiver vent stream (22826FG).

TFE vented from Condensation Reactor:

$\frac{0.00}{0.50} \frac{kg \ TFE}{kg \ CndRx}$ x 756 kg CndRx = 0 kg TFE

TFE vented from Crude Receiver

$\frac{0.18}{15.91} \frac{kg \ TFE}{kg \ CrRec}$ x 13,120 kg CrRec = 144 kg TFE

TFE vented from Foreshots Receiver

$\frac{0.00}{0.14} \frac{kg \ TFE}{kg \ FsRec}$ x 91 kg FsRec = 0 kg TFE

VOC Emissions

		0 kg from Condensation Reactor		
	+	144 kg from Crude Receiver		
	+	0 kg from Foreshots Receiver		
	=	144 kg TFE	=	144 kg VOC
				318 lb VOC

E. Methyl Perfluoro (5-(Fluoroformyl) -4-Oxahexanoate) (MAE) **CAS No. 69116-72-9**

HF Potential:

Each mole of MAE (MW = 322) can generate 1 mole of HF (MW = 20).

$$1\,kg\,PPF \cdot \frac{1\,mole MAE}{322\,g\,MAE} \cdot \frac{20\,g\,HF}{1\,mole HF} \cdot \frac{1\,mole HF}{1\,mole MAE} = 0.062\,kg\,HF$$

Therefore, each 1 kg of PPF generates 0.062 kg of HF

Quantity Released

Before-control MAE vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0\ kg\ MAE}{0.50\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0\ kg\ MAE}{15.91\ kg\ Crude Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0.04\ kg\ MAE}{0.14\ kg\ Foreshots Receiver Vent}$

MAE vented based on 756 kg total Condensation Reactor vent stream (22266FG).
MAE vented based on 13,120 kg total Crude Receiver vent stream (22701FG).
MAE vented based on 91 kg total Foreshots Receiver vent stream (22826FG).

Before control MAE vented from Condensation Reactor:

$\frac{0.00\ kg\ MAE}{0.50\ kg\ CndRx}$ x 756 kg CndRx = 0 kg MAE

MAE vented from Crude Receiver

$\frac{0.00\ kg\ MAE}{15.91\ kg\ CrRec}$ x 13,120 kg CrRec = 0 kg MAE

MAE vented from Foreshots Receiver

$\frac{0.04\ kg\ MAE}{0.14\ kg\ FsRec}$ x 91 kg FsRec = 24 kg MAE

Total before-control MAE vented = 24 kg MAE

After-control emissions utilizing the 99.6% control efficient Waste Gas Scrubber (WGS):

VOC Emissions

Waste Gas Scrubber
24 kg MAE
x (100%-99.6%)
= 0 kg MAE 0 kg VOC
= **0 lb. VOC**

HF Equivalent Emissions

0 kg MAE
x 0.062 kg HF/kg MAE
= 0.01 kg HF **0.01 lb. HF**

F. Propanoic Acid, 3-[1-[Difluoro [(Trifluoroethenyl) oxy] Methyl]-1,2,2,2-Tetrafluoroethoxy]-2,2,3,3 -Tetrafluoro-, Methyl Ester (EVE) **CAS No. 63863-43-4**

HF Potential:

EVE is a VOC without the potential to form HF

Quantity Released

EVE is a byproduct present in the EVE feed. It is an inert in VE-North that is vented to the WGS.

EVE vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0\ kg\ EVE}{0.50\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0\ kg\ EVE}{15.91\ kg\ Crude\,Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0.0 kg\ EVE}{0.14\ kg\ ForeshotsReceiverVent}$

EVE vented based on 756 kg total Condensation Reactor vent stream (22266FG).
EVE vented based on 13,120 kg total Crude Receiver vent stream (22701FG).
EVE vented based on 91 kg total Foreshots Receiver vent stream (22826FG).

EVE vented from Condensation Reactor:

0.00 / 0.50 kg EVE / kg CndRx	x	756 kg CndRx	=	0 kg EVE

EVE vented from Crude Receiver

0.00 / 15.91 kg EVE / kg CrRec	x	13,120 kg CrRec	=	0 kg EVE

EVE vented from Foreshots Receiver

0.00 / 0.14 kg EVE / kg FsRec	x	91 kg FsRec	=	3 kg EVE

VOC Emissions

		0 kg from Condensation Reactor		
	+	0 kg from Crude Receiver		
	+	3 kg from Foreshots Receiver		
	=	3 kg EVE	=	3 kg VOC
				7 lb VOC

G. Glycol Ethers (GE) **GLYET-Other**

The emissions of glycol ethers is based on a mass balance of glycol ethers consumed in the process.
The only GE emissions in EVE is TetraGlyme

Quantity Released

=	221	kg GE introduced into processes
=	106	kg GE transferred to H/C waste tank
=	115	kg GE unaccounted for and assumed emitted
=	**254**	**lb. Glycol Ethers**

Assume that the emissions of glycol ethers is split evenly between the three processes of Vinyl Ethers North.

Therefore:

Emissions of glycol ether from EVE = **254** **lb. Glycol Ethers**

H. Carbon Monoxide (CO)

CAS No. 630-08-0

HF Potential:

CO can not form HF

Quantity Released

CO is a byproduct from the Agitated Bed Reactor system.
They are inerts in VE-North that are vented to the WGS.

CO vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0\ kg\ CO}{0.50\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0.59\ kg\ CO}{14.91\ kg\ Crude\ Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0\ kg\ CO}{0.14\ kg\ Foreshots\ Receiver\ Vent}$

CO vented based on	756	kg total Condensation Reactor vent stream (22266FG).
CO vented based on	13,120	kg total Crude Receiver vent stream (22701FG).
CO vented based on	91	kg total Foreshots Receiver vent stream (22826FG).

CO vented from Condensation Reactor:

$\frac{0.00\ kg\ CO}{0.50\ kg\ CndRx}$ x 756 kg CndRx = 0 kg CO

CO vented from Crude Receiver

$\frac{0.59\ kg\ CO}{15.91\ kg\ CrRec}$ x 13,120 kg CrRec = 485 kg CO

CO vented from Foreshots Receiver

$\frac{0.00\ kg\ CO}{0.14\ kg\ FsRec}$ x 91 kg FsRec = 0 kg CO

CO Emissions

		0 kg from Condensation Reactor		
	+	485 kg from Crude Receiver		
	+	0 kg from Foreshots Receiver		
	=	485 kg CO	=	**1,070 lb CO**

I. VOC Summary

Nafion Compound Name		Before Control Generated		After Control Stack Emissions	
				VOC lb/yr	HF lb/yr
		kg/yr	lb/yr		
A.	HFP	264	581	580	
B.	HFPO	194	428	427	
C.	HFPO-Dimer	76	168	0.67	0.04
D.	TFE	144	318	318	
E.	MAE	24	53	0.01	0.01
F.	EVE	3	7	7	
G.	Glycol Ethers	115	254	254	
	Total	**821**	**1,810**	**1,586**	**0.05**

J. Point Source Summary

	Nafion Compound Name	Stack Emissions lb/yr	Equipment Emissions (Note 1) lb/yr	Maintenance Emissions (Note 2) lb/yr	Total Emissions lb/yr
A.	HFP	580	23.1	7.7	611
B.	HFPO	427	17.1	5.7	450
C.	HFPO-Dimer	0.67	0.0	0.009	1
D.	TFE	318	12.7	4.2	334
E.	MAE	0	0.0	0.0	0
F.	EVE	7	0.3	0.1	7
G.	Glycol Ethers	254	10.1	3.4	268
H.	CO	1,070	0.0	0.0	1,070
K.	ADN	0	2,536.0	0	2,536
	Total	**2,657**	**63**	**21**	2,741

Note 1 - See section titled "Equipment Emissions" for details
Note 2 - See section titled "Maintenance Emissions" for details

HF Equivalent Emissions

	Nafion Compound Name	Stack Emissions lb/yr	Equipment Emissions lb/yr	Maintenance Emissions lb/yr	Total Emissions lb/yr
C.	HFPO-Dimer	0.04	0.002	0.001	0.04
E.	MAE	0	0.000	0.000	0
	Total	**0.05**	**0.002**	**0.001**	**0.06**

The estimated HF equivalent emissions from Equipment Emissions were determined by multiplying the HFPO-Dimer HF Potential (0.06 lb. HF/lb. HFPO-Dimer) by the HFPO-Dimer Equipment Emissions for the Compound

$$\frac{0.06 \ \text{lb/yr HF}}{\text{lb/yr HFPO-Dimer}} \times 0.03 \ \text{lb/yr Equipment HFPO-Dimer} = 0.002 \ \text{lb/yr HF}$$

The estimated HF equivalent emissions from Maintenance Emissions were determined by multiplying the HFPO-Dimer HF Potential (0.06 lb. HF/lb. HFPO-Dimer) by the HFPO-Dimer Maintenance Emissions for the Compound

$$\frac{0.06 \ \text{lb/yr HF}}{\text{lb/yr HFPO-Dimer}} \times 0.01 \ \text{lb/yr Maintenance HFPO-Dimer} = 0.001 \ \text{lb/yr HF}$$

2005 AIR EMISSIONS INVENTORY SUPPORTING DOCUMENTATION

Emission Source ID No: NS-B

Emission Source Description: VE-North PPVE Manufacturing Process

Process & Emission Description: The VE-North PPVE manufacturing process is a continuous chemical reaction. All emissions from the process are vented through the Nafion Division Waste Gas Scrubber (Control Device ID No. NCD-Hdr) which has a documented control efficiency of 99.6% for all acid fluoride compounds. Some emitted compounds are assumed to pass completely through the scrubber, so the control efficiency for those compounds is assumed to be 0%. The control of emissions of specific compounds will be addressed and detailed in the following pages.

The PPVE process in VE-North emits compounds in the acid fluoride family. In the presence of water (such as in atmospheric moisture), these acid fluorides can eventually hydrolyze to hydrogen fluoride. For the purpose of this emissions inventory, a conservative approach will be taken and the acid fluorides will be reported both as a VOC and as the equivalent quantity of hydrogen fluoride.

Basis and Assumptions:

- The PPVE process flowsheet is the basis for relative concentrations of before-control emissions of gaseous wastes.

- Calculations of point source emissions are based on actual vent flow totals taken from the IP21 Historian.

- All emission determination calculations are available on the EXCEL spreadsheet found at S:/Everyone/martinas/VEN Air Emissions 2005 Annual Summary.xls.

Point Source Emission Determination

A. Hexafluoropropylene (HFP) — CAS No. 116-15-4

HF Potential:

HFP is a VOC without the potential to form HF

Quantity Released

HFP is a byproduct present in the HFPO feed. It is an inert in VE-North that is vented to the WGS.

HFP vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0.05\ kg\ HFP}{2.35\ kg\ CondRx\ VentFlow}$

Vented from the Crude Receiver $\frac{0.01\ kg\ HFP}{3.97\ kg\ Crude\ Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0.01\ kg\ HFP}{1.06\ kg\ ForeshotsReceiver\ Vent}$

Vented from the Stripper $\frac{30\ kg\ HFP}{100\ kg\ Stripper\ Vent}$

HFP vented based on 6,034 kg total Condensation Reactor vent stream (22266FG).
HFP vented based on 9,245 kg total Crude Receiver vent stream (22701FG).
HFP vented based on 808 kg total Foreshots Receiver vent stream (22826FG).
HFP vented based on 8,860 kg total Stripper vent stream (22231FC).

HFP vented from Condensation Reactor:

$$\frac{0.05\ kg\ HFP}{2.35\ kg\ CndRx} \times 6{,}034\ kg\ CndRx = 140\ kg\ HFP$$

HFP vented from Crude Receiver

$$\frac{0.01\ kg\ HFP}{3.97\ kg\ CrRec} \times 9{,}245\ kg\ CrRec = 32\ kg\ HFP$$

HFP vented from Foreshots Receiver

$$\frac{0.01\ kg\ HFP}{1.06\ kg\ FsRec} \times 808\ kg\ FsRec = 7\ kg\ HFP$$

HFP vented from Stripper

$$\frac{30\ kg\ HFP}{100\ kg\ Strpr} \times 8{,}860\ kg\ Strpr = 2{,}658\ kg\ HFP$$

VOC Emissions

	140 kg from Condensation Reactor	
+	32 kg from Crude Receiver	
+	7 kg from Foreshots Receiver	
	2,658 kg from Stripper	
=	2,837 kg HFP	= 2,837 kg VOC
		6,254 lb VOC

B. Hexafluoropropylene oxide (HFPO) **CAS No. 428-59-1**

HF Potential:

HFPO is a VOC without the potential to form HF

Quantity Released

HFPO is a byproduct present in the HFPO feed. It is an inert in VE-North that is vented to the WGS.

HFPO vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0.11\ kg\ HFPO}{2.35\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0\ kg\ HFPO}{3.97\ kg\ Crude\ Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0\ kg\ HFPO}{1.06\ kg\ ForeshotsReceiver\ Vent}$

Vented from the Stripper $\frac{60\ kg\ HFPO}{100\ kg\ Stripper\ Vent}$

HFPO vented based on 6,034 kg total Condensation Reactor vent stream (22266FG).
HFPO vented based on 9,245 kg total Crude Receiver vent stream (22701FG).
HFPO vented based on 808 kg total Foreshots Receiver vent stream (22826FG).
HFP vented based on 8,860 kg total Stripper vent stream (22231FC).

HFPO vented from Condensation Reactor:

$\frac{0.11\ kg\ HFPO}{2.35\ kg\ CndRx}$ x 6,034 kg CndRx = 292 kg HFPO

HFPO vented from Crude Receiver

$\frac{0.00\ kg\ HFPO}{3.97\ kg\ CrRec}$ x 9,245 kg CrRec = 0 kg HFPO

HFPO vented from Foreshots Receiver

$\frac{0.00\ kg\ HFPO}{1.06\ kg\ FsRec}$ x 808 kg FsRec = 0 kg HFPO

HFP vented from Stripper

$\frac{60\ kg\ HFPO}{100\ kg\ Strpr}$ x 8,860 kg Strpr = 5,316 kg HFPO

VOC Emissions

		292 kg from Condensation Reactor		
	+	0 kg from Crude Receiver		
	+	0 kg from Foreshots Receiver		
	+	5,316 kg from Stripper		
=		5,608 kg HFPO	=	5,608 kg VOC
				12,362 lb VOC

C. Perfluoropropionyl fluoride (PPF) **CAS No. 422-61-7**

HF Potential:

Each mole of PPF (MW = 166) can generate 1 mole of HF (MW = 20).

$$1\,kg\,PPF \cdot \frac{1\,mole PPF}{166 g\,PPF} \cdot \frac{20 g\,HF}{1\,mole HF} \cdot \frac{1\,mole HF}{1\,mole PPF} = 0.120 kg\,HF$$

Therefore, each 1 kg of PPF generates 0.120 kg of HF

Quantity Released

Before-control PPF vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{2.14\ kg\ PPF}{2.35\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0\ kg\ PPF}{3.97\ kg\ Crude\ Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0\ kg\ PPF}{1.06\ kg\ ForeshotsReceiver\ Vent}$

Vented from the Stripper $\frac{10\ kg\ PPF}{100\ kg\ Stripper\ Vent}$

PPF vented based on 6,034 kg total Condensation Reactor vent stream (22266FG).
PPF vented based on 9,245 kg total Crude Receiver vent stream (22701FG).
PPF vented based on 808 kg total Foreshots Receiver vent stream (22826FG).
PPF vented based on 8,860 kg total Stripper vent stream (22231FC).

Before control PPF vented from Condensation Reactor:

$\frac{2.14\ kg\ PPF}{2.35\ kg\ CndRx}$ x 6,034 kg CndRx = 5,485 kg PPF

PPF vented from Crude Receiver

$\frac{0.00\ kg\ PPF}{3.97\ kg\ CrRec}$ x 9,245 kg CrRec = 0 kg PPF

PPF vented from Foreshots Receiver

$\frac{0.00\ kg\ PPF}{1.06\ kg\ FsRec}$ x 808 kg FsRec = 0 kg PPF

PPF vented from Stripper

$\frac{10\ kg\ PPF}{100\ kg\ Strpr}$ x 8,860 kg Strpr = 886 kg PPF

Total before-control PPF vented = 6,371 kg PPF

After-control emissions utilizing the 99.6% control efficient Waste Gas Scrubber (WGS):

VOC Emissions

		6,371 kg PAF		
Waste Gas Scrubber	x	(100%-99.6%)		
	=	25 kg PAF	=	25 kg VOC
			=	**56 lb. VOC**

HF Equivalent Emissions

	25 kg PAF		
x	0.120 kg HF/kg PAF		
=	3 kg HF	=	**6.8 lb. HF**

D. Tetrafluoroethylene (TFE) **CAS No. 116-14-3**

HF Potential:

TFE is a VOC without the potential to form HF

Quantity Released

TFE is a byproduct present in the TFE feed. It is an inert in VE-North that is vented to the WGS.

TFE vented per the process flowsheet

Vented from the Condensation Reactor: $\dfrac{0 \; kg \; TFE}{2.35 \; kg \; Cond \; Rx \; Vent \; Flow}$

Vented from the Crude Receiver $\dfrac{2.17 \; kg \; TFE}{3.97 \; kg \; Crude \; Receiver \; Vent}$

Vented from the Foreshots Receiver $\dfrac{0.0045 \; kg \; TFE}{1.06 \; kg \; Foreshots Receiver Vent}$

Vented from the Stripper $\dfrac{0 \; kg \; TFE}{100 \; kg \; Stripper \; Vent}$

TFE vented based on 6,034 kg total Condensation Reactor vent stream (22266FG).
TFE vented based on 9,245 kg total Crude Receiver vent stream (22701FG).
TFE vented based on 808 kg total Foreshots Receiver vent stream (22826FG).
TFE vented based on 8,860 kg total Stripper vent stream (22231FC).

TFE vented from Condensation Reactor:

0.00 / 2.35 kg TFE / kg CndRx	x	6,034 kg CndRx	=	0 kg TFE

TFE vented from Crude Receiver

2.17 / 3.97 kg TFE / kg CrRec	x	9,245 kg CrRec	=	5,051 kg TFE

TFE vented from Foreshots Receiver

0.0045 / 1.06 kg TFE / kg FsRec	x	808 kg FsRec	=	3 kg TFE

TFE vented from Stripper

0 kg TFE / 100 kg Strpr	x	8,860 kg Strpr	=	0 kg TFE

VOC Emissions

		0 kg from Condensation Reactor		
	+	5,051 kg from Crude Receiver		
	+	3 kg from Foreshots Receiver		
	+	0 kg from Stripper		
=		5,055 kg TFE	=	5,055 kg VOC
				11,144 lb VOC

E. Perfluoropropyl vinyl ether (PPVE) **CAS No. 1623-5-8**

HF Potential:

PPVE is a VOC without the potential to form HF

Quantity Released

PPVE vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0 \text{ kg PPVE}}{2.35 \text{ kg Cond Rx Vent Flow}}$

Vented from the Crude Receiver $\frac{0.50 \text{ kg PPVE}}{3.97 \text{ kg Crude Receiver Vent}}$

Vented from the Foreshots Receiver $\frac{0.88 \text{ kg PPVE}}{1.06 \text{ kg ForeshotsReceiverVent}}$

Vented from the Stripper $\frac{0 \text{ kg PPVE}}{100 \text{ kg Stripper Vent}}$

PPVE vented based on	6,034 kg total Condensation Reactor vent stream (22266FG).
PPVE vented based on	9,245 kg total Crude Receiver vent stream (22701FG).
PPVE vented based on	808 kg total Foreshots Receiver vent stream (22826FG).
PPVE vented based on	8,860 kg total Stripper vent stream (22231FC).

PPVE vented from Condensation Reactor:

$$\frac{0.00 \text{ kg PPVE}}{2.35 \text{ kg CndRx}} \times 6{,}034 \text{ kg CndRx} = 0 \text{ kg PPVE}$$

PPVE vented from Crude Receiver

$$\frac{0.50 \text{ kg PPVE}}{3.97 \text{ kg CrRec}} \times 9{,}245 \text{ kg CrRec} = 1{,}175 \text{ kg PPVE}$$

PPVE vented from Foreshots Receiver

$$\frac{0.88 \text{ kg PPVE}}{1.06 \text{ kg FsRec}} \times 808 \text{ kg FsRec} = 670 \text{ kg PPVE}$$

PPVE vented from Stripper

$$\frac{0 \text{ kg PPVE}}{100 \text{ kg Strpr}} \times 8{,}860 \text{ kg Strpr} = 0 \text{ kg PPVE}$$

VOC Emissions

		0 kg from Condensation Reactor		
	+	1,175 kg from Crude Receiver		
	+	670 kg from Foreshots Receiver		
	+	0 kg from Stripper		
=		1,845 kg PPVE	=	1,845 kg VOC
				4,068 lb VOC

F. Perfluoro-2-butene (C4) **CAS No. 360-89-4**

HF Potential:

C4s are VOCs without the potential to form HF

Quantity Released

C4s are perfluorobutenes that are byproducts from the Agitated Bed Reactor system.
They are inerts in VE-North that is vented to the WGS.

C4s vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0\ kg\ C4s}{2.35\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0.01\ kg\ C4s}{3.97\ kg\ Crude\ Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0.15\ kg\ C4s}{1.06\ kg\ Foreshots\ Receiver\ Vent}$

Vented from the Stripper $\frac{0\ kg\ C4s}{100\ kg\ Stripper\ Vent}$

C4s vented based on	6,034 kg total Condensation Reactor vent stream (22266FG).
C4s vented based on	9,245 kg total Crude Receiver vent stream (22701FG).
C4s vented based on	808 kg total Foreshots Receiver vent stream (22826FG).
C4s vented based on	8,860 kg total Stripper vent stream (22231FC).

C4s vented from Condensation Reactor:

$$\frac{0.00\ kg\ C4s}{2.35\ kg\ CndRx} \times 6{,}034\ kg\ CndRx = 0\ kg\ C4s$$

C4s vented from Crude Receiver

$$\frac{0.01\ kg\ C4s}{3.97\ kg\ CrRec} \times 9{,}245\ kg\ CrRec = 21\ kg\ C4s$$

C4s vented from Foreshots Receiver

$$\frac{0.15\ kg\ C4s}{1.06\ kg\ FsRec} \times 808\ kg\ FsRec = 114\ kg\ C4s$$

C4s vented from Stripper

$$\frac{0\ kg\ C4s}{100\ kg\ Strpr} \times 8{,}860\ kg\ Strpr = 0\ kg\ C4s$$

VOC Emissions

		0 kg from Condensation Reactor		
	+	21 kg from Crude Receiver		
	+	114 kg from Foreshots Receiver		
	+	0 kg from Stripper		
=		135 kg C4s	=	135 kg VOC
				298 lb VOC

G. Perfluoropentene (C5)

CAS No. 376-87-4

HF Potential:

C5s are VOCs without the potential to form HF

Quantity Released

C5s are perfluorobutenes that are byproducts from the Agitated Bed Reactor system.
They are inerts in VE-North that are vented to the WGS.

C5s vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0\ kg\ C5s}{2.35\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0\ kg\ C5s}{3.97\ kg\ Crude\ Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0.02\ kg\ C5s}{1.06\ kg\ Foreshots Receiver\ Vent}$

Vented from the Stripper $\frac{0\ kg\ C5s}{100\ kg\ Stripper\ Vent}$

C5s vented based on	6,034	kg total Condensation Reactor vent stream (22266FG).
C5s vented based on	9,245	kg total Crude Receiver vent stream (22701FG).
C5s vented based on	808	kg total Foreshots Receiver vent stream (22826FG).
C5s vented based on	8,860	kg total Stripper vent stream (22231FC).

C5s vented from Condensation Reactor:

$\frac{0.00\ kg\ C5s}{2.35\ kg\ CndRx}$ x 6,034 kg CndRx = 0 kg C5s

C5s vented from Crude Receiver

$\frac{0.00\ kg\ C5s}{3.97\ kg\ CrRec}$ x 9,245 kg CrRec = 0 kg C5s

C5s vented from Foreshots Receiver

$\frac{0.02\ kg\ C5s}{1.06\ kg\ FsRec}$ x 808 kg FsRec = 14 kg C5s

C4s vented from Stripper

$\frac{0\ kg\ C5s}{100\ kg\ Strpr}$ x 8,860 kg Strpr = 0 kg C5s

VOC Emissions

		0 kg from Condensation Reactor		
	+	0 kg from Crude Receiver		
	+	14 kg from Foreshots Receiver		
	+	0 kg from Stripper		
=		14 kg C5s	=	14 kg VOC
				30 lb VOC

H. Carbon Monoxide (CO)

CAS No. 630-08-0

HF Potential:
CO can not form HF

Quantity Released

CO is a byproduct from the Agitated Bed Reactor system.
They are inerts in VE-North that are vented to the WGS.

CO vented per the process flowsheet

Vented from the Condensation Reactor: $\dfrac{0\ kg\ CO}{2.35\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\dfrac{1.27\ kg\ CO}{3.97\ kg\ Crude\ Receiver\ Vent}$

Vented from the Foreshots Receiver $\dfrac{0\ kg\ CO}{1.06\ kg\ ForeshotsReceiverVent}$

Vented from the Stripper $\dfrac{0\ kg\ CO}{100\ kg\ Stripper\ Vent}$

CO vented based on	6,034 kg total Condensation Reactor vent stream (22266FG).
CO vented based on	9,245 kg total Crude Receiver vent stream (22701FG).
CO vented based on	808 kg total Foreshots Receiver vent stream (22826FG).
CO vented based on	8,860 kg total Stripper vent stream (22231FC).

CO vented from Condensation Reactor:

$$\frac{0.00\ kg\ CO}{2.35\ kg\ CndRx} \times 6{,}034\ kg\ CndRx = 0\ kg\ CO$$

CO vented from Crude Receiver

$$\frac{1.27\ kg\ CO}{3.97\ kg\ CrRec} \times 9{,}245\ kg\ CrRec = 2{,}965\ kg\ CO$$

CO vented from Foreshots Receiver

$$\frac{0.00\ kg\ CO}{1.06\ kg\ FsRec} \times 808\ kg\ FsRec = 0\ kg\ CO$$

CO vented from Stripper

$$\frac{0\ kg\ CO}{100\ kg\ Strpr} \times 8{,}860\ kg\ Strpr = 0\ kg\ CO$$

CO Emissions

		0 kg from Condensation Reactor		
	+	2,965 kg from Crude Receiver		
	+	0 kg from Foreshots Receiver		
	+	0 kg from Stripper		
=		2,965 kg CO	=	**6,537 lb CO**

I. VOC Summary

Nafion Compound Name		Before Control Generated		After Control Stack Emissions	
				VOC	HF
		kg/yr	lb/yr	lb/yr	lb/yr
A.	HFP	2,837	6,254	6,254	
B.	HFPO	5,608	12,362	12,362	
C.	PPF	6,371	14,046	56	6.8
D.	TFE	5,055	11,144	11,144	
E.	PPVE	1,845	4,068	4,068	
F.	C4	135	298	298	
G.	C5	14	30	30	
	Total	21,864	48,202	**34,212**	**6.8**

J. Point Source Summary

Nafion Compound Name		Stack Emissions lb/yr	Equipment Emissions (Note 1) lb/yr	Maintenance Emissions (Note 2) lb/yr	Total Emissions lb/yr
A.	HFP	6,254	249.6	82.8	6,586
B.	HFPO	12,362	493.4	163.7	13,019
C.	PPF	56	2.2	0.7	59
D.	TFE	11,144	444.8	147.5	11,736
E.	PPVE	4,068	162.4	53.9	4,284
F.	C4	298	11.9	3.9	314
G.	C5	30	1.2	0.4	32
H.	CO	6,537	0.0	0.0	6,537
K.	AN	0	6,675.8	0.0	6,676
	Total	**40,749**	**1,366**	**453**	**42,567**

Note 1 - See section titled "Equipment Emissions" for details
Note 2 - See section titled "Maintenance Emissions" for details

HF Equivalent Emissions

Nafion Compound Name		Stack Emissions lb/yr	Equipment Emissions lb/yr	Maintenance Emissions lb/yr	Total Emissions lb/yr
C.	PPF	6.8	0.27	0.09	7.13
	Total	**6.8**	**0.27**	**0.09**	**7.13**

The estimated HF equivalent emissions from Equipment Emissions were determined by multiplying the PPF HF Potential (0.12 lb. HF/lb. PPF) by the PPF Equipment Emissions (4.22 lb./yr) for the Compound

$$0.12 \ \frac{\text{lb/yr HF}}{\text{lb/yr PPF}} \times 2.24 \ \text{lb/yr Equipment PPF} = 0.270 \ \text{lb/yr HF}$$

The estimated HF equivalent emissions from Maintenance Emissions were determined by multiplying the PPF HF Potential (0.12 lb. HF/lb. PPF) by the PPF Maintenance Emissions (0.13 lb./yr) for the Compound

$$0.12 \ \frac{\text{lb/yr HF}}{\text{lb/yr PPF}} \times 0.74 \ \text{lb/yr Maintenance PPF} = 0.090 \ \text{lb/yr HF}$$

2005 AIR EMISSIONS INVENTORY SUPPORTING DOCUMENTATION

Emission Source ID No: NS-B

Emission Source Description: VE-North PSEPVE Manufacturing Process

Process & Emission Description: The VE-North PSEPVE manufacturing process is a continuous chemical reaction. All emissions from the process are vented through the Nafion Division Waste Gas Scrubber (Control Device ID No. NCD-Hdr) which has a documented control efficiency of 99.6% for all acid fluoride compounds. Some emitted compounds are assumed to pass completely through the scrubber, so the control efficiency for those compounds is assumed to be 0%. The control of emissions of specific compounds will be addressed and detailed in the following pages.

The PSEPVE process in VE-North emits compounds in the acid fluoride family. In the presence of water (such as in atmospheric moisture), these acid fluorides can eventually hydrolyze to hydrogen fluoride. For the purpose of this emissions inventory, a conservative approach will be taken and the acid fluorides will be reported both as a VOC and as the equivalent quantity of hydrogen fluoride.

Basis and Assumptions:

- The PSEPVE process flowsheet is the basis for relative concentrations of before-control emissions of gaseous wastes.

- Calculations of point source emissions are based on actual vent flow totals taken from the IP21 Historian.

- All emission determination calculations are available on the EXCEL spreadsheet found at S:/Everyone/martinas/VEN Air Emissions 2005 Annual Summary.xls.

Point Source Emission Determination

A. HFP **CAS No. 116-15-4**
Hexafluoropropylene

HF Potential:

HFP is a VOC without the potential to form HF

Quantity Released

HFP is a byproduct present in the HFPO feed. It is an inert in VE-North that is vented to the WGS.

HFP vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0.15\,kg\,HFP}{3.66\,kg\,CondRxVentFlow}$

Vented from the Crude Receiver $\frac{3.12\,kg\,HFP}{18.76\,kg\,Crude\,Receiver\,Vent}$

Vented from the Foreshots Receiver $\frac{0\,kg\,HFP}{0.33\,kg\,ForeshotsReceiverVent}$

HFP vented based on 740 kg total Condensation Reactor vent stream (22266FG).
HFP vented based on 24,218 kg total Crude Receiver vent stream (22701FG).
HFP vented based on 43 kg total Foreshots Receiver vent stream (22826FG).

HFP vented from Condensation Reactor:

$$\frac{0.15\text{ kg HFP}}{3.66\text{ kg CndRx}} \times 740\text{ kg CndRx} = 29\text{ kg HFP}$$

HFP vented from Crude Receiver

$$\frac{3.12\text{ kg HFP}}{18.76\text{ kg CrRec}} \times 24{,}218\text{ kg CrRec} = 4{,}025\text{ kg HFP}$$

HFP vented from Foreshots Receiver

$$\frac{0.00\text{ kg HFP}}{0.33\text{ kg FsRec}} \times 43\text{ kg FsRec} = 0\text{ kg HFP}$$

VOC Emissions

	29 kg from Condensation Reactor		
+	4,025 kg from Crude Receiver		
+	0 kg from Foreshots Receiver		
=	4,054 kg HFP	=	4,054 kg VOC
			8,919 lb VOC

B. HFPO **CAS No. 428-59-1**
Hexafluoropropylene oxide

HF Potential:

HFPO is a VOC without the potential to form HF

Quantity Released

HFPO is a byproduct present in the HFPO feed. It is an inert in VE-North that is vented to the WGS.

HFPO vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{3.28\ kg\ HFPO}{3.66\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0\ kg\ HFPO}{18.76\ kg\ Crude Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0\ kg\ HFPO}{0.33\ kg\ Foreshots Receiver Vent}$

HFPO vented based on	740 kg total Condensation Reactor vent stream (22266FG).
HFPO vented based on	24,218 kg total Crude Receiver vent stream (22701FG).
HFPO vented based on	43 kg total Foreshots Receiver vent stream (22826FG).

HFPO vented from Condensation Reactor:
$$\frac{3.28\ \text{kg HFPO}}{3.66\ \text{kg CndRx}} \times 740\ \text{kg CndRx} = 663\ \text{kg HFPO}$$

HFPO vented from Crude Receiver
$$\frac{0.00\ \text{kg HFPO}}{18.76\ \text{kg CrRec}} \times 24{,}218\ \text{kg CrRec} = 0\ \text{kg HFPO}$$

HFPO vented from Foreshots Receiver
$$\frac{0.00\ \text{kg HFPO}}{0.33\ \text{kg FsRec}} \times 43\ \text{kg FsRec} = 0\ \text{kg HFPO}$$

VOC Emissions

	663 kg from Condensation Reactor		
+	0 kg from Crude Receiver		
+	0 kg from Foreshots Receiver		
=	663 kg HFPO	=	663 kg VOC
			1,458 lb VOC

C. PPF **CAS No. 422-61-7**
Perfluoropropionyl fluoride

HF Potential:

Each mole of PPF (MW = 166) can generate 1 mole of HF (MW = 20).

$$1\,kg\,PPF \cdot \frac{1\,molePPF}{166\,g\,PPF} \cdot \frac{20\,g\,HF}{1\,moleHF} \cdot \frac{1\,moleHF}{1\,molePPF} = 0.120\,kg\,HF$$

Therefore, each 1 kg of PPF generates 0.120 kg of HF

Quantity Released

Before-control PPF vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0.20\ kg\ PPF}{3.66\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0\ kg\ PPF}{18.76\ kg\ Crude\ Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0\ kg\ PPF}{0.33\ kg\ Foreshots\ Receiver\ Vent}$

PPF vented based on 740 kg total Condensation Reactor vent stream (22266FG).
PPF vented based on 24,218 kg total Crude Receiver vent stream (22701FG).
PPF vented based on 43 kg total Foreshots Receiver vent stream (22826FG).

Before control PPF vented from Condensation Reactor:

$\frac{0.20\ kg\ PPF}{3.66\ kg\ CndRx}$ x 740 kg CndRx = 41 kg PPF

PPF vented from Crude Receiver

$\frac{0.00\ kg\ PPF}{18.76\ kg\ CrRec}$ x 24,218 kg CrRec = 0 kg PPF

PPF vented from Foreshots Receiver

$\frac{0.00\ kg\ PPF}{0.33\ kg\ FsRec}$ x 43 kg FsRec = 0 kg PPF

Total before-control PPF vented = 41 kg PPF

After-control emissions utilizing the 99.6% control efficient Waste Gas Scrubber (WGS):

VOC Emissions

Waste Gas Scrubber
41 kg PPF
x (100%-99.6%) Control Efficiency
= 0.17 kg PAF = **0.17** kg VOC
= **0.36** **lb. VOC**

HF Equivalent Emissions

0 kg PPF
x 0.120 kg HF/kg PPF
= 0.02 kg HF **0.04 lb. HF**

D. TFE **CAS No. 116-14-3**
Tetrafluoroethylene

HF Potential:

TFE is a VOC without the potential to form HF

Quantity Released

TFE is a byproduct present in the TFE feed. It is an inert in VE-North that is vented to the WGS.

TFE vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0\ kg\ TFE}{3.66\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0.01\ kg\ TFE}{18.76\ kg\ Crude Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0\ kg\ TFE}{0.33\ kg\ Foreshots Receiver Vent}$

TFE vented based on 740 kg total Condensation Reactor vent stream (22266FG).
TFE vented based on 24,218 kg total Crude Receiver vent stream (22701FG).
TFE vented based on 43 kg total Foreshots Receiver vent stream (22826FG).

TFE vented from Condensation Reactor:

0.00 / 3.66 kg TFE / kg CndRx	x	740 kg CndRx	=	0 kg TFE

TFE vented from Crude Receiver

0.01 / 18.76 kg TFE / kg CrRec	x	24,218 kg CrRec	=	12 kg TFE

TFE vented from Foreshots Receiver

0.00 / 0.33 kg TFE / kg FsRec	x	43 kg FsRec	=	0 kg TFE

VOC Emissions

		0 kg from Condensation Reactor			
	+	12 kg from Crude Receiver			
	+	0 kg from Foreshots Receiver			
=		12 kg TFE	=	12 kg VOC	
				26 lb VOC	

E. PSEPVE **CAS No. 1623-5-8**

Perfluoro-2-(2-Fluorosulfonylethoxy) Propyl Vinyl Ether

HF Potential:

PSEPVE is a VOC without the potential to form HF

Quantity Released

PSEPVE vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0\ kg\ PSEPVE}{3.66\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0\ kg\ PSEPVE}{18.76\ kg\ Crude Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0.07\ kg\ PSEPVE}{0.33\ kg\ Foreshots Receiver Vent}$

PSEPVE vented based on 740 kg total Condensation Reactor vent stream (22266FG).
PSEPVE vented based on 24,218 kg total Crude Receiver vent stream (22701FG).
PSEPVE vented based on 43 kg total Foreshots Receiver vent stream (22826FG).

PSEPVE vented from Condensation Reactor:

0.00 / 3.66 kg PSEPVE / kg CndRx	x	740 kg CndRx	=	0 kg PSEPVE

PSEPVE vented from Crude Receiver

0.00 / 18.76 kg PSEPVE / kg CrRec	x	24,218 kg CrRec	=	0 kg PSEPVE

PSEPVE vented from Foreshots Receiver

0.07 / 0.33 kg PSEPVE / kg FsRec	x	43 kg FsRec	=	8.78 kg PSEPVE

VOC Emissions

		0 kg from Condensation Reactor		
	+	0 kg from Crude Receiver		
	+	8.78 kg from Foreshots Receiver		
=		8.78 kg PSEPVE	=	8.78 kg VOC
				19.31 lb VOC

F. C4 **CAS No. 360-89-4**
Perfluoro-2-butene

HF Potential:

C4s are VOCs without the potential to form HF

Quantity Released

C4s are perfluorobutenes that are byproducts from the Agitated Bed Reactor system.
They are inerts in VE-North that is vented to the WGS.

C4s vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0 \; kg \; C4}{3.66 \; kg \; Cond \; Rx \; Vent \; Flow}$

Vented from the Crude Receiver $\frac{0.46 \; kg \; C4}{18.76 \; kg \; Crude Receiver \; Vent}$

Vented from the Foreshots Receiver $\frac{0.10 \; kg \; C4}{0.33 \; kg \; Foreshots Receiver Vent}$

C4s vented based on 740 kg total Condensation Reactor vent stream (22266FG).
C4s vented based on 24,218 kg total Crude Receiver vent stream (22701FG).
C4s vented based on 43 kg total Foreshots Receiver vent stream (22826FG).

C4s vented from Condensation Reactor:
0.00 / 3.66 kg C4s / kg CndRx x 740 kg CndRx = 0 kg C4s

C4s vented from Crude Receiver
0.46 / 18.76 kg C4s / kg CrRec x 24,218 kg CrRec = 593 kg C4s

C4s vented from Foreshots Receiver
0.10 / 0.33 kg C4s / kg FsRec x 43 kg FsRec = 12 kg C4s

VOC Emissions

		0 kg from Condensation Reactor	
	+	593 kg from Crude Receiver	
	+	12 kg from Foreshots Receiver	
=		605 kg C4s	= 605 kg VOC
			1,331 lb VOC

G. HFPO Trimer **CAS No. 2641-34-1**
Perfluoro-2,5-Dimethyl-3,6-Dioxanonanoyl

HF Potential:

Each mole of HFPO Trimer (MW = 498) can generate 1 mole of HF (MW = 20).

$$1\,kg\,MA \cdot \frac{1\,mole Trimer}{498\,g\,Trimer} \cdot \frac{20\,g\,HF}{1\,mole HF} \cdot \frac{1\,mole HF}{1\,mole Trimer} = 0.0402 kg\,HF$$

Therefore, each 1 kg of HFPO Trimer generates 0.040 kg of HF

Quantity Released

HFPO Trimer is a byproduct formed in the Condensation Reactor system.

HFPO Trimer vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0\ kg\ HFPO\ Trimer}{3.66\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver: $\frac{0\ kg\ HFPO Trimer}{18.76\ kg\ Crude Receiver\ Vent}$

Vented from the Foreshots Receiver: $\frac{0.01\ kg\ HFPO\ Trimer}{0.33\ kg\ Foreshots Receiver\ Vent}$

HFPO Trimer vented based on 740 kg total Condensation Reactor vent stream (22266FG).
HFPO Trimer vented based on 24,218 kg total Crude Receiver vent stream (22701FG).
HFPO Trimer vented based on 43 kg total Foreshots Receiver vent stream (22826FG).

Before control HFPO Trimer vented from Condensation Reactor:

$\frac{0.00}{3.66}$ kg HFPO Trimer / kg CndRx x 740 kg CndRx = 0 kg HFPO Trimer

HFPO Trimer vented from Crude Receiver

$\frac{0.00}{18.76}$ kg HFPO Trimer / kg CrRec x 24,218 kg CrRec = 0 kg HFPO Trimer

HFPO Trimer vented from Foreshots Receiver

$\frac{0.01}{0.33}$ kg HFPO Trimer / kg FsRec x 43 kg FsRec = 1.76 kg HFPO Trimer

Total before-control HFPO Trimer vented 1.76 kg VOC

After-control emissions utilizing the 99.6% control efficient Waste Gas Scrubber (WGS):

VOC Emissions

		1.76	kg HFPO Trimer	
Waste Gas Scrubber	x	(100%-99.6%)	Control Efficiency	
	=	0.0070	kg HFPO Trimer	= 0.0070 kg VOC
				= **0.015 lb. VOC**

HF Equivalent Emissions

	0.0070	kg HFPO Trimer	
x	0.040	kg HF/kg HFPO Trimer	
=	0.00028	kg HF	**0.00062 lb. HF**

H. Monoadduct (MA) **CAS No. 4089-57-0**
Tetrafluoro-2-[Tetrafluoro-2-(Fluorosulfonyl)Ethoxy]-Propanoyl Fluoride

HF Potential:

Each mole of MA (MW = 346) can generate 1 mole of HF (MW = 20).

$$1\,kg\,MA \cdot \frac{1\,mole\,MA}{346\,g\,MA} \cdot \frac{20\,g\,HF}{1\,mole\,HF} \cdot \frac{1\,mole\,HF}{1\,mole\,MA} = 0.058\,kg\,HF$$

Therefore, each 1 kg of MA generates 0.058 kg of HF

Quantity Released

Before-control MA vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0\ kg\ MA}{3.66\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0\ kg\ MA}{18.76\ kg\ Crude\,Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0.0045\,kg\ MA}{0.33\ kg\ Foreshots\,Receiver\,Vent}$

MA vented based on 740 kg total Condensation Reactor vent stream (22266FG).
MA vented based on 24,218 kg total Crude Receiver vent stream (22701FG).
MA vented based on 43 kg total Foreshots Receiver vent stream (22826FG).

Before control MA vented from Condensation Reactor:

$\frac{0.00\ kg\ MA}{3.66\ kg\ CndRx}$ x 740 kg CndRx = 0 kg MA

MA vented from Crude Receiver

$\frac{0.00\ kg\ MA}{18.76\ kg\ CrRec}$ x 24,218 kg CrRec = 0 kg MA

MA vented from Foreshots Receiver

$\frac{0.0045\ kg\ MA}{0.33\ kg\ FsRec}$ x 43 kg FsRec = 0.585 kg MA

Total before-control MA vented = 0.585 kg MA

After-control emissions utilizing the 99.6% control efficient Waste Gas Scrubber (WGS):

VOC Emissions

		0.585 kg MA	
Waste Gas Scrubber	x	(100%-99.6%) Control Efficiency	
	=	0.00234 kg MA	= 0.00234 kg VOC
			= **0.005 lb. VOC**

HF Equivalent Emissions

	0.00234 kg MA	
x	0.058 kg HF/kg MA	
=	0.00 kg HF	**0.00 lb. HF**

I. Diadduct (DA) **CAS No. 4089-58-1**

Tetrafluoro-2[Hexafluoro-2-(Tetrafluoro-2-{Fluorosulfonyl}Ethoxy) Propoxy Propionyl Fluoride

HF Potential:

Each mole of DA (MW = 512) can generate 1 mole of HF (MW = 20).

$$1\,kg\,MA \cdot \frac{1\,mole\,DA}{512\,g\,DA} \cdot \frac{20\,g\,HF}{1\,mole\,HF} \cdot \frac{1\,mole\,HF}{1\,mole\,DA} = 0.039\,kg\,HF$$

Therefore, each 1 kg of DA generates 0.039 kg of HF

Quantity Released

Before-control DA vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0\ kg\ DA}{3.66\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0\ kg\ DA}{18.76\ kg\ Crude\,Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0.13\ kg\ DA}{0.33\ kg\ Foreshots\,Receiver\,Vent}$

DA vented based on 740 kg total Condensation Reactor vent stream (22266FG).
DA vented based on 24,218 kg total Crude Receiver vent stream (22701FG).
DA vented based on 43 kg total Foreshots Receiver vent stream (22826FG).

Before control DA vented from Condensation Reactor:

$\frac{0.00\ kg\ DA}{3.66\ kg\ CndRx}$ x 740 kg CndRx = 0 kg DA

DA vented from Crude Receiver

$\frac{0.00\ kg\ DA}{18.76\ kg\ CrRec}$ x 24,218 kg CrRec = 0 kg DA

DA vented from Foreshots Receiver

$\frac{0.13\ kg\ DA}{0.33\ kg\ FsRec}$ x 43 kg FsRec = 16.97 kg DA

Total before-control DA vented = 16.97 kg DA

After-control emissions utilizing the 99.6% control efficient Waste Gas Scrubber (WGS):

VOC Emissions

Waste Gas Scrubber		16.97 kg DA		
	x	(100%-99.6%) Control Efficiency		
	=	0.0679 kg DA	=	0.068 kg VOC
			=	**0.150 lb. VOC**

HF Equivalent Emissions

	0.0679 kg DA		
x	0.039 kg HF/kg DA		
=	0.00265 kg HF	=	**0.01 lb. HF**

J. Hydro PSEPVE **CAS No. 755-02-9**
Tetrafluoro-2-[Trifluoro-2-(1;2,2,2-Tetra-fluoroethoxy)-1-(Trifluoromethyl) Ethoxy]-Ethane Sulfonyl Fluoride

HF Potential:

Hydro-PSEPVE is a VOC without the potential to form HF

Quantity Released

Hydro-PSEPVE vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0\ kg\ Hydro-PSEPVE}{3.66\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0\ kg\ Hydro-PSEPVE}{18.76\ kg\ Crude Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0.0045\ kg\ Hydro-PSEPVE}{0.33\ kg\ ForeshotsReceiverVent}$

Hydro-PSEPVE vented based on 740 kg total Condensation Reactor vent stream (22266FG).
Hydro-PSEPVE vented based on 24,218 kg total Crude Receiver vent stream (22701FG).
Hydro-PSEPVE vented based on 43 kg total Foreshots Receiver vent stream (22826FG).

Hydro-PSEPVE vented from Condensation Reactor:

$\frac{0.00\ kg\ Hydro\text{-}PSEPVE}{3.66\ kg\ CndRx}$ x 740 kg CndRx = 0 kg Hydro-PSEPVE

Hydro-PSEPVE vented from Crude Receiver

$\frac{0.00\ kg\ Hydro\text{-}PSEPVE}{18.76\ kg\ CrRec}$ x 24,218 kg CrRec = 0 kg Hydro-PSEPVE

Hydro-PSEPVE vented from Foreshots Receiver

$\frac{0.0045\ kg\ Hydro\text{-}PSEPVE}{0.33\ kg\ FsRec}$ x 43 kg FsRec = 0.585 kg Hydro-PSEPVE

VOC Emissions

	0 kg from Condensation Reactor			
+	0 kg from Crude Receiver			
+	0.585 kg from Foreshots Receiver			
=	0.585 kg Hydro-PSEPV	=	0.585 kg VOC	
			1.287 lb VOC	

K. Iso-PSEPVE — CAS No. 34805-58-8

Perfluoro-1-Methyl-2-(2 Fluorosulfonyl Ethoxy) Ethyl Vinyl Ether

HF Potential:

Iso-PSEPVE is a VOC without the potential to form HF

Quantity Released

Iso-PSEPVE vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0\ kg\ Iso-PSEPVE}{3.66\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{0\ kg\ Iso-PSEPVE}{18.76\ kg\ Crude\ Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0.014\ kg\ Iso-PSEPVE}{0.014\ kg\ Foreshots\ Receiver\ Vent}$

Iso-PSEPVE vented based on 740 kg total Condensation Reactor vent stream (22266FG).
Iso-PSEPVE vented based on 24,218 kg total Crude Receiver vent stream (22701FG).
Iso-PSEPVE vented based on 43 kg total Foreshots Receiver vent stream (22826FG).

Iso-PSEPVE vented from Condensation Reactor:

$\frac{0.00\ kg\ Iso\text{-}PSEPVE}{3.66\ kg\ CndRx} \times 740\ kg\ CndRx = 0\ kg\ Iso\text{-}PSEPVE$

Iso-PSEPVE vented from Crude Receiver

$\frac{0.00\ kg\ Iso\text{-}PSEPVE}{18.76\ kg\ CrRec} \times 24{,}218\ kg\ CrRec = 0\ kg\ Iso\text{-}PSEPVE$

Iso-PSEPVE vented from Foreshots Receiver

$\frac{0.014\ kg\ Iso\text{-}PSEPVE}{0.33\ kg\ FsRec} \times 43\ kg\ FsRec = 1.755\ kg\ Iso\text{-}PSEPVE$

VOC Emissions

	0 kg from Condensation Reactor		
+	0 kg from Crude Receiver		
+	1.755 kg from Foreshots Receiver		
=	1.755 kg Iso-PSEPVE	=	1.755 kg VOC
			3.861 lb VOC

L. Glycol Ethers (GE) **GLYET-Other**

The emissions of glycol ethers is based on a mass balance of glycol ethers consumed in the process. The only GE emissions in PSEPVE is DiGlyme

Quantity Released

=	2,100	kg GE introduced into processes
=	700	kg GE transferred to H/C waste tank
=	1,400	kg GE unaccounted for and assumed emitted
=	**3086**	**lb. Glycol Ethers**

Assume that the emissions of glycol ethers is split evenly between the three processes of Vinyl Ethers North.

Therefore:

Emissions of glycol ether from PSEPVE = **3086** **lb. Glycol Ethers**

M. Sulfonyl Fluoride (SOF2) **CAS No. 7783-42-8**

HF Potential:

Each mole of SOF2 (MW = 86) can generate 2 mole of HF (MW = 20).

$$1\,kg\,MA \cdot \frac{1\,mole SOF2}{86\,g\,SOF2} \cdot \frac{20\,g\,HF}{1\,mole HF} \cdot \frac{2\,mole HF}{1\,mole SOF2} = 0.465 kg\,HF$$

Therefore, each 1 kg of SOF2 generates 0.465 kg of HF

Quantity Released

Before-control SOF2 vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0\ kg\ SOF2}{3.66\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{2.04\ kg\ SOF2}{18.76\ kg\ Crude Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0\ kg\ SOF2}{0.33\ kg\ Foreshots Receiver Vent}$

SOF2 vented based on	740 kg total Condensation Reactor vent stream (22266FG).
SOF2 vented based on	24,218 kg total Crude Receiver vent stream (22701FG).
SOF2 vented based on	43 kg total Foreshots Receiver vent stream (22826FG).

Before control SOF2 vented from Condensation Reactor:

$$\frac{0.00\ kg\ SOF2}{3.66\ kg\ CndRx} \times 740\ kg\ CndRx = 0\ kg\ SOF2$$

SOF2 vented from Crude Receiver

$$\frac{2.04\ kg\ SOF2}{18.76\ kg\ CrRec} \times 24{,}218\ kg\ CrRec = 2{,}634\ kg\ SOF2$$

SOF2 vented from Foreshots Receiver

$$\frac{0.00\ kg\ SOF2}{0.33\ kg\ FsRec} \times 43\ kg\ FsRec = 0\ kg\ SOF2$$

Total before-control SOF2 vented = 2,634 kg SOF2

After-control emissions utilizing the 99.6% control efficient Waste Gas Scrubber (WGS):

SOF2 Emissions

Waste Gas Scrubber		2,634 kg SOF2	
	x	(100%-99.6%) Control Efficiency	
	=	11 kg SOF2	23 lb. SOF2

HF Equivalent Emissions

	11 kg SOF2	
x	0.465 kg HF/kg SOF2	
=	4.90 kg HF	**10.80 lb. HF**

N. Carbon Monoxide (CO) **CAS No. 630-08-0**

CO is a criteria pollutant

Quantity Released

CO are perfluorobutenes that are byproducts from the Agitated Bed Reactor system.
They are inerts in VE-North that are vented to the WGS.

CO vented per the process flowsheet

Vented from the Condensation Reactor: $\frac{0\ kg\ CO}{3.66\ kg\ Cond\ Rx\ Vent\ Flow}$

Vented from the Crude Receiver $\frac{1.30\ kg\ CO}{18.76\ kg\ Crude Receiver\ Vent}$

Vented from the Foreshots Receiver $\frac{0\ kg\ CO}{0.33\ kg\ Foreshots Receiver Vent}$

CO vented based on 740 kg total Condensation Reactor vent stream (22266FG).
CO vented based on 24,218 kg total Crude Receiver vent stream (22701FG).
CO vented based on 43 kg total Foreshots Receiver vent stream (22826FG).

CO vented from Condensation Reactor:

0.00 / 3.66 kg CO / kg CndRx	x	740 kg CndRx	=	0 kg CO

CO vented from Crude Receiver

1.30 / 18.76 kg CO / kg CrRec	x	24,218 kg CrRec	=	1,684 kg CO

CO vented from Foreshots Receiver

0.00 / 0.33 kg CO / kg FsRec	x	43 kg FsRec	=	0 kg CO

CO Emissions

	0 kg from Condensation Reactor		
+	1,684 kg from Crude Receiver		
+	0 kg from Foreshots Receiver		
=	1,684 kg CO	=	**3,712 lb CO**

O. VOC Summary

		Before Control Generated		After Control Stack Emissions	
				VOC	HF
	Nafion Compound Name	kg/yr	lb/yr	lb/yr	lb/yr
A.	HFP	4,054	8,919	8,919	
B.	HFPO	663	1,458	1,458	
C.	PPF	41	91	0.36	0
D.	TFE	12	26	26	
E.	PSEPVE	9	19	19	
F.	C4	605	1,331	1,331	
G.	HFPO Trimer	1.76	3.86	0	0
H.	MA	0.59	1.29	0.01	0
I.	DA	16.97	37.41	0.15	0
J.	Hydro PSEPVE	0.59	1.29	1.29	
K.	Iso PSEPVE	1.76	3.87	3.86	
L.	Glycol Ethers	1,400	3,086	3,086	
	Total	**6,805**	**14,978**	**14,845**	**0**

P. Point Source Summary

	Nafion Compound Name	Stack Emissions lb/yr	Equipment Emissions (Note 1) lb/yr	Maintenance Emissions (Note 2) lb/yr	Total Emissions lb/yr
A.	HFP	8,919	356	118	9,393
B.	HFPO	1,458	58	19	1,536
C.	PPF	0.36	0.01	0.00	0.4
D.	TFE	26	1.0	0.3	27
E.	PSEPVE	19.31	0.77	0.26	20.3
F.	C4	1,331	53	18	1,401
G.	HFPO Trimer	0.015	0	0.000	0
H.	MA	0.005	0	0.000	0
I.	DA	0.150	0.006	0.0020	0.158
J.	Hydro-PSEPVE	1.287	0.051	0.017	1.36
K.	Iso-PSEPVE	3.861	0.15	0.051	4.1
L.	Glycol Ethers	3,086	123.19	40.861	3,250
M.	SOF2	23	0.9	0.31	24
N.	CO	3,712	0	0	3,712
	Total	18,580	593	197	**19,371**

Note 1 - See section titled "Equipment Emissions" for details
Note 2 - See section titled "Maintenance Emissions" for details

HF Equivalent Emissions

	Nafion Compound Name	Stack Emissions lb/yr	Equipment Emissions lb/yr	Maintenance Emissions lb/yr	Total Emissions lb/yr
C.	PPF	0.04	0.00	0.00	0.05
G.	HFPO Trimer	0.00	0.00	0.00	0.00
H.	MA	0.00	0.00	0.00	0.00
I.	DA	0.01	0.00	0.00	0.01
M.	SOF2	10.80	0.43	0.14	11.38
	Total	**10.85**	**0.43**	**0.14**	**11.43**

The estimated HF equivalent emissions from Equipment Emissions were determined by multiplying the PPF HF Potential (0.12 lb. HF/lb. PPF) by the PPF Equipment Emissions (0.04 lb./yr) for the Compound

$$0.12 \ \frac{\text{lb/yr HF}}{\text{lb/yr PPF}} \times 0.01 \ \text{lb/yr Equipment PPF} = 0.002 \ \text{lb/yr HF}$$

The estimated HF equivalent emissions from Maintenance Emissions were determined by multiplying the PPF HF Potential (0.12 lb. HF/lb. PPF) by the PPF Maintenance Emissions (0.001 lb./yr) for the Compound

$$0.12 \ \frac{\text{lb/yr HF}}{\text{lb/yr PPF}} \times 0.005 \ \text{lb/yr Maintenance PPF} = 0.001 \ \text{lb/yr HF}$$

2005 Equipment Emissions Determination

Equipment Emissions (EE) are a function of the number of emission points in the plant (valves, flanges, pump seals). For the equipment emission calculations the inventory shown below is conservative and based on plant and process diagrams.

Note that the division scrubber efficiency is 99.6% for control of acid fluorides.

A. Equipment Emissions from Condensation Reactor System

Assume that: 100% of process materials are VOCs ;
90% are acid fluorides that are emitted from the stack ;
10% are non-acid fluorides that are emitted from the stack.

Condensation Tower (vents to stack)

*Valve and Flange Factors can be found on Fugitive Emission Leak rates worksheet

Valve emissions:	462	valves	×	valves x	0.00039 lb/hr/valve	=	0.180	lb/hr VOC from EE
Flange emissions:	924	flanges	×	flanges x	0.00018 lb/hr/flange	=	0.166	lb/hr VOC from EE
Pump emissions:	0	pumps	×	pumps x	0.00115 lb/hr/pump	=	0.000	lb/hr VOC from EE
				Total fugitive emission rate		=	0.347	lb/hr VOC from EE

Condensation Tower VOC

From Acid Fluorides:

	0.347	lb/hr VOC from EE
×	3,803	hours/year
×	90%	fraction of EE that are acid fluorides
=	1,186	lb VOC

From Non-Acid Fluorides:

	0.347	lb/hr VOC from EE
×	3,803	hours/year
×	10%	fraction of EE that are non-acid fluorides
=	132	lb VOC

Total Condensation Tower Equipment Emissions:

VOC:		1,186	lb VOC from acid fluorides
	+	132	lb VOC from non-acid fluorides
	=	**1,318**	**lb VOC**

B. Equipment Emissions from Agitated Bed Reactor System

Assume that: 100% of process materials are VOCs ;
2% are acid fluorides that are emitted from the stack ;
98% are non-acid fluorides that are emitted from the stack.

Valve emissions:	85	valves	×	valves x	0.00039 lb/hr/valve	=	0.033	lb/hr VOC from EE
Flange emissions:	170	flanges	×	flanges x	0.00018 lb/hr/flange	=	0.031	lb/hr VOC from EE
Pump emissions:	0	pumps	×	pumps x	0.00115 lb/hr/pump	=	0.000	lb/hr VOC from EE
					Total fugitive emission rate	=	0.064	lb/hr VOC from EE

Agitated Bed Reactor System VOC from Equipment Emissions

From Acid Fluorides:		0.064	lb/hr VOC from EE
	×	3,803	hours/year
	×	2%	fraction of EE that are acid fluorides
	=	5	lb VOC
From Non-Acid Fluorides:		0.064	lb/hr VOC from EE
	×	3,803	hours/year
	×	98%	fraction of EE that are non-acid fluorides
	=	238	lb VOC

Total Agitated Bed Reactor System Equipment Emissions:

VOC:		5	lb VOC from acid fluorides
	+	238	lb VOC from non-acid fluorides
	=	**242**	**lb VOC**

C. Equipment Emissions from Refining System

Assume that: 100% of process materials are VOCs ;
2% **are acid fluorides** that are emitted from the stack ;
98% **are non-acid fluorides** that are emitted from the stack.

Valve emissions:	162	valves	×	valves x	0.00039 lb/hr/valve	=	0.063	lb/hr VOC from EE
Flange emissions:	324	flanges	×	flanges x	0.00018 lb/hr/flange	=	0.058	lb/hr VOC from EE
Pump emissions:	0	pumps	×	pumps x	0.00115 lb/hr/pump	=	0.000	lb/hr VOC from EE
					Total fugitive emission rate	=	0.122	lb/hr VOC from EE

Refining System VOC from Equipment Emissions

From Acid Fluorides:

	0.122	lb/hr VOC from EE
×	3,803	hours/year
×	2%	fraction of EE that are acid fluorides
=	9	lb VOC

From Non-Acid Fluorides:

	0.122	lb/hr VOC from EE
×	3,803	hours/year
×	98%	fraction of EE that are non-acid fluorides
=	453	lb VOC

Total Refining System Equipment Emissions:

VOC:		9	lb VOC from acid fluorides
	+	453	lb VOC from non-acid fluorides
	=	**462**	**lb VOC**

D. Total Equipment Emissions

Emission Source	Stack Emissions	Non-Stack Emissions	Total Emissions
	VOC lb	VOC lb	VOC lb
Condensation Tower	1,318		1,318
Agitated Bed Reactor	242		242
Refining		462	462
AN		6,676	6,676
ADN		2,536	2,536
Total	**1,560**	**9,674**	**11,234**

E. Speciated Equipment Emissions VOC Summary

Nafion® Compound	EVE Emissions (lbs)		PPVE Emissions (lbs)		PSEPVE Emissions (lbs)		Total Emissions (lbs)	
	Stack	Equip.	Stack	Equip.	Stack	Equip.	Stack	Equip.
HFP	580	23.1	6,254	249.6	8,919	356	15,752	629
HFPO	427	17.1	12,362	493.4	1,458	58	14,248	569
HFPO-Dimer	0.67	0.0	0		0		1	0
EVE	6.65	0.3	0		0		7	0
PPVE	0		4,068	162.4	0		4,068	162
PSEPVE	0		0		19.31	1	19	1
PPF	0		56	2.2	0.36	0	57	2
TFE	318	12.7	11,144	444.8	26	1	11,487	458
SOF2	0		0		23	1	23	1
C4	0		298	11.9	1,331	53	1,628	65
C5	0		30	1.2	0.00		30	1
DA	0		0		0.150	0	0	0
Glycol Ethers	254	10.1	0		3,086	123	3,341	133
Hydro-PSEPVE	0		0		1.29	0	1	0
Iso-PSEPVE	0		0		3.861	0	4	0
AN	0		0	6,676	0.000	0.000	0	6,676
ADN	0	2,536	0		0.000	0.000	0	2,536
TOTAL	**1,586**	**2,599**	**34,212**	**8,041**	**14,868**	**593**	**50,666**	**11,234**

Note: Speciated equipment emissions were estimated by assuming that each compound's equipment emission concentration was equal to that compound's stack emission fraction of the total stack emission. For example, the stack emission of HFP from the EVE process was 663 lb., with the total stack emission from the Vinyl Ethers North processes being 13,747 pounds. The total equipment emissions were 1,435 pounds (less ADN and AN since they are only emitted through equipment).

Therefore, the HFP equipment emissions from the EVE process were determined by:

$$580 \text{ lb. HFP} \times \frac{2{,}022 \text{ lb. Total equipment emissions less ADN and AN}}{50{,}666 \text{ lb. Total stack emmisions}} = 23.1 \text{ lb. HFP}$$

2005 Maintenance Emission Determination

A. Background

Periodically, the process vessels in the VE-North plant are emptied for campaign switches and for maintenance. During the deinventory process, the liquid is transferred to another process vessel and then the gases are evacuated to the division waste gas scrubber. The amount of gasses from the condensation reactor, crude receiver and foreshots receiver are already included in the vent flowmeter readings used to calculate emissions in previous sections. This section estimates maintenance emissions for the rest of the major process vessels.

B. Condensation Tower

Assume the following:

(a) void fraction in distillation columns is 40%
(b) ideal gas behavior
(c) vessels are at atmospheric pressure
(d) ambient temperature (25 deg C)
(e) gases are 90% acid fluorides and 10% non-acid fluorides
(f) average molecular weight (MW) for acid fluoride component based on the average respective average acid fluoride MW for each campaign
Therfore the average molecular weight for VE-North is 392
(g) average MW for non-acid fluoride component = 156 (assumed to be HFP)
(h) number of deinventory events = 4

List of Process Vessels

Condensation Tower	Volume (ft^3)	Volume (gallons)
Reactor Decanter	5	41
Stripper Feed Decanter	7	51
Stripper Column	17	130
Stripper Overhead Receiver	5	40
A/F Column	27	203
A/F Overhead Receiver	14	106
A/F Tails Decanter	1	10
ABR Feed Tank	27	202
Total Volume	**105**	784

VOC Emissions

n = PV/RT, where P = 14.7 psia, V = 105 ft^3, R = 10.73 psia-ft^3/lb-mol degR, T = 537 degrees R

$$n = \frac{PV}{RT} = \frac{14.7 \text{ psia} \times 105 \text{ ft}^3}{10.73 \frac{\text{psia-ft}^3}{\text{lb-mol degR}} \times 537 \text{ deg R}} = 0.27 \frac{\text{lb-mol gas}}{\text{deinventory event}}$$

$$0.27 \frac{\text{lb-mol gas}}{\text{deinventory event}} \times \frac{4 \text{ deinventory events}}{\text{year}} = 1.07 \frac{\text{lb-mol gas}}{\text{year}}$$

$$1.07 \frac{\text{lb-mol gas}}{\text{year}} \times 10\% \text{ non-acid fluorides} \times 156 \frac{\text{lb non-A/F}}{\text{lb-mol gas}} = 16.7 \frac{\text{lb non-A/F}}{\text{year}}$$

Before-control A/F vented from Condensation:

$$1.07 \frac{\text{lb-mol gas}}{\text{year}} \times 90\% \text{ acid fluorides} \times 392 \frac{\text{lb A/F}}{\text{lb-mol gas}} = 377 \frac{\text{lb A/F}}{\text{year}}$$

After-control emissions utilizing the 99.6% control efficient Waste Gas Scrubber (WGS):

	377	lb/yr A/F VOC
×	(100%-99.6%)	control efficiency
	1.5	lb/yr A/F VOC

Total VOC:

	16.7	lb/yr non-A/F VOC
+	1.5	lb/yr A/F VOC
	18.2	**lb/yr VOC**

C. Agitated Bed Reactor & Refining

Assume the following:

(a) void fraction in distillation columns is 40%
(b) ideal gas behavior
(c) vessels are at atmospheric pressure
(d) ambient temperature (25 deg C)
(e) gases are 100% vinyl ethers which are 100% VOC
(f) average molecular weight (MW) for acid fluoride component based on the average respective average acid fluoride MW for each campaign
Therfore the average molecular weight for VE-North is 392
(g) number of deinventory events = 4

HF Potential

Vinyl ethers are VOCs without the potential to form HF

List of Process Vessels

Agitated Bed Reactor & Refining	Volume (ft^3)	Volume (gallons)
Ether Still	107	803
Ether Still Overhead Receiver	9	69
Product Receiver	46	348
Total Volume	**163**	1220

VOC Emissions

n = PV/RT, where P = 14.7 psia, R = 10.73 psia-ft^3/lb-mol degR, V = 163 ft^3, T = 537 degrees R

$$n = \frac{PV}{RT} = \frac{14.7 \text{ psia} \times 163 \text{ ft}^3}{10.73 \frac{\text{psia-ft}^3}{\text{lb-mol degR}} \times 537 \text{ deg R}} = 0.42 \frac{\text{lb-mol gas}}{\text{deinventory event}}$$

$$0.42 \frac{\text{lb-mol gas}}{\text{deinventory event}} \times \frac{4 \text{ deinventory events}}{\text{year}} = 1.66 \frac{\text{lb-mol gas}}{\text{year}}$$

$$1.66 \frac{\text{lb-mol gas}}{\text{year}} \times \frac{392 \text{ lb VOC}}{\text{lb-mol gas}} = \mathbf{652.6} \ \frac{\textbf{lb VOC}}{\textbf{year}}$$

D. Total Maintenance Emissions

Emission Source	Stack Emissions
	VOC lb
Condensation Tower	18
Agitated Bed Reactor & Refining	653
Total	**671**

E. Speciated Maintenance Emissions VOC Summary

Nafion® Compound	EVE Emissions (lbs)		PPVE Emissions (lbs)		PSEPVE Emissions (lbs)		Total Emissions (lbs)	
	Stack	Maint.	Stack	Maint.	Stack	Maint.	Stack	Maint.
HFP	580	7.7	6,254	82.8	8,919	118	15,752	209
HFPO	427	5.7	12,362	163.7	1,458	19	14,248	189
HFPO-Dimer	1	0.009	0		0		1	0
EVE	7	0.1	0		0		7	0
PPVE	0		4,068	53.9	0		4,068	54
PSEPVE	0		0		19.31	0.26	19	0
PPF	0		56	0.7	0.36	0.00	57	1
TFE	318	4.2	11,144	147.5	26	0.3	11,487	152
SOF2	0		0		23	0.3	23	0
C4	0		298	3.9	1,331	17.6	1,628	22
C5	0		30	0.4	0		30	0
DA	0		0		0.150	0.002	0	0
Glycol Ethers	254	3.4	0		3,086	40.861	3,341	44
Hydro-PSEPVE	0		0		1.287	0.017	1	0
Iso-PSEPVE	0		0		3.861	0.051	4	0
TOTAL	**1,586**	**21**	**34,212**	**453**	**14,868**	**197**	**50,666**	**671**

Note: Speciated maintenance emissions were estimated by assuming that each compound's emission concentration from maintenance activities was equal to that compound's stack emission fraction of the total stack emission. For example, the stack emission of HFP from the EVE process was 259 lb., with the total stack emission from the Vinyl Ethers North processes being 43,109 pounds. The total maintenance emissions were 141 pounds.

Therefore, the HFP maintenance emissions from the EVE process were determined by:

$$580 \text{ lb. HFP} \times \frac{671 \text{ lb. Total maintenance emissions}}{50{,}666 \text{ lb. Total stack emmisions}} = 7.7 \text{ lb. HFP}$$

2005 Accidental Releases to Atmosphere

A. 2005-032 **Date: 3/14/2005**

Material Released:	**Perfluoropropyl vinyl ether (PPVE)**	**CAS No. 1623-5-8**
Quantity Released:	0.1 lbs	
Total VOC	0.1 lbs VOC	

HF Potential:

PPVE is a VOC without the potential to form HF

B. 2005-081 **Date: 7/15/2005**

B1	Material Released:	**Diadduct (DA)**	**CAS No. 4089-58-1**
	Quantity Released:	74 kgs	
	Total VOC	163 lbs VOC	

HF Potential:

Each mole of DA (MW = 512) can generate 1 mole of HF (MW = 20).

$$1\,kg\,DA \cdot \frac{1\,mole\,DA}{512\,g\,DA} \cdot \frac{20\,g\,HF}{1\,mole\,HF} \cdot \frac{1\,mole\,HF}{1\,mole\,DA} = 0.039\,kg\,HF$$

Therefore, each 1 kg of DA generates 0.039 kg of HF

HF Equivalent Emissions

	74	kg DA		
x	0.039	kg HF/kg DA		
=	2.89	kg HF	=	**6.36 lb. HF**

B2 Material Released: **Monoadduct (MA)** **CAS No. 4089-57-0**
Quantity Released: 64 kgs
Total VOC 141 lbs VOC

HF Potential:

Each mole of MA (MW = 346) can generate 1 mole of HF (MW = 20).

$$1\,kg\,MA \cdot \frac{1\,mole\,MA}{346\,g\,MA} \cdot \frac{20\,g\,HF}{1\,mole\,HF} \cdot \frac{1\,mole\,HF}{1\,mole\,MA} = 0.058\,kg\,HF$$

Therefore, each 1 kg of MA generates 0.058 kg HF

HF Equivalent Emissions

	64	kg MA		
x	0.058	kg HF/kg MA		
=	3.71	kg HF	=	**8.18 lb. HF**

B3 Material Released: **Perfluoropropionyl fluoride (PPF)** **CAS No. 422-61-7**
Quantity Released: 8 kgs
Total VOC 17.6 lbs VOC

HF Potential:

Each mole of PPF (MW = 166) can generate 1 mole of HF (MW = 20).

$$1\,kg\,PPF \cdot \frac{1\,molePPF}{166g\,PPF} \cdot \frac{20g\,HF}{1\,moleHF} \cdot \frac{1\,moleHF}{1\,molePPF} = 0.120kg\,HF$$

Therefore, each 1 kg of PPF generates 0.120 kg HF

HF Equivalent Emissions

	8	kg PPF		
x	0.058	kg HF/kg PPF		
=	0.46	kg HF	=	**1.02 lb. HF**

B4 Material Released: **HFPO Trimer** **CAS No. 2641-34-1**
Quantity Released: 52 kgs
Total VOC 115 lbs VOC

HF Potential:

Each mole of HFPO Trimer (MW = 498) can generate 1 mole of HF (MW = 20).

$$1\,kg\,MA \cdot \frac{1\,mole Trimer}{498\,g\,Trimer} \cdot \frac{20\,g\,HF}{1\,mole HF} \cdot \frac{1\,mole HF}{1\,mole Trimer} = 0.0402 kg\,HF$$

Therefore, each 1 kg of HFPO Trimer generates 0.0402 kg HF

HF Equivalent Emissions

	52	kg HFPO Trimer		
x	0.0402	kg HF/kg HFPO Trimer		
=	2.09	kg HF	=	**4.61 lb. HF**

C. Total Emissions from Accidental Releases

* Note when new chemical added to table below you must update Summary Tab

Source	PPVE (lb)	DA (lb)	MA (lb)	PPF (lb)	HFPO Trimer (lb)	VOC (lb/yr)	HF (lb/yr)
A. 2005-032	0.1					0.1	0.0
B. 2005-081		163	141	18	115	437	20.2
Total	**0.1**	**163**	**141**	**18**	**115**	**437**	**20.2**

2005 Emission Summary

Report date 4/13/2006
Prepared by Amy Martin

A. VOC Emissions Summary

Nafion® Compound	CAS Chemical Name	CAS No.	PE/PM Emissions (lbs)	Accidental Releases (lbs)	Total Emissions (lbs)
COF2	Carbonyl Fluoride	353-50-4	475	0	475
PAF	Perfluoroacetyl Fluoride	354-34-7	1,128	0	1,128
PMPF	Perfluoromethoxypropionyl fluoride	2927-83-5	1,106	0	1,106
PEPF	Perfluoroethoxypropionyl fluoride	1682-78-6	428	0	428
PMVE	Perfluoromethyl vinyl ether	1187-93-5	5,103	0	5,103
PEVE	Perfluoroethyl vinyl ether	10493-43-3	1,389	110	1,499
HFP	Hexafluoroproplyene	116-15-4	3,900	0	3,900
HFPO	Hexafluoroproplyene Epoxide	428-59-1	4,299	0	4,299
AN	Acetonitrile	75-05-8	151	0	151
HFPO Dimer	Perfluoro-2-Propoxy Propionyl Fluoride	2062-98-8	7	0	7
MD			66	0	66
HydroPEVE			13	0	13
PPVE	Perfluoropropyl vinyl ether	1623-05-8	13	0	13
	Total VOC Emissions (lbs)		**18,080**	**110**	**18,190**
	Total VOC Emissions (tons)		**9.0**	**0.1**	**9.1**

B. VOC Control Device Efficiency

VOCs Generated				VOCs Emitted After Control			
Point Source Generated (lbs)	Equipment Emissions (lbs)	Maintenance Emissions (lbs)	Total VOC Generated (lbs)	Point Source Emissions (lbs)	Equipment Emissions (lbs)	Maintenance Emissions (lbs)	Total VOC Emitted (lbs)
517,985	4,796		522,781	13,284	4,796		18,080

	522,781	lb VOC generated
-	18,080	lb VOC emitted
=	504,701	lb VOC removed in control device

	504,701	lb VOC removed in control device
/	522,781	lb VOC generated
=	**96.54%**	VOC control device efficiency

C. Toxic Air Pollutant and Hazardous Air Pollutant Summary (TAPS/HAPS)

Nafion® Compound	CAS Chemical Name	CAS No.	PE/PM Emissions (lbs)	Accidental Releases (lbs)	Total Emissions (lbs)
HF	Hydrogen Fluoride	7664-39-3	610	0.00	610
Acetonitrile	Acetonitrile	75-05-8	151	0.0	151

D. HF Control Device Efficiency

	478	lb HF emitted from Point Sources
/	(100%-99.6%)	Stack Efficiency
=	119,589	lb HF sent to control device from Point Sources

	119,589	lb HF sent to control device from Point Sources
-	610	lb HF emitted (all sources)
=	118,979	lb HF removed in control device

	118,979	lb HF removed in control device
/	119,589	lb HF generated
=	**99.49%**	**HF control device efficiency**

E. Overall Emission Control Device Efficiency

	522,781	Total lb VOC generated
+	119,589	Total lb HF generated
=	642,370	lb total emissions generated

	504,701	Total lb VOC removed in control device
+	118,979	Total lb HF removed in control device
=	623,680	lb total emissions removed in control device

	623,680	lb total emissions removed in control device
/	642,370	lb total emissions generated
=	**97.09%**	**Overall emission control device efficiency**

2005 AIR EMISSIONS INVENTORY SUPPORTING DOCUMENTATION

Emission Source ID No: NS-C

Emission Source Description: VE-South PEPM Manufacturing Process

Process & Emission Description: The VE-South PEPM manufacturing process is a continuous chemical reaction. All emissions from the process are vented through the VE-South Waste Gas Scrubber (Control Device ID No. NCD-Hdr2) which has a documented control efficiency of 99.6% for all acid fluoride compounds. Some emitted compounds are assumed to pass completely through the scrubber, so the control efficiency for those compounds is assumed to be 0%. The control of emissions of specific compounds will be addressed and detailed in the following pages.

The PEPM process in VE-South emits compounds in the acid fluoride family. In the presence of water (such as in atmospheric moisture), these acid fluorides can eventually hydrolyze to hydrogen fluoride. For the purpose of this emissions inventory, a conservative approach will be taken and the acid fluorides will be reported both as a VOC and as the equivalent quantity of hydrogen fluoride.

Basis and Assumptions:

- A process flowsheet, developed from operating data during a typical month, May 2005, is the basis for relative concentrations of before-control emissions of gaseous wastes.
- The flowsheet is available under the "flowsheet" tab for reference and includes the basis for ratios used in this calculation.
- Because an overall material balance for the year is used for calculation of emissions, "maintenance emissions" related to turnarounds are assumed to be included with the calculated emissions. The usual practice is to deinventory liquids and then vent vessels to the Waste Gas Scrubber.
- All emission determination calculations are available on the EXCEL spreadsheet found at: S:/Everyone/martinas/Emissions/2005/VES 2005 Emissions.xls

J. VOC Summary - All sources

Nafion Compound Name		After Control Stack Emissions		Equipment Emissions (Note 1)		Maintenance Emissions (Note 2)		Total Emissions	
		lb/yr VOC	lb/yr HF	lb/yr VOC	lb/yr HF	lb/yr VOC	lb/yr HF	lb/yr VOC	lb/yr HF
A.	COF2	411	249	64	39			475	288
B.	PAF	1,066	184	62	11			1128	194
C.	PMPF	411	35	695	59			1106	94
D.	PEPF	138	10	290	20			428	30
E.	PMVE	3,481	0	1622	0			5103	0
F.	PEVE	0	0	1389	0			1389	0
G.	HFP	3,888	0	13	0			3900	0
H.	HFPO	3,888	0	411	0			4299	0
	HFPO Dimer			7	0			7	0
	MD			66	3			66	3
	HydroPEVE			13	0			13	0
	PPVE			13	0			13	0
	AN			151	0			151	0
	Total	**13,284**	**478**	**4,796**	**132**	**0**	**0**	**18,080**	**610**

Note 1 - See section titled "Equipment Emissions" for details
Note 2 - See section titled "Maintenance Emissions" for details

Stripper column

Inventoried with	30	gal fluorocarbon
Equivalent mass FC	375.75	lb fluorocarbon

Component	Mass fraction	lb
COF2	0.09	34
PAF	0.04	15
HFP	0.03	11
PMPF	0.59	222
PEPF	0.23	86
Dimer	0.01	4
MD	0.01	4

AF column — all FC (70% PMPF, 27% PEPF, 1.5% dimer, 1.5% MD)

Inventoried with	30	gal fluorocarbon
Equivalent mass FC	375.75	lb fluorocarbon

Component	Mass fraction	lb
PMPF	0.7	263
PEPF	0.27	101
Dimer	0.015	6
MD	0.015	6

AF overhead

Inventoried with	1000	kg FC
	2200	lb FC

Component	Mass fraction	lb
PMPF	0.72	1,584
PEPF	0.28	616

AF decanter

Inventoried with	30	gal fluorocarbon
Equivalent mass FC	375.75	lb fluorocarbon

Component	Mass fraction	lb
PMPF	0.72	271
PEPF	0.28	105

HFPO tank

	135	gal HFPO	
	1555.605	lb HFPO	1.38 SG

Waste FC tank

Inventoried with	40	gal fluorocarbon
Equivalent mass FC	501	30% refining waste (?), 70% is condensation waste (4% dimer, 67% MD, 29% ED)

Component	Mass fraction	lb	
Dimer	0.028	14.028	assumes 70% is condensation waste (4% dimer, 67% MD, 29% ED)
MD	0.469	234.969	
ED	0.203	101.703	
PEPF	0.099	49.599	assumes 30% is waste from refining purges, high boilers PEPF, hydro PEVE, and PPVE
Hydro PEVE	0.099	49.599	
PPVE	0.099	49.599	

Average system composition - Condensation

	lb	%	VOC emissions (lb)	Equivalent HF (lb)
COF2	241	3.63%	64	39
PAF	235	3.53%	62	11
HFP	26	0.39%	7	0
HFPO	1,557	23.41%	411	0
PMPF	2,591	38.94%	684	59
PEPF	1,057	15.88%	279	20
Dimer	28	0.42%	7	0.4
MD	249	3.74%	66	3
AN	571	8.58%	151	0
HydroPEV	50	0.75%	13	0
PPVE	50	0.75%	13	0
total	6,653		1756	132

B. Fugitive Emissions from Agitated Bed Reactor System & Refining

Valve emissions:	555 valves x	0.00039	lb/hr/valve	=	0.216	lb/hr FE
Flange emissions:	1110 flanges x	0.00018	lb/hr/flange	=	0.200	lb/hr FE
Pump emissions:	12 pump x	0.00115	lb/hr/pump	=	0.014	lb/hr FE
Total fugitive emission rate				=	0.430	lb/hr FE

ABR & Refining VOC

Total ABR & Refining Fugitive Emissions:

	0.43	lb/hr FE
x	7,069	Operating hr/yr
=	3,040	lb FE

ABR/Crude system

Inventoried with 1500 kg FC
3300 lb FC

Component	Mass fraction	lb	
CO2	0.33	1,089	**Not a VOC**
PMPF	0.01	33	
PEPF	0.01	33	
HFP	0.005	17	
PEVE	0.22	726	
PMVE	0.425	1,403	

Refining

Inventoried with 3000 kg FC
6600 lb FC

Component	Mass fraction	lb
PMVE	0.5	3300
PEVE	0.5	3300

Average System Composition - ABR/Refining

	lb	%	VOC emissions (lb)	Equivalent HF (lb)
PMPF	33	0.37%	11	1
PEPF	33	0.37%	11	1
HFP	17	0.19%	6	0
PEVE	4,026	45.69%	1389	0
PMVE	4,703	53.37%	1622	0
total	8,811		3,040	2

C. Acetonitrile fugitive emissions

No normal process vents of AN to stack. Equipment emissions are estimated above for normal process composition and leaks.

A material balance is also done to ensure all AN losses are accounted for. When material balance shows negative loss, only the estimated equipment emissions are included.

VOC Emission

AN to hydrocarbon waste from VE-S = total HC waste - VE-N waste= 32,132

Assume that: **5%** of spent acetonitrile are fluorocarbons.

AN portion of hydrocarbon waste stream:

	32,132	kg to H/C waste
x	(1-(.05))	
=	30,525	kg AN to H/C waste
	10,240	kg AN fed
-	30,525	kg AN to waste
	-20,285	kg AN lost = 0 **kg VOC**
		0 **lb VOC** additional AN loss

Note: Based on this material balance, it is assumed that no AN is emitted to atmosphere from fugitive emissions, other than what is determined above.
The amount of hydrocarbon sent to waste is probably overestimated due to inaccuracies in calculation of VE-N portion of the waste.

D. Total Fugitive Emissions

Emission Source	Total Emissions lb VOC
Condensation Tower	1,605
Agitated Bed Reactor & Refining	3,040
AN	151
Total	**4,796**

E. Speciated Equipment Emissions Summary

Nafion® Compound	Equipment Emissions	
	lb VOC	lb HF
COF2	64	39
PAF	62	11
HFP	13	0
HFPO	411	0
PMPF	695	59
PEPF	290	20
HFPO Dimer	7	0.4
MD	66	3
HydroPEVE	13	0
PPVE	13	0
PEVE	1,389	0
PMVE	1,622	0
AN	151	0
TOTAL	**4,796**	**132**

2005 Accidental Releases to Atmosphere

A. 2005-151 Date: 10/1/2005 **CAS No. 1187-93-5**

Material Released: PMVE
Quantity Released: 50 kg 110.00 lbs PEVE

HF Potential:
PEVE is a VOC without the potential to form HF.

B. Total Emissions from Accidental Releases

Summary			lb/yr VOC Total
A.	PMVE		110
	Total		**110**

From Condensation balance

COF_2 vented = COF_2 fed - COF_2 converted to MD in FC waste - COF_2 converted to PMPF

= 1706 kg COF_2 vented from condensation

PAF vented = PAF fed - PAF converted to ED in FC waste - PAF converted to PEPF

= 530 kg PAF vented from condensation

$$COF2\ fraction = \frac{1706}{2{,}258} = 0.76$$

$$PAF\ fraction = \frac{530}{2{,}258} = 0.23$$

The remaing 1% is assumed to be nitrogen, which is contained in the vapor space of the reactor.

Reactor vent composition is determined by:

$$\frac{\text{kg COF2 vented}}{\text{kg PMVE produced}} = \boxed{0.06}$$

$$\frac{\text{kg PAF vented}}{\text{kg PEVE produced}} = \boxed{0.04}$$

From ABR balance:

PMPF vented to WGS = PMPF fed to ABR - PMPF converted to PMVE

= 5949 kg PMPF vented to WGS

PEPF vented to WGS = PEPF fed to ABR - PEPF converted to PEVE

= 1823 kg PEPF vented to WGS

ABR vent relationships:

$$\frac{\text{kg PMPF vented}}{\text{kg PMVE produced}} = \boxed{0.21}$$

$$\frac{\text{kg PEPF vented}}{\text{kg PEVE produced}} = \boxed{0.15}$$

2005 Air Emissions Inventory Supoorting Documentation

Emission Source ID No.: NS-D

Emission Source Description: Nafion RSU Process

Process and Emission Description:

The RSU process is a continuous manufacturing process. All emissions from this process vent to the Nafion Division Waste Gas Scrubber (WGS),Control Device ID No. NCD-Hdr1, which has a documented efficiency of 99.6%. The control of emissions of certain compounds will be addressed in the attached spreadsheet. Certain components (i.e. TFE) pass completely through the scrubber, therefore the efficiency is assumed to be 0%.

Basis and Assumptions:

The RSU process flowsheet #4 (W1207831) is used as a basis for relative compositions and flow rates of vent streams to the division WGS. A 30 kg/hr maximum RSU production rate is used as the basis for maximum vent rates.

Information Inputs and Source of Inputs:

Information Input	Source of Inputs
RSU production quantity	RSU Production Facilitator
Speciated emission rates	RSU Process Flowsheet #4 (W1207831)

Point Source Emissions Determination:

Point source emissions for individual components are given in the following pages. A detailed explanation of the calculations are attached.

Equipment Emissions and Fugitive Emissions Determination:

Emissions from equipment leaks which vent as stack (point source) emissions and true fugitive (non-point source) emissions have been determined using equipment component emission factors established by DuPont. The determination of those emissions are shown in a separate section of this supporting documentation.

Emission Summary

A. VOC Emissions by Compound and Source

Nafion® Compound	CAS Chemical Name	CAS No.	Point Source Emissions	Fugitive Emissions (lbs)	Equipment Emissions (lbs)	Accidental Emissions (lbs)	Total VOC Emissions (lbs)
TFE	Tetrafluoroethylene	116-14-3	2325.6	0	215.1	0	2540.7
PAF	Trifluoroacetyl Fluoride	354-34-7	6.4	0	0.6	0	7.0
RSU	Difluoro(Fluorosulfonyl)Acetyl Fluoride	677-67-8	2.2	0	0.2	0.0	2.4
SU	2-Hydroxytetrafluoroethane Sulfonic Acid Sultone	697-18-7	6.4	0	0.6	0	7.0
EDC	1,2-Dichloroethane	107-06-2	0	14.5	0	0	14.5
Total for 2005			**2340.6**	**14.5**	**216.5**	**0.0**	**2571.6**
						Tons	**1.29**

B. Toxic Air Pollutant Summary

Nafion® Compound	CAS Chemical Name	CAS No.	Point Source Emissions	Fugitive Emissions (lbs)	Equipment Emissions (lbs)	Accidental Emissions (lbs)	Total TAP Emissions (lbs)
HF	Hydrogen Fluoride	7664-39-3	2.06	0	28.1	0.0	**28.15**
H2SO4	Sulfuric Acid	7664-93-9	8.9	124.1	0	0	**133.0**

C. Criteria Air Pollutant Summary

Nafion® Compound	CAS Chemical Name	CAS No.	Point Source Emissions	Fugitive Emissions (lbs)	Equipment Emissions (lbs)	Accidental Emissions (lbs)	Total VOC Emissions (lbs)
SO2	Sulfur dioxide	7446-09-5	3.5	0	0	0	**3.5**

D. Total RSU Plant Non-Point Source Emissions

Emission Source	Equipment Emissions		Fugitive Emissions		
	VOC lb/yr	HF lb/yr	VOC lb/yr	SO3 lb/yr	H2SO4 lb/yr
A. Equipment Emissions from SU Reactor, Rearranger, Still and Hold Tank	216.5	28.1	0	0	0
B. Fugitive Emissions From SO3 Storage Tank and Vaporizer	0	0	0	101.3	124.1
C. Fugitive Emissions From EDC Tank	0	0	14.5	0	0
Total for 2005	216.5	28.1	14.5	101.3	124.1

E. VOC Emission by Source Type

Nafion® Compound	Emissions from Stack (lb)	Equipment Emissions (lb)	Fugitive Emissions (lb)	Accidental Releases (lb)	Total Emissions (lb)
TFE	2325.6	215.1	0	0	2540.7
PAF	6.4	0.6	0	0	7.0
RSU	2.2	0.2	0	462.0	464.4
SU	6.4	0.6	0	0	7.0
EDC	0	0	14.5	0	14.5
Total	**2340.6**	**216.5**	**14.5**	**462.0**	**3033.6**

Note: Speciated equipment emissions were estimated by assuming that each compound's equipment emission concentration was equal to that compound's stack emission fraction of the total stack emission.

Example: The TFE equipment emissions were determined by the ratio of the TFE stack emission (1,997.9 lb) divided by the total stack emission (2,010.8 lb), multiplied by the total equipment emissions (229.4 lb).

Specifically:

$$\frac{2325.6}{2340.6} \times 216.5 = 215.1 \text{ lb. TFE}$$

Accidental Releases to Atmosphere

A. NA Date: NA

Material Released: RSU
Quantity Released: 0 lbs

Material Released: SO3
Quantity Released: 0 lbs

Material Released: TFE
Quantity Released: 0 lbs

HF Potential:
1 mole of RSU will generate 1 mole of HF

$$1\,\text{kg RSU} \times \frac{1\,\text{mole RSU}}{180\,\text{g RSU}} \times \frac{20\,\text{g HF}}{1\,\text{mole HF}} \times \frac{1\,\text{mole HF}}{1\,\text{mole RSU}} = 0.111\,\text{kg HF}$$

Therefore, each 1 lb of RSU generates 0.111 lb of HF

Quantity VOC Released:

0.0 lbs RSU = 0.0 lbs VOC from RSU

0.0 lbs SO3 = 0 lb VOC from SO3

0.0 lbs TFE = 0 lb VOC from TFE

Total VOC Released = **0.0** **lbs VOC from RSU**

Quantity HF Released:
HF Equivalent Emissions = 0 lb RSU
x 0.111 lb HF/lb RSU
0.0 lb HF

B. Total Emissions from Accidental Releases

Source		lb RSU	lb SO3	lb TFE	lb/yr VOC	lb/yr HF
A.	NA	0.0	0	0	0.0	0.00
Total for 2005		**0.0**	**0**	**0**	**0.0**	**0.00**

2005 AIR EMISSIONS INVENTORY SUPPORTING DOCUMENTATION

Emission Source ID No.: NS-E

Emission Source Description: Nafion Liquid Waste Stabilization

Process & Emission Description:

The Nafion liquid waste stabilization is a continuous system of storage with batch neutralization. To comply with the regulatory requirements of RCRA SubPart CC, neither the storage tank nor the reactor vent during normal operating conditions. All venting from this system occurs as a non-routine maintenance activity, which is detailed in the following pages. All emissions from this system are vented through the Nafion Division Waste Gas Scrubber (Control Device ID No. NCD-Hdr1) which has a documented control efficiency of 99.6% for acid fluoride compounds. The control of emissions of specific compounds will be addressed and detailed in the following pages.

The Nafion liquid waste stabilization process emits compounds in the acid fluoride family. In the presence of water, these acid fluorides will eventually hydrolyse to hydrogen fluoride. For the purpose of this emissions inventory, a conservative approach will be take and the acid fluorides will be reported both as a VOC and as the equivalent quantity of hydrogen fluoride.

Basis and Assumptions:

- For the HF emissions the entire gas flow is assumed to be HF
- The VOC emissions are assumed to be 30% COF2 and 70% TAF
- The reactor and storage tank are assumed to have the same concentration.
- The ideal gas law is used.

Information Inputs and Source Inputs:

Information Input	Source of Inputs
Weight of Tank	IP21 (H3450WG and H3606WG)
Category and Reason for Emission	Waste Mechanical Facilitator

Point Source Emissions Determination:

Shown on the following pages

Fugitive Emissions Determination:

Shown on the following pages.

Stack Emissions from Maintenance Activity or Emergency Activity

Background
Before performing maintenance on the reactor or storage tank, the pressure from the system is vented to the Division WGS. Each vent is recorded in IP21 by the weight before and after the vent. There can be times when the pressure in either the reactor or storage tank rises rapidly due to reaction. During these times if the pressure rises above 700 kpa in either tank, a pressure control valve can be opened to vent the tank to avoid the relief valve opening. See chart below.

Date	Tank	Category	Reason	Tank Weight	
				Initial (kg)	Final (kg)
5/3/05	Storage Tank	Emergency	Pressure spike	634	610
8/22/05	Storage Tank	Emergency	Pressure spike	638	617
10/8/05	Storage Tank	Maintenance	Shutdown work	215	155

Sample calculation using maintenance activity dated 5/3/05

Initial Weight minus Final Weight equals kg vented to Division WGS

634 kg minus 610 kg equals 24 kg vented to WGS

Assume that all of the above is VOC emissions This assumption also overstates the true emissions as inerts, such as nitrogen are not counted.

After-control emissions utilizing the 99.6% control efficient Waste Gas Scrubber (WGS):

Percentage of acid fluoride VOCs removed by the WGS = 99.6%
Percentage of acid fluoride VOCs vented from the WGS = 100% minus 99.6%
Percentage of acid fluoride VOCs vented from the WGS = 0.4%

Therefore, VOCs vented to the atmosphere from the 5/3/05 maintenance activity is equal to:

Amount of VOCs vented to WGS: 24 kg of VOC
Percentage of VOCs vented from the WGS: x 0.4%
Quantity of VOCs vented from the WGS: = 0.096 kg VOC
= **0.2116 lb VOC**

Stack Emissions from Maintenance Activity (cont.)

VOC Emissions by Compound

Assume that the vapor is 30% COF2 and 70% TAF. This assumption is based on process knowledge of the system.

Quantity of VOCs vented from the WGS (see previous page) = **0.2116 lb VOC**

COF2 (carbonyl fluoride) **CAS No. 353-50-4**

Sample calculation using maintenance activity dated 5/3/05

VOC emissions would be equal to:

$$\frac{0.212 \text{ lb VOC}}{} \left| \frac{0.30 \text{ lb COF2}}{\text{lb VOC}} \right. = 0.0635 \text{ lb COF2}$$

TAF (telomeric acid fluoride) **CAS No. 690-43-7**
(perfluoro-3,5,7, 9,11-pentaoxadodecanoyl fluoride)

Sample calculation using maintenance activity dated 5/3/05

VOC emissions would be equal to:

$$\frac{0.212 \text{ lb VOC}}{} \left| \frac{0.70 \text{ lb TAF}}{\text{lb VOC}} \right. = 0.1481 \text{ lb VOC}$$

Stack Emissions from Maintenance Activity (cont.)

HF Potential

Assume that the vapor is 30% COF2 and 70% TAF. This assumption is based on process knowledge of the system.

COF2 (carbonyl fluoride) **CAS No. 353-50-4**

Each mole of COF2 (MW = 66) can generate 2 moles of HF (MW =20)

1 lb COF2	1 mole COF2	20 lb HF	2 moles HF	=	0.606 lb of HF
	66 lb COF2	mole HF	1 mole COF2		

Therefore, each 1 lb of COF2 generates 0.606 lb of HF

TAF (telomeric acid fluoride) **CAS No. 690-43-7**
(perfluoro-3,5,7, 9,11-pentaoxadodecanoyl fluoride)

Each mole of TAF (MW = 330) can generate 1 mole of HF (MW =20)

1 lb TAF	1 mole TAF	20 lb HF	1 moles HF	=	0.061 lb of HF
	330 lb TAF	mole HF	1 mole TAF		

Therefore, each 1 lb of TAF generates 0.061 lb of HF

Sample calculation using maintenance activity dated 5/3/05

Quantity of VOCs vented from the WGS (see Page 2) = **0.2116 lb VOC**

HF equivalent emissions would be equal to:

0.212 lb VOC	0.30 lb COF2	0.606 lb HF	=	0.0385 lb HF
	lb VOC	lb COF2		

0.212 lb VOC	0.70 lb TAF	0.061 lb HF	=	0.009 lb HF
	lb VOC	lb TAF		

Therefore, HF vented to the atmosphere from the 5/3/05 maintenance activity is equal to:

0.0385 lb HF + 0.009 lb HF = 0.0474 lb HF

Stack Emissions from Maintenance Activity (cont.)

Calculation page

Date	Tank	Category	Reason	Weight of Tank		Emitted VOC (lb)	Emitted HF (lb)
				Initial (kg)	Final (kg)		
5/3/05	Storage Tank	Emergency	Pressure spike	634	610	0.212	0.047
8/22/05	Storage Tank	Emergency	Pressure spike	638	617	0.181	0.041
10/8/05	Storage Tank	Maintenance	Shutdown work	215	155	0.527	0.118

Total Emissions	0.92	0.21

Total VOC = 0.92 lb

VOC = 0.0004597 ton STACK EMISSIONS

Total HF = 0.21 lb STACK EMISSIONS

Speciated VOC Stack Emissions

The VOC emissions from the Waste Liquid Stabilization process is assumed to be comprised of 30% by weight of COF2 and 70% by weight of TAF. The emission of these compounds from each of the following events is determined simply by multiplying the total emitted VOC by 30% to determine the COF2 emission and 70% to determine the TAF emission.

Date	Tank	Category	Reason	Emitted VOC (lb)	Emitted COF2 (lb)	Emitted TAF (lb)
5/3/05	Storage Tank	Emergency	Pressure spike	0.212	0.063	0.148
8/22/05	Storage Tank	Emergency	Pressure spike	0.181	0.054	0.127
10/8/05	Storage Tank	Maintenance	Shutdown work	0.527	0.158	0.369

Total Emissions	0.92	0.28	0.64

Fugitive Emissions Leak Rates for Process Equipment

Using the following table, the Fugitive Emissions Rates will be calculated:

Component	Service	Emission Factors (lb/hr/component)
Pump Seals	Light Liquid	0.00115
Valves	Light Liquid	0.00036
Flanges	All	0.00018

VOC Fugitive Emissions from Equipment Components

2	Pump Seals	x	0.00115	lb/hr/pumpseal	=	0.0023	lb/hr VOC
148	Valves	x	0.00036	lb/hr/valve	=	0.0533	lb/hr VOC
45	Flanges	x	0.00018	lb/hr/flange	=	0.0081	lb/hr VOC
	Total VOC Emissions from Equipment Leaks				=	0.0637	lb/hr VOC

Total Annual Fugitive VOC Emissions:

0.0637 lb/hr VOC x 8760 hr/year = 557.84 lb VOC for 2005
0.2789 tons VOC

Speciated Fugitive VOC Emissions by Compound:

Assume that the emissions are 30% COF2 and 70% TAF. This assumption is based on process knowledge of the system.

$$\frac{557.8 \text{ lb VOC}}{} \left| \frac{0.30 \text{ lb COF2}}{\text{lb VOC}} \right. = \mathbf{167.35 \text{ lb COF2}}$$

$$\frac{557.8 \text{ lb VOC}}{} \left| \frac{0.70 \text{ lb TAF}}{\text{lb VOC}} \right. = \mathbf{390.49 \text{ lb TAF}}$$

See Page 3 for HF equivalents calculation:

$$\frac{557.8 \text{ lb VOC}}{} \left| \frac{0.30 \text{ lb COF2}}{\text{lb VOC}} \right| \frac{0.606 \text{ lb HF}}{\text{lb COF2}} = 101.42 \text{ lb HF}$$

$$\frac{557.8 \text{ lb VOC}}{} \left| \frac{0.70 \text{ lb TAF}}{\text{lb VOC}} \right| \frac{0.061 \text{ lb HF}}{\text{lb TAF}} = 23.666 \text{ lb HF}$$

101.42 lb HF + 23.666 lb HF = **125.1 lb HF**

Emission Summary

A. VOC Emissions by Compound and Source

Nafion® Compound	CAS Chemical Name	CAS No.	Stack Emissions (lbs)	Fugitive Emissions (lbs)	Total Emissions (lbs)
COF2	Carbonyl fluoride	116-14-3	0.28	167.4	167.6
TAF	Perfluoro-3,5,7, 9,11-pentaoxadodecanoyl fluoride	690-43-7	0.64	390.5	391.1
			Total VOC (lb)		**558.8**
			Total VOC (ton)		**0.28**

B. Toxic Air Pollutant Summary

Nafion® Compound	CAS Chemical Name	CAS No.	Stack Emissions (lbs)	Fugitive Emissions (lbs)	Total Emissions (lbs)
HF	Hydrogen fluoride	7664-39-3	0.21	125.1	125.3

Emission Summary

A. VOC Emissions by Compound and Source

Nafion® Compound	CAS Chemical Name	CAS No.	Point Source Emissions (lbs)	Fugitive Emissions (lbs)	Equipment Emissions (lbs)	Accidental Emissions (lbs)	Total VOC Emissions (lbs)
DMC	Carbonic Acid, Dimethy Ester	616-38-6	145.5	220.3	0	0	365.8
DME	Dimethyl ether	115-10-6	0.0	0.1	0	0	0.1
MTVE	Methyl Trifluorovinyl Ether	3823-94-7	0.01	0.01	0	0	0.0
MTFE	1-methoxy-1,1,2,2-tetrafluoroethane	425-88-7	0.01	0.02	0	0	0.0
MTP	Methyl-3-methoxy-	755-73-7	0.01	0.01	0	0	0.0
BMTK	Bis(2-methoxytetrafluoroethyl)ketone	1422-71-5	0.00	0.001	0	0	0.0
MTP Acid	MTP Acid	93449-21-9	0.00	0.000	0	0	0.0
TFE	Tetrafluoroethylene	116-14-3	22.2	33.6	0	0	55.9
CH3F	Methyl Fluoride	593-53-3	7.4	11.2	9.0	0	27.6
MMF	Propanoic Acid, 2,2,3-Trifluoro-3-oxo,methyl ester	69116-71-8	0	0.0	32.0	0	32.0
Total VOC for 2005			**175.2**	**265.3**	**41.0**	**0**	**481.5**
						VOC (Tons)	**0.24**

B. Toxic Air Pollutant Summary

Nafion® Compound	CAS Chemical Name	CAS No.	Point Source Emissions (lbs)	Fugitive Emissions (lbs)	Equipment Emissions (lbs)	Accidental Emissions (lbs)	Total Emissions (lbs)
HF	Hydrogen Fluoride	7664-39-3	0	34.5	5	0	39.8

C. Total RSU Plant Non-Point Source Emissions

Emission Source	Fugitive Emissions		Equipment Emissions	
	VOC lb/yr	HF lb/yr	VOC lb/yr	HF lb/yr
A. Fugitive emissions from MMF equipment outside of the barricade:	265.3	34.5	0	0
B. Equipment Emissions From MMF Reactor and Transfer Tank	0	0	41.0	5.3
Total for 2002	**265.3**	**34.5**	**41.0**	**5.3**

E. VOC Emission by Source Type

Nafion® Compound	Emissions from Stack (lb)	Fugitive Emissions (lb)	Equipment Emissions (lb)	Accidental Releases (lb)	Total Emissions (lb)
DMC	145.5	220.3	0	0	365.8
DME	0.0	0.1	0	0	0.1
MTVE	0.01	0.01	0	0	0.02
MTFE	0.01	0.02	0	0	0.03
MTP	0.01	0.01	0	0	0.02
BMTK	0.001	0.001	0	0	0.002
MTP Acid	0.0003	0.000	0	0	0.001
TFE	22.2	33.6	0	0	55.9
CH3F	7.4	11.2	9.0	0	27.6
MMF	0	0	32.0	0	32.0
Total	**175.2**	**265.3**	**41.0**	**0.0**	**481.5**

Note: Speciated equipment emissions were estimated by assuming that each compound's equipment emission concentration was equal to that compound's stack emission fraction of the total stack emission.

Example: The DMC equipment emissions were determined by the ratio of the DMC stack emission (254.7 lb) divided by the total stack emission (306.7 lb), multiplied by the total equipment emissions (358.9 lb).

Specifically: $\frac{145.5}{175.2} \;\Big|\; 265.3 \quad = \quad 220.3$ lb. DMC

Yearly Emission Summary

A. VOC Compound Summary

NS-G SR/CR Resins Manufacturing Process			
Nafion® Compound	CAS Chemical Name	CAS No.	Emission (lbs)
PSEPVE	Perfluoro-2-(2-Fluorosulfonylethoxy) Propyl Vinyl Ether	16090-14-5	426
EVE	Propanoic Acid, 3-[1-[Difluoro[(Trifluoroethenyl)oxy]Methyl]-1,2,2,2-Tetrafluoroethoxy]-2,2,3,3-Tetrafluoro-Methyl Ester	63863-43-4	-1,909
TFE	Tetrafluoroethylene	116-14-3	34,111
E-2	2H-Perfluoro(5-Methyl-3,6-Dioxanonane)	3330-14-1	-32
		Total VOC Emissions (lbs)	**32,596**
		Total VOC Emissions (tons)	**16.3**

B. Toxic Air Pollutant Summary

NS-G SR/CR Resins Manufacturing Process			
Nafion® Compound	CAS Chemical Name	CAS No.	Emission (lbs)
F-113	Trichloro-1,2,2-trifluoro-1,1,2 Ethane	76-13-1	3,442
HF	Hydrogen Fluoride	7664-39-3	0.4
MeOH	Methanol	67-56-1	449
		Total VOC Emissions (lbs)	**3,891**
		Total VOC Emissions (tons)	**1.9**

Point Source Emission Determination

A. HF
Hydrogen Fluoride

CAS No. 7664-39-3

HF Potential:

Some SR polymer is fluorinated with a mixture of 10% F2 90% N2.
Each mole of Fluorine (F2) reacts with one mole of SR polymer in the Fluorinator to produce 1 mole of HF.

$$R - CF_2 - H + F_2 \rightarrow HF + R - CF_3$$

Quantity Released:

Vapor released to scrubber during initial fluorine charge:

F2 introduced during the initial fluorine charge to Fluorinator:

$$\frac{2.2\ lb\ F_2}{h}\ x\ 0.1\ F_2\ x\ 0.5\ hour = 0.11\ lb\ F_2$$

Estimate 75% of initial fluorine reacts with polymer during each batch:

$$0.75\ x\ 0.11\ lb\ F_2\ x\ \frac{1\ lbmol\ HF}{1\ lbmol\ F_2}\ x\ \frac{1\ lbmol\ F_2}{38\ lb\ F_2}\ x\ \frac{20\ lbHF}{1\ lbmol\ HF} = 0.0434\ lb\ HF$$

Vapors released to scrubber during initial fluorine charge: 0.0434 lb HF per batch

Vapor released to scrubber during remainder of fluorination cycle:

F2 feed :

$$0.88\ lb/h\ F_2\ x\ 0.10\ F_2\ x\ 12\ hours = 1.056\ lb\ F_2$$

Estimate 60% of fluorine reacts with polymer:

$$0.60\ x\ 1.056\ lb\ F_2\ x\ \frac{1\ lbmol\ HF}{1\ lbmol\ F_2}\ x\ \frac{1\ lbmol\ F_2}{38\ lb\ F_2}\ x\ \frac{20\ lbHF}{1\ lbmol\ HF} = 0.3335\ lb\ HF$$

Vapors released to scrubber during fluorination cycle: 0.3335 lb HF per batch

Unreacted Fluorine released to scrubber: 0.4499 lb F2 per batch

Total vapors to scrubber: 0.0434 + 0.3335 + 0.4499 = 0.8268 lb HF and F2 per fluorination batch

Emissions per batch utilizing 99% fluorine scrubber efficiency:

NOTE: 99% conversion based on studies of Washington Works' Fluorine Scrubbers

0.8268 lb HF and F2 per fluorination batch
x (1 - 0.99)
= 0.0083 lb HF and F2 per fluorination batch

After-Control HF and F2 Emissions: 51 fluorination batches x 0.0083 lb HF and F2 per fluorination batch = 0.422 lb HF and F2

B. MeOH
Methanol

CAS No. 67-56-1

Methanol can potentially be emitting from two tank vents in Polymerization. The Recovery Tank operates at a low enough temperature that no methanol exists in the vapor space, thus no methanol is released. The Recirculation Tank vents whenever condensed liquid is introduced into the tank. This calcuation is based on a Vapor-Liquid Equilibrium calculation for E2, VE, and methanol.

Recirculation Tank Vent Rate:

Recirc Tank Vapor Space: 180 gal x $\frac{3.79 \text{ L}}{1 \text{ gal}}$ x 0.50 level = 341 L in vapor space

Recirc Tank Vent Rate: Assume vent rate is directly proportional to volume of liquid displacing the gas = $\frac{425 \text{ kg/h}}{1.67 \text{ kg/L}}$ (Recycle Feed Rate / Specific Gravity of Liquid) = 254.49 L/h

$\frac{21.37 \text{ mol}}{341 \text{ L in vapor space}}$ x $\frac{254.49 \text{ L}}{1 \text{ h}}$ = 15.9 mol/h

Mass Flow Rate of Methanol:

15.9 mol/h x 0.057 vol% MeOH x $\frac{31.034 \text{ g MeOH}}{1 \text{ mol MeOH}}$ = 28.2 g/h MeOH

Methanol Emissions: 28.2 g/h MeOH x 7233 hours = 203998 g MeOH
449 lb MeOH

E. F-113
Trichloro-1,2,2-trifluoro-1,1,2 Ethane

CAS No. 76-13-1

1. E2 Mass Balance:

	0	kg F-113 Beginning Inventory
+	0	kg F-113 Shipments
+	1561	kg F-113 used with 3P in Polymerization
+	0	kg F-113 used with 3P in Semi-Works
-	0	kg F-113 waste sent off plant
-	0	kg F-113 Ending Inventory
	1561	kg F-13 emission between SW & Polymerization

2. Division of Emissions between SW & Polymerization

0	kg F-113 Ending Inventory
0	kg F-113 Shipments
0	kg F-113 used with 3P in Semi-Works
0	kg F-113 used by Semi-Works

1561	kg F-113 used with 3P in Polymerization
0	kg Refined by Polymerization in Recycle Still
1561	kg F-113 used by Polymerization

Polymerization % = (1561 kg F-113 used by Polymeriz'n x 100) / (1561 kg F-113 Total) = 100.0 %

3. E2 Emission from Polymerization: (100.0 % / 100) x 1561 kg F-113 Emission = 1561 kg F-113 emission from Polymerization
3442 lb F-113 emission from Polymerization

Emission source/Operating Scenario Data

1. Emission Source ID No.

Actual emissions per pollutant listed for source/process identified on page 1:

Criteria (NAAQS) pollutants	Pollutant code	Emissions-Criteria pollutants (tons/yr)					Emission estimation method code	control efficiency
		2001	2002	2003	2004	2005		
Carbon Monoxide	CO	0	0	0	0	0	8	
NOx	NOx	0	0	0	0	0	8	
TSP	TSP	0	0	0	0	0	8	
PM 2.5	PM-2.5	0	0	0	0	0	8	
PM 10	PM-10	0	0	0	0	0	8	
SO2	SO2	0	0	0	0	0	8	
VOC	VOC	18.8	9.3	9.6	5.1	13.0	8	0%

HAP/TAP pollutants	**CAS #**	**Emissions HAP/TAPs lbs/yr**						
Acetic Acid	64-19-7	50.1	78.3	166.0	257.9	353.8	8	0%
Hydrogen Fluoride	7664-39-03	96	89	66	89	88	8	0%

NS-H Membrane treatment (extrusion & hydrolysis) summary report.

DMSO Emissions yr	Units	2004 values	2005
Waste Shipped	lbs/yr	0	77420
Waste in storage tk yr end	gallons	1734	591.6
Waste in storage tk yr end	lbs	17687	6034
Waste % in storage tk yr end	%	29%	10%
DMSO Waste Content	wt%	11%	11%
DMSO Shipped as Waste liquid	lbs/yr	1946	9180
	% change	-90.9	371.8
DMSO pumped to waste treatment	lbs/yr	13599	13599
DMSO Inventory			
inv. Begin year	drums	16	21
inv. End year	drums	21	12
DMSO Drums Rec	drums	56	84
Wt/Drum	lb/drum	500	520
total DMSO consumed	lbs	25500	48360
% consumption change	%	-48%	90%
DMSO Emissions into air	lbs/yr	9956	25581
DMSO Emissions into air	tons/yr	5.0	12.8
	% change	-47.5	156.9
Acetic Acid Emissions air			
1st Quarter	hrs	68.5	28.6
2nd Quarter	hrs	93.3	154.8
3rd Quarter	hrs	90.2	198.88
4th Quarter	hrs	103.0	104.7
Total	hrs	355.0	487.0
Acetic Acid Emissions Rate	lbs/hr	0.727	0.727
Acetic Acid HAP/TAP Emissions	lbs/yr	*257.9*	*353.8*
	% change	55.4	37.2
Total VOC Emissions	lbs/yr	10214	25935
Total VOC Emissions	tons/yr	5.1	13.0
	% change	-46.6	153.9

Emission source/Operating Scenario Data

1. Emission Source ID No. NS-I

Actual emissions per pollutant listed for source/process identified on page 1:

Criteria (NAAQS) pollutants	Pollutant code	Emissions-Criteria pollutants (tons/yr)				Emission estimation method code	control efficiency
		2002	2003	2004	2005		
Carbon Monoxide	CO	0	0	0	0	8	
NOx	NOx	0	0	0	0	8	
TSP	TSP	0.13	0.15	0.17	0.15	8	0%
PM 2.5	PM-2.5	0.13	0.15	0.17	0.15	8	0%
PM 10	PM-10	0.13	0.15	0.17	0.15	8	0%
SO2	SO2	0	0	0	0	8	
VOC	VOC	10.9	13.1	15.1	12.8	8	0%

NS-I Membrane Spraybooth summary.

Coating Process yr		2002	2003	2004	2005	
Max Spray Coat Rate (2 guns)	cc/min	400	400	400	400	
Max Process Rate	gal/hr	6.3	6.3	6.3	6.3	
Paint Batches	batch	137	169	193	166	from spraycoating paint & binder lab results
Gallons/batch	gals	25	25	25	25	
Gallons from Original batches	gals	3425	4225	4825	4150	
Remade batches	batchs	22	0	10	0	from spraycoating paint & binder lab results NG first samples.
Gallons added/batch	gals	5	5	5	5	
Gallons added to remake batchs	gals	110	0	50	0	
Annual Process Throughput	gals/yr	3535	4225	4875	4150	
Coating Density	lb/gal	7.928	7.928	7.928	7.928	
Coating Consumed	lbs/yr	28025	33496	38649	32901	
	% change	-13.78	19.52	15.38	-14.87	
VOC Emissions						
Ethanol	wt %	69%	69%	69%	69%	
Methanol	wt %	1%	1%	1%	1%	
1-Propanol	wt %	8%	8%	8%	8%	
Annual VOC Emissions	lbs/yr	21860	26127	30146	25663	
	tons/yr	10.9	13.1	15.1	12.8	

Emission source/Operating Scenario Data for year 2005

1. Emission Source ID No.	NS-I
2. Emission Source Description:	Nafion® Resin Membrane Coating process
3. Operating Scenario Description:	OS-19 Nafion® Resin Membrane coating process
4. SCC Number/Description:	301 999 98 / * other organic chemical manufacture not listed.
5. Through put in CY kgs:	4150 gal
6. Fuel Information:	None
7: Capture Efficiency:	100%
8. Control Device Information	None

9. Stack or emission release point information:

stack ID	stack height feet	stack diameter feet	temperature deg. F.	velocity feet/sec	volume flow rate (acfm)	release point description	ERP description
NEP-1	50	2	ambient	0.4	75	Vertical	Nafion® membrane coating

10. Operating Schedule: OS-19	Hours per last year		2116.946				
	hours/day	24	days/wk 7		wks/yr	52	
11. Typical Start & End times for Operating Scenar		Continuous when used					
12. Seasonal periods percent annual	Jan-Mar	29%	April-June	24%	July-Sept	27%	Oct-Dec 20%

AIR EMISSIONS INVENTORY SUPPORTING DOCUMENTATION

Emission Source ID No.: NS-J3

Emission Source Description: Nafion Semiworks A/E Lab

Process Description:
The Nafion Semiworks A/E lab occasionally hydrolyzes Nafion® membrane. The solution used to hydrolyze the membrane is a mixture of DMSO/Water/KOH. This operation is carried out in a five (5) gallon stainless steel tank that is heated to an operating temperature of between 75 deg C and 80 deg C. This process is conducted in a lab hood and all emissions are vented through the hood (NEP-J3). This process is run on an as needed basis with a total annual throughput of 20-40 square meters of Nafion® Membrane.

This process will emit DMSO. For the purpose of this emissions inventory, a very liberal approach will be taken as to the total amount of DMSO used is liberated to the atmosphere via evaporation. In reality, DMSO is a very non-volatile compound, with a vapor pressure of 0.5 mm Hg at 25 deg C, and therefore only a fraction of it would volatilize.

Basis and Assumptions:

(1) All DMSO in the hydrolysis solution is volatilized. This assumption is obviously a gross overstatement of the actual emissions.

(2) The 5 gal stainless steel tank is operated at 50% capacity (2.5 gal) and the hydrolysis solution is changed out every 2 months. This equates to a total of 15 gallons per year used in this operation.

Information Inputs and Source of Inputs:

Information Input	Source of Inputs
DMSO Solution Quantity	A/E Lab Technician

Point Source Emissions Determination:
The point source emissions are given on the following page.

Dimethyl Sulfoxide (DMSO) **CAS No. 67-68-5**

Quantity of DMSO Generated:

The hydrolysis solution is composed of 30% DMSO, 60% Water; and 10% KOH on a weight ba:
The density of the solution is approximately 9 lbs. per gallon.
Total yearly consumption of solution is 15 gallons.
On a weight basis, this is equivalent to 135 lbs of solution (15 gal. x 9 lbs./gal.)
Therefore, the total amount of possible DMSO emitted is 40 lbs (135 lbs. x 30% = 40 lbs.)
40 lbs./yr. of DMSO is equivalent to 0.020 tons/yr. of DMSO emitted.

Fugitive Emissions Determination:
N/A

Emissions Summary:

NS-J3 Nafion® Semiworks No. 3			
Nafion® compound	CAS Chemical name	CAS No.	Emission (pounds)
DMSO	Dimethyl Sulfoxide	67-68-5	40
		Total VOC Emissions (pounds)	40
		Total VOC Emissions (tons)	0.02

Emission Summary

A. VOC Emissions by Compound and Source

Nafion® Compound	CAS Chemical Name	CAS No.	Point Source Emissions (lbs)	Fugitive Emissions (lbs)	Equipment Emissions (lbs)	Accidental Emissions (lbs)	Total VOC Emissions (lbs)
E1	Propane, 1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)-	3330-15-2	581.2	53.7	6.3	0	641.2
E2	2H-perfluoro(5-methyl-3,6-dioxanonane)	3330-14-1	443.9	40.5	54.2	0	538.5
E3	2H-perfluoro-5,8-dimethyl-3,6,9-trioxadodecane	3330-16-3	3.9	0.4	2.5	0	6.8
	Total for 2005		1,028.9	94.5	63.0	0	1,186.5
						Tons	**0.59**

Emission Summary

A. VOC Compound Summary

NS-L TFE/HCl Separation Process			
Nafion® Compound	**CAS Chemical Name**	**CAS No.**	**Emission (lbs)**
TFE	Tetrafluoroethylene	116-14-3	41,130
		Total VOC Emissions (lbs)	**41,130**
		Total VOC Emissions (tons)	**20.6**

B. Toxic Air Pollutant Summary

NS-L TFE/HCl Separation Process			
Nafion® Compound	**CAS Chemical Name**	**CAS No.**	**Emission (lbs)**
HCl	Hydrogen Chloride	76-470-10	126.0

2005 Air Emmisions Inventory for SW-1 and SW-2

SW-1

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
VOC's	0.0	0.0	0.0	94.8	316.4	240.4	281.01	228.4	0.0	0.0	0.0	0.0	1161
F113	0.0	0.0	0.0	706.4	730.3	738.7	35.79	13.6	0.0	0.0	0.0	0.0	2224.7
AF's	0.0	0.0	0.0	2.8	8.4	4.1	0.00	0.0	0.0	0.0	0.0	0	15.2
HCl	0.0	0.3	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0	0.3

Qtr's	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Total
VOC's	0.0	651.6	509.4	0.0	1161
F113	0.0	2175.3	49.4	0.0	2224.7
AF's	0.00	15.24	0.0	0.00	15.2
HCl	0.29	0.00	0.00	0.00	0.3

SW-2 (Only record emissions in support of SW polymerization operations)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
VOC's	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F113	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AF's	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000

Qtr's	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Total
VOC's	0.0	0.0	0.0	0.0	0.0
F113	0.0	0.0	0.0	0.0	0.0
AF's	0.000	0.000	0.00	0.00	0.000

General explanation:

Semi-works is a research & development area that operates under a wide range of conditions. Emissions are calculated for each individual campaign. These campaigns fall into two categories. One is polymerization campaigns and the other is slurry reclaim campaigns. In both cases, material balance is used to determine emissions. Since all emissions occur within the semi-works facility, there are all assumed to be point source emissions via the process stack SW-1. The only emissions calculated for SW-2 are acid fluoride emissions associated with running melt flow samples under the lab hood.

Polymerization Campaign Emissions Determination:
The production and raw material information is entered for each campaign on a worksheet. The individual sheets in this workbook are copies of the completed worksheets for each campaign. Data in green fields is entered when applicable for the polymerization campaign. The other cells are calculated cells. The emissions for the campaign are calculated at the bottom of the worksheet. For the annual emissions calculations, the emissions from these campaigns are totaled onto a summary sheet. In this workbook, that is called "Campaign Summary". A summary by month is found on "Year End Summary".

Example Mass Balance Calculations for polymerization campaigns: (using ***5-SXF-1.1*** *worksheet for example)*
The emissions are determined by mass balance around the system. Data used in the calculation is obtained from production records and entered into the worksheet. The following is entered into the worksheet after each campaign:

1) Enter the starting material at the beginning of the campaign. This would include any material in the recovery tank and condensate tank. The composition of the material in each tank is determined by lab analysis and/or on-line GC.
2) Enter the amount of initiator added to the system, based on integrator on initiator feed. The concentration of initiator is determined by lab analysis.
3) Enter the amount of TFE added to the system, based on the integrator for TFE feed.
4) Enter the amounts of solvent (E2, F113) and monomer (PSEPVE) added to the system during the campaign. Drum weights before and after the campaign are used to determine this.

Enter starting and addition data as described in steps 1-4 above in the green shaded areas.
Spreadsheet sums all inputs for each component in right hand column (column M)....see embedded comments for details

Starting Material

Item	Recovery Tank	Monomer Tank	Condensate Tank	Initiator Tank	Addition (TFE)	Addition (E2)	Addition (PS)	Addition (F113)		Totals
Weight (Kg):	0.00	0.00	0.00	20.08	114.39	0.00	97.00	666.00	0.00	
Compositions:										
%E2	0.00%		94.00%	96.00%	0.00%	100.00%	0.00%	0.00%	0.00%	
%PSEPVE	8.00%		6.00%			0.00%	100.00%	0.00%	45.00%	
%TFE	0.00%		0.00%		100.00%	0.00%	0.00%	0.00%	0.00%	
%F113	92.00%		0.00%	0.00%		0.00%	0.00%	100.00%	55.00%	
%Inititiato	0.00%		0.00%	4.00%		0.00%	0.00%	0.00%	0.00%	
Weights										
E2	0.00	0.00	0.00	19.28	0.00	0.00	0.00	0.00	0.00	19.3
PSEPVE	0.00	0.00	0.00	0.00	0.00	0.00	97.00	0.00	0.00	97.0
TFE	0.00	0.00	0.00	0.00	114.39	0.00	0.00	0.00	0.00	114.4
F113	0.00	0.00	0.00	0.00	0.00	0.00	0.00	666.00	0.00	666.0
Inititiator	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.8

5) Enter the amount and composition of material in the recovery tank, condensate tank, in collection drum, or held up in the system at the end of the campaign. Spreadsheet sums all inputs for each component in right hand column (column M)....similar to above

Ending Material

Item	Recovery Tank		Condensate Tank	E2 tank	Drained to drum	Holdup		Totals
Tank level (jet off)								
Weight (Kg):	200.00		107.00		85.00	0.00	0.00	
Compositions								
%E2	3.89%		4.69%	100.00%	4.69%	72.00%		
%PSEPVE	7.50%		6.92%		6.92%	28.00%		
%TFE	0.00%				0.00%	0.00%		
%F113	87.79%		88.20%		88.20%	0.00%		
%Inititiato	0.00%				0.00%	0.00%		
Weights								
E2	7.78	0.00	5.02	0.00	3.99	0.00	0.00	16.8
PSEPVE	15.00	0.00	7.40	0.00	5.88	0.00	0.00	28.3
TFE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
F113	175.58	0.00	94.37	0.00	74.97	0.00	0.00	344.9
Inititiator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

6) Enter total weight of polymer produced, and average EW.
7) Enter approximate weight (5 kg) of adhesions on vessel walls and in piping. The adhesions are assumed to be pTFE with an EW of 1700.
8) Enter amount and composition of slurry left over at the end of the campaign. The EW is assumed to be 1080 as a result of over saturation of initiator and limited TFE present during shutdown conditions.

Production						
Item	Polymer	Adhesions	Slurry			
Weight (Kg):	138.30	5.00	0.00			
Compositions						
EW	1470	1700	1000			
%Polymer	1	1	0.1			
%E2			0.72			
%PSEPVE			0.28			
%TFE			0			
%F113			0.79011			
Weights						Totals
Polymer	138.30	5.00	0.00			143.3
E2	0.00	0.00	0.00			0.0
PSEPVE	41.96	1.31	0.00			43.3
TFE	96.34	3.69	0.00			100.0
F113	0.00	0.00	0.00			0.0
VE in Poly	41.96	1.31	0.00			

The total for each component added, remaining, and production output as calculated in column M for each section of the spreadsheet above is duplicated in the table below. Emissions are difference between amount consumed and amount in product.

Material Balance Summary							
Compound	Added	Remaining	Used	Production	Other		*Totals*
E2	19.3	16.8	2.5	0.0			2.5
PSEPVE	97.0	28.3	68.7	43.3			25.4
TFE	114.4	0.0	114.4	100.0			14.4
F113	666.0	344.9	321.1	0.0			321.1
Inititiator	0.8	0.0	0.8	0.0			0.8

The final section of the spreadsheet summarizes the reportable emissions in pounds for SW-1. Refer to embedded comments for details.

Lbs of Emissions	
SW-1	
VOC's	**94.8 lbs**
F-113	**706.4 lbs**
AF's	**2.766 lbs**

9) Enter in the number of melt flow samples processed in the semi-works lab during the campaign. This is entered in the green box under SW-2. If all samples are sent to the mfg lab, this will be zero.

SW-2	
# of MF samples	**0**
grams emissions	**0 g**
lbs of emissions	**0.0000 lb**

Example Mass Balance Calculations for slurry reclaim campaigns:
The slurry reclaim process is used to recover valuable solvent and monomer from drums of polymer slurry. The semi-works flash dryer is used to flash off the solvent and monomer liquid into a vapor state, so that the solids can be collected in a bag filter. The vapors are then condensed back into liquid which can be reclaimed. Due to a high nitrogen (noncondensible) flow, some of the solvent and monomer escapes the condenser as vapor to the SW-1 stack. A mass balance approach is used to determine how much vapor has been lost, so that this can be included in annual air emissions summary.

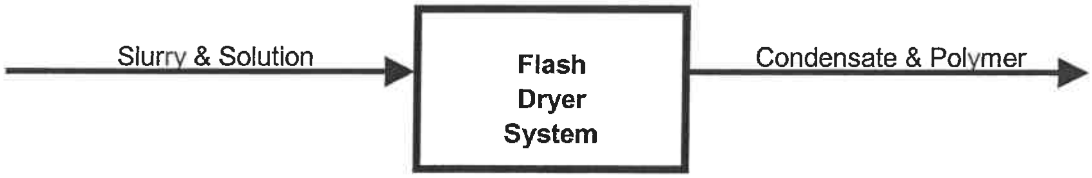
Here is a summary of the material balance calculation.

1) Weight of drums processed through the system are recorded. The reported composition of the drums is used to determine VOC and F113 content. Solids and other non-recoverable waste are backed out, based on a material balance on solids (polymer and waste collected).
2) Any fresh E2 solution used for startup of the flash drying system is accounted for in the balance.
3) Outputs include weight of reclaimed liquid collected in drums, weight of solid polymer collected, and weight of solid waste in drums.

	Campaign Starts:	**4/21/2005**	**5/3/2005**	**6/15/2005**	**7/25/2005**	**8/23/2005**	**2/2/2005**	
	Campaign Ends:	**4/27/2005**	**5/14/2005**	**6/20/2005**	**7/28/2005**	**9/1/2005**	**2/17/2005**	
							TA 05-1506	
SW-1		5-SXF-1.1	5-SXF-2.1	5-SXF-3.1	Reclaim	Reclaim	EVE-P	**Total**
VOC's	**lbs**	94.82	316.37	240.45	281.01	228.44	0.00	**1161.08**
F-113	**lbs**	706.37	730.29	738.66	35.79	13.56	0.00	**2224.68**
AF's	**lbs**	2.77	8.36	4.11	0.00	0.00	0.00	**15.242**
HCl	**lbs**	0	0	0	0	0	0.2904	**0.2904**
SW-2								
lbs of emissions	**lbs**	0	0	0	0	0	0	0

Flash Dryer Slurry Reclaim Material Balance

Start Date 8/23/05 End Date 9/1/05



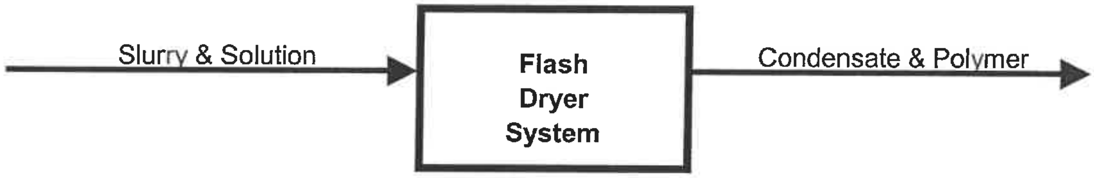
Accumulation
0

Total material fed:	**1809** kg	Total mat'l collected:	**1699** kg
VOCs	1633.79	VOCs	1529.955
F113	8.21	F113	2.0448
polymer/other	167	polymer/other	167

Total lost through stack:	**110** kg	
Total run time w/ sol'n or slurry:	**41** hours	
Rate of mat'l lost through stack:	**2.68** kg/hr	
VOC lost through stack	103.8348 kg	228.4366 lb
F113 lost through stack	6.1652 kg	13.56344 lb

Flash Dryer Slurry Reclaim Material Balance

Start Date 7/25/05 End Date 7/28/05



Accumulation
223

Total material fed:	**3415** kg	Total mat'l collected:	**3048**
VOCs	2941.29	VOCs	2590.559
F113	29.71	F113	13.441
polymer/other	444	polymer/other	444

Total lost through stack:	**144** kg	
Total run time w/ sol'n or slurry:	**70** hours	
Rate of mat'l lost through stack:	**2.06** kg/hr	
VOC lost through stack	127.731 kg	281.0082
F113 lost through stack	16.269 kg	35.7918

2005 AIR EMISSIONS INVENTORY SUPPORTING DOCUMENTATION

Emission Source ID No.: U-MeCl

Emission Source Description: Fugitive emissions of Methylene Chloride

Process & Emission Description:

Methylene Chloride is used as a heat exchanging fluid in many of the processes in Nafion. It is a closed loop system. All emissions from this system are a result of equipment leaks or spills.

Basis and Assumptions:

A material balance is used for calculating fugitive emissions.

Information Inputs and Source Inputs:

Information Input	Source of Inputs
Methylene Chloride Emissions	SARA 313 Report from Nafion Waste Shipment Clerk

Point Source Emissions Determination:

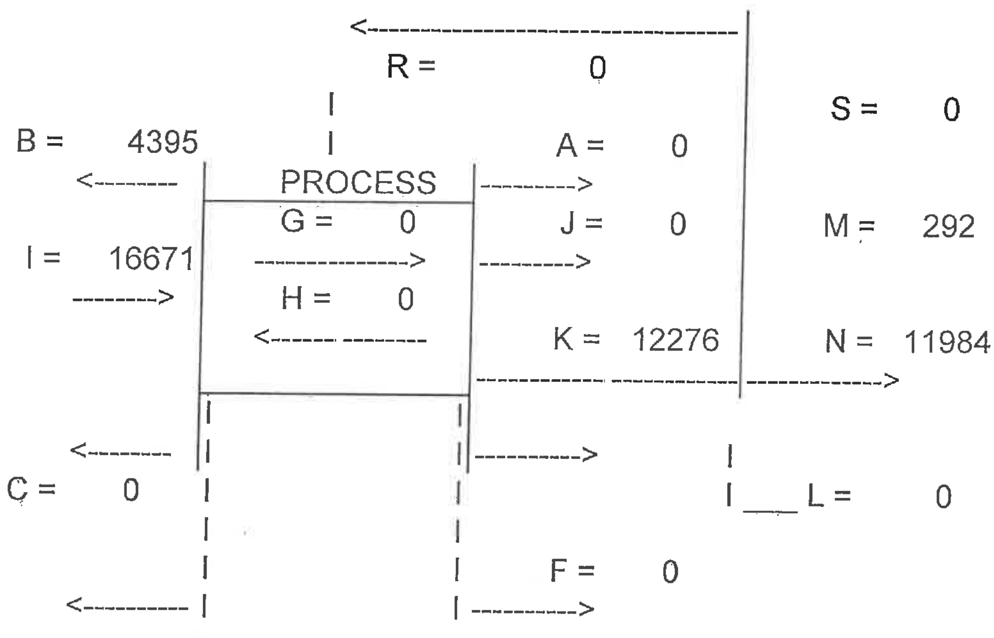
None

Fugitive Emissions Determination:

Shown on the following page.

√ Reportable 2005

SARA 313 2005
All units in Lbs.
Material Balance For: Methylene Chloride



A = Emitted to Air - Permitted Point Source	0
B = Emitted to Air - Fugitive & Releases	4395
C = Emitted to Ground - (Release)	0
F = Emitted to Water - (Release)	0
G = Generated In Process - (Specify How)	0
H = Destroyed or Transformed in Process - (Specify How)	0
I = Introduced into Process - (Raw Ingredients Consumed)	16671
J = Shipped off with Product	0
K = Generated as Waste in Current Year	12276
L = Waste Stored from Previous Year	0
M = Waste Stored at End of Current Year	292
N = Total Waste Shipped During Current Year	11984
R = Returned to System w/o Recycling Step (From Prev Year)	0
S = Diallylamine & Propylene Oxide added to adjust pH.	0

NOTES:

B - Includes incident 2005 - 176 = <50 lbs, 126 = <1 lb, 040 - <1 lb
= Total of 52 lbs for incidents

+Beg. Inv.	23732
+Purchas	15600
-End Inv.	22661
Total	16671

2005 Air Emissions Inventory Supporting Documentation

Emission Source ID No.: SGS-A

Emission Source Description: SentryGlas Plus Process

Process and Emission Description:

The SentryGlas Plus Process is a continuous process in which solid resin is extruded into a rigid sheet. There is no chemical reactions or processes associated with this process. The solid resin is delivered to the site, where it and another solid powder are then mechanically charged into the process. These solids are then extruded into the final sheeting. All air emissions from this process result from the evolution of volatile compounds, which are entrained in the resin, from the resin due to the heat of extrusion.

Basis and Assumptions:

The emission rates from the SentryGlas Plus Process is based on the emissions from a sister manufacturing facility in Germany. For simplicity, the reported emissions are based solely on the emissions from the process at full production design rates. This approach should over-estimate the emissions, in part due to no credit being taken for the organics that would be expected to solubilize in the waterused in the liquid ring vacuum pump. Also note that there is no control device associated with this process.

Information Inputs and Source of Inputs:

Information Inputs	Source of Inputs
Tinting Process total throughput pounds for the year	SentryGlas Plus Production Coordinator
Annual production run time (hours for year)	SentryGlas Plus Production Coordinator

Point Source Emissions Determination:

Point source emissions for individual components are given in the following pages. A detailed explanation of the calculations is attached.

Equipment Emissions and Fugitive Emissions Determination:

The SentryGlas Plus Process is completely contained in a closed building, and as such there are no non-point source (fugitive) emissions associated with this process.

Emission Summary

A. VOC Emissions by Compound and Source

SentryGlas® Plus Compound	CAS Chemical Number	Point Source Emissions (lbs)	Total VOC Emissions (lbs)
Ethylene	74-85-1	1,022	**1,022**
Methacrylic acid	79-41-4	3,323	**3,323**
Methanol	67-56-1	511	**511**
Mineral Spirits	8052-41-3	8,026	**8,026**
	Total VOC Emissions in 2005 (lb)		**12,882**
	Total VOC Emissions in 2005 (ton)		**6.44**

B. Particulate Matter Emissions by Compound and Source

SentryGlas® Plus Compound	CAS Chemical Name	Point Source Emissions (lbs)	Total PM Emissions (lbs)
Tinuvin 328	25973-55-1	1,125	**1,125**
	Total PM Emissions in 2005 (lb)		**1,124.6**
	Total TSP Emissions in 2005 (ton)		**0.56**
	Total PM10 Emissions in 2005 (ton)		**0.56**
	Total PM2.5 Emissions in 2005 (ton)		**0.56**

C. Hazardous Air Polluntant Summary

SentryGlas® Plus Compound	CAS Chemical Name	Point Source Emissions (lbs)	Total Emissions (lbs)
Methanol	67-56-1	511	511

AIR EMISSIONS INVENTORY SUPPORTING DOCUMENTATION

Emission Source ID No.:

INSIG-N1

Emission Source Description:

Nafion® Waste DMSO Storage Tank

Process Description:

This tank is used as an intermediate storage space for disposal of DMSO (dimethyl sulfoxide) offsite. DMSO is used in the Hydrolysis process and can not currently be disposed of onsite. When the material in Hydrolysis can no longer be used for the process, the chemical is transferred to the Waste DMSO Storage Tank. From this tank, a truck comes and disposes of the DMSO solution. The tank is open to the atmosphere with a gooseneck pipe coming off the top that ends 12" above the diked area.

Basis and Assumptions:

- Direct vent to atmosphere
- Tank volume = 6000 gallons or 802 ft^3
- DMSO vapor pressure = 0.46 mm Hg @ 20°C
- Molar volume of an Ideal Gas @ 0°C and 1 atm = 359 ft^3/(lb-mole)
- Molecular Weight of DMSO = 78 (78 lb DMSO / lb-mole DMSO)
- Assume one complete tank volume turnover per day for point source emissions.
- Assume DuPont Good Emission Factor on Equipment Leaks for fugitive emissions (See Appendix A).
- Flange emissions were used for all equipment except valves and pumps.

Information Inputs and Source of Inputs:

Information	Source
Total shipped DMSO (lb/yr) (#5 on State Inventory Form)	Catherine Bass, Global Supply Support
Vapor pressure	MSDS #22310402, CAS #67-68-5
Tank volume	Procedure PR-70, W1535321, or NBPF000351
Number of Each Type of Equipment	W1535321 and verifying at source
% Production/ Quarter (#12 on State Inventory Form)	Master Production Scheduler (David Garwood) via SAP BW Reporting

Dimethyl sulfoxide (DMSO) **CAS No. 67-68-5**

Point Source Emissions Determination:

Vapor pressure of DMSO = 0.46 mm Hg at 20°C

Mole fraction DMSO in vapor (using Dalton's law):

$$\text{Mole fraction DMSO} = \frac{\text{Vapor pressure DMSO}}{\text{Total pressure in tank}} = \frac{0.46 \text{ mm Hg}}{760 \text{ mm Hg}} = \frac{0.000605 \text{ mole DMSO}}{\text{mole gas in tank}}$$

Molar volume at 0°C and 1 atm = 359 ft^3 ⇒ Molar volume at 20°C and 1 atm = 385 ft^3

Pounds of DMSO per tank volume:

$$\frac{802 \text{ ft}^3}{\text{tank volume}} * \frac{\text{lb-mole}}{385 \text{ ft}^3} * \frac{0.000605 \text{ mole DMSO}}{\text{lb-mole gas in tank}} * \frac{78 \text{ lb DMSO}}{\text{mole DMSO}} = \frac{0.098 \text{ lb DMSO}}{\text{tank volume}}$$

Total DMSO emissions per year from tank volume:

$$\frac{0.098 \text{ lb DMSO}}{\text{tank volume}} * \frac{1 \text{ tank volume}}{\text{day}} * \frac{365 \text{ days}}{\text{year}} * \frac{1 \text{ ton}}{2000 \text{ lbs}} = \mathbf{0.018 \text{ ton DMSO / yr}}$$

Fugitive Emissions Determination:

Equipment Component	Number of Components	Good Factor (lb/hr/component)	Emissions (lb/hr)	Emissions (ton/yr)
Pump Seal	1	0.0075	0.0075	0.033
Heavy Liquid Valve	20	0.00352	0.0704	0.308
Open-ended Line	1	0.0215	0.0215	0.094
Flange/Connection	9	0.00031	0.00279	0.012
			Total	**0.447**

Good factor (lb/hr/component) × Number of Components = Emissions (lb/hr)

Emissions (lb/hr) × 1 ton / 2000 lbs × 24 hr/day × 365 days/year = Emissions (ton/yr)

Total fugitive DMSO emissions per year = **0.447 ton DMSO / year**

Emissions Summary:

Point Source Emissions + Fugitive Emissions = Total Emissions

0.018 ton DMSO / year + 0.447 ton DMSO / year = **0.47 ton DMSO / year**

2005 Air Emissions Inventory Supporting Documentation

Emission Source ID No.: WTS-A

Emission Source Description: Central Wastewater Treatment Plant

Process and Emission Description:

The Wastewater Treatment Plant (WWTP) consists of the biological treatment of process and sanitary wastewater utilizing extended aeration. The WWTP is comprised of an open equalization basin and open-top tanks and clarifiers. The basin is mixed using floating mixers and the tanks are aerated primarily with diffused air.

Emissions from the WWTP result from the volatilization of solubilized compounds which are air stripped via the aeration of the wastewater. The extent of the volatilization is a function of the specific compound's solubility in water and its vapor pressure, typically expressed as the compound's Henrys Law Constant. Also, the volatilization of an organic compound is dependent on its rate of biodegradability. For example, methanol which is a Hazardous Air Pollutant (HAP), is highly biodegradable, and as such its biodegradation rate is much faster than its volatilazation rate, thereby limiting the air emissions of methanol from the WWTP.

Basis and Assumptions:

The emissions of methanol and dimethylformamide from the WWTP were determined using the EPA WATER8 model. This modeling takes into account the specific operational units of the WWTP to predict the ultimate fate of specific compounds. Two major compounds that are treated in the WWTP are ethylene glycol and butyraldehyde. The Henry's Law Constant for ethylene glycol is 6.0 × 10e-08 atm-m3/mole which is very similar to the Henry's Law Constant for dimethylformamide of 7.4 × 10e-08 atm-m3/mole. Not surprisingly, ethylene glycol and dimethylformamide are both exempt from the wastewater control requirements of 40 CFR 63 Subpart G as both are excluded from Table 9 of that subpart.

Because of the above, it will be assumed that the WWTP unit operation's emission factors for ethylene glycol are the same as those for dimethylformamide. However, the biodegradation rate of ethylene glycol will be assumed to be the same as that of methanol, since the technical literature found in the Handbook of Environmental Data on Organic Chemicals indicates that for an acclimated system, ethylene glycol is biodegraded at twice the rate of methanol. To be conservative, the slower methanol rate will be used.

The Henry's Law Constant for butyraldehyde is 1.15 × 10e-04 atm-m3/mole which is higher than the Henry's Law Constant for methanol of 4.55 × 10e-06 atm-m3/mole, meaning the quantity that is air stripped from the wastewater would be expected to be higher than that for methanol. According to the Handbook of Environmental Data on Organic Chemicals, butyraldehyde is biodegraded at the same rate of methanol in an acclimated system.

Because of the above, it will be assumed that the WWTP unit operation's emission factors for butyraldehyde are twice as those for methanol. To be conservative, the biodegradation rate of butyraldehyde will be assumed to be the same as that of the slower dimethylformamide rate.

Information Inputs and Source of Inputs:

Information Inputs	**Source of Inputs**
Estimated quantity of compounds entering the WWTP for the year	SARA 313 Report and other Air Emission Inventory inputs

Fugitive Emissions Determination:

All emissions from the WWTP are fugitive. Estimates of the emission for individual components are given in the following pages.

2005 Emissions from Wastewater Treatment Plant (WTS-A)

	BA	DMF	EtGly	MeOH
To WWTP from Butacite (lb)	59,200	43,277	8,145	410,800
To WWTP from Nafion (lb)	-	-	-	42,124
To WWTP from PMDF (lb)	-	-	-	-
To WWTP from SentryGlas (lb)	-	-	-	-
To WWTP from Other Sources (lb)	-	-	-	-
Total to WWTP (lb)	59,200	43,277	8,145	452,924
Quantity entering EQB (lb)	59,200	43,277	8,145	452,924
Percent of compound volatilized	23.42%	0.29%	0.29%	11.71%
Quantity volatilized from EQB (lb)	13,865	126	24	53,037
Quantity leaving EQB (lb)	45,335	43,151	8,121	399,887
Quantity entering Predigester (lb)	45,335	43,151	8,121	399,887
Percent of compound volatilized	8.30%	0.10%	0.10%	4.15%
Quantity volatilized from Predigester (lb)	3,763	43	8	16,595
Quantity leaving Predigester (lb)	41,573	43,108	8,113	383,291
Quantity entering Aeration Tank (lb)	41,573	43,108	8,113	383,291
Percent of compound volatilized	0.16%	0.002%	0.002%	0.08%
Quantity volatilized from Aeration Tank (lb)	67	1	0	307
Percent of compound biodegraded	94.40%	94.40%	99.74%	99.74%
Quantity biodegraded in Aeration Tank (lb)	39,244	40,694	8,092	382,295
Quantity leaving to Cape Fear River (lb)	2,262	2,413	21	690
Butacite Quantity to Cape Fear River (lb)	2,262	2,413	21	626
Nafion Quantity to Cape Fear River (lb)	-	-	-	64
PMDF Quantity to Cape Fear River (lb)				
SentryGlas Quantity to Cape Fear River (lb)				
Nafion Quantity to Cape Fear River (lb)				
Total Quantity to Cape Fear River (lb)	2,262	2,413	21	690
Butacite Fraction Volatilized to Air (lb)	17,694	170	32	63,435
Nafion Fraction Volatilized to Air (lb)	-	-	-	6,505
PMDF Fraction Volatilized to Air (lb)	-	-	-	-
SentryGlas Fraction Volatilized to Air (lb)	-	-	-	-
Nafion Fraction Volatilized to Air (lb)	-	-	-	-
Total Volatilized to Air (lb)	17,694	170	32	69,939

* Source of Reduction Factors: EPA WATER8 computer model

BA = Butyraldehyde
DMF = Dimethylformamide
EtGly = Ethylene Glycol
MeOH = Methanol

2005 Air Emissions Summary

WTS-A Central Wastewater Treatment Plant

A. VOC Compound Summary

Compound	CAS Chemical Name	CAS No.	Emission (lbs)
BA	Butyraldehyde	123-72-8	17,694
DMF	Dimethylformamide	68-12-2	170
EtGly	Ethylene Glycol	107-21-1	32
MeOH	Methanol	67-56-1	69,939
	Total VOC Emissions (lbs)		87,835
	Total VOC Emissions (tons)		43.9

B. Hazardous Air Pollutant Summary

Compound	CAS Chemical Name	CAS No.	Emission (lbs)
DMF	Dimethylformamide	68-12-2	170
EtGly	Ethylene Glycol	107-21-1	32
MeOH	Methanol	67-56-1	69,939

Conversion of concentration from ppmv to mg/m^3

Compound	Molecular Weight (grams per mole)	Odor Threshold (ppmv)	Odor Threshold (mg/m^3)
Methyl amine	31	0.021	0.026
Ammonia	17	1.5	1.035
Hydrogen sulfide	34	0.13	0.179
Methyl mercaptan	48	0.002	0.004
Dimethyl sulfide	62	0.001	0.048
3-Methyl-1H-indole	131	0.019	0.101

Scrubber (ID No. WTCD-3) design air flow rate is 23,850 cubic feet per minute.

This flow rate is converted to cubic meters per year by the following:

$$23{,}850\,\frac{\text{ft}^3}{\text{min}} \times 0.0283\,\frac{\text{m}^3}{\text{ft}^3} \times 60\,\frac{\text{min}}{\text{hr}} \times 8{,}760\,\frac{\text{hr}}{\text{yr}} = 354{,}756{,}350\,\frac{\text{m}^3}{\text{yr}}$$

Emissions Determination:

		Multiplied by:	Multiplied by:	Equals:
Compound	**Odor Threshold (mg/m^3)**	**Scrubber Flow Rate (m^3/yr)**	**Mass Conversion (lb/mg)**	**Emission Rate (lb/yr)**
Methyl amine	0.026	354,756,350	2.2046×10^{-6}	20.3
Ammonia (Note 1)	1.035	354,756,350	2.2046×10^{-6}	809.5
Hydrogen sulfide (Note 1)	0.179	354,756,350	2.2046×10^{-6}	140.0
Methyl mercaptan (Note 1)	0.004	354,756,350	2.2046×10^{-6}	3.1
Dimethyl sulfide (Note 1)	0.048	354,756,350	2.2046×10^{-6}	37.5
3-Methyl-1H-indole	0.101	354,756,350	2.2046×10^{-6}	79.0

Note 1: These compounds are listed as HAPs and/or TAPs

VOC Emissions Determination:

Methyl amine	20.3 lb/yr
Methyl mercaptan	3.1 lb/yr
Dimethyl sulfide	37.5 lb/yr
3-Methyl-1H-indole	79.0 lb/yr
Total VOC	**139.9 lb/yr**
Total VOC	**0.07 TPY**

Supporting Documentation for WWTP Sludge Dryers (WTS-B and WTS-C)

The Specific Conditions for the Impingement Type Wet Scrubber (ID No. WTCD-1) listed in Item VII(1) of the site's Air Permit equipment list is discussed under Part 1 Section 2.1(F)(1) of that permit. The Permit states that the scrubber is to control the "odorous emissions from the wastewater treatment sludge dryers (Nos. WTC-B and WTS-C)."

Major categories of offensive odors from the drying of activated sludge could generally be grouped into the following:

Odor Category	Common Chemical in Odor Category	Odor Threshold of Common Chemical (ppmv)
Amines	Methyl amine	0.021
Ammonia	Ammonia	1.5
Hydrogen sulfide	Hydrogen sulfide	0.13
Mercaptans	Methyl mercaptan	0.002
Organic sulfides	Dimethyl sulfide	0.001
Skatole	3-Methyl-1H-indole	0.019

Based on the lack of odors coming from the discharge of the WWTP Sludge Dryer scrubber, and the low odor threshold of the possible odorous compounds coming from the scrubber, it is believed that only an insignificant amount of VOCs could be emitted from this source.

To quantify the worst-case scenario, it will be assumed that the scrubber is running continuously for the entire year with the above compounds being vented at their odor threshold concentration. This is an obvious overstatement of actual emissions since the WWTP Scrubber normally operates with no detectable odors.

Conversion of concentration expressed as ppmv to mg/m^3 is via the following equation:

$$\frac{mg}{m^3} = \frac{ppmv \times 12.187 \times \text{Molecular Weight}}{(273.15 + \text{Temperature})°C}$$

For the purpose of this concentration conversion, it will be assumed that the actual scrubber discharge temperature is a constant 27 °C. Therefore, the above equation reduces to:

$$\frac{mg}{m^3} = 0.0406 \times ppmv \times \text{Molecular Weight}$$

For example, converting 0.021 ppmv of methyl amine (MW = 31) to mg/m^3 follows:

$$0.0406 \times 0.021\,ppmv \times 31\frac{grams}{mole} = 0.026\frac{mg}{m^3}$$

2005 AIR EMISSIONS INVENTORY

SITEWIDE LABORATORY AND OTHER NON-MANUFACTURING HAP/TAP EMISSIONS

The basis for the determination of the TAP and HAP emissions from the various sitewide quality control and research laboratories, which are exempted from permitting under NCAC Title 15A 2Q.0102(b)(1)(C), or other non-manufacturing usage (such as chlorine for drinking water disinfection), is the simplified approach whereby the total quantity of a TAP/HAP chemical purchased during the year for laboratory or non-manufacturing usage is assumed to have volatilized and is therefore shown as an air emission.

Obviously this is an overstatement of the actual air emissions, but given the small quantity of the laboratory chemicals or other non-manufacturing usage, and the difficult task of determining actual emissions, this approach was chosen.

A. VOC Emissions

Air Emission Compound	Permitted limit (lb)	Density kg/L	12-month Total	Reporting Quarter 1Q05	2Q05	3Q05	4Q05
Bromine	2.92 lb/hr	3.12	8.8	4.4	4.4		
Chloroform	6,882 lb/yr		1.3			1.3	
Ethyl Acetate	2,046 lb/hr	0.902	11.9	11.9			
n-Hexane	965 lb/day	0.6594	2.9	2.9			
Hydrogen Chloride	10 lb/hr	1.16	15.3		15		
Triethylamine	n/a	0.726	73.5		73.5		

Total VOC emissions (lb)	113.7
Total VOC emissions (tons)	0.06

B. TAP Emissions

Air Emission Compound	Permitted limit (lb)	Density kg/L	12-month Total	Reporting Quarter 1Q05	2Q05	3Q05	4Q05
Bromine	2.92 lb/hr	3.12	8.8	4.4	4.4		
Chloroform	6,882 lb/yr		1.3			1.3	
Ethyl Acetate	2,046 lb/hr	0.902	11.9	11.9			
n-Hexane	965 lb/day	0.6594	2.9	2.9			
Hydrogen Chloride	10 lb/hr	1.16	15.3		15		

Riverwater Chlorine Fugitive Emissions Basis

Equipment Component	River Water Service	Domestic Water Service	Total Components	Excellent Rating (lb/hr/component)	Service (hr/yr)	Emissions (lb/yr)
Angle Valves	1	1	2	0.00039	8760	7
Pressure Relief Seals	0	0	0			0
Open Ended Lines	0	0	0			0
Connections including fusible plugs	33	3	36	0.00018	8760	57
Sampling Connections	0	0	0			0

Total Pounds of Chlorine	**64**

QUESTIONS FOR DETERMINING UNIT-SPECIFIC FACTOR CATEGORY

1. Are techniques available and used to routinely locate specific leaks? Examples include SO2 bombs, ammonia solution, special detectors (such as those for HCN or phosgene), chemical badges, and sniff testers.
Yes

2. Do you perform leak checks in this process area at least once per day?
Yes, Continous Monitor.

3. Are specific procedures used on each start-up to minimized fugitive emissions? Examples include hydrostatic tests, special leak tests, etc.
Yes

4. Do you have a documented check list startup procedure that helps locate routine leaks?
Yes

5. Do you have a formal procedure that requires leaks be repaired in a timely manner, including use of overtime if necessary?
Yes