

ATTACHMENT I – AIR EMISSIONS INFORMATION

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1. Air Emissions Information

1.1 ESTIMATED FACILITY EMISSIONS

A summary of estimated facility emissions, preliminary emissions calculations, a discussion of emission controls, and process flow diagrams for the scrubbers associated with Hoods 115 through 119 are provided as [Appendix I-A](#). Air emissions will further be controlled as prescribed by the conditions of the Class II air quality permit issued by PCAQCD. A discussion of the air emission standards prescribed 40 CFR Part 264 is provided below.

1.2 AIR EMISSION STANDARDS

1.2.1 Air Emission standards for process vents

[40 CFR, Part 264, Subpart AA]

This subpart applies to process vents associated with distillation, fractionation, thin-film evaporation, solvent extraction, or air or steam stripping operations that manage hazardous wastes with organic concentrations of at least 10 ppmw, if these operations are conducted in one of the following:

- A unit that is subject to the permitting requirements of 40 CFR Part 270, or
- A unit that is not exempt from permitting under the provisions of 40 CFR 262.17 and that is located at a hazardous waste management facility otherwise subject to the permitting requirements of 40 CFR, Part 270; or
- A unit that is exempt from permitting under the provisions of 40 CFR 262.34(a) and is not a recycling unit under the provisions of 40 CFR 261.6.

No processing equipment, process vents, pumps, compressors, valves, surface impoundments or containment buildings are present at the Facility that are subject to the Air Emission Standards of 40 CFR, Part 264, Subpart AA.

1.2.2 Air Emission Standards for Equipment Leaks

[40 CFR Part 264, Subpart BB]

40 CFR, Part 264, Subpart BB (Subpart BB) applies to equipment at hazardous waste treatment, storage and disposal facilities which contains or contacts hazardous wastes with 10 percent or more (by weight) organics content.

Organic waste consolidation and fuel blending at the Facility is subject to the requirements of Subpart BB. No other system has the potential to contain or contact hazardous wastes with 10 percent or more (by weight) organics. A Subpart BB inspection and monitoring plan is included as [Appendix I-B](#). This plan will be revised and refined after construction and installation of the affected equipment are completed.

1.2.3 Air Emission Standards for Tanks and Containers

[40 CFR Part 264, Subpart CC]

Subpart CC applies to both tanks and containers that are holding hazardous waste streams with an average volatile organic (VOC) concentration at the point of origin of that is equal to, or greater than 500 parts per million by volume (ppmv). VOC concentrations are determined, in part, by lab analyses. Analyses of hazardous waste streams with an average VOC concentration at the point of origin of that is equal to, or greater than 500 ppmv are reviewed at least once every 12 months following the date of the initial determination and updated as necessary. A Subpart CC inspection and monitoring plan for the tanks, containers, and closed vent system managed at the Facility that are subject to Subpart CC requirements is included in [Appendix I-C](#). This plan will be revised and refined after construction and installation of the tanks and closed vent system are completed.

APPENDIX I-A

Emissions Data

CLIENT: Triumvirate
LOCATION: Casa Grande, Arizona
PROJECT TITLE: Preliminary Process Design
PROJECT NO.: 220301-CC

DOCUMENT NO.: Emissions Summary
ISSUED BY: AEF
ISSUE DATE: 7/27/2022
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[illegible]

CASA GRANDE, ARIZONA FACILITY


CONCEPTUAL PROCESS DESIGN

EMISSIONS CALCULATIONS



TRIUMVIRATE ENVIRONMENTAL
SOMERVILLE, MA

Process Project No:
TRE-220301-CC

Rev.	Date	Prepared by	Comments
	08/02/2022	A.FELKER/K.PACE/M.JONES	For Regulatory Review

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1. DEPACK/REPACK BAY EMISSIONS AND CONTROLS

1.1. Introduction

Miscellaneous mixed waste materials (both solids and liquids) arrive at the facility in drums, boxes or other containers. Once they arrive, they are unpacked and segregated by material type. When applicable, similar materials are consolidated into a common container for offsite treatment/disposal. The depack/consolidate/repack area contains five bays for different material types. It is assumed that each bay resembles a walk-in fume hood with an opening approximately 10 ft. wide and 10 ft. tall and enclosed on three sides. Air is pulled through each bay by an outdoor fan so that airborne contaminants do not enter the building and that the working area is well ventilated. Each bay has a vented hood leading outside to a scrubber and, in the case of the three organic bays, a carbon canister for final control of contaminants before the air is discharged to the atmosphere. The different types of waste materials expected for each depack/consolidate/repack bay are as follows:

- Bay 1: Acids
- Bay 2: Alkali
- Bay 3: Organics/Toxics
- Bay 4: Organics/Toxics
- Bay 5: Organics/Toxics

1.2. Emission Estimates Approach

EPA guideline AP-42 has been used to estimate an emission rate of volatiles in the waste materials being depacked/repacked. The closest approximation to the depack/repack process given in AP-42 is solvent degreasing using trichloroethane in an open tank, which generates an emission of 0.15 lb/hr-ft². The emission area is based on the assumption of one open 55 gallon drum, which has a diameter of 21 inches and an open area of 2.41 ft².

Trichloroethane is used as the model compound for the estimation of the organics scrubber emissions. For the acid system, 37% HCl has been chosen, and for the alkaline system, 20% NH₃. Both of these chemicals are at the high end of volatility for their chemical class. For 37% HCl, the ratio of its vapor pressure to that of trichloroethane is about 2.5, and for 20% NH₃, the ratio is 5.4. 24 hour/day, 365 day/yr operation is assumed.

The air flow that will sweep through the hood and carry the emitted contaminate out of the building is based on the hood face area and a face velocity of 120 scfm/ft². Assuming an open face area of 100 ft², each bay will need a fan capable of handling at least 12,000 scfm. The air is assumed to be at atmospheric pressure, 100°F, and contain 1 mole% H₂O.

1.3. Emissions Control

Per Triumvirate's request, there will be one scrubber for the acid bay, one scrubber for the alkaline bay, and one scrubber for the three organic bays. The acid scrubber will use a caustic scrubbing solution, and the alkaline bay will use an acid scrubbing solution. The organics bay scrubber will use a proprietary encapsulant that can aid in organics removal, though not to a very high extent. For this reason, the organics scrubber will be followed by carbon beds for final gas polishing.

The preliminary design for the scrubbers assumes a superficial velocity of 400 feet/min and a minimum liquid rate of 3 gpm/ft². For acids and bases, a conservative removal rate of 95% is assumed (actual removal rates are often > 99% depending on specific compound). For organics with an encapsulant package, a 50% removal rate is assumed.

The clean-up of the air leaving the organics bays poses a unique challenge. Some organic contaminants are miscible or at least slightly soluble in water, while others have very limited solubility. The organics scrubber system is designed for both potentials. It uses a water scrubber aided by a hydrocarbon encapsulant package to capture as much organic VOCs as possible within the contact time of the vapor in the scrubber bed. It is followed by two or more carbon adsorption beds to capture most of the organic constituents that were not removed in the scrubber. Organics loading is assumed 20 wt% based on vendor information. In the event that certain organics are only poorly removed in the scrubber, they will most likely be removed by the carbon, which simply means the bed will need to be changed more frequently.

1.4. Heat and Material Balance

Process Flow Diagrams for the scrubber systems showing stream numbers and mass balances have been developed. A summary of the streams is given below:

ACID Scrubber	assume	95	% removal	
Acid Proxy:	37% HCl			
Stream number	1	2	3	4
Stream Description	Contaminated Air leaving Bay	Scrubbing liquid flow	Scrubbed Air into Fan	Scrubbed Air out Fan to Stack
Vapor volume Flow, CFM	12000	NA	11945	11669
Vapor mass flow, lb/hr	50490	NA	51222	51222
Temperature, F	100	80	80	90
Pressure, psia	14.60	20.00	14.40	15.00
Density, lb/ft3	0.070	65	0.072	0.074
Acid mass flow, lb/hr	0.875	NA	0.044	0.044
Acid ppm wt	17.3	NA	0.9	0.9
Liquid Flow, gpm	NA	85	NA	NA
Annual release, lb/yr				383

Alkaline Scrubber	assume	95	% removal	
Alkali Proxy:	20% NH3			
Stream number	1	2	3	4
Stream Description	Contaminated Air leaving Bay	Scrubbing liquid flow	Scrubbed Air into Fan	Scrubbed Air out Fan to Stack
Vapor volume Flow, CFM	12000	NA	11945	11669
vapor mass flow, lb/hr	50490	NA	51222	51222
Temperature, F	100	80	80	90
Pressure, psia	14.60	20.00	14.40	15.00
Density, lb/ft3	0.070	65	0.072	0.074
Alkali mass flow, lb/hr	1.92	NA	0.096	0.096
Alkali ppm wt	38.0	NA	1.9	1.9
Liquid Flow, gpm	NA	85	NA	NA
Annual release, lb/yr				841

ORGANICS Scrubber: 3 bay operation	assume	50	% scrubber removal	95	% carbon removal
ORGANIC Proxy:	trichloroethane				
Stream number	1	2	3	4	
Stream Description	Contaminated Air leaving Bay	Scrubbing liquid flow	Scrubbed Air into Carbon Bed	Scrubbed Air out Fan to Stack	
Vapor volume Flow, CFM	36000	NA	35789	34959	
vapor mass flow, lb/hr	151471	NA	153618	153618	
Temperature, F	100	80	80	90	
Pressure, psia	14.60	20.00	14.40	15.00	
Density, lb/ft3	0.070	65	0.072	0.074	
Organic mass flow, lb/hr	0.36	NA	0.181	0.009	
Organic, pm wt	2.4	NA	1.2	0.1	
Liquid Flow, gpm	NA	236	NA	NA	
Annual release, lb/yr (post carbon)				79	

In addition to the streams described above, there will be streams of spent wash liquor periodically purged from each of the three scrubber reservoirs. Assuming the blowdown contains 10% by weight of the absorbed component, the total daily blowdown from all three scrubbers is about 82 gal. This blowdown will need to go to the neutralization tank for treatment or disposed of separately.

1.5. Vendor Information

A number of vendors have provided preliminary equipment configurations for the proposed scrubber and carbon systems. Vee Interests shared the design for a recently delivered 12000 cfm scrubber. They suggest the acid and alkaline scrubbers would have a diameter of 5 to 6 feet, a packed bed height of 12', two 165 gpm pumps, and a blower with an 8" WC head. These numbers agree well with the equipment sizing guidelines used. They have not provided sizing information for the organics scrubber. Verantis did not provide any specific detail for their design but did include an information brochure.

Vapor Technologies supplies hydrocarbon encapsulant additive packages for scrubbing systems. Three product candidates are described in Attachment 3.

Carbon adsorption information was provided by Continental Carbon and General Carbon. Neither has off-the-shelf units that can handle the full 36,000 acfm flow of the organic system in a single vessel, so two of their largest standard systems in parallel would likely be required. Continental Carbon can also supply specialized activated carbon for odor removal in addition to organics.

1.6. Estimated Emissions Summary

A summary of the estimated emissions on an hourly, daily, and annual basis for the Depack/Repack operations is given below. These are based on assumptions that will need to be confirmation by the equipment vendor based on their experience. In the meantime, these will serve as a first approximation for maximum expected releases.

Emissions Summary				
	lb/hr	lb/day	lb/yr	Assumptions
Acid Gas Scrubber				
Vapor	0.044	1.1	385	95% of feed removed
blowdown	8.3	200.0	73,000	blowdown at 10% acid conc
Alkaline Gas Scrubber				
vapor	0.096	2.3	841	95% of feed removed
blowdown	18.3	438.0	159,870	blowdown at 10% alkali conc
Organics Scrubber				
blowdown	1.8	44.0	16,060	blowdown at 10% organics conc
Carbon Bed				
VOC vapor	0.009	0.2	79	50% of feed absorbed
organics (out with carbon)	0.172	4.1	1507	95% of feed adsorbed
Carbon usage	0.86	20.6	7534	20% loading per General Carbon

2. EMISSION CALCULATIONS – WASTEWATER BLEND TANKS

2.1. Acid Emissions from Wastewater Blend Tank using HCL at pH of -1

2.1.1. Liquid Phase

Worst case scenario assumed to be -1 pH of HCl in tank while filling tank.

$$H_3O^+ = 10^{-pH}$$

$$H_3O^+ = 10^{-(-1)} = 10 \text{ M HCl}$$

Calculate mass of HCl in liter of solution

$$10 = \frac{\text{mass}}{\text{molar mass}}$$

$$\text{mass} = 10 \times \text{molar mass} = 360.460 \frac{g}{l}$$

$$\left(360.460 \frac{g}{l}\right) \times \left(\frac{1 \text{ lb}}{453.59 \text{ g}}\right) \times \left(\frac{3.79 \text{ l}}{1 \text{ gal}}\right) = 3.0118 \text{ lb/gal}$$

3.0118 lbs HCl in a gallon of solution. HCl has a specific gravity of 1.18 = 9.8412 lb/gal

$$\frac{3.0118 \text{ lbs}}{9.8412 \text{ lb/gal}} = 0.3054 \text{ gal}$$

0.306 gal HCl and 0.694 gal H₂O in solution or 30.6% HCl and 69.4% H₂O

Assume 20,000 gallon tank is $\frac{1}{2}$ full = 10,000 gallons or:

$$3060 \text{ gal HCl} \times 8.34 \times 1.18 = \mathbf{30,114.072 \text{ lb HCl}}$$

$$6940 \text{ H}_2\text{O} \times 8.34 = \mathbf{55,520 \text{ lb H}_2\text{O}}$$

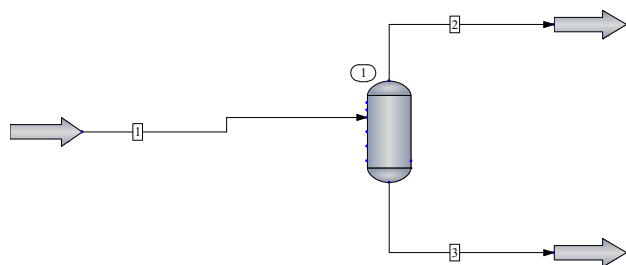
2.1.2. Headspace

Air has density of approximately 0.071149 lb/ft³ at 13.97 psia, 69.6°F and 13.4% relative humidity.

$$\left(0.071149 \frac{\text{lb}}{\text{ft}^3}\right) \times \left(\frac{1 \text{ ft}^3}{7.48 \text{ gal}}\right) = 0.009511 \text{ lb/gal}$$

In the 10,000 lb headspace you have 95.11 lb of air = **75.14 lb N₂** and **19.97 lb O₂**

Place all material in a stream and perform an isentropic flash at the worst case design temperature of 69.6°F



Simulation: Acid Emissions Calcs

STREAM PROPERTIES

Stream No.	1	2	3
Name			
-- Overall --			
Mass flow lb/h	85729.19	108.1779	85621
Temp F	69.6	69.6	69.6
Pres psig	-0.726	-0.726	-0.726
Average mol wt	21.9194	29.463	21.9123

Flow rates in lb/h

Hydrogen Chlorid	30114.07	13.2523	30100.82
Water	55520	0.3353	55519.66
Oxygen	19.97	19.561	0.409
Nitrogen	75.15	75.0292	0.1208
Sulfuric Acid	0	0	0

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In the 10,000 gallons of headspace in the tank, there will be 13.2523 lb of HCl or 0.001325 lb HCl/gal.

Assuming a tank filling pumping rate of 250 gpm, the HCl emissions from tank will be approximately:
0.3312 lb/minute.

Processing 40,000 gal/day material = average tank loading of 40,000 gal. or 160 minutes of filling at 250 gpm fill rate.

Total daily emissions from scrubber would be 0.3312 lb/min HCl x 160 minutes/day x 365 day/year =
19,342.1 lb HCl/year

Assuming a scrubber removal efficiency of 95% results in 96.7 lb/year

2.2. Acid Emissions from Wastewater Blend Tank using H₂SO₄ at pH of -1

2.2.1. Liquid Phase

Worst case scenario assumed to be -1 pH of H₂SO₄ in tank while filling tank.

$$H_3O^+ = 10^{-pH}$$

$$H_3O^+ = 10^{-(-1)} = 10 M H_2SO_4$$

Calculate mass of H₂SO₄ in liter of solution

$$10 = \frac{mass}{molar\ mass}$$

$$mass = 10 \times molar\ mass\ 980.79\ g$$

$$\left(980.79\ \frac{g}{l}\right) \times \left(\frac{1\ lb}{453.59\ g}\right) \times \left(\frac{3.79\ l}{1\ gal}\right) = 8.195\ lb/gal$$

8.195 lbs H₂SO₄ in a gallon of solution. H₂SO₄ has a specific gravity of 1.8 = 15.012 lb/gal

$$\frac{8.195\ lbs}{15.012\ lb/gal} = 0.5555\ gal$$

0.5458 gal H₂SO₄ and 0.4542 gal H₂O in solution or 54.58% H₂SO₄ and 45.42% H₂O

Assume 20,000 gallon tank is ½ full = 10,000 gallons or:

5,458 gal HCl x 8.34 x 1.8 = **81,935.5 lb H₂SO₄**

4,542 gal H₂O x 8.34 = **37,880.3 lb H₂O**

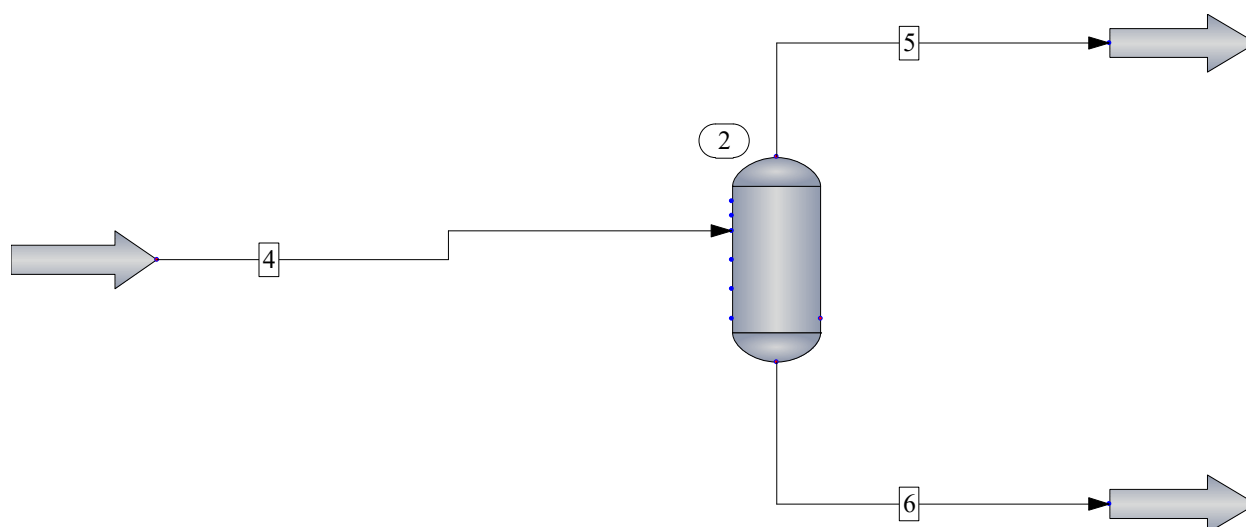
2.2.2. Headspace

Air has density of approximately 0.071149 lb/ft³ at 13.97 psia, 69.6°F and 13.4% relative humidity.

$$\left(0.071149 \frac{lb}{ft^3}\right) \times \left(\frac{1 ft^3}{7.48 gal}\right) = 0.009511 lb/gal$$

In the 10,000 lb headspace you have 95.11 lb of air = **75.14 lb N₂** and **19.97 lb O₂**

Place all material in a stream and perform an isentropic flash at the worst case design temperature of 69.6°F



Simulation: Acid Emissions Calcs

STREAM PROPERTIES

Stream No.	4	5	6
Mass flow lb/h	119911	91.1081	119819.8
Temp F	69.6	69.6	69.6
Pres psig	-0.726	-0.726	-0.726

Flow rates in lb/h

Hydrogen Chlorid	0	0	0
Water	37880.3	1.4213	37878.88
Oxygen	19.97	16.8618	3.1082
Nitrogen	75.15	72.6951	2.4549
Sulfuric Acid	81935.5	0.1299	81935.38

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In the 10,000 gallons of headspace in the tank, there will be 0.1299 lb of H₂SO₄ or 0.00001299 lb H₂SO₄/gal.

Assuming a tank filling pumping rate of 250 gpm, the H₂SO₄ emissions from tank will be approximately: 0.003247 lb/minute.

Worst Case calculated as 0.3312 lb/min H₂SO₄. Assume 99.5% scrubber efficiency = 0.001656 lb/min emission to atmosphere

Processing 40,000 gal/day material = average tank loading of 40,000 gal. or 160 minutes of filling at 250 gpm fill rate.

Total daily emissions from scrubber would be 0.2649 lb H₂SO₄/min x 160 minutes/day x 365 day/year =
15,470.2 lb H₂SO₄/year

Assuming a scrubber removal efficiency of 95% results in 77.3 lb/year

2.3. Caustic Emissions from Wastewater Blend Tank using Caustic at pH of 14

2.3.1. Liquid Phase

Worst case scenario assumed to be 14 pH of NaOH in tank while filling tank.

$$OH^- = 10^{-pOH}$$

$$OH^- = 10^{-(0)} = 1 \text{ M NaOH}$$

Calculate mass of NaOH in liter of solution

$$1 = \frac{\text{mass}}{\text{molar mass}}$$

$$\text{mass} = 1 \times \text{molar mass} = 39.997 \frac{g}{l}$$

$$\left(39.997 \frac{g}{l}\right) \times \left(\frac{1 \text{ lb}}{453.59 \text{ g}}\right) \times \left(\frac{3.79 \text{ l}}{1 \text{ gal}}\right) = 0.3341 \text{ lb/gal}$$

0.3341 lbs NaOH in a gallon of solution. NaOH has a specific gravity of 1.52 = 12.6768 lb/gal

$$\frac{.3341 \text{ lbs}}{12.6768 \text{ lb/gal}} = 0.02635 \text{ gal}$$

0.02635 gal NaOH and 0.9736 gal H2O in solution or 2.6% NaOH and 97.36% H2O

Assume 20,000 gallon tank is $\frac{1}{2}$ full = 10,000 gallons or:

$$263 \text{ gal NaOH} \times 8.34 \times 1.52 = \mathbf{3,334 \text{ lb NaOH}}$$

$$9,736 \text{ gal H}_2\text{O} \times 8.34 = \mathbf{80,809 \text{ lb H}_2\text{O}}$$

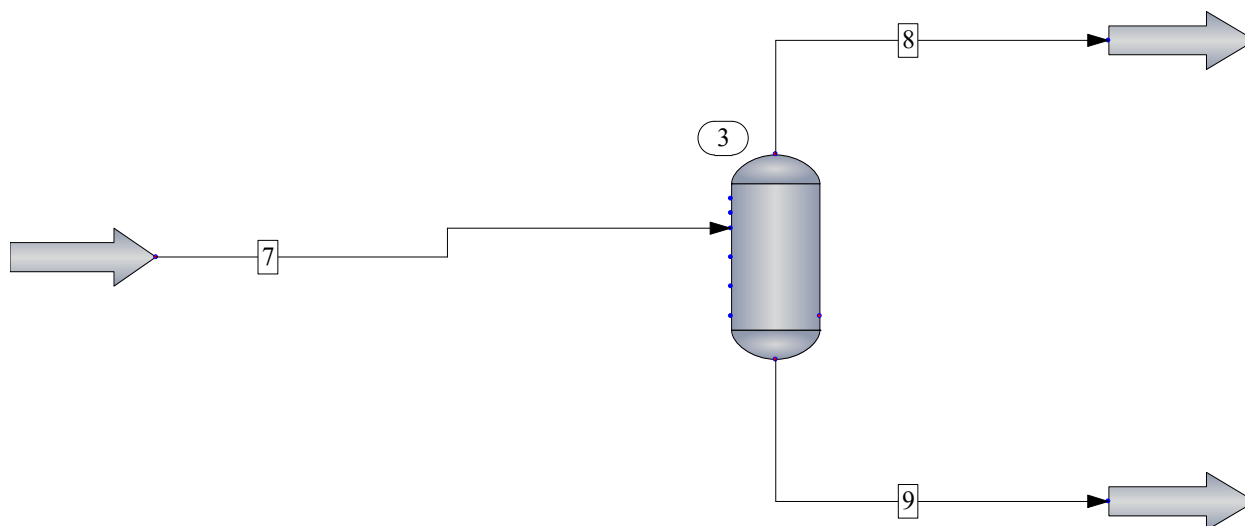
2.3.2. Headspace

Air has density of approximately 0.071149 lb/ft³ at 13.97 psia, 69.6°F and 13.4% relative humidity.

$$\left(0.071149 \frac{\text{lb}}{\text{ft}^3}\right) \times \left(\frac{1 \text{ ft}^3}{7.48 \text{ gal}}\right) = 0.009511 \text{ lb/gal}$$

In the 10,000 lb headspace you have 95.11 lb of air = **75.14 lb N₂** and **19.97 lb O₂**

Place all material in a stream and perform an isentropic flash at the worst case design temperature of 69.6°F



Simulation: Acid Emissions Calcs

STREAM PROPERTIES

Stream No.	7	8	9
Mass flow lb/h	84238.12	96.6132	84141.51
Temp F	69.6	69.6	69.6
Pres psig	-0.726	-0.726	-0.726
Vapor mole fraction	0.000741	1	0
Flow rates in lb/h			
Hydrogen Chlorid	0	0	0
Water	80809	1.5046	80807.5
Oxygen	19.97	19.9595	0.0105
Nitrogen	75.15	75.1492	0.0008
Sulfuric Acid	0	0	0
Sodium Hydroxide	3334	0	3334

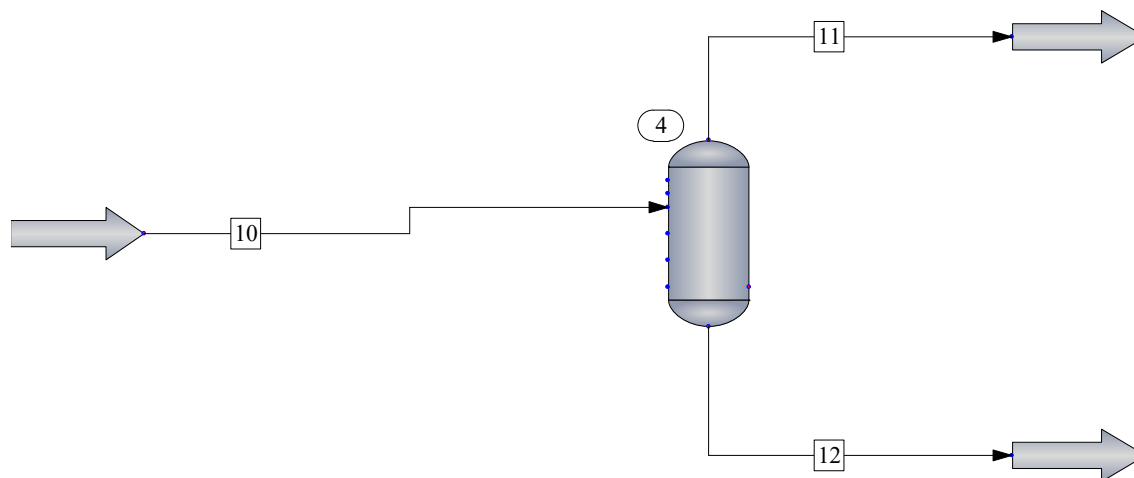
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In the 10,000 gallons of headspace in the tank, there will be only trace amounts NaOH (2.63×10^{-20} lb).

2.3.1. Caustic Emissions from Wastewater Blend Tank using Caustic and Ammonia

As an alternate case, it was assumed that the tank contained caustic solution as noted above and a tank truck of 30% (wt.) ammonia was a part of the mixture.



Simulation: Acid Emissions Calcs

STREAM PROPERTIES

Stream No.	10	11	12
Molar flow lbmol/h	3674.537	3.5813	3670.956
Mass flow lb/h	67332.12	99.7123	67232.41
Temp F	108.5	108.5	108.5
Pres psig	-0.726	-0.726	-0.726
Vapor mole fraction	0.000975	1	0
Flow rates in lb/h			
Hydrogen Chloride	0	0	0
Water	51224	5.3423	51218.66
Oxygen	19.97	19.6613	0.3087
Nitrogen	75.15	74.5576	0.5924
Sulfuric Acid	0	0	0
Sodium Hydroxide	3334	0	3334
Ammonia	12679	0.1511	12678.85

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In the 10,000 gallons of headspace in the tank, there will be 0.1511 lb of NH₃ or 0.00001511 lb NH₃/gal.

Assuming a tank filling pumping rate of 250 gpm, the NH_3 emissions from tank will be approximately: 0.003777 lb/minute.

Processing 40,000 gal/day material = average tank loading of 40,000 gal. or 160 minutes of filling at 250 gpm fill rate.

Total daily emissions from scrubber would be $0.003777 \text{ lb NH}_3/\text{min} \times 160 \text{ minutes/day} \times 365 \text{ day/year} =$
220.58 lb NH_3 /year

Assume 99.5% scrubber efficiency = **1.103 lb/year NH_3** emission to atmosphere

3. WASTEWATER EVAPORATION AND CONCENTRATION SYSTEM

3.1. Introduction

Raw wastewater that has been neutralized needs to be disposed of, but to keep disposal costs down Triumvirate will evaporate most of prior to disposition of the concentrate. Process alternatives for concentration include:

1. Mechanical evaporation: wastewater is sprayed into the air from a pond, which results in a portion of the water evaporating. The contents of the pond continue evaporate until a viscosity limit is reached, at which time the remaining sludge is sent to disposal off site. This process has very low capital and operating costs, but high land requirement. VOCs in the incoming water are released to atmosphere.
2. Thermal evaporation: wastewater is evaporated using a heat source (steam or direct firing) up to a viscosity limit or precipitation limit, and the resulting sludge is disposed of. There are two competing technologies, one that involves heating an aqueous stream recirculating at high velocity to prevent equipment fouling (forced circulation), and another that is direct fired. All VOCs entering the system are released to the atmosphere. The recirculating system has a higher capital and operating cost than the direct fired process.
3. Mechanical vapor recompression: wastewater is vaporized at low pressure with steam during start up, but once up to temperature this system uses mechanical recompression of the vapor which can then condense to vaporize incoming water. This process is very energy efficient but results in a liquid distillate product. A final sludge is also produced. This process has very high capital cost but relatively low operating cost. There is very little release of VOCs into the air, as most will stay in the distillate, which limits the uses it can have unless the VOCs are removed prior to evaporation.

A summary of these alternatives is given in the following table:

Type	mechanical evap - spray	mechanical evap- surface vibratory	Thermal Evap - direct fire	Thermal Evap - forced convection	Mechanical Vapor Recompression
vendor info source	RWI	RWI	Encon	Encon	Encon
Feed	40000 gpd	40000 gpd	40000 gpd	40000 gpd	40000 gpd
evap product	36000 gpd vapor	36000 gpd vapor	36000 gpd vapor	36000 gpd vapor	36000 gpd distillate
sludge	4000 gpd	4000 gpd	4000 gpd	4000 gpd	4000 gpd
Capital (ex boiler)	\$0.20 - 0.25MM	\$0.32 - \$0.36MM	\$2.0 - \$2.5MM	\$3.6 - \$5.3 MM	\$6.0 - \$10.0 MM
Land, ft2	16875	36479	<1000	< 1000	<2000
Evap pond required?	yes	yes	no	no	no
indoor/outdoor	outdoor	outdoor	either	either	either
steam boiler req'd	no	no	no	yes	yes
steam rate req'd	NA	NA	NA	19000 lb/hr	2500 lb/hr (intermittent)
opex (gas& elec)	\$105,120	\$52,560	\$1,314,000	\$2,102,400	\$302,220
VOC release	to atm	to atm	to atm	to atm	to distillate
Assumptions					
\$9.50/1000 scf natural gas					
\$0.15/kWh electricity					
8-9 surface vibratory units required, 4 operating on average					
4-5 spray units required, 2 operating on average					
3 direct fire thermal units required					
1 mechanical vapor recompression unit					
1 thermal forced circulation unit					
capital cost of boiler not included					

After a thorough evaluation, Triumvirate has decided to proceed with the direct fired approach.

3.2. Feed from Wastewater Neutralization

The incoming water stream is expected to have the following characteristics:

- pH between 6 – 7
- $\text{VOC} \leq 500$ ppmwt
- Total dissolved solids: TBD

3.3. Evaporation

The evaporated water stream must meet regulations for air emissions. At a feed rate of 40,000 gal/day and a maximum VOC concentration of 500 ppm, the potential average daily emission rate of VOCs is 166.6 lbs. At the stated 365 day/yr operating rate, this translates to a potential worst-case emission of 60,809 lb/yr VOC. The maximum daily emission at 2000 gph feed and 500 ppm VOC is 200 lb/day. These VOCs will likely be a combination of aromatics, ketones, aldehydes, alcohols, esters, ethers, halogenated organics, and low molecular weight sulfur compounds.

3.4. VOC Control

While it may be possible to obtain a permit for this quantity of VOC release, it is more likely that an alternative control technique to limit the VOC emission will be required. Given the fact that the bulk of the wastewater will be eventually leave as a vapor, a steam stripper upstream of the evaporator is an ideal solution.

While it may be possible to obtain a permit for this quantity of VOC release, it is more likely that an alternative control technique to limit the VOC emission will be required. Given the fact that the bulk of the wastewater will be eventually leave as a vapor, a steam stripper upstream of the evaporator is an ideal solution.

In a steam stripper, water containing dissolved VOCs is fed to the top of a packed tower. Steam is injected in the bottom of the tower, heating the water to just below its boiling temperature and driving off the VOCs as vapor along with a small amount of water. These vapors leave the top of the column and are condensed. The feed-to-steam ratio is typically 6:1 or greater. The latent heat of the steam serves to heat the water from ambient to near boiling. This energy would have been added at the evaporator anyway, so the duty in the evaporator is reduced by a similar amount. A detailed article about steam stripping of VOCs is given in Attachment 5.

To evaluate the effectiveness of steam stripping on a range of VOCs, a steam stripper was modeled in commercial process simulation software (Chemcad). A nominal feed rate of 27.7 gpm (corresponding to

40,000 gpd) was spiked with equal parts of seven organic compounds: benzene, toluene, acetone, n-butanol, methyl tert-butyl ether (MTBE), trichloromethane, and carbon tetrachloride, totaling 500 ppmwt. 50 psig saturated steam was fed to the bottom of the tower.

Using a steam flowrate of 2150 lb/hr, the feed was stripped down to ppb levels of organics. The net effect of this is to reduce the potential emissions from over 60000 pounds per year to less than 100 pounds per year. The water load to the evaporator increased from 40,000 gpd to about 45,000 gpd, but because the incoming water is at its boiling point, the duty on the evaporator stays about the same at an average of about 15.7 MM BTU/hr.

The overhead vapor from the stripper is condensed (either against incoming feed, a water-cooled condenser, or both) and sent to an accumulator. The condensate will form either one or two liquid layers, depending on the type of the organics and amount of water sent overhead. For the test case, 1,148 gpd of an aqueous stream containing most of acetone, butanol, and MTBE was generated, while 9 gpd of a water-free layer containing most of the benzene, toluene, trichloromethane and carbon tetrachloride was formed. These streams will need to be disposed of.

A PFD of the system has been provided. A summary of the stripper performance for this hypothetical case is given below:

Stream number	1	2	3	4	5	6	7
Stream Description	Feed to Stripper	Steam	Stripper Overhead	Condensed Stripper Overhead	Organic Distillate	Aqueous Distillate	Stripped Water
Liquid flow, gpm	27.8	NA	NA	0.8	negl	0.8	31.2
gpd	40032	NA	NA	1152	8.7	1148	44928
Temperature, F	80	298	222	110	110	110	225
Pressure, psig	15.3	50.0	3.3	1.3	15.0	15.0	15.0
Composition, lb/hr							
water	13908.6	2150.0	394.8	394.8	negl	394.8	15663.8
benzene	1.00	0.00	1.00	1.00	0.76	0.24	negl
toluene	1.00	0.00	1.00	1.00	0.85	0.16	negl
acetone	1.00	0.00	1.00	1.00	0.02	0.99	negl
nbutanol	1.00	0.00	1.00	1.00	0.00	1.00	negl
MTBE	1.00	0.00	1.00	1.00	0.15	0.85	negl
trichloromethane	1.00	0.00	1.00	1.00	0.65	0.35	negl
carbon tetrachloride	1.00	0.00	1.00	1.00	0.88	0.12	negl
salts	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Total	13915.6	2150	401.8	401.8	3.3	398.5	15663.8
ppm organics	503					9285	<1

There are other issues to consider when designing a steam stripper for reliable operation, primarily fouling of the vessel internals. Since the incoming wastewater composition is variable and contains many unknown components, the design will need to take this into account. A number of vendors design and build steam strippers for water treatment, among them Koch Modular, Branch Environmental, and Mach Engineering.

After leaving the steam stripper, the treated water flows to an accumulator which acts a buffer tank for feeding the evaporators. As mentioned above, Triumvirate has decided to use direct fired evaporators due to their low capital cost and established technology. Encon is a preferred vendor, though there are others that can be considered.

Encon has proposed using three 650 gph evaporators. The evaporators operate in batch mode. Each evaporator is fed with 2,000 gallons of treated wastewater. Once filled, the burners fire up and the evaporation process begins. Evaporated water is mixed with burner flue gas and sent to a stack via a process blower. Once the liquid in the chamber falls to the low level setpoint, the burners are shutdown and the sludge is pumped out to the sludge accumulator. When the chamber is empty the cycle is repeated. The estimated cycle time is three hours.

Assuming a need for process water in the plant, (boiler feed water for steam, dilution water, makeup water, etc.), one of the evaporators could be configured to produce distillate. Encon can design a system to meet Triumvirate's process water needs.

It is assumed that 90% of the treated wastewater fed to the unit will be evaporated, leaving 10% as sludge. This sludge will contain all the incoming salts, polymers, and any high boiling organics not removed in the stripper and will require disposal.

The mass balance for one evaporator batch has been developed based on preliminary assumptions for natural gas composition, burner operation, and cycle time, all of which will need to be validated by the vendor.

A summary of the evaporator performance is given below:

EVAPORATOR SUMMARY	assume	90	%evaporation	
Stream number	1	2	3	4
Stream Description	Stripped Wastewater Feed	Natural Gas	Combined Water/Flue Gas out Evaporator	Sludge to Disposal
Vapor volume per batch, scf	NA	20000	732,172	NA
Temperature, F	210	80	by vendor	210
Pressure, psia	45	30	15	45
liquid volume per batch, gal	2000	NA	NA	200
liquid mass per batch, lb	16000	NA	NA	1600
Assumptions				
Nat Gas LHV=1000 BTU/scf				
burner efficiency = 80%				
excess O2=3%				
density of water at 210F = 8.0 lb/gal				
# of Evaporators = 3				
Batches/day per evaporator = 8				

3.5. Steam Boiler Package Unit

If a steam stripper is in the scope, a steam boiler package unit will be required. A preliminary mass balance for a 2,500 lb/hr steam unit is given below:

Steam Boiler Summary	2500 lb/hr basis				
Stream number	1	2	3	4	5
Stream Description	Water feed	Natural Gas	Steam	Flue Gas	Blowdown
Vapor volumetric flow scfh	NA	3555	52,661	39,795	NA
vapor mass flow lb/hr	NA	163	2500	2909	NA
Temperature, F	80	80	300	by vendor	210
Pressure, psia	80	30	65	15	65
liquid volumetric flow gpm	302	NA	NA	NA	2
liquid mass flow lb/hr	2513	NA	NA	NA	13
Assumptions					
Nat Gas LHV=1000 BTU/scf					
burner efficiency = 80%					
excess O2=3%					
0.5% blowdown					
Deaeration neglected					

Water-tube Steam Boiler Package Units are quite common and many vendors exist.

3.6. Estimated Emissions Summary

A summary of the estimated emissions on an hourly, daily, and annual basis for the Wastewater Concentration operations is given below. These are based on assumptions that will need confirmation by the equipment vendor based on their experience. In the meantime, these will serve as a first approximation for maximum expected releases.

Emissions Summary				
	lb/hr	lb/day	lb/yr	Assumptions
Steam Stripper				
Aqueous waste (10000 ppm organics)	398.5	9564.0	3,490,860	highly dependent on VOC composition
100% Organic waste	3.3	79.2	28,908	500 ppm VOC feed, mix of organics
Evaporators				
flue gas+ water vapor	46,497	1,115,933	NA	90% H2O evap, 80% burner eff, 3% ex. O2
VOC vapor	<0.012	<0.27	<100	based on stripper removal assumptions
sludge	1600	38400	14,016,000	10% of feed
Steam Boiler				
flue gas	3,044	73,061	NA	80% burner eff, 3% ex O2
blowdown	0.542	13.0	4745	0.5% of feed

4. DETERMINATION OF PARTICULATE MATTER (PM) AND VOLATILE ORGANIC COMPOUND (VOC) EMISSIONS FROM STABILIZATION/NEUTRALIZATION AREA

For both PM and VOC emissions, the emissions were calculated multiple ways, and the most conservative result was chosen to represent emissions at this early stage of the Casa Grande project.

4.1. Particulate Matter Emissions Estimates

4.1.1. Estimation 1

Per the Introduction to EPA AP-42: Compilation of Emission Factors¹, the equation for emission estimation is as follows:

$$E = A \times EF \times \left(1 - \frac{ER}{100}\right)$$

where:

E = emissions,

A = activity rate,

EF = emission factor, and

ER = overall emission reduction efficiency, %.

¹ EPA (January 1995) Introduction to AP 42

Activity Rate, A

The activity rate, A, for this operation is based on a throughput of twelve (12) 80 yd³ (2160 ft³) batches of waste per day that utilize 0.2 lb reagent per lb of waste. The density of the waste is assumed to be 111 lb/ft³. Therefore, the total throughput of waste and reagent is as follows:

$$\begin{aligned} \text{Annual Throughput of Waste} &= 12 \frac{\text{batches}}{\text{day}} \times 2160 \frac{\text{ft}^3}{\text{batch}} \times 111 \frac{\text{lb}}{\text{ft}^3} \times 365 \frac{\text{days}}{\text{yr}} \\ &= 1,051,200,000 \frac{\text{lb waste}}{\text{yr}} = 525,600 \frac{\text{tons}}{\text{yr}} \end{aligned}$$

$$\begin{aligned} \text{Annual Usage of Reagent} &= 1,051,200,000 \frac{\text{lb waste}}{\text{yr}} \times \frac{0.2 \text{ lb reagent}}{1 \text{ lb waste}} \\ &= 210,240,000 \frac{\text{lb reagent}}{\text{yr}} = 105,120 \frac{\text{tons}}{\text{yr}} \end{aligned}$$

$$\begin{aligned} \text{Activity Rate or Throughput} = \text{Waste} + \text{Reagent} &= 1,051,200,000 \text{ lbs} + 210,240,000 \\ &= 1,261,440,000 \frac{\text{lbs}}{\text{yr}} = 630,720 \frac{\text{tons}}{\text{yr}} \end{aligned}$$

Emission Factor, EF

To obtain an emission factor, EF, for the Stabilization/Neutralization Area, the handling of the waste streams and reagents was compared to the descriptions listed in AP-42. The addition of these materials to the pits most closely resembles the batch drop operations described in Section 13.2.4 Aggregate Handling and Storage Piles². The following equation is given for estimating particulate emissions from drop operations:

² EPA AP 42, Fifth Edition, Volume I Chapter 13: Miscellaneous Sources, Section 13.2.4

$$EF = k(0.0032) \times \frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

where:

EF = emission factor (lb/ton)

k = particle size multiplier (dimensionless)

U = mean wind speed, miles per hour (mph)

M = material moisture content (%)

EPA regulations exist for inhalable particles <10 µm and fine inhalable particles <2.5 µm. Therefore, emissions factors were calculated for both of these sizes using the associated particle size multipliers listed in AP-42 Section 13.2.4 – 0.35 for <10 µm and 0.053 for <2.5 µm. Wind speed was estimated to be 1.14 mph based on the 100 fpm capture velocity of the ventilation hood and an average moisture content of 5% was assumed for the waste streams and reagents.

The emission factor for <10 µm particles is as follows:

$$EF = 0.35 \times 0.0032 \times \frac{\left(\frac{1.14}{5}\right)^{1.3}}{\left(\frac{5}{2}\right)^{1.4}}$$

$$EF = 0.00112 \times \frac{0.146}{3.61} = 0.0000452 \text{ lb/ton}$$

The emission factor for <2.5 µm particles is as follows:

$$EF = 0.053 \times 0.0032 \times \frac{\left(\frac{1.14}{5}\right)^{1.3}}{\left(\frac{5}{2}\right)^{1.4}}$$

$$EF = 0.000017 \times \frac{0.146}{3.61} = 0.0000069 \text{ lb/ton}$$

Overall Emission Reduction Efficiency, ER

Per EPA-452/F-03-025 Air Pollution Control Technology Fact Sheet for Fabric Filter – Pulse-Jet Cleaned Type Control Devices³, typical design efficiencies are between 99 and 99.9% for new equipment. To be conservative, the overall emission reduction factor, ER, is assumed to be 99% at this time. This efficiency can be updated once vendor specific information is obtained.

Overall Emissions Rates

For 10 µm particles,

$$E = A \times EF \times \left(1 - \frac{ER}{100}\right)$$

$$E = 630,720 \frac{\text{tons}}{\text{yr}} \times 0.0000452 \frac{\text{lb}}{\text{ton}} \times \left(1 - \frac{99}{100}\right) = 28.5 \frac{\text{lb}}{\text{yr}} \times 0.01 = 0.3 \text{ lb PM}_{10}/\text{yr}$$

³ EPA-452/F-03-025 Air Pollution Control Technology Fact Sheet for Fabric Filter – Pulse-Jet Cleaned Type Control Devices.

For 2.5 µm particles,

$$E = A \times EF \times \left(1 - \frac{ER}{100}\right)$$

$$E = 630,720 \frac{\text{tons}}{\text{yr}} \times 0.0000069 \frac{\text{lb}}{\text{ton}} \times \left(1 - \frac{99}{100}\right) = 4.35 \frac{\text{lb}}{\text{yr}} \times 0.01 = 0.04 \text{ lb PM}_{2.5}/\text{yr}$$

4.1.2. Estimation 2

Particulate emissions were also calculated using an alternate emission factor for truck dumping from Muleski, Cowherd, and Kinsey (2005)⁴. The worst case PM₁₀ emission factor of 0.0011 lb/ton was used along with the PM_{2.5}:PM₁₀ ratio of 0.4.

For 10 µm particles,

$$E = A \times EF \times \left(1 - \frac{ER}{100}\right)$$

$$E = 630,720 \frac{\text{tons}}{\text{yr}} \times 0.0011 \frac{\text{lb}}{\text{ton}} \times \left(1 - \frac{99}{100}\right) = 694 \frac{\text{lb}}{\text{yr}} \times 0.01 = 6.9 \text{ lb PM}_{10}/\text{yr}$$

For 2.5 µm particles,

$$E = A \times EF \times \left(1 - \frac{ER}{100}\right)$$

$$E = 630,720 \frac{\text{tons}}{\text{yr}} \times 0.0011 \frac{\text{lb PM}_{10}}{\text{ton}} \times 0.4 \frac{\text{lb PM}_{2.5}}{\text{lb PM}_{10}} \times \left(1 - \frac{99}{100}\right) = 277 \frac{\text{lb}}{\text{yr}} \times 0.01$$

$$= 2.8 \text{ lb PM}_{2.5} / \text{yr}$$

⁴ Muleski, G.E., Cowherd Jr., C, and Kinsey, J.S. (2005). Particulate Emissions from Construction Activities. Journal of Air & Waste Management Association, Vol. 55.

4.1.3. Estimation 2

Total particulate emissions were also calculated based on the standard efficiency for the filter media that was specified by US Air Filtration for dust collection of the materials used in the Stabilization/Neutralization Area using the following equation and assumptions:

$$\text{Maximum Total Particulate Emissions (lb/year)} = \text{Dust Collection Air Flow Rate (ft}^3/\text{min)} \times \text{Filter Efficiency (grains/ft}^3) \times 1 \text{ lb/7000 grains} \times \text{Operating Time (minutes/year)}$$

- US Air Filtration Standard Efficiency for Filter Media = 0.005 grains per dry standard cubic feet
- Dust Collection Air Flow Rate = 48,000 ft³/min

Therefore,

Maximum Total Particulate Emissions

$$= 48,000 \text{ ft}^3/\text{min} \times 0.005 \text{ grains/ft}^3 \times 1 \text{ lb/7000 grains} \times 60 \text{ min/hr} \times 24 \text{ hrs} \\ \text{/day} \times 365 \text{ days/year} = 18,020 \text{ lb total PM/year} = 9 \text{ tons total PM/year}$$

Since Estimation 2 provides a more conservative result than Estimation 1 for PM₁₀ and PM_{2.5} emissions, **Estimation 2** was selected as the preliminary PM₁₀ and PM_{2.5} emissions estimates for the Stabilization/Neutralization Area. Estimation 3 provides an estimate of the total particulate emissions per year.

4.2. Volatile Organic Compounds (VOC) Emissions Estimates

4.2.1. Estimation 1

To estimate the annual VOC emissions expected from the Stabilization/Neutralization area, the following equation was used:

$$\begin{aligned} \text{Estimated Annual VOC Emissions} & \left(\text{lb} \frac{\text{VOC}}{\text{yr}} \right) \\ &= \text{Emission Rate} \left(\frac{\text{lb VOC}}{\text{ft}^2 - \text{sec}} \right) \times \text{Pit Surface Area} (\text{ft}^2) \times \text{Batch Time} (\text{sec} \\ & \quad / \text{batch}) \times \text{Annual Batches} \left(\frac{\text{batches}}{\text{yr}} \right) \times \left(1 - \frac{\text{ER}}{100} \right) \end{aligned}$$

The following assumptions were made:

- VOC emission factors listed in Remediation of Petroleum Contaminated Soils: Biological, Physical, and Chemical Processes (1998)⁵ were referenced. The highest instantaneous emission rate from a waste oily sludge with 0.8% VOC applied to a surface was 370.7 $\mu\text{g}/\text{m}^2\text{-s}$ (7.6×10^{-8} $\text{lb}/\text{ft}^2\text{-s}$). For a more conservative emissions estimate, this emission rate was not reduced to reflect the difference in initial VOC concentration for the waste in the stabilization area (<500 ppm, 0.5%) vs. the waste in the referenced study (8000 ppm, 0.8%).
- The surface area is assumed to be the area of stabilization/neutralization pit (18' x 12' = 216 ft^2).
- The time for volatilization is assumed to be the time allowed for a batch to process. (12 batches per day are processed using 2 pits which allows 4 hrs (14400 sec) per batch.)
- The total number of batches per year is 12 batches per day x 365 days per year = 4380 batches/yr.
- Per EPA-456/F-99-004 Technical Bulletin System for VOC: Carbon, Zeolite, or Polymers⁶, typical design efficiencies are between 95 and 98% for well-designed adsorber systems. To be conservative, the overall emission reduction factor, ER, is assumed to be 95% at this time. This efficiency can be updated once vendor specific information is obtained.
- The material in the stabilization/neutralization pits is mixed throughout the processing of the batch. Therefore, the material exposed to the surrounding air is being turned over repeatedly. Increasing the surface area to account for these changeovers was considered. However, the time that each section of fresh material is exposed to the surrounding air is equal to the total batch

⁵ Riser-Roberts (1998). Remediation of Petroleum Contaminated Soils: Biological, Physical, and Chemical Processes

⁶ EPA-456/F-99-004 Technical Bulletin System for VOC: Carbon, Zeolite, or Polymers (1999)

time divided by the number of changeovers/turns of the material. Therefore, the emissions result is the same regardless of if only a single surface area is exposed for the entire batch time or if multiple changeovers expose fresh material repeatedly for shorter durations.

Therefore,

Estimated Annual VOC Emissions

$$= 7.6 \times 10^{-08} \frac{lb}{ft^2 \cdot sec} \times 216 ft^2 \times 14400 \frac{sec}{batch} \times 4380 \frac{batches}{yr} \times \left(1 - \frac{95}{100}\right)$$

$$= 52 \frac{lb VOC emitted}{yr}$$

4.2.2. Estimation 2

VOC emissions were also estimated using a mass balance assuming 30% of VOC in the incoming waste becomes airborne during the stabilization process. This rate of VOC volatilization is based on Michigan Permit to Install 302-07A⁷ issued to US Ecology, Inc.

$$Estimated Annual VOC Emissions \left(\frac{lb VOC}{yr} \right)$$

$$= Annual Waste Throughput \left(\frac{lb waste}{year} \right) \times Max VOC Concentration (lb VOC$$

$$/lb waste) \times Estimated Airborne VOC \left(\frac{lb VOC volatilized}{lb VOC} \right) \times \left(1 - \frac{ER}{100}\right)$$

⁷ Michigan Department of Environmental Quality Air Quality Division, Permit to Install 302-07A issued to US Ecology, Inc. on March 17, 2014, for Wayne County, Michigan.

$$\begin{aligned}
 & \text{Estimated Annual VOC Emissions} \left(\frac{\text{lb VOC}}{\text{yr}} \right) \\
 &= 1,051,200,000 \left(\frac{\text{lb waste}}{\text{year}} \right) \times 499 \text{ (lb VOC} \\
 & \text{ /1,000,000 lb waste)} \times \left(\frac{0.3 \text{ lb VOC volatilized}}{1 \text{ lb VOC}} \right) \times \left(1 - \frac{95}{100} \right) \\
 &= 157,365 \text{ lb VOC airborne/yr} \times 0.05 = 7,868 \text{ lb VOC emitted/yr} \\
 &= 3.9 \text{ tons VOC emitted/yr}
 \end{aligned}$$

Since Estimation 2 provides a more conservative result than Estimation 1, **Estimation 2** was selected as the preliminary VOC emissions estimate for the Stabilization/Neutralization Area.

If Triumvirate prefers to avoid classification as a major source per Pinal County Air Quality Code of Regulations AND to avoid the extra cost of installing carbon beds to reduce VOC emissions, then Triumvirate may decide to limit throughput. If the Stabilization Area was the only source of hazardous air pollutant emissions for Casa Grande, then the throughput would need to be limited to 3.8 batches per day or 166,400 tons per year in order for VOC emissions to remain below 25 tons/year.

On the other hand, if Triumvirate prefers to maximize Stabilization Area throughput AND to avoid classification as a major source per Pinal County Air Quality Code of Regulations, the installation of carbon beds with 95% efficiency would reduce emissions to the point that 76 batches could be processed per day or 3.3 million tons per year without becoming a major source. This throughput is impractically high for the process but is used to illustrate the difference in emissions with and without an abatement device. These results are summarized in Table 1.

Case	Stabilization Area Throughput (tons/year)	Unabated VOC Emissions (tons/year)	Abated VOC Emissions (tons/year)
Base Case	525,600	79	3.9
Max Throughput with No Abatement	166,400	25	1.2
Max Throughput with Abatement	3,328,800	500	25

Table 1. Various cases to show impact of throughput and abatement on emissions. Data is based on the assumptions that 25 tons combined hazardous air pollutant (HAP) emissions/year is the threshold for becoming a major source, all VOC emissions are HAP's, and abatement efficiency is 95%. Other types of emissions and emissions from other areas of the facility are neglected.

5. DETERMINATION OF TANK STANDING LOSSES USING AP-42 GUIDELINES

5.1. Preliminary Calculations – Determination of Contents

$$T_{LA} = 0.4T_{AA} + 0.6T_B + 0.005\alpha I$$

T_{LA} = Average Daily Liquid Surface Temperature, °R

T_{AA} = Average Daily Ambient Temperature for hottest month of July, °R

T_B = Liquid Bulk Temperature for hottest month of July, °R

I = Average Daily Total Insolation for Phoenix Arizona, BTU/ft²•d

α = Tank Surface Solar Absorptance = 0.64 for diffuse aluminum in average condition⁸ which is assumed to be similar to stainless steel.

The average daily dry bulb temperature during the hottest month of the year (July) is 90.8 °F

$$T_{AA} = 550.5^\circ\text{R}$$

$$T_B = T_{AA} + 0.003\alpha \times I$$

$$I = 1,802 \text{ BTU/ft}^2\cdot\text{d from table}^9$$

$$T_B = 550.5^\circ\text{R} + 0.003 \times 0.64 \times 1,802 \frac{\text{BTU}}{\text{ft}^2\cdot\text{d}} = 553.95^\circ\text{R}$$

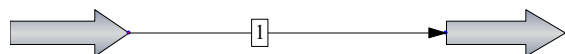
⁸ From Table 7.1-6 of AP-42 Tank Emissions document

⁹ From Table 7.1-7 of AP-42 Tank Emissions document. Data for Phoenix, AZ used (approximately 45 miles NNE of Casa Grande)

$$T_{LA} = 0.4(550.5^{\circ}R) + 0.6(553.95^{\circ}R) + 0.005 \times 0.64 \times 1,802 \frac{\text{BTU}}{\text{ft}^2 \cdot \text{d}}$$

$$T_{LA} = 220.20^{\circ}R + 332.37^{\circ}R + 5.7664^{\circ}R = 558.3364^{\circ}R = 98.3^{\circ}F$$

From CHEMCAD Simulation Software



Simulation: Fuels Blending Worst Case Emissions

STREAM PROPERTIES

Stream No. 1

Name

-- Overall --

Temp F **90.8**

Pres psia **14**

Average mol wt 78.511

Actual dens lb/ft³ 39.2014

Vpres psia 11.1

Component mass %

Hexane 49.77601

Isopentane 50.22399

CHEMCAD 8.0.2

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Assume that the tank contains a mixture of 50.2% hexane and 49.8% isopentane which results in a vapor pressure of 11.1 psia for the average liquid temperature at the highest monthly average dry bulb temperature.

5.2. Level 1 Control Calculations

The tank is 23 ft. high (H) and 12 ft. in diameter (D) with a cone roof and flat bottom.

The volume of a 12 ft. diameter Cone Roof is:

$$H_{RO} = \left(\frac{1}{3}\right) H_R$$

$$H_R = S_R \times R_S$$

$$H_R = 0.0625 \times 12 \text{ ft.} = 0.75 \text{ ft.}$$

$$H_{RO} = \left(\frac{1}{3}\right) 0.75 \text{ ft.} = 0.25 \text{ ft.}$$

The flooded volume of the tank (T/T) is calculated as follows:

$$V = (H + H_{RO}) \times \pi \left(\frac{D}{2}\right)^2$$

$$V = 23.25 \text{ ft} \times \pi \left(\frac{12 \text{ ft.}}{2}\right)^2$$

$$V = 2,629.43 \text{ ft}^3 = 19,663.5 \text{ gal.}$$

The total volume of the vessel is 19,664 gallons when flooded which means that it is less than the 20,000 gallon threshold requiring Level 2 Controls. The tank will require Level 1 controls according to 40 CFR §264.1084(b)(1)(i) through (b)(1)(iii) which applies for a tank where:

- i. The capacity is less than 75 m³ (19,813 gal) with a maximum organic vapor pressure of 76.6 kPa (11.11 psia);
- ii. The hazardous waste in the tank is not heated by the owner or operator to a temperature greater than the temperature at which the maximum organic vapor pressure of the hazardous waste is determined for the purpose of complying with i above; and
- iii. The hazardous waste in the tanks is not treated using a waste stabilization process.

5.3. Tank Breathing Calculations

These calculations apply to a tank with a diameter of 12 feet and a height (T/T) of 21 feet containing a mixture of 50.2% hexane and 49.8% isopentane in Casa Grande, Arizona.¹⁰

L_S = Standing Losses (Breathing), lb/yr

$$L_S = 365V_VW_VK_EK_S$$

Where V_V = Vapor Space volume, ft³

$$V_V = \frac{\pi}{4}D^2H_{VO}$$

W_V = Vapor Density, lb/ft³

$$W_V = \frac{M_V P_{VA}}{RT_V}$$

K_E = Vapor Space Expansion Factor, per day

$$K_E = \frac{\Delta T_V}{T_{LA}} + \frac{\Delta P_V - \Delta P_B}{P_A - P_{VA}}$$

K_S = Vented Vapor Space Saturation Factor, dimensionless

$$K_S = \frac{1}{1 + 0.0553P_{VA}H_{VO}}$$

D = Diameter of Tank, ft

H_{VO} = Vapor Space Outage, ft

M_V = Molecular Weight of Vapor, lb/lb-mole

P_{VA} = Vapor Pressure at the Average Daily Liquid Surface Temperature, psia

R = Ideal Gas Constant

¹⁰ Using AP-42 Methodology for Calculating Tank Emissions for a Fixed Roof Tank

T_V = Average Vapor Temperature, °R

T_{LA} = Average Daily Liquid Surface Temperature, °R

ΔT_V = Average Daily Vapor Temperature Range, °R

ΔP_V = Average Daily Vapor Pressure Range, psia

ΔP_B = Breather Vent Pressure Setting Range, psi

P_A = Atmospheric Pressure

Calculate components of standing loss equation

Tank Vapor Space Volume, V_V

$$V_V = \frac{\pi}{4} D^2 H_{VO}$$

and

$$H_{VO} = H_S - H_L + H_{RO}$$

H_S = Tank Shell Height of 23 ft.

H_L = Stock Liquid Height, 11.5 ft (1/2 shell height due to continuous filling/emptying)

H_{RO} = roof outage, ft = 0.25 ft. (from above)

$$H_{VO} = H_S - H_L + H_{RO}$$

$$H_{VO} = 23 \text{ ft} - 11.5 \text{ ft} + 0.25 = 11.75 \text{ ft}$$

and

$$V_V = \frac{\pi}{4} D^2 H_{VO}$$

$$V_V = \frac{3.1415}{4} (12 \text{ ft})^2 \times 11.75 \text{ ft} = 1,328.75 \text{ ft}^3$$

Calculate Vapor Density, W_v

Calculate the Average Daily Liquid Surface Temperature, T_{LA}

$$T_{LA} = 0.4T_{AA} + 0.6T_B + 0.005\alpha I$$

T_{AA} = Average Daily Ambient Temperature, °R

T_B = Liquid Bulk Temperature, °R

I = Average Daily Total Insolation, BTU/ft²•d

α = Tank Surface Solar Absorptance = 0.64 for diffuse aluminum in average condition¹¹ which is assumed to be similar to stainless steel.

¹¹ From Table 7.1-6 of AP-42 Tank Emissions document

$$T_{AA} = \frac{T_{AX} + T_{AN}}{2}$$

$$T_{AX} = \text{Average Daily Maximum Ambient Temperature}^{12} = 85.8^{\circ}\text{F} + 459.7 = 545.5^{\circ}\text{R}$$

$$T_{AN} = \text{Average Daily Minimum Ambient Temperature}^{13} = 64.0^{\circ}\text{F} + 459.7 = 523.7^{\circ}\text{R}$$

$$T_{AA} = \frac{T_{AX} + T_{AN}}{2}$$

$$T_{AA} = \frac{545.5 + 523.7}{2} = 534.6^{\circ}\text{R}$$

$$T_B = T_{AA} + 0.003\alpha \times I$$

$$I = 1,802 \text{ BTU/ft}^2 \cdot \text{d from table}^{14}$$

¹² From Table 7.1-7 of AP-42 Tank Emissions document. Data for Phoenix, AZ used (approximately 45 miles NNE of Casa Grande)

¹³ From Table 7.1-7 of AP-42 Tank Emissions document. Data for Phoenix, AZ used (approximately 45 miles NNE of Casa Grande)

¹⁴ From Table 7.1-7 of AP-42 Tank Emissions document. Data for Phoenix, AZ used (approximately 45 miles NNE of Casa Grande)

$$T_B = 534.6 \text{ }^{\circ}\text{R} + 0.003 \times 0.64 \times 1,802 \frac{\text{BTU}}{\text{ft}^2 \cdot \text{d}} = 538.15 \text{ }^{\circ}\text{R}$$

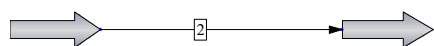
so

$$T_{LA} = 0.4(534.6 \text{ }^{\circ}\text{R}) + 0.6(538.15 \text{ }^{\circ}\text{R}) + 0.005 \times 0.64 \times 1,802 \frac{\text{BTU}}{\text{ft}^2 \cdot \text{d}}$$

$$T_{LA} = 213.84^{\circ}\text{R} + 322.89^{\circ}\text{R} + 5.7664^{\circ}\text{R} = 542.49^{\circ}\text{R} = 82.8^{\circ}\text{F}$$

Calculate the Vapor Pressure at the Average Daily Liquid Surface Temperature

Use ChemCAD to find the vapor pressure at T_{LA} ,



Simulation: Fuels Blending Worst Case Emissions

STREAM PROPERTIES

Stream No.	2
Name	
-- Overall --	
Temp F	82.8
Pres psia	14
Average mol wt	78.511
Actual dens lb/ft3	39.4764
Vpres psia	9.489

Component mass %

Hexane	49.776
Isopentane	50.224

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$P_{VA} = 9.489 \text{ psia}$

Calculate Average Vapor Temperature

$$T_V = 0.7T_{AA} + 0.3T_B + 0.009\alpha I$$

$$T_V = 0.7(534.6\text{ }^{\circ}\text{R}) + 0.3(538.15\text{ }^{\circ}\text{R}) + 0.009 \times 0.64 \times 1,802 \frac{\text{BTU}}{\text{ft}^2 \cdot \text{d}}$$

$$T_V = 374.22\text{ }^{\circ}\text{R} + 161.445\text{ }^{\circ}\text{R} + 10.3795\text{ }^{\circ}\text{R} = 546.04\text{ }^{\circ}\text{R}$$

Now calculate Stock Density:

$$W_V = \frac{M_V P_{VA}}{RT_V}$$

$$W_V = \frac{(78.511) \times (9.489\text{ psia})}{(10.731) \times (546.04\text{ }^{\circ}\text{R})} = 0.1271 \frac{\text{lb}}{\text{ft}^3}$$

Calculate the Vapor Space Expansion Factor

$$K_E = \frac{\Delta T_V}{T_{LA}} + \frac{\Delta P_V - \Delta P_B}{P_A - P_{VA}}$$

P_{VA} = Vapor Pressure at the Average Daily Liquid Surface Temperature, psia = 9.489 psia from above.

T_{LA} = Average Daily Liquid Surface Temperature, $^{\circ}\text{R}$ = 542.49 $^{\circ}\text{R}$

ΔT_V = Average Daily Vapor Temperature Range, $^{\circ}\text{R}$

ΔP_V = Average Daily Vapor Pressure Range, psia

ΔP_B = Breather Vent Pressure Setting Range, psi

P_A = Atmospheric Pressure = 13.97 psia for Casa Grande, Arizona

$$\Delta T_V = 0.7\Delta T_A + 0.02\alpha I$$

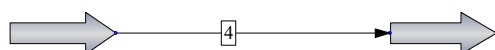
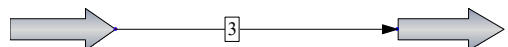
$$\Delta T_V = 0.7(T_{AX} - T_{AN}) + 0.02\alpha I$$

$$\Delta T_V = 0.7(545.5 - 523.7 \text{ } ^\circ R) + 0.02 \times 0.64 \times 1,802 \frac{\text{BTU}}{\text{ft}^2 \cdot \text{d}} = 38.33 \text{ } ^\circ R$$

Find the average daily vapor pressures

$$T_{AX} = \text{Average Daily Maximum Ambient Temperature}^{15} = 85.8^{\circ}\text{F} + 459.7 = 545.5^{\circ}\text{R}$$

$$T_{AN} = \text{Average Daily Minimum Ambient Temperature}^{16} = 64.0^{\circ}\text{F} + 459.7 = 523.7^{\circ}\text{R}$$



Simulation: Fuels Blending Worst Case Emissions

STREAM PROPERTIES

Stream No.	3	4
Name		
-- Overall --		
Temp F	85.5	64
Pres psia	13.97	13.97
Average mol wt	78.511	78.511
Actual dens lb/ft3	39.3839	40.1108
Vpres psia	10.01	6.425
Component mass %		
Hexane	49.77601	49.776006
Isopentane	50.22399	50.223991

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¹⁵ From Table 7.1-7 of AP-42 Tank Emissions document. Data for Phoenix, AZ used (approximately 45 miles NNE of Casa Grande)

¹⁶ From Table 7.1-7 of AP-42 Tank Emissions document. Data for Phoenix, AZ used (approximately 45 miles NNE of Casa Grande)

$$K_E = \frac{\Delta T_V}{T_{LA}} + \frac{\Delta P_V - \Delta P_B}{P_A - P_{VA}}$$

$$K_E = \frac{38.33}{542.49} + \frac{(10.01 - 6.425) - (0.03 - -0.03)}{13.97 - 9.489}$$

$$K_E = 0.7866$$

Calculate Vented Vapor Space Saturation Factor

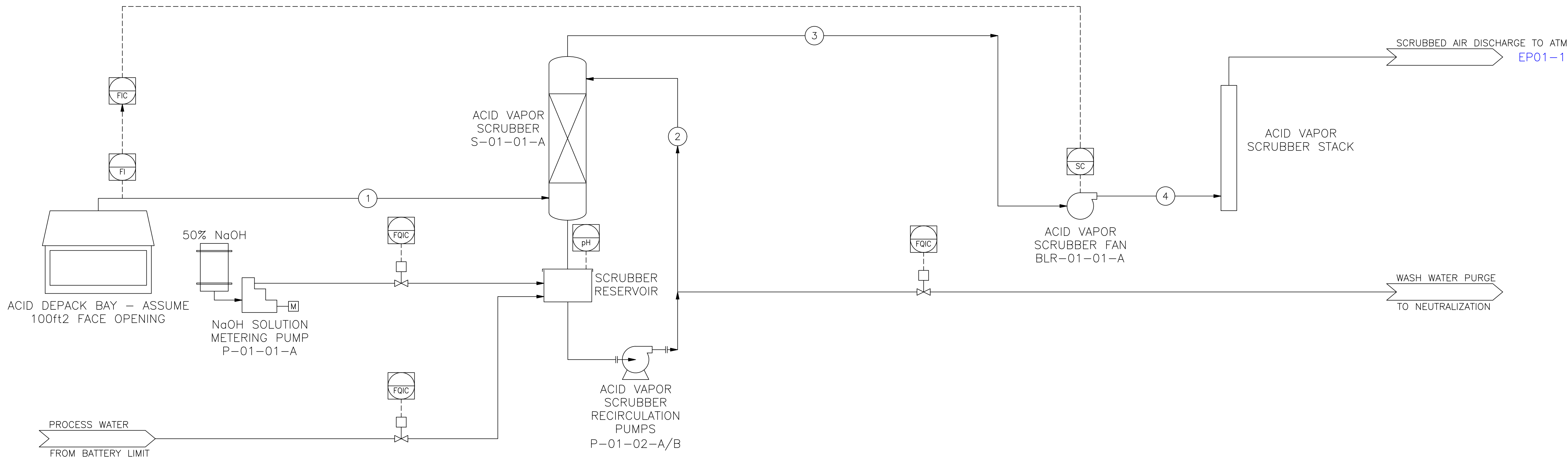
$$K_S = \frac{1}{1 + (0.053 \times P_{VA} \times H_{VO})}$$

$$K_S = \frac{1}{1 + (0.053 \times 9.489 \times 11.75)} = 0.1447$$

$$\text{Standing Losses} = L_S = 365 V_V W_V K_E K_S$$

$$L_S = 365 \times 1328.75 \times 0.1271 \times 0.7866 \times 0.1447 = 7,016.23 \text{ lb/yr}$$

Worst case scenario tank losses using a mix of isopentane and hexane are 19.2 lb/day on average per tank or approximately 7,016.2 lb/year per tank.



ACID Scrubber				
Acid Proxy: assume 37% HCl 95 % removal				
Stream number	1	2	3	4
Stream Description	Contaminated Air leaving Bay	Scrubbing liquid flow	Scrubbed Air into Fan	Scrubbed Air out Fan to Stack
Vapor volume Flow, CFM	12000	NA	11945	11669
Vapor mass flow, lb/hr	50490	NA	51222	51222
Temperature, F	100	80	80	90
Pressure, psia	14.60	20.00	14.40	15.00
Density, lb/ft3	0.070	65	0.072	0.074
Acid mass flow, lb/hr	0.875	NA	0.044	0.044
Acid ppm wt	17.3	NA	0.9	0.9
Liquid Flow, gpm	NA	85	NA	NA
Annual release, lb/yr				383

AO	7/27/22	TRE-220301-CC	RAK	MJ	AEF	NEW DRAWING - ISSUED FOR REGULATORY REVIEW
REV	DATE	PROJECT NO.	DRWN	CHKD	ENGR	REVISION DESCRIPTION

PROCESS

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ENVIRONMENTAL

Drawing Title:

CASA GRANDE
ACID DEPACK BAY SCRUBBER SYSTEM
CONCEPTUAL PROCESS FLOW DIAGRAM

Drawn By: RAK

Checked By: MJ

App'd By: AEF

Date: 06/07/22

Date: 06/08/22

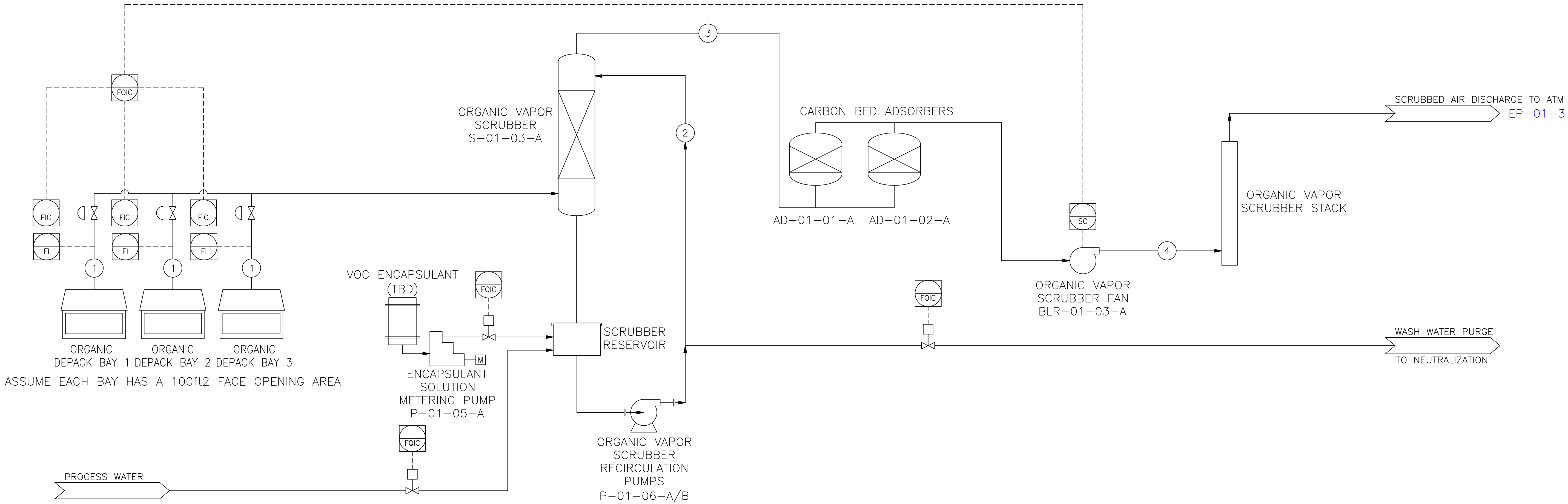
Date: 06/08/22

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Drawing Number: PFD -01-001

Revision: 0

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ORGANICS Scrubber: 3 bay operation				
ORGANIC Proxy:	assume	50	% scrubber removal	95
	trichloroethane			% carbon removal
Stream number	1	2	3	4
Stream Description	Contaminated Air leaving Bay	Scrubbing liquid flow	Scrubbed Air into Carbon Bed	Scrubbed Air out Fan to Stack
Vapor volume Flow, CFM	36000	NA	35789	34959
vapor mass flow, lb/hr	151471	NA	153618	153618
Temperature, F	100	80	80	90
Pressure, psia	14.60	20.00	14.40	15.00
Density, lb/ft3	0.070	65	0.072	0.074
Organic mass flow, lb/hr	0.36	NA	0.181	0.009
Organic, pm wt	2.4	NA	1.2	0.1
Liquid Flow, gpm	NA	236	NA	NA
Annual release, lb/yr (post carbon)				79

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Drawing Title:

CASA GRANDE
ORGANIC DEPACK BAYS SCRUBBER SYSTEM
CONCEPTUAL PROCESS FLOW DIAGRAM

Drawn By: RAK

Checked By: MJ

App'd By: AEF

Date: 06/07/22

Date: 06/08/22

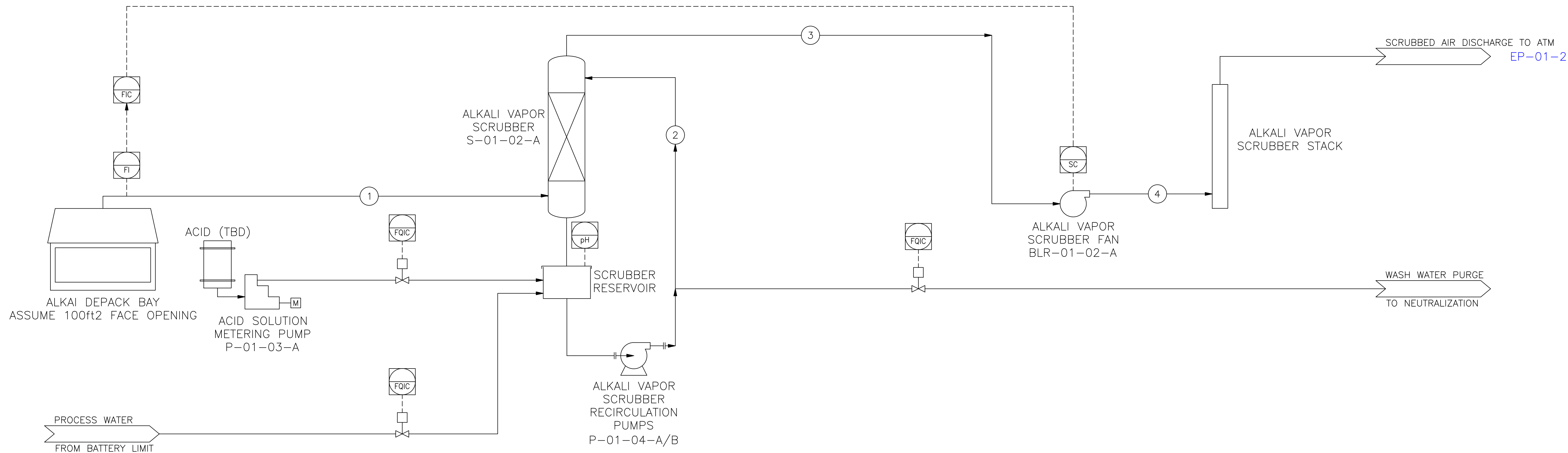
Date: 06/08/22

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Drawing Number: PFD -01-003

Revision: 0

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Alkaline Scrubber		assume	95	% removal
Alkali Proxy:		20% NH3		
Stream number	1	2	3	4
Stream Description	Contaminated Air leaving Bay	Scrubbing liquid flow	Scrubbed Air into Fan	Scrubbed Air out Fan to Stack
Vapor volume Flow, CFM	12000	NA	11945	11669
vapor mass flow, lb/hr	50490	NA	51222	51222
Temperature, F	100	80	80	90
Pressure, psia	14.60	20.00	14.40	15.00
Density, lb/ft3	0.070	65	0.072	0.074
Alkali mass flow, lb/hr	1.92	NA	0.096	0.096
Alkali ppm wt	38.0	NA	1.9	1.9
Liquid Flow, gpm	NA	85	NA	NA
Annual release, lb/yr				841

0	7/27/22	TRE-220301-CC	RAK	MJ	AEF	NEW DRAWING - ISSUED FOR REGULATORY REVIEW
REV	DATE	PROJECT NO.	DRWN	CHKD	ENGR	REVISION DESCRIPTION

PROCESS

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ENVIRONMENTAL

Drawing Title:

CASA GRANDE
BASE DEPACK BAY SCRUBBER SYSTEM
CONCEPTUAL PROCESS FLOW DIAGRAM

Drawn By: RAK	Checked By: MJ	App'd By: AEF
Date: 06/07/22	Date: 06/08/22	Date: 06/08/22
Scale: NONE	Drawing Number: PFD -01-002	Revision: 0
Sheet 01 of 01		

APPENDIX I-B

Subpart BB

Air Emission Standards for Equipment Leaks Inspection and Monitoring Plan

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Subpart BB Air Emission Standards for Equipment Leaks
Inspection and Monitoring Plan

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Appendix IB-4	Equipment Repair Log
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List of Tables

Table IB-1	List of Equipment Subject to Subpart BB
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1. Applicability

Subpart BB of 40 CFR 264 (Subpart BB) applies to equipment at hazardous waste treatment, storage and disposal facilities which contains or contacts hazardous wastes with 10 percent or more (by weight) organics content. Subpart BB is applicable because the Facility will treat and store hazardous waste and is subject to the permitting requirements of 40 CFR 270.

This section describes a program for controlling leaks from Facility equipment that contains or contacts hazardous waste with organic concentrations of at least 10 percent by weight. Equipment subject to this include any pumps, valves, open-ended valves, and flanges associated with the transfer and/or consolidation of waste in tanks or containers at the Facility.

1.1 DEFINITIONS [40 CFR 264.1031]

1.1.1 In Light Liquid Service

Refers to a piece of equipment that contains or contacts a waste stream where the vapor pressure of one or more of the components in the waste stream is greater than 0.3 kilopascals (kPa) at 20°C, the total concentration of the pure components having a vapor pressure greater than 0.3 kPa at 20°C is equal to or greater than 10% by weight, and the fluid is a liquid at operating conditions.

1.1.2 Closed-Vent System

A system that is not open to the atmosphere and that is composed of piping, connections, and if necessary, flow-inducing devices that transport gas or vapor from a piece or pieces of equipment to a control device.

1.1.3 Control Device

An enclosed combustion device, vapor recovery system (e.g., condenser or adsorber), or flare. Any device the primary function of which is the recovery or capture of solvents or other organics for use, reuse, or sale is not a control device.

1.1.4 Open-ended Valve or Pipe

Any valve, except pressure relief valves, having one side of the valve seat in contact with process fluid and one side open to the atmosphere, either directly or through open piping.

1.1.5 Hazardous Waste Management Unit Shutdown

A work practice or operational procedure that stops operation of a hazardous waste management unit or part of a hazardous waste management unit. An unscheduled work practice or operational procedure that stops operation for less than 24 hours is not a hazardous waste management unit shutdown. The use of spare equipment and technically feasible bypassing of equipment without stopping operation are not hazardous waste management unit shutdowns.

1.2 SERVICE CLASSIFICATION

Equipment used for fuel blending and organic waste consolidation meets the definition of “in light liquid service” as described in 40 CFR 264.1031. Supporting documentation that meets the requirements of 264.1063(h) for determining whether the system is in light liquid service will be maintained as part of the facility operating record.

1.3 EQUIPMENT MARKING

All equipment subject to Subpart BB will be marked in such a manner that it can be distinguished readily from pieces of equipment not subject to Subpart BB. All equipment subject to Subpart BB will be assigned unique identification numbers prior to implementation of Subpart BB. This information will be maintained as part of the facility operating record.

1.4 DELAY OF REPAIR

Delay of repair is allowed if the repair is technically infeasible without a hazardous waste management unit shutdown.

Delay of repair is also allowed if the equipment is isolated from the hazardous waste management unit and does not continue to contain or contact hazardous waste with 10 percent or more (by weight) organics content.

2. Equipment Monitoring

2.1 PUMPS IN LIGHT LIQUID SERVICE

Several hazardous waste streams accepted at the Facility contains light liquids, defined as 20 percent or more of components with vapor pressures greater than 2.25 mm Hg at 68o F. When light liquids are processed at the Facility, the pump, valves, piping, flanges, connectors, and relief devices used are visually inspected each calendar week in which operations occur for liquids dripping from the seals in the process line. Pumps in light liquid service are listed in [Table IB-1](#).

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This table will be amended if additional pumps to be used in light liquid service are added and the amended [Table IB-1](#) will be submitted to ADEQ for a Class I permit modification. The results of visual inspections are recorded in the equipment use log provided in [Appendix IB-1](#).

2.1.1 Monitoring Pumps in Light Liquid Service

Each seal in the pumps used for light liquids, including pumps used to transfer to or from tanks on transportation vehicles, are monitored at least monthly for vapor leaks using a photoionization detector (PID) unless designated for no detectable emissions as described in this section. Monitoring follows EPA Method 21 requirements for daily calibration, adjusting for the appropriate range and response, and using a response factor for the specific compounds being monitored. A copy of Method 21 is provided in [Appendix IB-2](#).

A RAE MiniRAE 3000 PID with an 11.7 eV lamp measuring VOCs in a range of 1,000 to 15,000 ppm, with a resolution of ± 1.0 ppm is used for monitoring the pumps. A copy of the miniRAE 3,000+ product sheet is provided as [Appendix IB-3](#). The miniRAE will be calibrated with methane or n-hexane with a 4,000 to 6,000 ppm calibration standard. The PID instrument is maintained in the Hazardous Waste Management and Processing office when not in use.

A leak is detected when liquids are observed to be dripping from a seal or when vapor monitoring indicates readings of 10,000 parts per million (ppm) above background levels. Monitoring for vapor leaks will be conducted at least once per month when pumping, transferring or processing of light liquids is conducted.

Any pump in light liquid service may be designated for no detectable emissions if the PID instrument reading is less than 250 ppm above background as determined using EPA Method 21. The PID will be calibrated to measure VOCs in a range of 0 to 1,000 ppm with a resolution of ± 0.1 ppm when evaluating pumps for no detectable emissions.

Pumps designated as having no detectable emissions are exempt from monthly monitoring for leaks requirements. Pumps designated as having no detectable emissions will be tested for compliance with this section initially upon designation, annually, and at other times as requested by ADEQ.

Pumps designated for no detectable emissions, as indicated by an instrument reading of less than 250 ppm above background, are exempt from the monitoring requirements of this section if the pump meets the following requirements:

- Has no externally actuated shaft penetrating the pump housing.

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- The pump operates with no detectable emissions as indicated by an instrument reading of less than 250 ppm above background as measured by the methods specified in 40 CFR §264.1063I.
- The pump is tested for compliance with no detectable emissions limit initially upon designation, annually, and at other times as requested by the ADEQ.

2.2 VALVES IN LIGHT LIQUID SERVICE

Equipment used to transfer light liquids, including transferring to, or from bulk tankers is monitored monthly to detect leaks by EPA Method 21. An instrument reading of 10,000 ppm or greater indicates detection of a leak.

Any valve for which a leak is not detected for two successive months will be monitored the first month of every succeeding quarter, beginning with the next quarter, until a leak is detected. If a leak is detected, the valve will be monitored monthly until a leak is not detected for two successive months.

Valves designated as having no detectable emissions is exempt from the monthly monitoring requirements of this section if the valve meets the following requirements:

- Has no external actuating mechanism in contact with the hazardous waste stream.
- The valve is operated with emissions less than 250 ppm above background as determined by EPA Method 21.
- The valve is tested for compliance with this section initially upon designation, annually, and at other times as requested by ADEQ.

2.3 OPEN ENDED VALVES AND LINES

Open-ended valves and lines in light liquid service are included in the list of equipment provided in [Table IB-1](#). Each open-ended valve and line is equipped with a cap, blind flange, plug, or a second valve. The cap, blind flange, plug, or second valve seals the open end at all times except during operations requiring hazardous waste stream flow. Each open-ended valve and line equipped with a second valve is operated to ensure that the valve on the hazardous waste stream end is closed before the second valve is closed and the open-ended valve is closed when the second valve is opened.

2.4 PRESSURE RELIEF VALVES

Pressure Relief Valves in light liquid service are included in the list of equipment provided in [Table IB-1](#). Each pressure relief valve is inspected for visible signs of damage, corrosion, or evidence of malfunction.

2.5 PUMPS, VALVES, FLANGES, AND OTHER CONNECTORS IN HEAVY LIQUID SERVICE

Pumps and valves, flanges, and other connectors in heavy liquid service (liquids with vapor pressures ≤ 0.3 kPa) are monitored within 5 days by EPA Method 21 if evidence of a potential leak is found by visual, audible, olfactory, or any other detection method. An instrument reading of 10,000 ppm or greater indicates detection of a leak. Identified leaks will be documented on the Equipment Use Log provided in [Appendix IB-1](#).

2.6 REPAIR REQUIREMENTS

When a leak is detected, a first attempt at repair is made within 5 calendar days of detecting the leak. Repair must begin as soon as practicable but must be made within 15 calendar days of detecting the leak.

Examples of first attempts include:

- Tightening the packing gland nuts on pumps;
- Tightening bolts on valves and flanges; and,
- Replacing worn gaskets

Any equipment that cannot be repaired to meet the leak standards is replaced.

2.7 DELAY IN LEAK REPAIR

Delay of repair of equipment for which leaks have been detected are allowed beyond 15 days if the equipment is isolated and does not remain in service. The delay in repair is documented in the Equipment Leak Repair Log provided [Appendix IB-4](#).

2.8 ADDITIONAL DELAY OF REPAIR

Additional delay of repair is allowed if the repair requires the use of a dual mechanical seal that includes a barrier fluid. Delay of repair is also allowed if the repair is completed as soon as practicable, but not later than 6 months after the leak is detected.

3. Methodology

Facility personnel trained in the inspection and monitoring program conduct the inspections and use PID instruments to perform monitoring for leaks of equipment. Inspection personnel visually inspect the exterior components of the equipment for evidence of any defect that could result in a leak.

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Evidence includes visible cracks, holes, gaps, and other open spaces when the equipment is operating. Visible vapor or liquid leakage also indicate a potential leak. Visible evidence of defects is recorded in the equipment use log and immediately reported to the Facility Manager.

Monitoring for equipment leaks is performed while the equipment is handling a light or heavy liquid. The PID is calibrated the same day as the monitoring consistent with manufacturer's instructions for instrument calibration. The instrument is checked during each day of use for calibration drift, consistent with instrument operating manual instructions. Instrument calibration and drift are recorded on the log sheet provided as [Appendix IB-5](#).

With the calibrated instrument running, the instrument probe tip is traversed around all potential leak interfaces as close to the interface as possible. All potential leak interfaces are monitored by the instrument probe.

The results of equipment determined to have no detectable emissions are recorded on the Equipment Use Log. If a leak is detected is recorded on the Equipment Use Log and the arithmetic difference recorded in the comments section. Monitoring results indicating a leak will be immediately reported to the Facility Manager.

4. Alternative Standard Selection

The Facility may elect to have all the valves associated with fuel blending and organic waste consolidation comply with the alternative standard that allows no greater than 2% of the valves to leak.

4.1 PERFORMANCE TEST

A performance test will be conducted initially upon designation (i.e., when first subject to rule) and annually thereafter. The ADEQ may request additional performance tests at other times.

The performance test will be conducted by monitoring all valves associated with fuel blending and organic waste consolidation within a one week period in accordance with 40 CFR 264.1063(b) and Method 21. If an instrument reading of 10,000 ppm or greater is obtained, a leak is detected. The leak percentage shall be determined by dividing the number of leaking valves by the total number of valves. If there are less than 50 total valves, then no valves are allowed to leak to comply with the alternative standard.

A copy of the performance test description and test results for the initial performance test will be submitted to ADEQ after the Facility's RCRA Part B permit has been issued.

4.2 REPAIR REQUIREMENTS

A first attempt at repair shall be made within 5 calendar days after detecting the leak during a performance test. First attempts include, but are not limited to, tightening or replacement of bonnet bolts, tightening of packing gland nuts, or injection of lubricant in lubricated packing.

Repair must begin as soon as practicable but must be made within 15 calendar days of detecting the leak except as described in Delay of Repair.

4.3 ADDITIONAL DELAY OF REPAIR

Additional delay of repair is allowed if the Facility determines emissions of purged material resulting from immediate repair are greater than the emissions likely to result from the delay of repair. When repairs are affected, the purged material will be collected and destroyed or recovered in a control device that complies with 40 CFR Part 264.1060.

4.4 PROCEDURES FOR DETECTABLE EMISSIONS

In addition to the requirements above, the background level will be determined in accordance with Method 21. The arithmetic difference between the maximum concentration indicated by the instrument and the background level is compared with 500 ppm for determining if a leak is present.

5. Recordkeeping Requirements

For each piece of equipment associated with fuel blending or organic waste consolidation subject to Subpart BB, the following information is recorded:

- Equipment identification number;
- Approximate location within the facility;
- Type of equipment (e.g., pump, valve);
- Percent by weight of total organics in the hazardous waste stream at the equipment;
- Hazardous waste state at the equipment (i.e., liquid); and
- Method of evaluation of compliance with the standard (e.g., monthly leak detection and repair, visual inspection, etc.).

When a leak is detected, the following is performed:

- A weatherproof tag with the equipment identification number and the date the potential leak was detected will be attached to the leaking equipment. This tag will be removed after the repair is made, except for a valve in accordance with 40 CFR 264.1064(c)(2) and (3).
- Information regarding the detection of the leak will be recorded as specified in 264.1064(d) and summarized below:
 - Instrument, operator, and equipment identification;

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- Date evidence of potential leak found for flanges and other connectors;
 - Date leak detected, dates repair attempted, and method applied;
 - Reasons and documentation for delay of repair, if applicable; and
 - Date of repair.
- The identification number, background level, and the maximum instrument reading will be recorded for each monitoring and inspection event.
 - The percent of valves found leaking during each monitoring period will be calculated and recorded.

6. Quality Assurance and Quality Control

Personnel performing inspections and monitoring review and sign documentation collected on a daily basis. The Facility Manager or his designee reviews the inspection and monitoring records for completeness on a monthly basis and performs a quarterly review of the daily monitoring reports to verify the number of components monitored and the time between monitoring events to identify any abnormal patterns. The Facility Manager or his designee documents his quarterly review of records and signs and dates the Equipment Use Logs on the line immediately beneath the last entry on the log reviewed in the quarterly review.

On an annual basis, the Facility Manager or his designee reviews all records pertaining to equipment monitoring and leak repair to ensure that all required records, logs, and databases are being maintained and are up to date. The annual review includes an inventory of Facility equipment to ensure that equipment subject to monitoring and leak repair requirements is properly identified and is being monitored.

During the annual review, the Facility Manager or his designee observes the calibration and monitoring of instruments used for equipment monitoring. The instrument review verifies that the entire equipment interface is properly monitored. Areas of noncompliance that are discovered will be reviewed by the Facility Manager. The Facility Manager will prepare and initiate a corrective action plan to resolve and document those issues. The corrective action plan will require implementation, as soon as practicable, of steps necessary to correct causes of noncompliance, and prevent, to the extent practicable, a recurrence of the cause of the noncompliance.

The Annual Review will be documented on an Annual Review form provided as [Appendix IB-6](#).

7. Reporting Requirements

Semiannual reporting is not required if leaks from valves and pumps are repaired within the specified time frames. The semiannual report, if necessary, will include the information specified in 264.1065(a) and summarized below:

- Facility EPA ID number, name, and address;
- Equipment ID number for the equipment not repaired within the required time period; and,
- Dates of hazardous waste management unit shutdowns (if any).

If a semiannual report is required, the report for the period of January through June shall be submitted by July 31 of that calendar year. The report for the period July through December shall be submitted by January 31 of the following calendar year.

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Table IB-1

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Table IB-1
List of Equipment Subject to Subpart BB

[illegible]

APPENDIX IB-1
Equipment Use Log

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EQUIPMENT USE LOG

[illegible]

APPENDIX IB-2
EPA Method 21

While we have taken steps to ensure the accuracy of this Internet version of the document, it is not the official version. Please refer to the official version in the FR publication, which appears on the Government Printing Office's eCFR website:

(http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&tpl=/ecfrbrowse/Title40/40cfr60_main_02.tpl)

Method 21 - Determination of Volatile Organic Compound Leaks

1.0 Scope and Application

1.1 Analytes.

Analyte	CAS No.
Volatile Organic Compounds (VOC)	No CAS number assigned.

1.2 Scope. This method is applicable for the determination of VOC leaks from process equipment. These sources include, but are not limited to, valves, flanges and other connections, pumps and compressors, pressure relief devices, process drains, open-ended valves, pump and compressor seal system degassing vents, accumulator vessel vents, agitator seals, and access door seals.

1.3 Data Quality Objectives. Adherence to the requirements of this method will enhance the quality of the data obtained from air pollutant sampling methods.

2.0 Summary of Method

2.1 A portable instrument is used to detect VOC leaks from individual sources. The instrument detector type is not specified, but it must meet the specifications and performance criteria contained in Section 6.0. A leak definition concentration based on a reference compound is specified in each applicable regulation. This method is intended to locate and classify leaks only, and is not to be used as a direct measure of mass emission rate from individual sources.

3.0 Definitions

3.1 *Calibration gas* means the VOC compound used to adjust the instrument meter reading to a known value. The calibration gas is usually the reference compound at a known concentration approximately equal to the leak definition concentration.

3.2 *Calibration precision* means the degree of agreement between measurements of the same known value, expressed as the relative percentage of the average difference between the meter readings and the known concentration to the known concentration.

3.3 *Leak definition concentration* means the local VOC concentration at the surface of a leak source that indicates that a VOC emission (leak) is present. The leak definition is an instrument meter reading based on a reference compound.

3.4 *No detectable emission* means a local VOC concentration at the surface of a leak source, adjusted for local VOC ambient concentration, that is less than 2.5 percent of the specified leak definition concentration. that indicates that a VOC emission (leak) is not present.

3.5 *Reference compound* means the VOC species selected as the instrument calibration basis for specification of the leak definition concentration. (For example, if a leak definition concentration is 10,000 ppm as methane, then any source emission that results in a local concentration that yields a meter reading of 10,000 on an instrument meter calibrated with methane would be classified as a leak. In this example, the leak definition concentration is 10,000 ppm and the reference compound is methane.)

3.6 *Response factor* means the ratio of the known concentration of a VOC compound to the observed meter reading when measured using an instrument calibrated with the reference compound specified in the applicable regulation.

3.7 *Response time* means the time interval from a step change in VOC concentration at the input of the sampling system to the time at which 90 percent of the corresponding final value is reached as displayed on the instrument readout meter.

4.0 *Interferences[Reserved]*

5.0 *Safety*

5.1 Disclaimer. This method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to performing this test method.

5.2 Hazardous Pollutants. Several of the compounds, leaks of which may be determined by this method, may be irritating or corrosive to tissues (*e.g.*, heptane) or may be toxic (*e.g.*, benzene, methyl alcohol). Nearly all are fire hazards. Compounds in emissions should be determined through familiarity with the source. Appropriate precautions can be found in reference documents, such as reference No. 4 in Section 16.0.

6.0 *Equipment and Supplies*

A VOC monitoring instrument meeting the following specifications is required:

6.1 The VOC instrument detector shall respond to the compounds being processed. Detector types that may meet this requirement include, but are not limited to, catalytic oxidation, flame ionization, infrared absorption, and photoionization.

6.2 The instrument shall be capable of measuring the leak definition concentration specified in the regulation.

6.3 The scale of the instrument meter shall be readable to ± 2.5 percent of the specified leak definition concentration.

6.4 The instrument shall be equipped with an electrically driven pump to ensure that a sample is provided to the detector at a constant flow rate. The nominal sample flow rate, as measured at the sample probe tip, shall be 0.10 to 3.0 l/min (0.004 to 0.1 ft³/min) when the probe is fitted with a glass wool plug or filter that may be used to prevent plugging of the instrument.

6.5 The instrument shall be equipped with a probe or probe extension or sampling not to exceed 6.4 mm (1/4in) in outside diameter, with a single end opening for admission of sample.

6.6 The instrument shall be intrinsically safe for operation in explosive atmospheres as defined by the National Electrical Code by the National Fire Prevention Association or other applicable regulatory code for operation in any explosive atmospheres that may be encountered in its use. The instrument shall, at a minimum, be intrinsically safe for Class 1, Division 1 conditions, and/or Class 2, Division 1 conditions, as appropriate, as defined by the example code. The instrument shall not be operated with any safety device, such as an exhaust flame arrestor, removed.

7.0 Reagents and Standards

7.1 Two gas mixtures are required for instrument calibration and performance evaluation:

7.1.1 Zero Gas. Air, less than 10 parts per million by volume (ppmv) VOC.

7.1.2 Calibration Gas. For each organic species that is to be measured during individual source surveys, obtain or prepare a known standard in air at a concentration approximately equal to the applicable leak definition specified in the regulation.

7.2 Cylinder Gases. If cylinder calibration gas mixtures are used, they must be analyzed and certified by the manufacturer to be within 2 percent accuracy, and a shelf life must be specified. Cylinder standards must be either reanalyzed or replaced at the end of the specified shelf life.

7.3 Prepared Gases. Calibration gases may be prepared by the user according to any accepted gaseous preparation procedure that will yield a mixture accurate to within 2 percent. Prepared standards must be replaced each day of use unless it is demonstrated that degradation does not occur during storage.

7.4 Mixtures with non-Reference Compound Gases. Calibrations may be performed using a compound other than the reference compound. In this case, a conversion factor must be determined for the alternative compound such that the resulting meter readings during source surveys can be converted to reference compound results.

8.0 Sample Collection, Preservation, Storage, and Transport

8.1 Instrument Performance Evaluation. Assemble and start up the instrument according to the manufacturer's instructions for recommended warm-up period and preliminary adjustments.

8.1.1 Response Factor. A response factor must be determined for each compound that is to be measured, either by testing or from reference sources. The response factor tests are required before placing the analyzer into service, but do not have to be repeated at subsequent intervals.

8.1.1.1 Calibrate the instrument with the reference compound as specified in the applicable regulation. Introduce the calibration gas mixture to the analyzer and record the observed meter reading. Introduce zero gas until a stable reading is obtained. Make a total of three measurements by alternating between the calibration gas and zero gas. Calculate the response factor for each repetition and the average response factor.

8.1.1.2 The instrument response factors for each of the individual VOC to be measured shall be less than 10 unless otherwise specified in the applicable regulation. When no instrument is available that meets this specification when calibrated with the reference VOC specified in the applicable regulation, the available instrument may be calibrated with one of the VOC to be measured, or any other VOC, so long as the instrument then has a response factor of less than 10 for each of the individual VOC to be measured.

8.1.1.3 Alternatively, if response factors have been published for the compounds of interest for the instrument or detector type, the response factor determination is not required, and existing results may be referenced. Examples of published response factors for flame ionization and catalytic oxidation detectors are included in References 1–3 of Section 17.0.

8.1.2 Calibration Precision. The calibration precision test must be completed prior to placing the analyzer into service and at subsequent 3-month intervals or at the next use, whichever is later.

8.1.2.1 Make a total of three measurements by alternately using zero gas and the specified calibration gas. Record the meter readings. Calculate the average algebraic difference between the meter readings and the known value. Divide this average difference by the known calibration value and multiply by 100 to express the resulting calibration precision as a percentage.

8.1.2.2 The calibration precision shall be equal to or less than 10 percent of the calibration gas value.

8.1.3 Response Time. The response time test is required before placing the instrument into service. If a modification to the sample pumping system or flow configuration is made that would change the response time, a new test is required before further use.

8.1.3.1 Introduce zero gas into the instrument sample probe. When the meter reading has stabilized, switch quickly to the specified calibration gas. After switching, measure the time required to attain 90 percent of the final stable reading. Perform this test sequence three times and record the results. Calculate the average response time.

8.1.3.2 The instrument response time shall be equal to or less than 30 seconds. The instrument pump, dilution probe (if any), sample probe, and probe filter that will be used during testing shall all be in place during the response time determination.

8.2 Instrument Calibration. Calibrate the VOC monitoring instrument according to Section 10.0.

8.3 Individual Source Surveys.

8.3.1 Type I—Leak Definition Based on Concentration. Place the probe inlet at the surface of the component interface where leakage could occur. Move the probe along the interface periphery while observing the instrument readout. If an increased meter reading is observed, slowly sample the interface where leakage is indicated until the maximum meter reading is obtained. Leave the probe inlet at this maximum reading location for approximately two times the instrument response time. If the maximum observed meter reading is greater than the leak definition in the applicable regulation, record and report the results as specified in the regulation reporting requirements. Examples of the application of this general technique to specific equipment types are:

8.3.1.1 Valves. The most common source of leaks from valves is the seal between the stem and housing. Place the probe at the interface where the stem exits the packing gland and sample the stem circumference. Also, place the probe at the interface of the packing gland take-up flange seat and sample

the periphery. In addition, survey valve housings of multipart assembly at the surface of all interfaces where a leak could occur.

8.3.1.2 Flanges and Other Connections. For welded flanges, place the probe at the outer edge of the flange-gasket interface and sample the circumference of the flange. Sample other types of nonpermanent joints (such as threaded connections) with a similar traverse.

8.3.1.3 Pumps and Compressors. Conduct a circumferential traverse at the outer surface of the pump or compressor shaft and seal interface. If the source is a rotating shaft, position the probe inlet within 1 cm of the shaft-seal interface for the survey. If the housing configuration prevents a complete traverse of the shaft periphery, sample all accessible portions. Sample all other joints on the pump or compressor housing where leakage could occur.

8.3.1.4 Pressure Relief Devices. The configuration of most pressure relief devices prevents sampling at the sealing seat interface. For those devices equipped with an enclosed extension, or horn, place the probe inlet at approximately the center of the exhaust area to the atmosphere.

8.3.1.5 Process Drains. For open drains, place the probe inlet at approximately the center of the area open to the atmosphere. For covered drains, place the probe at the surface of the cover interface and conduct a peripheral traverse.

8.3.1.6 Open-ended Lines or Valves. Place the probe inlet at approximately the center of the opening to the atmosphere.

8.3.1.7 Seal System Degassing Vents and Accumulator Vents. Place the probe inlet at approximately the center of the opening to the atmosphere.

8.3.1.8 Access door seals. Place the probe inlet at the surface of the door seal interface and conduct a peripheral traverse.

8.3.2 Type II—"No Detectable Emission". Determine the local ambient VOC concentration around the source by moving the probe randomly upwind and downwind at a distance of one to two meters from the source. If an interference exists with this determination due to a nearby emission or leak, the local ambient concentration may be determined at distances closer to the source, but in no case shall the distance be less than 25 centimeters. Then move the probe inlet to the surface of the source and determine the concentration as outlined in Section 8.3.1. The difference between these concentrations determines whether there are no detectable emissions. Record and report the results as specified by the regulation. For those cases where the regulation requires a specific device installation, or that specified vents be ducted or piped to a control device, the existence of these conditions shall be visually confirmed. When the regulation also requires that no detectable emissions exist, visual observations and sampling surveys are required. Examples of this technique are:

8.3.2.1 Pump or Compressor Seals. If applicable, determine the type of shaft seal. Perform a survey of the local area ambient VOC concentration and determine if detectable emissions exist as described in Section 8.3.2.

8.3.2.2 Seal System Degassing Vents, Accumulator Vessel Vents, Pressure Relief Devices. If applicable, observe whether or not the applicable ducting or piping exists. Also, determine if any sources exist in the ducting or piping where emissions could occur upstream of the control device. If the required ducting or piping exists and there are no sources where the emissions could be vented to the atmosphere upstream of

the control device, then it is presumed that no detectable emissions are present. If there are sources in the ducting or piping where emissions could be vented or sources where leaks could occur, the sampling surveys described in Section 8.3.2 shall be used to determine if detectable emissions exist.

8.3.3 Alternative Screening Procedure.

8.3.3.1 A screening procedure based on the formation of bubbles in a soap solution that is sprayed on a potential leak source may be used for those sources that do not have continuously moving parts, that do not have surface temperatures greater than the boiling point or less than the freezing point of the soap solution, that do not have open areas to the atmosphere that the soap solution cannot bridge, or that do not exhibit evidence of liquid leakage. Sources that have these conditions present must be surveyed using the instrument technique of Section 8.3.1 or 8.3.2.

8.3.3.2 Spray a soap solution over all potential leak sources. The soap solution may be a commercially available leak detection solution or may be prepared using concentrated detergent and water. A pressure sprayer or squeeze bottle may be used to dispense the solution. Observe the potential leak sites to determine if any bubbles are formed. If no bubbles are observed, the source is presumed to have no detectable emissions or leaks as applicable. If any bubbles are observed, the instrument techniques of Section 8.3.1 or 8.3.2 shall be used to determine if a leak exists, or if the source has detectable emissions, as applicable.

9.0 Quality Control

Section	Quality control measure	Effect
8.1.2	Instrument calibration precision check	Ensure precision and accuracy, respectively, of instrument response to standard.
10.0	Instrument calibration	

10.0 Calibration and Standardization

10.1 Calibrate the VOC monitoring instrument as follows. After the appropriate warm-up period and zero internal calibration procedure, introduce the calibration gas into the instrument sample probe. Adjust the instrument meter readout to correspond to the calibration gas value.

Note: If the meter readout cannot be adjusted to the proper value, a malfunction of the analyzer is indicated and corrective actions are necessary before use.

11.0 Analytical Procedures[Reserved]

12.0 Data Analyses and Calculations[Reserved]

13.0 Method Performance[Reserved]

14.0 Pollution Prevention[Reserved]

15.0 Waste Management[Reserved]

16.0 References

1. Dubose, D.A., and G.E. Harris. Response Factors of VOC Analyzers at a Meter Reading of 10,000 ppmv for Selected Organic Compounds. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2-81051. September 1981.
2. Brown, G.E., *et al.* Response Factors of VOC Analyzers Calibrated with Methane for Selected Organic Compounds. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2-81-022. May 1981.
3. DuBose, D.A. *et al.* Response of Portable VOC Analyzers to Chemical Mixtures. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2-81-110. September 1981.
4. Handbook of Hazardous Materials: Fire, Safety, Health. Alliance of American Insurers. Schaumburg, IL. 1983.

17.0 Tables, Diagrams, Flowcharts, and Validation Data[Reserved]

APPENDIX IB-3
MiniRAE 3000 Product Data Sheet

MiniRAE® 3000 +

Portable Handheld VOC Monitor

The MiniRAE 3000 + is a comprehensive handheld VOC (Volatile Organic Compound) monitor that uses a third-generation patented PID technology to accurately measure one of the highest levels of ionizable chemicals available on the market. The MiniRAE 3000 + is a comprehensive handheld VOC (Volatile Organic Compound) monitor that uses a third-generation patented PID technology to accurately measure one of the highest levels of ionizable chemicals available on the market.

It provides full-range measurement from 0 to 15,000 ppm of VOCs. The MiniRAE 3000 + has a built-in wireless modem that allows real-

time data connectivity with the command center located up to 2 miles (3 km) away through a Bluetooth connection to a RAELink 3* portable modem or optionally via Mesh Network.



Workers can quickly measure VOCs and wirelessly transmit data

- Highly accurate VOC measurements
- Reflex PID Technology™
- Low maintenance—easy access to lamp and sensor
- Low cost of ownership
- 3-year 10.6eV lamp warranty
- BLE module & dedicated APP for Enhanced Datalogging capability



FEATURES & BENEFITS

- Third-generation patented PID technology
- Reflex PID Technology™
- VOC detection range from 0 to 15,000 ppm
- 3-second response time
- Humidity compensation with built-in humidity and temperature sensors
- Six-month datalogging
- Highly connectivity capability through multiple wireless module options
- Large graphic display with integrated flashlight
- Multi-language support with 10 languages encoded
- IP- 67 waterproof design

APPLICATIONS

- Oil and Gas
- HazMat
- Industrial Safety
- Civil Defense
- Environmental and Indoor Air Quality



Instrument Specifications	
Size	10" L x 3.0" W x 2.5" H (25.5 cm x 7.6 cm x 6.4 cm)
Weight	26 oz (738 g)
Sensors	Photoionization sensor with standard 10.6 eV or optional 9.8 eV or 11.7 eV lamp
Battery	<ul style="list-style-type: none"> Rechargeable, external field-replaceable Lithium-Ion battery pack Alkaline battery adapter
Running time	16 hours of operation (12 hours with alkaline battery adapter)
Display Graphic	4 lines, 28 x 43 mm, with LED backlight for enhanced display readability
Keypad	1 operation and 2 programming keys, 1 flashlight on/off
Direct Readout	Instantaneous reading <ul style="list-style-type: none"> VOCs as ppm by volume (mg/m³) High values STEL and TWA Battery and shutdown voltage Date, time, temperature
Alarms	95dB at 12" (30 cm) buzzer and flashing red LED to indicate exceeded preset limits <ul style="list-style-type: none"> High: 3 beeps and flashes per second Low: 2 beeps and flashes per second STEL and TWA: 1 beep and flash per second Alarms latching with manual override or automatic reset Additional diagnostic alarm and display message for low battery and pump stall
EMC/RFI	Compliant with EMC directive (2004/108/EC) EMI and ESD test: 100MHz to 1GHz 30V/m, no alarm Contact: ±4kV Air: ±8kV, no alarm
IP Rating	<ul style="list-style-type: none"> IP-67 unit off and without flexible probe IP-65 unit running
Datalogging	Standard 6 months at one-minute intervals
Calibration	Two-point or three-point calibration for zero and span. Reflex PID Technology™ Calibration memory for 8 calibration gases, alarm limits, span values and calibration dates
Sampling Pump	<ul style="list-style-type: none"> Internal, integrated flow rate at 500 cc/mn Sample from 100' (30m) horizontally or vertically
Low Flow Alarm	Auto pump shutoff at low-flow condition
Communication & Data Download	<ul style="list-style-type: none"> Download data and upload instrument set-up from PC through charging cradle or using BLE module and dedicated APP Wireless data transmission through built-in RF modem
Wireless Network	Mesh RAE Systems Dedicated Wireless Network
Wireless Range (Typical)	Up to 15ft (5m) for BLE EchoView Host: LOS > 660 ft (200 m) ProRAE Guardian & RAEMesh Reader: LOS > 660 ft (200 m) ProRAE Guardian & RAELink3 Mesh: LOS > 330 ft (100 m)
Safety	US and Canada: CSA, Classified as Intrinsically Safe for use in Class I, Division 1 Groups A, B, C, D
Certifications	Europe: ATEX II 2G EEx ia IIC T4
Temperature	-4° to 122° F (-20° to 50° C)
Humidity	0% to 95% relative humidity (non-condensing)

For more information

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Datasheet_MiniRAE 3000+_DS-1018_EN
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Instrument Specifications	
Attachments	Durable bright yellow rubber boot
Warranty	3 years for 10.6 eV lamp, 1 year for pump, battery, sensor and instrument
Wireless Frequency	ISM license-free band. IEEE 802.15.4 Sub 1GHz
Wireless Approvals	FCC Part 15, CE R&TTE, Others ¹
Radio Module	Supports BLE or Bluetooth or RM900

¹ Contact RAE Systems for country-specific wireless approvals and certificates. Specifications are subject to change.

Sensor Specifications			
Gas Monitor	Range	Resolution	Response Time T90
VOCs	0 to 999.9 ppm 1,000 to 15,000 ppm	0.1 ppm 1 ppm	< 3 s < 3 s

MONITOR ONLY INCLUDES:

- MiniRAE 3000 + Monitor, Model PGM-7320
- Wireless communication module built in, as specified
- Datalogging with ProRAE Studio II Package
- Charging/download adapter
- RAE UV lamp, as specified
- Flex-I-Probe™
- External filter
- Rubber boot
- Alkaline battery adapter
- Lamp-cleaning kit
- Tool kit
- Soft leather case

OPTIONAL CALIBRATION KIT ADDS:

- 100 ppm isobutylene calibration gas, 34L
- Calibration regulator and flow controller

OPTIONAL GUARANTEED COST-OF-OWNERSHIP PROGRAM:

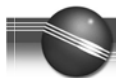
- 4-year repair and replacement warranty
- Annual maintenance service

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Correction Factors, Ionization Energies*, And Calibration Characteristics

Correction Factors and Ionization Energies

RAE Systems PIDs can be used for the detection of a wide variety of gases that exhibit different responses. In general, any compound with ionization energy (IE) lower than that of the lamp photons can be measured.* The best way to calibrate a PID to different compounds is to use a standard of the gas of interest. However, correction factors have been determined that enable the user to quantify a large number of chemicals using only a single calibration gas, typically isobutylene. In our PIDs, correction factors can be used in one of three ways:

- 1) Calibrate the monitor with isobutylene in the usual fashion to read in isobutylene equivalents. Manually multiply the reading by the correction factor (CF) to obtain the concentration of the gas being measured.
- 2) Calibrate the unit with isobutylene in the usual fashion to read in isobutylene equivalents. Call up the correction factor from the instrument memory or download it from a personal computer and then call it up. The monitor will then read directly in units of the gas of interest.
- 3) Calibrate the unit with isobutylene, but input an equivalent, "corrected" span gas concentration when prompted for this value. The unit will then read directly in units of the gas of interest.

* The term "ionization energy" is more scientifically correct and replaces the old term "ionization potential." High-boiling ("heavy") compounds may not vaporize enough to give a response even when their ionization energies are below the lamp photon energy. Some inorganic compounds like H_2O_2 and NO_2 give weak response even when their ionization energies are well below the lamp photon energy.

Example 1:

With the unit calibrated to read isobutylene equivalents, the reading is 10 ppm with a 10.6 eV lamp. The gas being measured is butyl acetate, which has a correction factor of 2.6. Multiplying 10 by 2.6 gives an adjusted butyl acetate value of 26 ppm. Similarly, if the gas being measured were trichloroethylene (CF = 0.54), the adjusted value with a 10 ppm reading would be 5.4 ppm.

Example 2:

With the unit calibrated to read isobutylene equivalents, the reading is 100 ppm with a 10.6 eV lamp. The gas measured is m-xylene (CF = 0.43). After downloading this factor, the unit should read about 43 ppm when exposed to the same gas, and thus read directly in m-xylene values.

Example 3:

The desired gas to measure is ethylene dichloride (EDC). The CF is 0.6 with an 11.7 eV lamp. During calibration with 100 ppm isobutylene, insert 0.6 times 100, or 60 at the prompt for the calibration gas concentration. The unit then reads directly in EDC values.

Conversion to mg/m^3

To convert from ppm to mg/m^3 , use the following formula:

$$\text{Conc. (mg/m}^3\text{)} = \frac{[\text{Conc. (ppmv)} \times \text{mol. wt. (g/mole)}]}{\text{molar gas volume (L)}}$$

For air at 25 °C (77 °F), the molar gas volume is 24.4 L/mole and the formula reduces to:

$$\text{Conc. (mg/m}^3\text{)} = \text{Conc. (ppmv)} \times \text{mol. wt. (g/mole)} \times 0.041$$

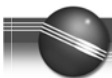
For example, if the instrument is calibrated with a gas standard in ppmv, such as 100 ppm isobutylene, and the user wants the display to read in mg/m^3 of hexane, whose m.w. is 86 and CF is 4.3, the overall correction factor would be $4.3 \times 86 \times 0.041$ equals 15.2.

Correction Factors for Mixtures

The correction factor for a mixture is calculated from the sum of the mole fractions X_i of each component divided by their respective correction factors CF_i :

$$CF_{\text{mix}} = 1 / (X_1/CF_1 + X_2/CF_2 + X_3/CF_3 + \dots X_i/CF_i)$$

Thus, for example, a vapor phase mixture of 5% benzene and 95% n-hexane would have a CF_{mix} of $CF_{\text{mix}} = 1 / (0.05/0.53 + 0.95/4.3) = 3.2$. A reading of 100 would then correspond to 320 ppm of the total mixture, comprised of 16 ppm benzene and 304 ppm hexane.



For a spreadsheet to compute the correction factor and TLV of a mixture see the appendix at the end of the CF table.

TLVs and Alarm Limits for Mixtures

The correction factor for mixtures can be used to set alarm limits for mixtures. To do this one first needs to calculate the exposure limit for the mixture. The Threshold Limit Value (TLV) often defines exposure limits. The TLV for the mixture is calculated in a manner similar to the CF calculation:

$$\text{TLV mix} = 1 / (X_1/\text{TLV}_1 + X_2/\text{TLV}_2 + X_3/\text{TLV}_3 + \dots X_i/\text{TLV}_i)$$

In the above example, the 8-h TLV for benzene is 0.5 ppm and for n-hexane 50 ppm. Therefore the TLV of the mixture is $\text{TLV}_{\text{mix}} = 1 / (0.05/0.5 + 0.95/50) = 8.4$ ppm, corresponding to 8.0 ppm hexane and 0.4 ppm benzene. For an instrument calibrated on isobutylene, the reading corresponding to the TLV is:

$$\text{Alarm Reading} = \text{TLV}_{\text{mix}} / \text{CF}_{\text{mix}} = 8.4 / 3.2 = 2.6 \text{ ppm}$$

A common practice is to set the lower alarm limit to half the TLV, and the higher limit to the TLV. Thus, one would set the alarms to 1.3 and 2.6 ppm, respectively.

Calibration Characteristics

a) Flow Configuration. PID response is essentially independent of gas flow rate as long as it is sufficient to satisfy the pump demand. Four main flow configurations are used for calibrating a PID:

- 1) Pressurized gas cylinder (Fixed-flow regulator):** The flow rate of the regulator should match the flow demand of the instrument pump or be slightly higher.
- 2) Pressurized gas cylinder (Demand-flow regulator):** A demand-flow regulator better matches pump speed differences, but results in a slight vacuum during calibration and thus slightly high readings.
- 3) Collapsible gas bag:** The instrument will draw the calibration gas from the bag at its normal flow rate, as long as the bag valve is large enough. The bag should be filled with enough gas to allow at least one minute of flow (~ 0.6 L for a MiniRAE, ~0.3 L for MultiRAE).

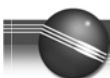
4) T (or open tube) method: The T method uses a T-junction with gas flow higher than the pump draw. The gas supply is connected to one end of the T, the instrument inlet is connected to a second end of the T, and excess gas flow escapes through the third, open end of the T. To prevent ambient air mixing, a long tube should be connected to the open end, or a high excess rate should be used. Alternatively, the instrument probe can be inserted into an open tube slightly wider than the probe. Excess gas flows out around the probe.

The first two cylinder methods are the most efficient in terms of gas usage, while the bag and T methods give slightly more accurate results because they match the pump flow better.

b) Pressure. Pressures deviating from atmospheric pressure affect the readings by altering gas concentration and pump characteristics. It is best to calibrate with the instrument and calibration gas at the same pressure as each other and the sample gas. (Note that the cylinder pressure is not relevant because the regulator reduces the pressure to ambient.) If the instrument is calibrated at atmospheric pressure in one of the flow configurations described above, then 1) pressures slightly above ambient are acceptable but high pressures can damage the pump and 2) samples under vacuum may give low readings if air leaks into the sample train.

c) Temperature. Because temperature effects gas density and concentration, the temperature of the calibration gas and instrument should be as close as possible to the ambient temperature where the unit will be used. We recommend that the temperature of the calibration gas be within the instrument's temperature specification (typically 14° to 113° F or -10° to 45° C). Also, during actual measurements, the instrument should be kept at the same or higher temperature than the sample temperature to avoid condensation in the unit.

d) Matrix. The matrix gas of the calibration compound and VOC sample is significant. Some common matrix components, such as methane and water vapor can affect the VOC signal. PIDs are



most commonly used for monitoring VOCs in air, in which case the preferred calibration gas matrix is air. For a MiniRAE, methane, methanol, and water vapor reduce the response by about 20% when their concentration is 15,000 ppm and by about 40% at 30,000 ppm. Despite earlier reports of oxygen effects, RAE PID responses with 10.6 eV lamps are independent of oxygen concentration, and calibration gases in a pure nitrogen matrix can be used. H₂ and CO₂ up to 5 volume % also have no effect.

- e) Concentration.** Although RAE Systems PIDs have electronically linearized output, it is best to calibrate in a concentration range close to the actual measurement range. For example, 100 ppm standard gas for anticipated vapors of 0 to 250 ppm, and 500 ppm standard for expected concentrations of 250 to 1000 ppm. The correction factors in this table were typically measured at 50 to 100 ppm and apply from the ppb range up to about 1000 ppm. Above 1000 ppm the CF may vary and it is best to calibrate with the gas of interest near the concentration of interest.
- f) Filters.** Filters affect flow and pressure conditions and therefore all filters to be used during sampling should also be in place during calibration. Using a water trap (hydrophobic filter) greatly reduces the chances of drawing water aerosols or dirt particles into the instrument. Regular filter replacements are recommended because dirty filters can adsorb VOCs and cause slower response time and shifts in calibration.
- g) Instrument Design.** High-boiling (“heavy”) or very reactive compounds can be lost by reaction or adsorption onto materials in the gas sample train, such as filters, pumps and other sensors. Multi-gas meters, including EntryRAE, MultiRAE and AreaRAE have the pump and other sensors upstream of the PID and are prone to these losses. Compounds possibly affected by such losses are shown in green in the table, and may give slow response, or in extreme cases, no response at all. In many cases the multi-gas meters can still give a rough indication of the relative concentration, without giving an accurate,

quantitative reading. The ppbRAE and MiniRAE series instruments have inert sample trains and therefore do not exhibit significant loss; nevertheless, response may be slow for the very heavy compounds and additional sampling time up to a minute or more should be allowed to get a stable reading.

Table Abbreviations:

CF = Correction Factor (multiply by reading to get corrected value for the compound when calibrated to isobutylene)

NR = No Response

IE = Ionization Energy (values in parentheses are not well established)

C = Confirmed Value indicated by “+” in this column; all others are preliminary or estimated values and are subject to change

ne = Not Established ACGIH 8-hr. TWA

C## = Ceiling value, given where 8-hr.TWA is not available

Disclaimer:

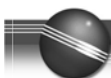
Actual readings may vary with age and cleanliness of lamp, relative humidity, and other factors. For accurate work, the instrument should be calibrated regularly under the operating conditions used. The factors in this table were measured in dry air at room temperature, typically at 50-100 ppm. CF values may vary above about 1000 ppm.

Updates:

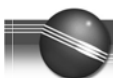
The values in this table are subject to change as more or better data become available. Watch for updates of this table on the Internet at

<http://www.raesystems.com>

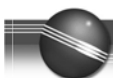
IE data are taken from the CRC Handbook of Chemistry and Physics, 73rd Edition, D.R. Lide (Ed.), CRC Press (1993) and NIST Standard Ref. Database 19A, NIST Positive Ion Energetics, Vers. 2.0, Lias, et.al., U.S. Dept. Commerce (1993). Exposure limits (8-h TWA and Ceiling Values) are from the 2005 ACGIH Guide to Occupational Exposure Values, ACGIH, Cincinnati, OH 2005. Equations for exposure limits for mixtures of chemicals were taken from the 1997 TLVs and BEIs handbook published by the ACGIH (1997).



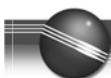
Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Acetaldehyde		75-07-0	C ₂ H ₄ O	NR	+	6	+	3.3	+	10.23	C25
Acetic acid	Ethanoic Acid	64-19-7	C ₂ H ₄ O ₂	NR	+	22	+	2.6	+	10.66	10
Acetic anhydride	Ethanoic Acid Anhydride	108-24-7	C ₄ H ₆ O ₃	NR	+	6.1	+	2.0	+	10.14	5
Acetone	2-Propanone	67-64-1	C ₃ H ₆ O	1.2	+	1.1	+	1.4	+	9.71	500
Acetone cyanohydrin	2-Hydroxyisobutyronitrile	75-86-5	C ₄ H ₇ NO					4	+	11.1	C5
Acetonitrile	Methyl cyanide, Cyanomethane	75-05-8	C ₂ H ₃ N					100		12.19	40
Acetylene	Ethyne	74-86-2	C ₂ H ₂					2.1	+	11.40	ne
Acrolein	Propenal	107-02-8	C ₃ H ₄ O	42	+	3.9	+	1.4	+	10.10	0.1
Acrylic acid	Propenoic Acid	79-10-7	C ₃ H ₄ O ₂			12	+	2.0	+	10.60	2
Acrylonitrile	Propenenitrile	107-13-1	C ₃ H ₃ N			NR	+	1.2	+	10.91	2
Allyl alcohol		107-18-6	C ₃ H ₆ O	4.5	+	2.4	+	1.6	+	9.67	2
Allyl chloride	3-Chloropropene	107-05-1	C ₃ H ₅ Cl			4.3		0.7		9.9	1
Ammonia		7664-41-7	H ₃ N	NR	+	9.7	+	5.7	+	10.16	25
Amyl acetate	mix of n-Pentyl acetate & 2-Methylbutyl acetate	628-63-7	C ₇ H ₁₄ O ₂	11	+	2.3	+	0.95	+	<9.9	100
Amyl alcohol	1-Pentanol	75-85-4	C ₅ H ₁₂ O			5		1.6		10.00	ne
Aniline	Aminobenzene	62-53-3	C ₇ H ₇ N	0.50	+	0.48	+	0.47	+	7.72	2
Anisole	Methoxybenzene	100-66-3	C ₇ H ₈ O	0.89	+	0.58	+	0.56	+	8.21	ne
Arsine	Arsenic trihydride	7784-42-1	AsH ₃			1.9	+			9.89	0.05
Benzaldehyde		100-52-7	C ₇ H ₆ O					1		9.49	ne
Benzenamine, N-methyl-	N-Methylphenylamine	100-61-8	C ₇ H ₉ N			0.7				7.53	
Benzene		71-43-2	C ₆ H ₆	0.55	+	0.53	+	0.6	+	9.25	0.5
Benzonitrile	Cyanobenzene	100-47-0	C ₇ H ₅ N			1.6				9.62	ne
Benzyl alcohol	α-Hydroxytoluene, Hydroxymethylbenzene, Benzenemethanol	100-51-6	C ₇ H ₈ O	1.4	+	1.1	+	0.9	+	8.26	ne
Benzyl chloride	α-Chlorotoluene, Chloromethylbenzene	100-44-7	C ₇ H ₇ Cl	0.7	+	0.6	+	0.5	+	9.14	1
Benzyl formate	Formic acid benzyl ester	104-57-4	C ₈ H ₈ O ₂	0.9	+	0.73	+	0.66	+		ne
Boron trifluoride		7637-07-2	BF ₃	NR		NR		NR		15.5	C1
Bromine		7726-95-6	Br ₂	NR	+	1.30	+	0.74	+	10.51	0.1
Bromobenzene		108-86-1	C ₆ H ₅ Br			0.6		0.5		8.98	ne
2-Bromoethyl methyl ether		6482-24-2	C ₃ H ₇ OBBr			0.84	+			~10	ne
Bromoform	Tribromomethane	75-25-2	CHBr ₃	NR	+	2.5	+	0.5	+	10.48	0.5
Bromopropane, 1-	n-Propyl bromide	106-94-5	C ₃ H ₇ Br	150	+	1.5	+	0.6	+	10.18	ne
Butadiene	1,3-Butadiene, Vinyl ethylene	106-99-0	C ₄ H ₆	0.8		0.85	+	1.1		9.07	2
Butadiene diepoxide, 1,3-	1,2,3,4-Diepoxybutane	298-18-0	C ₄ H ₆ O ₂	25	+	3.5	+	1.2		~10	ne
Butanal	1-Butanal	123-72-8	C ₄ H ₈ O			1.8				9.84	
Butane		106-97-8	C ₄ H ₁₀			67	+	1.2		10.53	800
Butanol, 1-	Butyl alcohol, n-Butanol	71-36-3	C ₄ H ₁₀ O	70	+	4.7	+	1.4	+	9.99	20
Butanol, t-	tert-Butanol, t-Butyl alcohol	75-65-0	C ₄ H ₁₀ O	6.9	+	2.9	+			9.90	100
Butene, 1-	1-Butylene	106-98-9	C ₄ H ₈			0.9				9.58	ne
Butoxyethanol, 2-	Butyl Cellosolve, Ethylene glycol monobutyl ether	111-76-2	C ₆ H ₁₄ O ₂	1.8	+	1.2	+	0.6	+	<10	25
Butoxyethanol acetate	Ethanol, 2-(2-butoxyethoxy)-, acetate	124-17-4	C ₁₀ H ₂₀ O ₄			5.6				≤10.6	
Butoxyethoxyethanol	2-(2-Butoxyethoxy)ethanol	112-34-5	C ₈ H ₁₈ O ₃			4.6				≤10.6	
Butyl acetate, n-		123-86-4	C ₆ H ₁₂ O ₂			2.6	+			10	150
Butyl acrylate, n-	Butyl 2-propenoate, Acrylic acid butyl ester	141-32-2	C ₇ H ₁₂ O ₂			1.6	+	0.6	+		10
Butylamine, n-		109-73-9	C ₄ H ₁₁ N	1.1	+	1.1	+	0.7	+	8.71	C5
Butyl cellosolve	see 2-Butoxyethanol	111-76-2									
Butyl hydroperoxide, t-		75-91-2	C ₄ H ₁₀ O ₂	2.0	+	1.6	+			<10	1
Butyl mercaptan	1-Butanethiol	109-79-5	C ₄ H ₁₀ S	0.55	+	0.52	+			9.14	0.5
Carbon disulfide		75-15-0	CS ₂	4	+	1.2	+	0.44		10.07	10
Carbon tetrachloride	Tetrachloromethane	56-23-5	CCl ₄	NR	+	NR	+	1.7	+	11.47	5
Carbonyl sulfide	Carbon oxysulfide	463-58-1	COS							11.18	
Cellosolve	see 2-Ethoxyethanol										
CFC-14	see Tetrafluoromethane										
CFC-113	see 1,1,2-Trichloro-1,2,2-trifluoroethane										



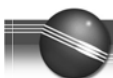
Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Chlorine		7782-50-5	Cl ₂					1.0	+	11.48	0.5
Chlorine dioxide		10049-04-4	ClO ₂	NR	+	NR	+	NR	+	10.57	0.1
Chlorobenzene	Monochlorobenzene	108-90-7	C ₆ H ₅ Cl	0.44	+	0.40	+	0.39	+	9.06	10
Chlorobenzotrifluoride, 4-	PCBTf, OXSOL 100	98-56-6	C ₇ H ₄ ClF ₃	0.74	+	0.63	+	0.55	+	<9.6	25
	p-Chlorobenzotrifluoride										
Chloro-1,3-butadiene, 2-	Chloroprene	126-99-8	C ₄ H ₅ Cl			3					10
Chloro-1,1-difluoroethane, 1-	HCFC-142B, R-142B	75-68-3	C ₂ H ₃ ClF ₂	NR		NR		NR		12.0	ne
Chlorodifluoromethane	HCFC-22, R-22	75-45-6	CHClF ₂	NR		NR		NR		12.2	1000
Chloroethane	Ethyl chloride	75-00-3	C ₂ H ₅ Cl	NR	+	NR	+	1.1	+	10.97	100
Chloroethanol	Ethylene chlorhydrin	107-07-3	C ₂ H ₅ ClO					2.9		10.52	C1
Chloroethyl ether, 2-	bis(2-chloroethyl) ether	111-44-4	C ₄ H ₈ Cl ₂ O	8.6	+	3.0	+				5
Chloroethyl methyl ether, 2-	Methyl 2-chloroethyl ether	627-42-9	C ₃ H ₇ ClO			3					ne
Chloroform	Trichloromethane	67-66-3	CHCl ₃	NR	+	NR	+	3.5	+	11.37	10
Chloro-2-methylpropene, 3-	Methallyl chloride, Isobutenyl chloride	563-47-3	C ₄ H ₇ Cl	1.4	+	1.2	+	0.63	+	9.76	ne
Chloropicrin		76-06-2	CCl ₃ NO ₂	NR	+	~400	+	7	+	?	0.1
Chlorotoluene, o-	o-Chloromethylbenzene	95-49-8	C ₇ H ₇ Cl			0.5		0.6		8.83	50
Chlorotoluene, p-	p-Chloromethylbenzene	106-43-4	C ₇ H ₇ Cl					0.6		8.69	ne
Chlorotrifluoroethene	CTFE, Chlorotrifluoroethylene	79-38-9	C ₂ ClF ₃	6.7	+	3.9	+	1.2	+	9.76	5
	Genetron 1113										
Chlorotrimethylsilane		75-77-4	C ₃ H ₉ ClSi	NR		NR		0.82	+	10.83	ne
Cresol, m-	m-Hydroxytoluene	108-39-4	C ₇ H ₈ O	0.57	+	0.50	+	0.57	+	8.29	5
Cresol, o-	o-Hydroxytoluene	95-48-7	C ₇ H ₈ O			1.0				8.50	
Cresol, p-	p-Hydroxytoluene	106-44-5	C ₇ H ₈ O			1.4				8.35	
Crotonaldehyde	trans-2-Butenal	123-73-9	C ₄ H ₆ O	1.5	+	1.1	+	1.0	+	9.73	2
		4170-30-3									
Cumene	Isopropylbenzene	98-82-8	C ₉ H ₁₂	0.58	+	0.54	+	0.4	+	8.73	50
Cyanogen bromide		506-68-3	CNBr	NR		NR		NR		11.84	ne
Cyanogen chloride		506-77-4	CNCl	NR		NR		NR		12.34	C0.3
Cyclohexane		110-82-7	C ₆ H ₁₂	3.3	+	1.4	+	0.64	+	9.86	300
Cyclohexanol	Cyclohexyl alcohol	108-93-0	C ₆ H ₁₂ O	1.5	+	0.9	+	1.1	+	9.75	50
Cyclohexanone		108-94-1	C ₆ H ₁₀ O	1.0	+	0.9	+	0.7	+	9.14	25
Cyclohexene		110-83-8	C ₆ H ₁₀			0.8	+			8.95	300
Cyclohexylamine		108-91-8	C ₆ H ₁₃ N			1.2				8.62	10
Cyclopentane 85%		287-92-3	C ₅ H ₁₀	NR	+	15	+	1.1		10.33	600
2,2-dimethylbutane 15%											
Cyclopropylamine	Aminocyclopropane	765-30-0	C ₃ H ₇ N	1.1	+	0.9	+	0.9	+		ne
Decamethylcyclopentasiloxane		541-02-6	C ₁₀ H ₃₀ O ₅ Si ₅	0.16	+	0.13	+	0.12	+		ne
Decamethyltetrasiloxane		141-62-8	C ₁₀ H ₃₀ O ₃ Si ₄	0.17	+	0.13	+	0.12	+	<10.2	ne
Decane		124-18-5	C ₁₀ H ₂₂	4.0	+	1.4	+	0.35	+	9.65	ne
Diacetone alcohol	4-Methyl-4-hydroxy-2-pentanone	123-42-2	C ₆ H ₁₂ O ₂			0.7					50
Dibromochloromethane	Chlorodibromomethane	124-48-1	CHBr ₂ Cl	NR	+	5.3	+	0.7	+	10.59	ne
Dibromo-3-chloropropane, 1,2-	DBCP	96-12-8	C ₃ H ₅ Br ₂ Cl	NR	+	1.7	+	0.43	+		0.001
Dibromoethane, 1,2-	EDB, Ethylene dibromide, Ethylene bromide	106-93-4	C ₂ H ₄ Br ₂	NR	+	1.7	+	0.6	+	10.37	ne
Dichlorobenzene, o-	1,2-Dichlorobenzene	95-50-1	C ₆ H ₄ Cl ₂	0.54	+	0.47	+	0.38	+	9.08	25
Dichlorodifluoromethane	CFC-12	75-71-8	CCl ₂ F ₂			NR	+	NR	+	11.75	1000
Dichlorodimethylsilane		75-78-5	C ₂ H ₆ Cl ₂ Si	NR		NR		1.1	+	>10.7	ne
Dichloroethane, 1,2-	EDC, 1,2-DCA, Ethylene dichloride	107-06-2	C ₂ H ₄ Cl ₂			NR	+	0.6	+	11.04	10
Dichloroethene, 1,1-	1,1-DCE, Vinylidene chloride	75-35-4	C ₂ H ₂ Cl ₂			0.82	+	0.8	+	9.79	5
Dichloroethene, c-1,2-	c-1,2-DCE, cis-Dichloroethylene	156-59-2	C ₂ H ₂ Cl ₂			0.8				9.66	200
Dichloroethene, t-1,2-	t-1,2-DCE, trans-Dichloroethylene	156-60-5	C ₂ H ₂ Cl ₂			0.45	+	0.34	+	9.65	200
Dichloro-1-fluoroethane, 1,1-	R-141B	1717-00-6	C ₂ H ₃ Cl ₂ F	NR	+	NR	+	2.0	+		ne
Dichloromethane	see Methylene chloride										



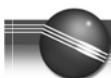
Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C IE (eV)	TWA
Dichloropentafluoropropane	AK-225, mix of ~45% 3,3-dichloro-1,1,1,2,2-pentafluoropropane (HCFC-225ca) & ~55% 1,3-Dichloro-1,1,2,2,3-pentafluoropropane (HCFC-225cb)	442-56-0 507-55-1	C ₃ HCl ₂ F ₅	NR	+	NR	+	25	+	ne
Dichloropropane, 1,2-		78-87-5	C ₃ H ₆ Cl ₂					0.7	10.87	75
Dichloro-1-propene, 1,3-		542-75-6	C ₃ H ₄ Cl ₂	1.3	+	0.96	+		<10	1
Dichloro-1-propene, 2,3-		78-88-6	C ₃ H ₄ Cl ₂	1.9	+	1.3	+	0.7	<10	ne
Dichloro-1,1,1-trifluoroethane, 2,2-	R-123	306-83-2	C ₂ HCl ₂ F ₃	NR	+	NR	+	10.1	+	11.5
Dichloro-2,4,6-trifluoropyridine, 3,5-	DCTFP	1737-93-5	C ₅ Cl ₂ F ₃ N	1.1	+	0.9	+	0.8	+	ne
Dichlorvos *	Vapona; O,O-dimethyl O-dichlorovinyl phosphate	62-73-7	C ₄ H ₇ Cl ₂ O ₄ P			0.9	+		<9.4	0.1
Dicyclopentadiene	DCPD, Cyclopentadiene dimer	77-73-6	C ₁₀ H ₁₂	0.57	+	0.48	+	0.43	+	8.8
Diesel Fuel		68334-30-5	m.w. 226			0.9	+			11
Diesel Fuel #2 (Automotive)		68334-30-5	m.w. 216	1.3		0.7	+	0.4	+	11
Diethylamine		109-89-7	C ₄ H ₁₁ N			1	+		8.01	5
Diethylaminopropylamine, 3-		104-78-9	C ₇ H ₁₈ N ₂			1.3				ne
Diethylbenzene	See Dowtherm J									
Diethylmaleate		141-05-9	C ₈ H ₁₂ O ₄			4				ne
Diethyl sulfide	see Ethyl sulfide									
Diglyme	See Methoxyethyl ether	111-96-6	C ₆ H ₁₄ O ₃							
Diisobutyl ketone	DIBK, 2,2-dimethyl-4-heptanone	108-83-8	C ₉ H ₁₈ O	0.71	+	0.61	+	0.35	+	9.04
Diisopropylamine		108-18-9	C ₆ H ₁₅ N	0.84	+	0.74	+	0.5	+	7.73
Diketene	Ketene dimer	674-82-8	C ₄ H ₄ O ₂	2.6	+	2.0	+	1.4	+	9.6
Dimethylacetamide, N,N-	DMA	127-19-5	C ₄ H ₉ NO	0.87	+	0.8	+	0.8	+	8.81
Dimethylamine		124-40-3	C ₂ H ₇ N			1.5			8.23	5
Dimethyl carbonate	Carbonic acid dimethyl ester	616-38-6	C ₃ H ₆ O ₃	NR	+	~70	+	1.7	+	~10.5
Dimethyl disulfide	DMDS	624-92-0	C ₂ H ₆ S ₂	0.2	+	0.20	+	0.21	+	7.4
Dimethyl ether	see Methyl ether									
Dimethylethylamine	DMEA	598-56-1	C ₄ H ₁₁ N	1.1	+	1.0	+	0.9	+	7.74
Dimethylformamide, N,N-	DMF	68-12-2	C ₃ H ₇ NO	0.7	+	0.7	+	0.8	+	9.13
Dimethylhydrazine, 1,1-	UDMH	57-14-7	C ₂ H ₈ N ₂			0.8	+	0.8	+	7.28
Dimethyl methylphosphonate	DMMP, methyl phosphonic acid dimethyl ester	756-79-6	C ₃ H ₉ O ₃ P	NR	+	4.3	+	0.74	+	10.0
Dimethyl sulfate		77-78-1	C ₂ H ₆ O ₄ S	~23		~20	+	2.3	+	0.1
Dimethyl sulfide	see Methyl sulfide									
Dimethyl sulfoxide	DMSO, Methyl sulfoxide	67-68-5	C ₂ H ₆ OS			1.4	+		9.10	ne
Dioxane, 1,4-		123-91-1	C ₄ H ₈ O ₂			1.3			9.19	25
Dioxolane, 1,3-	Ethylene glycol formal	646-06-0	C ₃ H ₆ O ₂	4.0	+	2.3	+	1.6	+	9.9
Dowtherm A see Therminol® *										
Dowtherm J (97% Diethylbenzene) *		25340-17-4	C ₁₀ H ₁₄			0.5				
DS-108F Wipe Solvent	Ethyl lactate/Isopar H/Propoxypropanol ~7:2:1	97-64-3 64742-48-9 1569-01-3	m.w. 118	3.3	+	1.6	+	0.7	+	ne
Epichlorohydrin	ECH Chloromethyloxirane, 1-chloro2,3-epoxypropane	106-89-8	C ₂ H ₅ ClO	~200	+	8.5	+	1.4	+	10.2
Ethane		74-84-0	C ₂ H ₆			NR	+	15	+	11.52
Ethanol	Ethyl alcohol	64-17-5	C ₂ H ₆ O			10	+	3.1	+	10.47
Ethanolamine *	MEA, Monoethanolamine	141-43-5	C ₂ H ₇ NO	5.6	+	1.6	+		8.96	3
Ethene	Ethylene	74-85-1	C ₂ H ₄			9	+	4.5	+	10.51
Ethoxyethanol, 2-	Ethyl cellosolve	110-80-5	C ₄ H ₁₀ O ₂			1.3			9.6	5
Ethyl acetate		141-78-6	C ₄ H ₈ O ₂			4.6	+	3.5	10.01	400
Ethyl acetoacetate		141-97-9	C ₆ H ₁₀ O ₃	1.4	+	1.2	+	1.0	<10	ne
Ethyl acrylate		140-88-5	C ₅ H ₈ O ₂			2.4	+	1.0	<10.3	5
Ethylamine		75-04-7	C ₂ H ₇ N			0.8			8.86	5



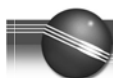
Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C IE (Ev)	TWA
Ethylbenzene		100-41-4	C ₈ H ₁₀	0.52	+	0.52	+	0.51	+	8.77 100
Ethyl caprylate	Ethyl octanoate	106-32-1	C ₁₀ H ₂₀ O ₂		+	0.52	+	0.51	+	
Ethylenediamine	1,2-Ethanediamine; 1,2-Diaminoethane	107-15-3	C ₂ H ₈ N ₂	0.9	+	0.8	+	1.0	+	8.6 10
Ethylene glycol *	1,2-Ethandiol	107-21-1	C ₂ H ₆ O ₂			16	+	6	+	10.16 C100
Ethylene glycol, Acrylate	2-hydroxyethyl Acrylate	818-61-1	C ₅ H ₈ O ₃			8.2				≤10.6
Ethylene glycol dimethyl ether	1,2-Dimethoxyethane, Monoglyme	110-71-4	C ₄ H ₁₀ O ₂	1.1		0.86		0.7		9.2 ne
Ethylene glycol monobutyl ether acetate	2-Butoxyethyl acetate	112-07-2	C ₈ H ₁₆ O ₃			1.3				≤10.6
Ethylene glycol, monothio	mercapto-2-ethanol	60-24-2	C ₂ H ₆ OS			1.5				9.65
Ethylene oxide	Oxirane, Epoxyethane	75-21-8	C ₂ H ₄ O			13	+	3.5	+	10.57 1
Ethyl ether	Diethyl ether	60-29-7	C ₄ H ₁₀ O			1.1	+	1.7		9.51 400
Ethyl 3-ethoxypropionate	EEP	763-69-9	C ₇ H ₁₄ O ₃	1.2	+	0.75	+			ne
Ethyl formate		109-94-4	C ₃ H ₆ O ₂					1.9		10.61 100
Ethylhexyl □acrylate, 2-	Acrylic acid 2-ethylhexyl ester	103-11-7	C ₁₁ H ₂₀ O ₂			1.1	+	0.5	+	ne
Ethylhexanol	2-Ethyl-1-hexanol	104-76-7	C ₈ H ₁₈ O			1.9				≤10.6
Ethylidenenorbornene	5-Ethylidene bicyclo(2,2,1)hept-2-ene	16219-75-3	C ₉ H ₁₂	0.4	+	0.39	+	0.34	+	≤8.8 ne
Ethyl (S)-(-)-lactate see also DS-108F	Ethyl lactate, Ethyl (S)-(-)-hydroxypropionate	687-47-8 97-64-3	C ₅ H ₁₀ O ₃	13	+	3.2	+	1.6	+	~10 ne
Ethyl mercaptan	Ethanethiol	75-08-1	C ₂ H ₆ S	0.60	+	0.56	+			9.29 0.5
Ethyl sulfide	Diethyl sulfide	352-93-2	C ₄ H ₁₀ S			0.5	+			8.43 ne
Formaldehyde	Formalin	50-00-0	CH ₂ O	NR	+	NR	+	1.6	+	10.87 C0.3
Formamide		75-12-7	CH ₃ NO			6.9	+	4		10.16 10
Formic acid		64-18-6	CH ₂ O ₂	NR	+	NR	+	9	+	11.33 5
Furfural	2-Furaldehyde	98-01-1	C ₅ H ₄ O ₂			0.92	+	0.8	+	9.21 2
Furfuryl alcohol		98-00-0	C ₅ H ₆ O ₂			0.80	+			<9.5 10
Gasoline #1		8006-61-9	m.w. 72			0.9	+			300
Gasoline #2, 92 octane		8006-61-9	m.w. 93	1.3	+	1.0	+	0.5	+	300
Glutaraldehyde	1,5-Pentanedial, Glutaric dialdehyde	111-30-8	C ₅ H ₈ O ₂	1.1	+	0.8	+	0.6	+	C0.05
Glycidyl methacrylate	2,3-Epoxypropyl methacrylate	106-91-2	C ₇ H ₁₀ O ₃	2.6	+	1.2	+	0.9	+	0.5
Halothane	2-Bromo-2-chloro-1,1,1-trifluoroethane	151-67-7	C ₂ HBrClF ₃					0.6		11.0 50
HCFC-22 see Chlorodifluoromethane HCFC-123 see 2,2-Dichloro-1,1,1-trifluoroethane HCFC-141B see 1,1-Dichloro-1-fluoroethane HCFC-142B see 1-Chloro-1,1-difluoroethane HCFC-134A see 1,1,1,2-Tetrafluoroethane HCFC-225 see Dichloropentafluoropropane										
Heptane, n-		142-82-5	C ₇ H ₁₆	45	+	2.8	+	0.60	+	9.92 400
Heptanol, 4-	Dipropylcarbinol	589-55-9	C ₇ H ₁₆ O	1.8	+	1.3	+	0.5	+	9.61 ne
Hexamethyldisilazane, 1,1,1,3,3,3- *	HMDS	999-97-3	C ₆ H ₁₉ NSi ₂			0.2	+	0.2	+	~8.6 ne
Hexamethyldisiloxane	HMDSx	107-46-0	C ₆ H ₁₈ OSi ₂	0.33	+	0.27	+	0.25	+	9.64 ne
Hexane, n-		110-54-3	C ₆ H ₁₄	350	+	4.3	+	0.54	+	10.13 50
Hexanol, 1-	Hexyl alcohol	111-27-3	C ₆ H ₁₄ O	9	+	2.5	+	0.55	+	9.89 ne
Hexene, 1-		592-41-6	C ₆ H ₁₂			0.8				9.44 30
HFE-7100	see Methyl nonafluorobutyl ether									
Histoclear (Histo-Clear)	Limonene/corn oil reagent		m.w. ~136	0.5	+	0.4	+	0.3	+	ne
Hydrazine *		302-01-2	H ₄ N ₂	>8	+	2.6	+	2.1	+	8.1 0.01
Hydrazoic acid	Hydrogen azide		HN ₃							10.7
Hydrogen	Synthesis gas	1333-74-0	H ₂	NR	+	NR	+	NR	+	15.43 ne
Hydrogen cyanide	Hydrocyanic acid	74-90-8	HCN	NR	+	NR	+	NR	+	13.6 C4.7
Hydrogen iodide *	Hydriodic acid	10034-85-2	HI			~0.6*				10.39
Hydrogen peroxide		7722-84-1	H ₂ O ₂	NR	+	NR	+	NR	+	10.54 1
Hydrogen sulfide		7783-06-4	H ₂ S	NR	+	3.3	+	1.5	+	10.45 10
Hydroxypropyl methacrylate		27813-02-1	C ₇ H ₁₂ O ₃	9.9	+	2.3	+	1.1	+	ne
		923-26-2								
Iodine *		7553-56-2	I ₂	0.1	+	0.1	+	0.1	+	9.40 C0.1



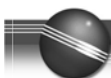
Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Iodomethane	Methyl iodide	74-88-4	CH ₃ I	0.21	+	0.22	+	0.26	+	9.54	2
Isoamyl acetate	Isopentyl acetate	123-92-2	C ₇ H ₁₄ O ₂	10.1		2.1		1.0		<10	100
Isobutane	2-Methylpropane	75-28-5	C ₄ H ₁₀			100	+	1.2	+	10.57	ne
Isobutanol	2-Methyl-1-propanol	78-83-1	C ₄ H ₁₀ O	19	+	3.8	+	1.5		10.02	50
Isobutene	Isobutylene, Methyl butene	115-11-7	C ₄ H ₈	1.00	+	1.00	+	1.00	+	9.24	Ne
Isobutyl acrylate	Isobutyl 2-propenoate	106-63-8	C ₇ H ₁₂ O ₂			1.5	+	0.60	+		Ne
Isoflurane	1-Chloro-2,2,2-trifluoroethyl difluoromethyl ether, forane	26675-46-7	C ₃ H ₂ ClF ₅ O	NR	+	NR	+	48	+	~11.7	Ne
Isooctane	2,2,4-Trimethylpentane	540-84-1	C ₈ H ₁₈			1.2				9.86	ne
Isopar E Solvent	Isoparaffinic hydrocarbons	64741-66-8	m.w. 121	1.7	+	0.8	+				Ne
Isopar G Solvent	Photocopier diluent	64742-48-9	m.w. 148			0.8	+				Ne
Isopar K Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 156	0.9	+	0.5	+	0.27	+		Ne
Isopar L Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 163	0.9	+	0.5	+	0.28	+		Ne
Isopar M Solvent	Isoparaffinic hydrocarbons	64742-47-8	m.w. 191			0.7	+	0.4	+		Ne
Isopentane	2-Methylbutane	78-78-4	C ₅ H ₁₂			8.2					Ne
Isophorone		78-59-1	C ₉ H ₁₄ O					3		9.07	C5
Isoprene	2-Methyl-1,3-butadiene	78-79-5	C ₅ H ₈	0.69	+	0.63	+	0.60	+	8.85	Ne
Isopropanol	Isopropyl alcohol, 2-propanol, IPA	67-63-0	C ₃ H ₈ O	500	+	6.0	+	2.7		10.12	200
Isopropyl acetate		108-21-4	C ₅ H ₁₀ O ₂			2.6				9.99	100
Isopropyl ether	Diisopropyl ether	108-20-3	C ₆ H ₁₄ O			0.8				9.20	250
Jet fuel JP-4	Jet B, Turbo B, F-40	8008-20-6 +	m.w. 115			1.0	+	0.4	+		Ne
	Wide cut type aviation fuel	64741-42-0									
Jet fuel JP-5	Jet 5, F-44, Kerosene type aviation fuel	8008-20-6 +	m.w. 167			0.6	+	0.5	+		29
		64747-77-1									
Jet fuel JP-8	Jet A-1, F-34, Kerosene type aviation fuel	8008-20-6 +	m.w. 165			0.6	+	0.3	+		30
		64741-77-1									
Jet fuel A-1 (JP-8)	F-34, Kerosene type aviation fuel	8008-20-6 +	m.w. 145			0.67					34
		64741-77-1									
Jet Fuel TS	Thermally Stable Jet Fuel, Hydrotreated kerosene fuel	8008-20-6 +	m.w. 165	0.9	+	0.6	+	0.3	+		30
		64742-47-8									
Limonene, D-	(R)-(+)-Limonene	5989-27-5	C ₁₀ H ₁₆			0.33	+			~8.2	Ne
Kerosene C10-C16 petro.distillate – see Jet Fuels		8008-20-6									
MDI – see 4,4'-Methylenebis(phenylisocyanate)											
Maleic anhydride	2,5-Furandione	108-31-6	C ₄ H ₂ O ₃							~10.8	0.1
Mesitylene	1,3,5-Trimethylbenzene	108-67-8	C ₉ H ₁₂	0.36	+	0.35	+	0.3	+	8.41	25
Methallyl chloride – see 3-Chloro-2-methylpropene											
Methane	Natural gas	74-82-8	CH ₄	NR	+	NR	+	NR	+	12.61	Ne
Methanol	Methyl alcohol, carbinol	67-56-1	CH ₄ O	NR	+	NR	+	2.5	+	10.85	200
Methoxyethanol, 2-	Methyl cellosolve, Ethylene glycol monomethyl ether	109-86-4	C ₃ H ₈ O ₂	4.8	+	2.4	+	1.4	+	10.1	5
Methoxyethoxyethanol, 2-	2-(2-Methoxyethoxy)ethanol	111-77-3	C ₇ H ₁₆ O	2.3	+	1.2	+	0.9	+	<10	Ne
	Diethylene glycol monomethyl ether										
Methoxyethyl ether, 2-	bis(2-Methoxyethyl) ether, Diethylene glycol dimethyl ether, Diglyme	111-96-6	C ₆ H ₁₄ O ₃	0.64	+	0.54	+	0.44	+	<9.8	Ne
Methyl acetate		79-20-9	C ₃ H ₆ O ₂	NR	+	6.6	+	1.4	+	10.27	200
Methyl acrylate	Methyl 2-propenoate, Acrylic acid methyl ester	96-33-3	C ₄ H ₆ O ₂			3.7	+	1.2	+	(9.9)	2
Methylamine	Aminomethane	74-89-5	CH ₅ N			1.2				8.97	5
Methyl amyl ketone	MAK, 2-Heptanone, Methyl pentyl ketone	110-43-0	C ₇ H ₁₄ O	0.9	+	0.85	+	0.5	+	9.30	50
Methyl bromide	Bromomethane	74-83-9	CH ₃ Br	110	+	1.7	+	1.3	+	10.54	1
Methyl t-butyl ether	MTBE, <i>tert</i> -Butyl methyl ether	1634-04-4	C ₅ H ₁₂ O			0.9	+			9.24	40
Methyl cellosolve	see 2-Methoxyethanol										
Methyl chloride	Chloromethane	74-87-3	CH ₃ Cl	NR	+	NR	+	0.74	+	11.22	50
Methylcyclohexane		107-87-2	C ₇ H ₁₄	1.6	+	0.97	+	0.53	+	9.64	400
Methylene bis(phenylisocyanate), 4,4'- *	MDI, Mondur M		C ₁₅ H ₁₀ N ₂ O ₂							Very slow ppb level response	0.005



Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Methylene chloride	Dichloromethane	75-09-2	CH ₂ Cl ₂	NR	+	NR	+	0.89	+	11.32	25
Methyl ether	Dimethyl ether	115-10-6	C ₂ H ₆ O	4.8	+	3.1	+	2.5	+	10.03	Ne
Methyl ethyl ketone	MEK, 2-Butanone	78-93-3	C ₄ H ₈ O	0.86	+	0.9	+	1.1	+	9.51	200
Methylhydrazine	Monomethylhydrazine, Hydrazomethane	60-34-4	C ₂ H ₆ N ₂	1.4	+	1.2	+	1.3	+	7.7	0.01
Methyl isoamyl ketone	MIAC, 5-Methyl-2-hexanone	110-12-3	C ₇ H ₁₄ O	0.8	+	0.76	+	0.5	+	9.28	50
Methyl isobutyl ketone	MIBK, 4-Methyl-2-pentanone	108-10-1	C ₆ H ₁₂ O	0.9	+	0.8	+	0.6	+	9.30	50
Methyl isocyanate	CH ₃ NCO	624-83-9	C ₂ H ₃ NO	NR	+	4.6	+	1.5		10.67	0.02
Methyl isothiocyanate	CH ₃ NCS	551-61-6	C ₂ H ₃ NS	0.5	+	0.45	+	0.4	+	9.25	ne
Methyl mercaptan	Methanethiol	74-93-1	CH ₄ S	0.65		0.54		0.66		9.44	0.5
Methyl methacrylate		80-62-6	C ₅ H ₈ O ₂	2.7	+	1.5	+	1.2	+	9.7	100
Methyl nonafluorobutyl ether	HFE-7100DL	163702-08-7, 163702-07-6	C ₅ H ₃ F ₉ O			NR	+	~35	+		ne
Methyl-1,5-pentanediamine, 2-(coats lamp) *	Dytek-A amine, 2-Methyl pentamethylenediamine	15520-10-2	C ₆ H ₁₆ N ₂			~0.6	+			<9.0	ne
Methyl propyl ketone	MPK, 2-Pentanone	107-87-9	C ₅ H ₁₂ O			0.93	+	0.79	+	9.38	200
Methyl-2-pyrrolidinone, N-	NMP, N-Methylpyrrolidone, 1-Methyl-2-pyrrolidinone, 1-Methyl-2-pyrrolidone	872-50-4	C ₅ H ₉ NO	1.0	+	0.8	+	0.9	+	9.17	ne
Methyl salicylate	Methyl 2-hydroxybenzoate	119-36-8	C ₈ H ₈ O ₃	1.3	+	0.9	+	0.9	+	~9	ne
Methylstyrene, α-	2-Propenylbenzene	98-83-9	C ₉ H ₁₀			0.5				8.18	50
Methyl sulfide	DMS, Dimethyl sulfide	75-18-3	C ₂ H ₆ S	0.49	+	0.44	+	0.46	+	8.69	ne
Mineral spirits	Stoddard Solvent, Varsol 1, White Spirits	8020-83-5, 8052-41-3, 68551-17-7	m.w. 144	1.0		0.69	+	0.38	+		100
Mineral Spirits - Viscor 120B Calibration Fluid, b.p. 156-207°C		8052-41-3	m.w. 142	1.0	+	0.7	+	0.3	+		100
Monoethanolamine - see Ethanolamine											
Mustard *	HD, Bis(2-chloroethyl) sulfide	505-60-2, 39472-40-7, 68157-62-0	C ₄ H ₈ Cl ₂ S			0.6					0.0005
Naphtha - see VM & P Naptha											
Naphthalene	Mothballs	91-20-3	C ₁₀ H ₈	0.45	+	0.42	+	0.40	+	8.13	10
Nickel carbonyl (in CO)	Nickel tetracarbonyl	13463-39-3	C ₄ NiO ₄			0.18				<8.8	0.001
Nicotine		54-11-5	C ₁₀ H ₁₄ N ₂			2.0				≤10.6	
Nitric oxide		10102-43-9	NO	~6		5.2	+	2.8	+	9.26	25
Nitrobenzene		98-95-3	C ₆ H ₅ NO ₂	2.6	+	1.9	+	1.6	+	9.81	1
Nitroethane		79-24-3	C ₂ H ₅ NO ₂					3		10.88	100
Nitrogen dioxide		10102-44-0	NO ₂	23	+	16	+	6	+	9.75	3
Nitrogen trifluoride		7783-54-2	NF ₃	NR		NR		NR		13.0	10
Nitromethane		75-52-5	CH ₃ NO ₂					4		11.02	20
Nitropropane, 2-		79-46-9	C ₃ H ₇ NO ₂					2.6		10.71	10
Nonane		111-84-2	C ₉ H ₂₀			1.4				9.72	200
Norpar 12	n-Paraffins, mostly C ₁₀ -C ₁₃	64771-72-8	m.w. 161	3.2	+	1.1	+	0.28	+		ne
Norpar 13	n-Paraffins, mostly C ₁₃ -C ₁₄	64771-72-8	m.w. 189	2.7	+	1.0	+	0.3	+		ne
Octamethylcyclotetrasiloxane		556-67-2	C ₈ H ₂₄ O ₄ Si ₄	0.21	+	0.17	+	0.14	+		ne
Octamethyltrisiloxane		107-51-7	C ₈ H ₂₄ O ₂ Si ₃	0.23	+	0.18	+	0.17	+	<10.0	ne
Octane, n-		111-65-9	C ₈ H ₁₈	13	+	1.8	+			9.82	300
Octene, 1-		111-66-0	C ₈ H ₁₆	0.9	+	0.75	+	0.4	+	9.43	75
Pentane		109-66-0	C ₅ H ₁₂	80	+	8.4	+	0.7	+	10.35	600
Peracetic acid *	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	C ₂ H ₄ O ₃	NR	+	NR	+	2.3	+		ne
Peracetic/Acetic acid mix *	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	C ₂ H ₄ O ₃			50	+	2.5	+		ne
Perchloroethene	PCE, Perchloroethylene, Tetrachloroethylene	127-18-4	C ₂ Cl ₄	0.69	+	0.57	+	0.31	+	9.32	25
PGME	Propylene glycol methyl ether, 1-Methoxy-2-propanol	107-98-2	C ₆ H ₁₂ O ₃	2.4	+	1.5	+	1.1	+		100



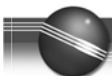
Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
PGMEA	Propylene glycol methyl ether acetate, 1-Methoxy-2-acetoxypropane, 1-Methoxy-2-propanol acetate	108-65-6	C ₆ H ₁₂ O ₃	1.65	+	1.0	+	0.8	+		ne
Phenol	Hydroxybenzene	108-95-2	C ₆ H ₆ O	1.0	+	1.0	+	0.9	+	8.51	5
Phosgene	Dichlorocarbonyl	75-44-5	CCl ₂ O	NR	+	NR	+	8.5	+	11.2	0.1
Phosgene in Nitrogen	Dichlorocarbonyl	75-44-5	CCl ₂ O	NR	+	NR	+	6.8	+	11.2	0.1
Phosphine (coats lamp)		7803-51-2	PH ₃	28		3.9	+	1.1	+	9.87	0.3
Photocopier Toner	Isoparaffin mix					0.5	+	0.3	+		ne
Picoline, 3-	3-Methylpyridine	108-99-6	C ₆ H ₇ N			0.9				9.04	ne
Pinene, α-		2437-95-8	C ₁₀ H ₁₆			0.31	+	0.47		8.07	ne
Pinene, β-		18172-67-3	C ₁₀ H ₁₆	0.38	+	0.37	+	0.37	+	~8	100
Piperylene, isomer mix	1,3-Pentadiene	504-60-9	C ₅ H ₈	0.76	+	0.69	+	0.64	+	8.6	100
Propane		74-98-6	C ₃ H ₈			NR	+	1.8	+	10.95	2500
Propanol, n-	Propyl alcohol	71-23-8	C ₃ H ₈ O			5		1.7		10.22	200
Propene	Propylene	115-07-1	C ₃ H ₆	1.5	+	1.4	+	1.6	+	9.73	ne
Propionaldehyde	Propanal	123-38-6	C ₃ H ₆ O			1.9				9.95	ne
Propyl acetate, n-		109-60-4	C ₅ H ₁₀ O ₂			3.5		2.3		10.04	200
Propylamine, n-	1-Propylamine, 1-Aminopropane	107-10-8	C ₃ H ₉ N	1.1	+	1.1	+	0.9	+	8.78	ne
Propylene carbonate *		108-32-7	C ₄ H ₆ O ₃			62	+	1	+	10.5	ne
Propylene glycol	1,2-Propanediol	57-55-6	C ₃ H ₈ O ₂	18		5.5	+	1.6	+	<10.2	ne
Propylene glycol propyl ether	1-Propoxy-2-propanol	1569-01-3	C ₆ H ₁₄ O ₂	1.3	+	1.0	+	1.6	+		ne
Propylene oxide	Methyloxirane	75-56-9	C ₃ H ₆ O	~240		6.6	+	2.9	+	10.22	20
		16088-62-3									
		15448-47-2									
Propyleneimine	2-Methylaziridine	75-55-8	C ₃ H ₇ N	1.5	+	1.3	+	1.0	+	9.0	2
Propyl mercaptan, 2-	2-Propanethiol, Isopropyl mercaptan	75-33-2	C ₃ H ₈ S	0.64	+	0.66	+			9.15	ne
Pyridine		110-86-1	C ₅ H ₅ N	0.78	+	0.7	+	0.7	+	9.25	5
Pyrrolidine (coats lamp)	Azacyclohexane	123-75-1	C ₄ H ₉ N	2.1	+	1.3	+	1.6	+	~8.0	ne
RR7300 (PGME/PGMEA)	70:30 PGME:PGMEA (1-Methoxy-2-propanol:1-Methoxy-2-acetoxypropane)	107-98-2	C ₄ H ₁₀ O ₂ / C ₆ H ₁₂ O ₃			1.4	+	1.0	+		ne
Sarin	GB, Isopropyl methylphosphonofluoridate	107-44-8	C ₄ H ₁₀ FO ₂ P			~3					
		50642-23-4									
Stoddard Solvent - see Mineral Spirits		8020-83-5									
Styrene		100-42-5	C ₈ H ₈	0.45	+	0.40	+	0.4	+	8.43	20
Sulfur dioxide		7446-09-5	SO ₂	NR		NR	+	NR	+	12.32	2
Sulfur hexafluoride		2551-62-4	SF ₆	NR		NR		NR		15.3	1000
Sulfuryl fluoride	Vikane	2699-79-8	SO ₂ F ₂	NR		NR		NR		13.0	5
Tabun *	Ethyl N, N-dimethylphosphoramidocyanidate	77-81-6	C ₅ H ₁₁ N ₂ O ₂ P			0.8					15ppt
Tetrachloroethane, 1,1,1,2-		630-20-6	C ₂ H ₂ Cl ₄					1.3		~11.1	ne
Tetrachloroethane, 1,1,1,2-		79-34-5	C ₂ H ₂ Cl ₄	NR	+	NR	+	0.60	+	~11.1	1
Tetrachlorosilane		10023-04-7	SiCl ₄	NR		NR		15	+	11.79	ne
Tetraethyl lead	TEL	78-00-2	C ₈ H ₂₀ Pb	0.4		0.3		0.2		~11.1	0.008
Tetraethyl orthosilicate	Ethyl silicate, TEOS	78-10-4	C ₈ H ₂₀ O ₄ Si			0.7	+	0.2	+	~9.8	10
Tetrafluoroethane, 1,1,1,2-	HFC-134A	811-97-2	C ₂ H ₂ F ₄			NR		NR			ne
Tetrafluoroethene	TFE, Tetrafluoroethylene, Perfluoroethylene	116-14-3	C ₂ F ₄			~15				10.12	ne
Tetrafluoromethane	CFC-14, Carbon tetrafluoride	75-73-0	CF ₄			NR	+	NR	+	>15.3	ne
Tetrahydrofuran	THF	109-99-9	C ₄ H ₈ O	1.9	+	1.7	+	1.0	+	9.41	200
Tetramethyl orthosilicate	Methyl silicate, TMOS	681-84-5	C ₄ H ₁₂ O ₄ Si	10	+	1.9	+			~10	1
Therminol® D-12 *	Hydrotreated heavy naphtha	64742-48-9	m.w. 160	0.8	+	0.51	+	0.33	+		ne
Therminol® VP-1 *	Dowtherm A, 3:1 Diphenyl oxide: Biphenyl	101-84-8	C ₁₂ H ₁₀ O			0.4	+				1
		92-52-4	C ₁₂ H ₁₀								
Toluene	Methylbenzene	108-88-3	C ₇ H ₈	0.54	+	0.50	+	0.51	+	8.82	50



Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C IE (eV)	TWA	
Tolylene-2,4-diisocyanate	TDI, 4-Methyl-1,3-phenylene-2,4-diisocyanate	584-84-9	C ₉ H ₆ N ₂ O ₂	1.4	+	1.4	+	2.0	+	0.002	
Trichlorobenzene, 1,2,4-	1,2,4-TCB	120-82-1	C ₆ H ₃ Cl ₃	0.7	+	0.46	+		9.04	C5	
Trichloroethane, 1,1,1-	1,1,1-TCA, Methyl chloroform	71-55-6	C ₂ H ₃ Cl ₃			NR	+	1	+	11	350
Trichloroethane, 1,1,2-	1,1,2-TCA	79-00-5	C ₂ H ₃ Cl ₃	NR	+	NR	+	0.9	+	11.0	10
Trichloroethene	TCE, Trichoroethylene	79-01-6	C ₂ HCl ₃	0.62	+	0.54	+	0.43	+	9.47	50
Trichloromethylsilane	Methyltrichlorosilane	75-79-6	CH ₃ Cl ₃ Si	NR		NR		1.8	+	11.36	ne
Trichlorotrifluoroethane, 1,1,2-	CFC-113	76-13-1	C ₂ Cl ₃ F ₃			NR		NR		11.99	1000
Triethylamine	TEA	121-44-8	C ₆ H ₁₅ N	0.95	+	0.9	+	0.65	+	7.3	1
Triethyl borate	TEB; Boric acid triethyl ester	150-46-9	C ₆ H ₁₅ O ₃ B			2.2	+	1.1	+	~10	ne
Triethyl phosphate	Ethyl phosphate	78-40-0	C ₆ H ₁₅ O ₄ P	~50	+	3.1	+	0.60	+	9.79	ne
Trifluoroethane, 1,1,2-		430-66-0	C ₂ H ₃ F ₃					34		12.9	ne
Trimethylamine		75-50-3	C ₃ H ₉ N			0.9				7.82	5
Trimethylbenzene, 1,3,5- - see Mesitylene		108-67-8									25
Trimethyl borate	TMB; Boric acid trimethyl ester, Boron methoxide	121-43-7	C ₃ H ₉ O ₃ B			5.1	+	1.2	+	10.1	ne
Trimethyl phosphate	Methyl phosphate	512-56-1	C ₃ H ₉ O ₄ P			8.0	+	1.3	+	9.99	ne
Trimethyl phosphite	Methyl phosphite	121-45-9	C ₃ H ₉ O ₃ P			1.1	+		+	8.5	2
Turpentine	Pinenes (85%) + other diisoprenes	8006-64-2	C ₁₀ H ₁₆	0.37	+	0.30	+	0.29	+	~8	20
Undecane		1120-21-4	C ₁₁ H ₂₄			2				9.56	ne
Varsol – see Mineral Spirits											
Vinyl acetate		108-05-4	C ₄ H ₆ O ₂	1.5	+	1.2	+	1.0	+	9.19	10
Vinyl bromide	Bromoethylene	593-60-2	C ₂ H ₃ Br			0.4				9.80	5
Vinyl chloride	Chloroethylene, VCM	75-01-4	C ₂ H ₃ Cl			2.0	+	0.6	+	9.99	5
Vinyl-1-cyclohexene, 4-	Butadiene dimer, 4-Ethenylcyclohexene	100-40-3	C ₈ H ₁₂	0.6	+	0.56	+			9.83	0.1
Vinylidene chloride - see 1,1-Dichloroethene											
Vinyl-2-pyrrolidinone, 1-	NVP, N-vinylpyrrolidone, 1-ethenyl-2-pyrrolidinone	88-12-0	C ₆ H ₉ NO	1.0	+	0.8	+	0.9	+		ne
Viscor 120B - see Mineral Spirits											
V. M. & P. Naphtha	Ligroin; Solvent naphtha; Varnish maker's & painter's naptha	64742-89-8	m.w. 111 (C ₈ -C ₉)	1.7	+	0.97	+				300
Xylene, m-	1,3-Dimethylbenzene	108-38-3	C ₈ H ₁₀	0.50	+	0.44	+	0.40	+	8.56	100
Xylene, o-	1,2-Dimethylbenzene	95-47-6	C ₈ H ₁₀	0.56	+	0.46	+	0.43		8.56	100
Xylene, p-	1,4-Dimethylbenzene	106-42-3	C ₈ H ₁₀	0.48	+	0.39	+	0.38	+	8.44	100
None				1		1		1			
Undetectable				1E+6		1E+6		1E+6			

* Compounds indicated in green can be detected using a MiniRAE 2000 or ppbRAE/+ with slow response, but may be lost by adsorption on a MultiRAE or EntryRAE. Response on multi-gas meters can give an indication of relative concentrations, but may not be quantitative and for some chemicals no response is observed.

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**Appendix I:****Example of Automatic Calculation of Correction Factors, TLVs and Alarm Limits for Mixtures**

(Calculations performed using Excel version of this database, available on request)

Compound	CF 9.8 eV	CF 10.6 eV	CF 11.7eV	Mol. Frac	Conc ppm	TLV ppm	STEL Ppm
Benzene	0.55	0.53	0.6	0.01	1	0.5	2.5
Toluene	0.54	0.5	0.51	0.06	10	50	150
Hexane, n-	300	4.3	0.54	0.06	10	50	150
Heptane, n-	45	2.8	0.6	0.28	50	400	500
Styrene	0.45	0.4	0.42	0.06	10	20	40
Acetone	1.2	1.1	1.4	0.28	50	750	1000
Isopropanol	500	6	2.7	0.28	50	400	500
None	1	1	1	0.00	0	1	
Mixture Value:	2.1	1.5	0.89	1.00	181	56	172
TLV Alarm Setpoint when Calibrated to Isobutylene:	26 ppm	37 ppm	62 ppm		ppm	ppm	ppm
STEL Alarm Setpoint, same Calibration	86 ppm	115 ppm	193 ppm				

APPENDIX IB-4
Equipment Leak Repair Log

Triumvirate - Casa Grande, Arizona
Subpart BB Air Emission Standards for Equipment Leaks
Inspection and Monitoring Plan

Equipment Leak Repair Log

[illegible]

APPENDIX IB-5
PID Calibration Log

Triumvirate - Casa Grande, Arizona
Subpart BB Air Emission Standards for Equipment Leaks
Inspection and Monitoring Plan

PID Calibration Log

[illegible]

APPENDIX IB-6
Annual Review Form

Triumvirate - Casa Grande, Arizona
Subpart BB Air Emission Standards for Equipment Leaks
Inspection and Monitoring Plan

Annual Review Form

Review Item	Compliant (Y/N)	Comments
Accuracy of Equipment List		
Tracking program for new equipment subject to Subpart BB		
Equipment Use Log		
Leak Monitoring		
Instrument Calibration Logs		
First attempt at repair records		
Delay in repair records		
Quarterly monitoring review		
QA/QC program implementation		
Qualifications of personnel implementing LDAR program		

Repair Program Evaluation	Number	Frequency
Number of equipment pieces identified		
Number of leaks detected		
Number of first attempts at repair beyond 5 days		
Number of delayed repairs		
Number of repairs beyond 30 days		
Unrepaired equipment with recurring leaks		

Date of Annual Review: _____

Name of Facility Manager or Designee: _____

Signature: _____

APPENDIX I-C

Subpart CC Air Emission Standards Tanks and Containers Inspection Monitoring Plan

Subpart CC Air Emission Standards for Tanks and Containers
Inspection and Monitoring Plan

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Subpart CC Air Emission Standards for Tanks and Containers Inspection and Monitoring Plan

1. Introduction

This document specifies the procedures Triumvirate Environmental (Arizona), Inc. (“Facility”) will integrate with overall facility operations to maintain compliance with the Air Emission Standards for Tanks, Surface Impoundments, and Containers in Subpart CC of (40 CFR Part 264 (Subpart CC). This inspection and monitoring plan summarizes the requirements for inspection and monitoring, equipment repairs, recordkeeping, and reporting under Subpart CC.

Subpart CC requires routine inspection and monitoring of tanks and containers. 40 CFR 264.1088(b) of Subpart CC requires that an owner/operator develop and implement a written plan and schedule to perform the inspection and monitoring requirements of Subpart CC. This document outlines the procedures The Facility will implement to comply with these inspection and monitoring requirements. These procedures are included as part of the Facility's inspection plan required under 40 CFR 264.15.

2. General Applicability

Only the tanks and containers that are specifically subject to Subpart CC are subject to the procedures outlined in this inspection and monitoring plan. The Facility does not own or operate surface impoundments. Therefore, surface impoundments are not discussed in this document.

This inspection and monitoring plan document addresses tanks and containers managed by Triumvirate that are subject to the Subpart CC air emission standards. Subpart CC standards are applicable to containers in which hazardous wastes are managed with the following exceptions:

- Tanks and containers in which only hazardous waste with an average volatile organic concentration of less than 500 ppmw is managed;
- Tanks and Containers in which only hazardous waste that meets applicable organic hazardous constituent treatment standards under the land disposal restrictions is managed; and
- Containers with a design capacity of less than or equal to 0.1 m³ (approximately 26 gallons).

2.1 DEFINITIONS

[40 CFR 264.1081]

2.1.1 Average Volatile Organic Concentration or average VOC concentration

The mass- weighted average volatile organic concentration of a hazardous waste as determined in accordance with the requirements of 40 CFR 264.1083 of Subpart CC (Waste Determination Procedures).

2.1.2 Closure Device

A cap, hatch, lid, plug, seal, valve, or other type of fitting that blocks an opening in a cover such that when the device is secured in the closed position it prevents or reduces air pollutant emissions to the atmosphere. Closure devices include devices that are detachable from the cover (e.g., a sampling port cap), manually operated (e.g., a hinged access lid or hatch), or automatically operated (e.g., a spring-loaded pressure relief valve).

Subpart CC Air Emission Standards for Tanks and Containers Inspection and Monitoring Plan

2.1.3 Container

Any portable device in which a material is stored, transported, disposed of, or otherwise handled.

2.1.4 Cover

A device that provides a continuous barrier over the hazardous waste managed in a unit to prevent or reduce air pollutant emissions to the atmosphere. A cover may have openings (such as access hatches, sampling ports, gauge wells) that are necessary for operation, inspection, maintenance, and repair of the unit on which the cover is used. A cover may be a separate piece of equipment that can be detached and removed from the unit, or a cover may be formed by structural features permanently integrated into the design of the unit. An example of a cover is a lid on a drum.

2.1.5 Fixed roof

A cover that is mounted on a unit in a stationary position and which does not move with fluctuations in the level of the material managed in the unit.

2.1.6 Hard-piping

Pipe or tubing that is manufactured and properly installed in accordance with relevant standards and good engineering practices.

2.1.7 In light material service

The container is used to manage a material for which both of the following conditions apply: The vapor pressure of one or more of the organic constituents in the material is greater than 0.3 kilopascals (kPa) (approximately 4.35×10^{-2} psi) at 20°C; and the total concentration of the pure organic constituents having a vapor pressure greater than 0.3 kPa (approximately 4.35×10^{-2} psi) at 20°C is equal to or greater than 20 percent by weight.

2.1.8 No detectable organic emissions

No escape of organics to the atmosphere as determined using the procedure specified in 40 CFR 264.1083(d) of Subpart CC (i.e., by an instrument reading less than 500 parts per million by volume (ppmv) above the background level when measured in accordance with the requirements of Method 21 (**Appendix IC-1**), and by no visible openings or defects in the device or system such as rips, tears, gaps, etc.

2.1.9 Point of waste origination

When the Facility owner/operator is the generator of the hazardous waste, the point of waste origination means the point where a solid waste produced by a system, process, or waste management unit is determined to be a hazardous waste as defined in 40 CFR Part 261. When the Facility owner/operator is not the generator of the hazardous waste, the point of waste origination means the point where the Facility accepts delivery or takes possession of the hazardous waste.

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2.1.10 Tank

A stationary device, designed to contain an accumulation of hazardous waste which is constructed primarily of non-earthen materials (e.g., wood, concrete, steel, plastic) which provide structural support.

2.1.11 Volatile organic concentration, or VO concentration

The fraction by weight of the volatile organic compounds contained in a hazardous waste expressed in terms of parts per million (ppmw) as determined by direct measurement or by knowledge of the waste in accordance with the requirements of 40 CFR 264.1083 of Subpart CC (Waste Determination Procedures). For the purpose of determining the VO concentration of a hazardous waste, organic compounds with a Henry's law constant value of at least 0.1 mole-fraction-in-the-gas-phase/mole-fraction-in-the-liquid-phase (0.1 Y/X) (which can also be expressed as 1.8×10^{-6} atmospheres/gram-mole/m³) at 25°Celsius must be included. Standard chemical reference books may be used to determine Henry's Law Constants.

3. Containers

40 CFR 264.1086 specifies three levels of air emission controls for containers depending on the size of the container, the types of wastes managed, and how the wastes are managed. These control levels and the Facility's container management procedures are specified in this section.

3.1 CONTAINER LEVEL I STANDARDS

[40 CFR 264.1086(c)]

The Facility will manage the following types of containers in accordance with Container Level I standards:

- 1) Containers with a design capacity greater than 0.1 m³ (approximately 26 gallons) and less than or equal to 0.46 m³ (approximately 119 gallons).

These containers may include, but are not limited to, 30-, 55-, and 80-gallon drums. The majority of containers managed at the Facility fall into this category.

- 2) Containers with a design capacity greater than 0.46 m³ (approximately 119 gallons) that are not "in light material service."

These containers are referred to as "bulk containers" by the United States Department of Transportation (USDOT) and include intermediate bulk containers (tote tanks), tank trucks, railcars, and roll off boxes. Containers of this size for which a determination regarding "in light material service" status has not been made will be managed in accordance with Container Level II standards described in [Section 3.2](#).

Where applicable, the Facility will comply with Container Level I standards using one of the following control methods specified by 40 CFR 264.1086(c)(1):

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- 1) The container will meet applicable USDOT hazardous material packaging regulations (this will be the Facility's primary method of complying with Container Level I standards); or
- 2) The container will be equipped with a cover and closure devices that form a continuous barrier over the container openings such that when the cover and closure devices are secured in the closed position there are no visible holes, gaps, or other open spaces (e.g., a lid on a drum, a suitably secured tarp on a roll-off box, or a bulk cargo container equipped with a screw-type cap).

3.2 CONTAINER LEVEL II STANDARDS

[40 CFR 264.1086(d)]

The Facility will manage the following types of containers in accordance with Container Level II standards:

- 1) Containers with a design capacity greater than 0.46 m³ (approximately 119 gallons) that are "in light material service."

These containers are referred to as "bulk containers" by the USDOT and include intermediate bulk containers (tote tanks), tank trucks, railcars, and roll off boxes.

- 2) Containers with a design capacity greater than 0.46 m³ (approximately 119 gallons) for which a determination has not been made regarding their status as "in light material service."

Where applicable, the Facility will comply with Container Level II standards using one of the following control methods specified by 40 CFR 264.1086(d)(1):

- 1) Containers subject to Container Level II standards at the Facility will meet applicable USDOT hazardous material packaging regulations, as allowed by 40 CFR 264.1087(d)(1)(i). This will be the Facility's primary method of complying with Container Level II standards.
- 2) Alternatively, The Facility may choose to use a non-DOT specification packaging and perform organic vapor monitoring in accordance with Method 21 of 40 CFR Part 60, Appendix A, or use a container that has been demonstrated within the preceding 12 months to be vapor-tight by using Method 27 of 40 CFR Part 60, Appendix A. This method of compliance with Container Level II standards will only be used in limited cases and only when the container is not to be shipped off-site.

3.3 CONTAINER LEVEL III STANDARDS

[40 CFR 264.1086(e)]

Currently, the Facility has no plans to conduct waste stabilization in containers. Waste stabilization will be conducted in two, 80-cubic yard tanks which are addressed in [Section 4](#).

3.4 CONTAINER MANAGEMENT PROCEDURES

Whenever hazardous waste subject to Subpart CC is in a container, all covers and closure devices for that container will be installed, secured, and maintained in the closed position except in the following

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situations:

- 1) A container that is RCRA-empty (40 CFR 261.7(b)) is not subject to Subpart CC and may be open at any time.
- 2) A closure device or cover may be opened to add waste or other material to the container. If the container is filled in one continuous operation, the closure devices must be secured in the closed position and the cover installed promptly upon conclusion of the filling operation. If the container is filled in discrete quantities or batches, the closure devices must be promptly secured in the closed position and the covers installed upon either the:
 - a. container being filled to its final fill level; the completion of a batch loading after which no additional material will be added within 15 minutes;
 - b. person performing the loading operation leaving the immediate vicinity of the container; or
 - c. shutdown of the process generating the material added to the container, whichever occurs first.
- 3) A closure device or cover may be opened to remove waste from the container. If the waste is removed in discrete quantities or batches, but the container is not RCRA-empty, the closure devices must be secured in the closed position and cover installed promptly upon completion of a batch removal after which no additional material will be removed within 15 minutes, or the person performing the unloading leaves the immediate vicinity of the container, whichever comes first.
- 4) A closure device or cover may be opened when access inside a container is needed to perform routine activities other than transfer of waste. Following completion of the activity, the closure device must be promptly secured in the closed position and the cover reinstalled.
- 5) Opening of a spring-loaded pressure-vacuum relief valve, conservation vent, or similar type of pressure relief device which vents to atmosphere during normal operations for the purpose of maintaining the container's internal pressure in accordance with the container's design specifications, such as during loading or diurnal temperature fluctuations (see 264.1086(c)(3)(iv) for details). The device must be designed to operate with no detectable organic emissions when closed.
- 6) Opening of a safety device to avoid unsafe conditions.

Transfers of hazardous wastes subject to Subpart CC into or out of containers subject to Container Level II standards will minimize exposure of the waste to the atmosphere, to the extent practical, considering the physical properties of the waste and good engineering and safety practices applicable to the hazards of the material.

Examples of such transfers include:

- 1) A submerged fill pipe or other submerged fill method to load liquids into the container.

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- 2) A vapor balancing system or a vapor recovery system to collect and control the vapors from the container filling operation.
- 3) A fitted opening in the top of a container through which the hazardous waste is filled and subsequently purging the transfer line before removing from the container opening.

3.5 INSPECTION AND MONITORING SCHEDULE

Containers shipped to the Facility will be inspected to determine if they meet USDOT specifications. In the event that a container does not meet DOT packaging requirements, waste stream data will be reviewed to determine if the container is subject to Subpart CC regulations (e.g., the hazardous waste contains over 500 ppm VOC). If subject to Subpart CC, the container will be inspected to determine if it meets Subpart CC Level I or Level II standards, as applicable.

Personnel performing the inspections have training in the implementation of Subpart CC standards, including inspections, recordkeeping, and repair of containers. Subpart CC training is included in the review of the Clean Air Act in the Introduction to RCRA training session and during the training session on Container Management and Storage.

An Inspection/Monitoring Log for containers that are subject to Subpart CC that do not meet DOT packaging requirements is maintained at the facility. The log includes container volume, waste type, and type of control. A sample Inspection/Monitoring Log is provided as [Appendix IC-2](#).

Containers at the Facility that are subject to Subpart CC standards will be inspected and monitored in accordance with the requirements of 40 CFR 264.1088, and the following schedule:

- 1) Containers managed under the Container Level I standards, or under the Container Level II standards meeting applicable USDOT packaging requirements

Perform a visual inspection of these hazardous waste containers, including covers and closure devices. Check for visible cracks, holes, gaps, or other open spaces into the interior of the container when the cover and closure devices are secured in the closed position. Confirm that the applicable control is effective in preventing emissions.

NOTE: ORGANIC VAPOR MONITORING IS NOT REQUIRED FOR CONTAINERS MEETING APPLICABLE USDOT PACKAGING REQUIREMENTS.

Perform these visual inspections in accordance with the following schedule:

- a) Initial visual inspection - At the time the containers are first accepted (i.e., prior to signing the manifest); and for containers generated on-site at the time hazardous waste subject to Subpart CC is added to the container.
- b) Six month follow up visual inspection - only for containers that remain at the facility for six months or longer, but less than one year.

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- 2) Containers managed under the Container Level II standards that do not meet applicable USDOT packaging requirements.

In the event a non-DOT specification packaging with a design capacity greater than 0.46 m³ (approximately 119 gallons) is used to store hazardous waste subject to Subpart CC, either:

- a) Perform organic vapor monitoring in accordance with Method 21, as specified by 40 CFR 264.1083(d) and 264.1086(g), when the container is accepted, or waste is first placed in it; or
- b) Use a container that has been demonstrated within the preceding 12 months to be vapor-tight by using Method 27 of 40 CFR Part 60, [Appendix IC-1](#).

In addition, for Container Level II containers not meeting USDOT packaging requirements perform visual inspections in accordance with the following schedule:

- a) Initial visual inspection - At the time the containers are first accepted (i.e., prior to signing the manifest); and for containers generated on-site at the time hazardous waste subject to Subpart CC is added to the container.
- b) Annual visual inspection (at least once every 12 months) - only for containers that remain at the facility for one year or more.

3.6 INSPECTION AND MONITORING PROCEDURES

3.6.1 Inspection Procedures

The Facility will visually inspect containers subject to Subpart CC and their covers and closure devices as follows:

- 1) View the entire container, its cover, and closure devices (e.g., bungs, valves, caps, etc.) for evidence of any defect that could result in air pollutant emissions.
- 2) Defects include, but are not limited to, visible cracks, holes, gaps, or other open spaces into the interior of the container when the cover and closure devices are secured in the closed position. In addition, visible vapor or liquid leakage may indicate a leak is present.
- 3) Note any visible evidence of any defect and the inspection date on the Inspection/Monitoring Log ([Appendix IC-2](#)).
- 4) Immediately report such observations to the Facility Maintenance Department for repair in accordance with Section 6. Note the dates when repair begins and the date when repair is completed on the Inspection/Monitoring Log.

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3.6.2 Monitoring Procedures

In addition to the inspection procedures specified in Section 5.1, for any non-DOT specification packaging with a design capacity greater than 0.46 m³ (approximately 119 gallons) used to store hazardous waste subject to Subpart CC, the Facility will monitor the container covers and closure devices. Triumvirate will maintain an organic vapor analyzer (OVA) on site. The OVA will be stored in the office of the Environmental Compliance Manager or other suitable location. The OVA will be inspected and calibrated by the Environmental Compliance Manager or designee before each use. An OVA Inspection/Calibration Log will be maintained at the facility as required by Subpart CC. The container covers and closure devices will be monitored as follows:

- 1) Perform monitoring in accordance with the procedures specified in Method 21 ([Appendix C-1](#)) and 40 CFR 264.1083(d). Use an instrument that meets applicable Method 21 criteria and calibrate the instrument before each day of use using the calibration gases specified by 40 CFR 264.1083(d)(5).
- 2) Determine the background level according to the procedures in Method 21.
- 3) Ensure the container cover and closure devices are secured in the closed position prior to monitoring.
- 4) Traverse the instrument probe around the potential leak interface as close to the interface as possible, as required by Method 21. Check each potential leak interface (i.e., a location where organic vapor leakage could occur) on the container, its cover, and associated closure devices, including but not limited to the:
 - a. interface of the cover rim and container wall;
 - b. periphery of any opening on the container or container cover and its associated closure device; and
 - c. sealing seat interface on a spring- loaded pressure-relief valve.
- 5) Perform monitoring when the container is filled with a material having a volatile organic concentration representative of the range of volatile organic concentrations for the hazardous wastes expected to be managed in this type of container.
- 6) If the arithmetic difference between the maximum organic concentration indicated by the instrument and the background level is less than 500 ppmv, then the container is considered to have no detectable organic emissions (i.e., it "passes").
- 7) If the arithmetic difference between the maximum organic concentration indicated by the instrument and the background level is equal to or greater than 500 ppmv, note this condition on the Inspection/Monitoring Log.
- 8) Immediately report such observations to the Facility Maintenance Department for repair in accordance with Section 6. Note the dates when repair begins and the date when repair is completed on the Inspection/Monitoring Log.

Subpart CC Air Emission Standards for Tanks and Containers Inspection and Monitoring Plan

3.7 REPAIRS

When a defect is detected by either a visual inspection, as described in [Section 3.6.1](#), or by leak detection monitoring, as described in [Section 3.6.2](#), the Facility will repair the container in the following manner:

- 1) The first attempt at repairing a container will be no later than 24 hours after the defect is detected.
- 2) Repair the container as soon as possible, but no later than 5 calendar days after detection of the defect.
- 3) If repair of the defect cannot be completed within 5 calendar days, then remove the hazardous waste from the container and do not use the container to manage hazardous waste until the defect is repaired. Note details on the Inspection/Monitoring Log.

3.8 RECORDKEEPING

The Facility will record and maintain the information described in this section in accordance with 40 CFR 264.1089. The Facility will maintain records specified in this section in the operating record filed on site or available electronically for a minimum of 3 years.

As specified by 40 CFR 264.1086(c)(5), for containers with a capacity of 0.46 m³ (approximately 119 gallons) or greater that also do not meet applicable DOT packaging requirements, Triumvirate will maintain a copy of the procedure used to determine that they are not “in light material service” when such a determination is performed. However, in general, Triumvirate will manage all such containers under the requirements for containers “in light material service,” rather than performing the determination.

For containers exempted from Subpart CC because they manage only wastes with an average volatile organic concentration of less than 500 ppmw, or for which volatile organics have been destroyed or removed, Triumvirate will maintain the following records:

- 1) For wastes with an average volatile organic concentration of less than 500 ppmw, information used for each waste determination, including waste stream profile data from the generator, in the facility operating record filed onsite in Casa Grande and/or available electronically. If analytical results are used, the date, time, and location of each sample will be recorded.
- 2) For wastes treated to remove volatile organics, the identification number of the incinerator, boiler, or industrial furnace in which the waste was treated.
- 3) For wastes that are exempt because they meet applicable organic treatment standards under the land disposal restrictions (LDR) (40 CFR 264.1082(c)(4)), Triumvirate already maintains LDR notifications as required by 40 CFR 268.7. Although these records are not required by Subpart CC, they can be used to document these determinations.

3.9 REPORTING

A written report will be submitted to the Arizona Department of Environmental Quality (ADEQ) within 15 calendar days of the time the Facility becomes aware of each occurrence when hazardous waste subject to Subpart CC emission control requirements is placed in a container not in compliance with Subpart CC emission control standards.

Each report will include the facility EPA identification number, facility name and address, a description of the noncompliance event and cause, the dates of noncompliance, and the actions taken to correct the noncompliance and prevent recurrence. The report will be signed and dated by an authorized representative of Triumvirate.

4. Tanks

Eight 19,644-gallon tanks will be used for waste solvent storage and fuel blending. Two 80-cubic yard that will be used for waste storage and stabilization. These ten tanks will be subject to Subpart CC. Tank Level I controls will be used on the eight solvent storage tanks and Tank Level II tanks will be used on the two stabilization vats for the reasons discussed in [Sections 4.1 and 4.2](#).

4.1 SOLVENT STORAGE AND FUEL BLENDING TANKS

The maximum organic vapor pressure allowed for a tank whose capacity is less than 75 m³ is 76.6 kPa. Based on the physical properties of the waste solvents that will be stored and blended for fuel, the organic vapor pressure of the wastes that are fuel blended will not exceed 76.6 kPa.

Each of the eight tanks will have a design capacity of less than 75 m³ (approx. 19,813 gallons) and will be equipped with and operated to comply Tank Level I control requirements identified in 40 CFR, Section 264.1084(c)(1) through (c)(4).

4.2 WASTE STORAGE AND STABILIZATION TANKS

40 CFR 264.1084(b)(2) requires that Tank Level II controls be used to control emissions from the two stabilization tanks.

4.3 TANK LEVEL II CONTROLS

[40 CFR 264.1084(d)]

Tank Level II controls will be 40 CFR 264.1084(d)(3), which stipulates that the two stabilization tanks must be vented through a closed vent system to a control device. The two stabilization tanks will be equipped with and operated to comply with Closed Vent system and control device requirements of 40 CFR, Section 264.1087.

4.4 INSPECTION AND MONITORING SCHEDULE

[40 CFR 264.1088(b)]

The eight tanks using Tank Level I controls and the closed vent system and control device for the two stabilization tanks will be inspected and monitored on a semi-annual basis.

4.5 INSPECTION AND MONITORING PROCEDURES

[40 CFR 264.1088(a)]

Note: Separate procedures for inspecting and monitoring tanks using Tank Level I controls and for inspecting the stabilization tanks using Tank Level II controls will be developed after the equipment has been installed and the inspection points are identified.

4.6 RECORDKEEPING

[40 CFR 264.1089]

4.6.1 Tank Level I Controls

[40 CFR 264.1089(b)(1) & (2)(i)]

For the eight tanks subject to Subpart CC using Tank Level I controls, the following information will be recorded:

- Tank identification number;
- Date of inspection;
- For each defect identified during the inspection:
 - The location of the defect;
 - A description of the defect; and
 - The corrective action taken to repair the defect.
- If the repair of the defect is delayed, additional information that will be recorded will include:
 - The reason for the repair delay;
 - The date that completion of the repair is expected.
- Records of each determination for the maximum organic vapor pressure of the hazardous waste in the tank performed in accordance with the requirements of 40 CFR Section 264.1084.

4.6.2 Tank Level II Controls

[40 CFR 264.1089(b)(1)&(2)(iv)]

For the two stabilization tanks using a closed vent system and control device, the following information will be recorded:

- Tank identification number;
- Date of inspection;
- For each defect identified during the inspection:
 - The location of the defect;
 - A description of the defect; and

- The corrective action taken to repair the defect.
- If the repair of the defect is delayed, additional information that will be recorded will include:
 - The reason for the repair delay;
 - The date that completion of the repair is expected.
- Records for the most recent set of calculations and measurements performed to verify that the enclosure meets the criteria of a permanent total enclosure.
- Certification that is signed and dated that the control device is designed to operate at the performance level documented by a design analysis.
- Design Analysis documentation.
- A description of the planned routine maintenance for the next 6-month period.
- A description of the planned routine maintenance for the previous 6-month period.
- The occurrence and duration of any malfunction of the control device system.
- The duration of each period during a malfunction when gases, vapors, or fumes are vented from the waste management unit through the closed-vent system to the control device while the control device is not properly functioning.
- Actions taken during periods of malfunction to restore a malfunctioning control device to its normal or usual manner of operation.
- Records of the management of carbon removed from a carbon adsorption system

4.7 REPORTING

[40 CFR 264.1090]

Written reports required by 264.1090 will be submitted to ADEQ:

- 1) Within 15 calendar days of discovery of any occurrence when hazardous waste is placed in the waste management unit in noncompliance with the conditions specified in 264.1082(c)(1) or (2);
- 2) Within 15 calendar days of discovery of any occurrence when hazardous waste is managed in a tank in noncompliance with conditions specified in 264.1084(b);
- 3) Semiannually for each occurrence during the previous 6-month period when the control device is operated continuously for 24 hours or longer in noncompliance.

Written reports required under numbers 1 and 2 above will include the Facility's EPA identification number, the Facility's name and address, a description of the noncompliance event and the cause, the dates of the noncompliance, and the actions taken to correct the noncompliance and prevent recurrence of the noncompliance. The report will be signed and dated by an authorized representative of the Facility owner or operator.

Written reports required under number 3 above will include the Facility's EPA identification number, the Facility's name and address, and an explanation why the control device could not be returned to compliance within 24 hours, and actions taken to correct the noncompliance. The report will be signed and dated by an authorized representative of the Facility owner or operator.

Appendix IC-1
EPA Method 21

Appendix IC-2
Subpart CC Container Inspection & Monitoring Log

Subpart CC
Container Inspection/Monitoring Log

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
Container ID	Waste Type	Container size	Type of Control	Control Acceptable? Yes/No	OVA reading (if “No” in Column 5)	Date of repair (if applicable)	Date repair completed (if applicable)	Comments (e.g., observations, follow up required)

- Notes:
- 1. This inspection log is solely for containers that are subject to Subpart CC that do not meet USDOT packaging requirements.
 - 2. Notify the Facility Manager immediately if defects are observed and/or an OVA reading indicates a leak.

Inspector: _____
(Printed name)

Date: _____