Attachment 2

Emission Calculations Spreadsheet

Crude Oil Speciation Summary

Annual Emissions

		Losses(lbs)												
Components	CAS #	RVP 0.98 Total Emissions	RVP 3.25 Total Emissions	RVP 3.27 Total Emissions	RVP 3.59 Total Emissions	RVP 3.96 Total Emissions	RVP 8.41 Total Emissions	Bakken 423 Total Emissions	Bakken 430 Total Emissions	Bakken 413 Total Emissions	Bakken 413 11psi Total Emissions	Max	Max case	Max 80% Bakken 20% Other
Crude oil		4,556.27	4,808.84	4,406.24	4,325.40	4,924.54	5,473.22	6,002.88	4,816.23	5,395.92	8,455.24	8,455.24	Bakken 413 High RVP Total Emissions	7,858.84
Hexane	110-54-3	24.54	24.66	23.04	22.56	24.76	23.64	0	0	103.52	118.63	118.63	Bakken 413 High RVP Total Emissions	99.86
Benzene	71-43-2	32.92	32.94	30.51	29.75	33.02	30.67	0	0	10.73	11.8	33.02	RVP 3.96	16.04
Isooctane	540-84-1	4.49	4.45	4.05	3.91	4.45	3.89	0	0	0	0	4.49	RVP 0.98	0.90
Toluene	108-88-3	47.69	47.42	43.37	42.05	47.42	42.28	0	0	16.11	16.59	47.69	RVP 0.98	22.81
Ethylbenzene	100-41-4	18.33	18.19	16.57	16.03	18.17	15.99	0	0	4.32	4.35	18.33	RVP 0.98	7.15
Xylene (-m)	108-38-3	63.94	63.44	57.76	55.9	63.39	55.71	0	0	14.06	14.13	63.94	RVP 0.98	24.09
Isopropyl benzene	98-82-8	4.53	4.5	4.09	3.96	4.49	3.94	0	0	0	0	4.53	RVP 0.98	0.91
1,2,4-Trimethylbenzene	95-63-6	14.88	14.76	13.42	12.98	14.74	12.9	0	0	0	0	14.88	RVP 0.98	2.98
Cyclohexane	110-82-7	38.69	38.73	35.89	35.01	38.82	36.13	0	0	24.72	27.27	38.82	RVP 3.96	29.58
Unidentified Components		4,306.27	4,559.75	4,177.55	4,103.26	4,675.29	5,248.08	5,647.82	4,381.87	4,836.90	7,766.82	7,766.82	Bakken 413 High RVP Total Emissions	7,263.07
Isopentane	78-78-4	0.00	0.00	0.00	0.00	0.00	0.00	124.89	208.2	139.66	184.76	208.20	Bakken 430	166.56
Pentane	109-66-0	0.00	0.00	0.00	0.00	0.00	0.00	209.61	210.3	215.8	277.6	277.60	Bakken 413 High RVP Total Emissions	222.08
Cyclopentane	287-92-3	0.00	0.00	0.00	0.00	0.00	0.00	20.55	15.86	13.37	16.49	20.55	Bakken 423	16.44
Xylene (-p)	106-42-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.81	8.86	8.86	Bakken 413 High RVP Total Emissions	7.09
Xylene (-o)	95-47-6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.92	7.94	7.94	Bakken 413 High RVP Total Emissions	6.35

Unloading Area Boiler Emissions

Maximum hourly heat input:	61.745	MMBtu/hr	3	Total Boilers
Maximum annual heat input	754,960	MMBtu/yr	3	Active on a short-term basis
Assumed heating value of natural gas	1,000	Btu/scf	2	Active on an annual basis
Maximum annual gas usage rate	755.0	MMscf/yr		

Emission factors

Pollutant	Emission Factor (lb/MMBtu)	Basis
NO_X	0.011	Low NO_X burner, BACT
CO	0.036	Proper combustion, BACT
SO_2	0.00725	2.59 gr S/100 scf NG daily max plus 25% saftey factor
SO_2	0.00367	1.31 gr S/100 scf NG annual average plus 25% saftey factor
PM_{10}	0.0075	BACT
$PM_{2.5}$	0.0075	Assumed equal to PM_{10}, BACT
VOC	0.005	Proper combustion, BACT
CO2e	117	

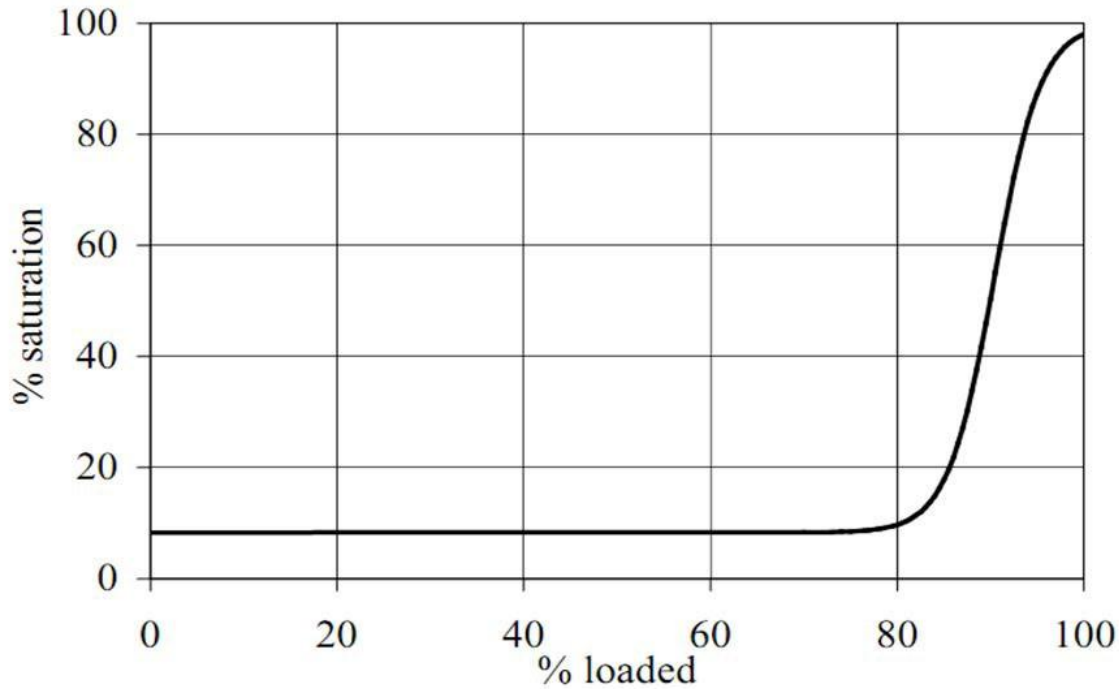
Emission calulations

Averging Period	Units	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	CO2e
1-Hour	lb/hr	2.038	6.67	1.343	1.389	1.389	0.926	21,672.5
24-hour	lb/day	48.902	160.04	32.222	33.342	33.342	22.228	520,139.9
Annual[1]	tpy	4.152	13.59	1.386	2.831	2.831	1.887	44,165.2

VCU Inerting Gas Air Calculations and VOC Profile Claculations

A theoretical profile of the fraction of VOC in the gases displaced while loading ships.

Figure 4 - concentration of hydrocarbon in vent gas as a function of % loaded (Courtesy John Zink Ltd)



20% VOC content required to stop assist gas
85% fraction of time that assist gas will be used (based on figure above)

VOC Profiles

	Jordan	90% air	50% air	Average Air %
Methane	1.41%	0.25%	1.23%	0.44%
Ethane	10.87%	1.90%	9.52%	3.43%
Propane	30.64%	5.37%	26.83%	9.66%
Butane	11.66%	2.04%	10.21%	3.68%
Pentane	2.09%	0.37%	1.83%	0.66%
Hexane	0.35%	0.06%	0.31%	0.11%
Heptane	0.08%	0.01%	0.07%	0.03%
Air	42.90%	90%	50%	82.00%
Total	100.00%	100.00%	100.00%	100.00%

Assuming the VOC concentration profile provided by Jordan would hold for other VOC/air combinations, concentration and heating value profiles for 90% air and 50% air profiles. These profiles were used to construct an approximation of the tank filling profile: 0% to 80% filled - constant 90% air, 80% to 100% filled - average of 50% air.

Inerting Gas Calculations

Estimated that the "air" portion of the displaced gases are actually ship exhaust, and that 12% of that gas is CO_2. Using the assumption that during 80% of the loading operation, the displaced gases were 90% "air," and an average of 50% "air" during the last 20% of the loading operation:

Fraction of the displaced gases assumed to be ship exhaust: 82%

			hourly max	
Total daily volume displaced	2,021,231	cf/day	179,665	cf/hr
Fraction that is ship exhaust	82%		82%	
Daily volume of ship exhaust emitted	1,657,409	cf/day	147,325	cf/hr
Assumed CO_2 fraction of ship exhaust	12%		12%	
Daily volume of CO_2 emitted	198,889	cf/day	17,679	cf/hr

Use ideal gas law to convert the volume of CO_2 to a mass:

m = MPV/RuT

V	5,632	m3 CO_2/day	500.61	m3 CO_2/hr
M	44	kg/kmol	44	kg/kmol
P	101.325	kPa	101.325	kPa
Ru	8.314	kJ/kmolK	8.314	kJ/kmolK
T	293.15	K	293.15	K
m	10,302	kg/day	915.7	kg/hr

Additional mass of CO_2 attributable to the inerting gas present in the tanks:

4,145	tons CO_2/yr	22,712	lbs CO_2/day	2,019	lbs CO_2/hr

Note: For a more conservaitve estimate of the quantity of inerting gas, the fraction of "air" in the displaced gases was assumed to be greater than when calculating the quantity of VOCs in the displaced gases.

VCU Emissions Summary

Displaced Tank Loading Vapors

Hourly

32,000	bbl/hr (maximum hourly)	768000	bbl/day	max daily
1,344,000	gal/hr (maximum hourly)			
179,665	ft3/hr (maximum hourly)			
144.2	MMBtu/hr (maximum hourly)			

Daily/Annual

360,000	bbl/day (annual average)	0.46875	fraction of max daily	
15,120,000	gal/day	131400000	bbl/yr	
2,021,231	ft3/day	100	ppm H_2S in vapor (maximum)	
67.6	MMBtu/hr	0.01%	H_2S in vapor	
1,622	MMBtu/day	PV=mRuT/M		
24	hours/day	m= PVM/RuT		
84,218	ft3/hr	P	0.987	atm
365	days/year	Ru	1.31443	ft^3*atm/lb-mol/K
591,959	MMBtu/yr	T	286	K (SO_2 MW)
737,749,295	ft3/yr	M	64	lb/lb-mol

Emissions from Displaced Vapor Combustion

Pollutant	Emission factor (lb/MMBtu)	Emissions (lb/hr)	Emissions (lb/day)	Emissions (tons/year)
NO_X	0.023	3.32	79.6	6.81
CO	0.010	1.44	34.6	2.96
SO_2	-	3.02	72.5	6.20
PM_{10}	0.0075	1.08	25.9	2.22
$PM_{2.5}$	0.0075	1.08	25.9	2.22
VOC	-	4.21	101.0	8.64
CO_2e	136	19,548	469,156	40,135

VCU Emissions Summary (continued)

Assist gas

30,600	cf/hr	(natural gas)	
292,613	cf/day		85% assist gas usage (annual)
106,803,563	cf/yr		
1,000	Btu/cf	(heating value of gas)	
30.6	MMBtu/hr		
293	MMBtu/day		
106,804	MMBtu/yr		
106,803,563	cf/yr		

Emissions from Assist Gas Combustion

Pollutant	Emission factor (lb/MMBtu)	Emissions (lb/hr)	Emissions (lb/day)	Emissions (tons/year)
NO_X	0.023	0.704	6.73	1.23
CO	0.010	0.306	2.93	0.534
SO_2	0.00725	0.222	2.12	0.387
PM_{10}	0.0075	0.230	2.19	0.401
$PM_{2.5}$	0.0075	0.230	2.19	0.401
VOC	0	0	0	0
CO_2e	117	3,580	34,236	6,248

CO_2e Emissions from Inerting Gas		
4,145	tons per year of CO_2	
22,712	lbs CO_2 / day	
2,019	lbs CO_2 / hr (max)	

Total

Pollutant	Emission factor (lb/MMBtu)	Emissions (lb/hr)	Emissions (lb/day)	Emissions (tons/year)
NO_X	-	4.02	86.3	8.04
CO	-	1.75	37.5	3.49
SO_2	-	3.24	74.6	6.59
PM_{10}	-	1.31	28.1	2.62
$PM_{2.5}$	-	1.31	28.1	2.62
VOC	-	4.21	101	8.64
CO_2e	-	25,147	526,104	50,528

Calculated Tank Loading Vapor Displacment Rate

Hourly worst case airflow	179,665 scf/hr
Daily/Annual Average Airflow	84,218 scf/hr
MVCU Control Efficiency	99.8%

Ideal Gas Law

PVM=mRuT --> V=mRuT/PM --> m=PVM/RuT

T =	293.15	K
P =	1	atm
Ru=	1.314	atm-ft^3/lbmol-K

VOC Profile from Jordan Technologies

	As Provided	Extrapolated[a]
Methane	1.41%	0.79%
Ethane	10.87%	6.09%
Propane	30.64%	17.17%
Butane	11.66%	6.53%
Pentane	2.09%	1.17%
Hexane	0.35%	0.20%
Heptane	0.08%	0.04%
Air	42.90%	68.00%
Total	100.00%	100.00%

Compound	MW (lb/lb-mol)	68% Air Condition Vol %	lb-mol/hr (shortterm)	lb-mol/hr (long term)	Heat of combustion[b] KJ/kg	Heat of combustion[c] Btu/lbmol	Mixture Btu/lbmol
Methane	16	0.790	3.69	1.73	55,530	381,986	3018.4
Ethane	30	6.092	28.41	13.32	51,900	669,404	40778.6
Propane	44	17.171	80.09	37.54	50,330	952,093	163486.5
i-Butane	58	6.535	30.48	14.29	49,150	1,225,607	80087.3
n-Pentane	72	1.171	5.46	2.56	47,760	1,478,416	17316.4
n-Hexane	86	0.196	0.91	0.43	47,760	1,765,885	3463.7
n-Heptane	100	0.045	0.21	0.10	48,100	2,067,973	927.1
Air	28.97	68	317.17	148.67	--	--	--
			Short Term	***Long Term***		**Total**	**309,078**
Flowrate	lb-mol/hr		466	219			
Startup Heat Input Rate	MMBtu/hr		144	68			
Carbon	(lb-mol C/hr)		457	214			
CO2 From Carbon	(lb CO2/hr)		20,106	9,425			
VOC to Combustor	lb C/hr		1406	659			
lb/MMBtu			0.0195	0.0195			

Notes:

a - Based on information provided by the MVCU manufacturer, the hydrocarbon content of the displaced vapors was assumed to average 32 percent by volume over all loading operations.

b - Higher Heat Values from at 25C (Table A-27). Thermodynamics an Engineering Approach (4th edition) by Y.A. Cengel and M.A. Boles, McGraw-Hill, New York, 2002.

c - Converted Heat of Combustion (KJ/Kg) to (Btu/lb)

CO2e From Displaced Vapor Combustion

Loading Crude Oil Into Ships and Ocean Barges
AP-42 Section 5.2 (Transporation and Marketing of Petroleum Liquids

CL = total loading loss (lb/1000 gal loaded)
Ca = 0.86 (Arrival EF, From AP-42, Table 5.2-3 - assume previous cargo was volatile and tank arrived uncleaned)
Cg = 1.84 (0.44*P -0.42) * (M*G)/T
where
P = true vapor pressure, psia
M = molecular weight of vapors
G = vapor growth factor = 1.02
T = temperature of liquid, degrees F = 68, degrees R = 527.67 °R

$$C_L = C_a + C_g = 0.86 + \left(1.84 * (0.44 * \mathrm{P} - 0.42) * \frac{M * G}{T}\right)$$

	P (psia)	M (lb/lb-mole)	CL (lb/1000 gal)	Throughput (bbl/hr)	Throughput (bbl/day)	PTE (lb/hr)	PTE (lb/day)	PTE (ton/yr)	Control Efficiency	PTE, controlled (lb/hr)	PTE, controlled (lb/day)	PTE, controlled (ton/yr)	Combusted (tpy)	CO2e (tpy)
Crude oil	11	44.8630473	1.5653	32,000	360,000	2,104	23,667	4,319	99.8%	4.21	47.3	8.64	4,311	12,944

Crude Oil Storage Tank Emissions

Tanks Operating Information	
6	Tanks
360,000	tank capacity (bbl)
15,120,000	tank capacity (gallons)
340,000	bbl/day (working volume)
20,683,333	bbl/yr/tank
868,700,000	gal/yr/tank
24	hours/day
365	days/year

Assumptions

100	ppm H2S
50	Vapor molecular weight of crude
34	molecular weight of H2S

		Per tank	*Total*	*Total*	*Total*
Components	**CAS #**	**Annual Losses (lbs)**	**Hourly Losses (lbs/hr)**	**Daily Losses (lbs/day)**	**Annual Losses (lbs/yr)**
Crude oil		7,858.84	5.38E+00	1.29E+02	4.72E+04
Hexane	110-54-3	99.86	6.84E-02	1.64E+00	5.99E+02
Benzene	71-43-2	16.04	1.10E-02	2.64E-01	9.63E+01
Isooctane	540-84-1	0.90	6.15E-04	1.48E-02	5.39E+00
Toluene	108-88-3	22.81	1.56E-02	3.75E-01	1.37E+02
Ethylbenzene	100-41-4	7.15	4.89E-03	1.17E-01	4.29E+01
Xylene (-m)	108-38-3	24.09	1.65E-02	3.96E-01	1.45E+02
Isopropyl benzene	98-82-8	0.91	6.21E-04	1.49E-02	5.44E+00
1,2,4-Trimethylbenzene	95-63-6	2.98	2.04E-03	4.89E-02	1.79E+01
Cyclohexane	110-82-7	29.58	2.03E-02	4.86E-01	1.77E+02
Unidentified Components		7,263.07	4.97E+00	1.19E+02	4.36E+04
Isopentane	78-78-4	166.56	1.14E-01	2.74E+00	9.99E+02
Pentane	109-66-0	222.08	1.52E-01	3.65E+00	1.33E+03
Cyclopentane	287-92-3	16.44	1.13E-02	2.70E-01	9.86E+01
Xylene (-p)	106-42-3	7.09	4.85E-03	1.17E-01	4.25E+01
Xylene (-o)	95-47-6	6.35	4.35E-03	1.04E-01	3.81E+01
Hydrogen Sulfide	7783-06-4	0.53	3.66E-04	8.78E-03	3.21E+00

Methane Emissions

Note: While crude oil that reaches the facility will likely be stabalized, it can be considered unstabilized for conservative CH4 emissions estimations. CH4 emissions were estimated using equation Y-22 from Federal GHGMRR 40 CFR 98 Y - Petroleum Refineries.

EQ Y-22:
CH4 = (0.1 * Qref)
where
CH4 = Annual methane emissions from storage tanks (metric tons/year)
Qref = Quantity of crude oil (MMbbl/year)

12.41	**Tons of Methane per year (total)**	2.068333333	per tank
260.61	**Tons of CO2e per year (total)**	43.435	per tank

Emergency Diesel Firewater Pumps Emission Calculations

Operating Information					
225	hp	167.8	kw/hr	1.6214	MMBtu/hr
12.1	gal/hr	134,000	BTU/gal		
34	hours/year				
1	hr/day				
3	Engines				

SO2 Calcs

15	ppm S (ULSD)
7	lb/gal (density of diesel fuel)
84.7	lb/hr (mass fuel use rate)
0.00127	lb/hr S
32	lb/lbmol (MW of S)
64	lb/lbmol (MW of SO2)
0.002541	lb/hr SO2

Emissions

Pollutant	Emission factor (g/kW-hr)	Emission Factor Description	Emissions (lb/hr)	Emissions (lb/day)	Emissions (tons/year)
NO_X	0.335	Manufacturer	0.372	0.372	0.00632
CO	1.60	Manufacturer	1.78	1.78	0.0302
SO_2	-	15 ppm ULSD fuel	0.00762	0.00762	0.000130
PM_{10}	0.17	Manufacturer	0.189	0.189	0.00321
$PM_{2.5}$	0.17	Manufacturer	0.189	0.189	0.00321
VOC	0.37	Manufacturer	0.411	0.411	0.00698
CO2e	717.13	40 CFR Part 98	796	796	13.5

Single Engine		
Emissions (lb/hr)	Emissions (lb/day)	Emissions (tons/year)
0.124	0.124	0.00211
0.592	0.592	0.0101
0.00254	0.00254	0.0000432
0.0629	0.0629	0.00107
0.0629	0.0629	0.00107
0.137	0.137	0.00233
265	265	4.51

CO2 Emission Factor Conversion From 40 CFR Part 98			
74.21 kg/MMBtu	163.6 lb/MMBtu	74209 g/Mmbtu	717.1 g/kw-hr

Fugitive Emissions due to Leaking Components

Summary of Fugitive Components by Type

Fugitive Component Type	Service	Total Number of Components	Number of Components Estimated to be Leakers (1.5% of Total)	Number of Components Estimated to be Pegged Leakers	Unloading Area Components	Tank Area Components	Dock Area Components
					Components Distribution		
Valves	All	2,753	42	1	2,050	509	194
Pump Seals	All	61	1	1	50	10	1
Connectors	All	360	6	1	270	90	0
Flanges	All	2,630	40	1	2,253	316	61
Others	All	1,486	23	1	1,185	172	129

Summary of Fugitive Component Emission Factors

Fugitive Component Type	Service	Non-Leakers		Screening Value Leakers				Pegged Leakers	
		Zero Emission Factor (lb/hr/source)	Non-Leaking Hours (hr/yr)	Leak Rate/Screening Correlation	Screening Value (SV) (ppmv)	Screening Value Emission Factor (lb/hr/source)	Screening Value Leaking Hours (hr/yr)	10,000 ppmv Pegged Emission Factor (lb/hr/source)	Pegged Leaking Hours (hr/yr)
Valves	All	1.7E-05	8,760	(kg/hr/source) = 2.29E-06 x $(SV)^{0.746}$	250	0.00031	8,760	0.14112	730
Pump Seals	All	5.3E-05	8,760	(kg/hr/source) = 5.03E-05 x $(SV)^{0.610}$	1,000	0.00750	8,760	0.16317	730
Connectors	All	1.7E-05	8,760	(kg/hr/source) = 1.53E-06 x $(SV)^{0.735}$	250	0.00020	8,760	0.06174	730
Flanges	All	6.8E-07	8,760	(kg/hr/source) = 4.61E-06 x $(SV)^{0.703}$	250	0.00049	8,760	0.18743	730
Others	All	8.8E-06	8,760	(kg/hr/source) = 1.36E-05 x $(SV)^{0.589}$	250	0.00078	8,760	0.16097	730

Summary of Fugitive Component Emissions

Fugitive Component Type	Service	Non-Leaker Emissions (lb/yr)	Screening Value Leaker Emissions (lb/yr)	Pegged Leaker Emissions (lb/yr)	Total Emissions (lb/yr)	Total Emissions (ton/yr)	Unloading Area Emissions (ton/yr)	Tank Area Emissions (ton/yr)	Dock Area Emissions (ton/yr)
							Emissions Distribution		
Valves	All	408.45	114.02	103.02	625.49	0.31	0.233	0.058	0.022
Pump Seals	All	27.81	65.69	119.11	212.62	0.11	0.087	0.017	0.002
Connectors	All	51.28	10.26	45.07	106.62	0.05	0.040	0.013	0.000
Flanges	All	15.51	172.75	136.82	325.08	0.16	0.139	0.020	0.004
Others	All	113.04	143.15	117.50	373.69	0.19	0.149	0.022	0.016
Total		**616.09**	**505.87**	**521.53**	**1,643.49**	**0.82**	**0.65**	**0.13**	**0.04**

Fugitive Emissions due to Leaking Components (continued)

Summary of Toxic Emissions

Pollutant	CAS #	Weight Fraction	Hourly Emissions (lb/hr)	Total Emissions (ton/yr)	Emissions Distribution: Unloading Area Emissions (ton/yr)	Emissions Distribution: Tank Area Emissions (ton/yr)	Emissions Distribution: Dock Area Emissions (ton/yr)
1,2,4-Trimethylbenzene	95-63-6	0.00065	1.2E-04	0.0005	0.0004	0.0001	0.0000
Benzene	71-43-2	0.00304	5.7E-04	0.0025	0.0020	0.0004	0.0001
Cyclohexane	110-82-7	0.00536	1.0E-03	0.0044	0.0035	0.0007	0.0002
Cyclopentane	287-92-3	0.00274	5.1E-04	0.0023	0.0018	0.0004	0.0001
Ethylbenzene	100-41-4	0.00145	2.7E-04	0.0012	0.0009	0.0002	0.0001
Hexane (-n)	110-54-3	0.01643	3.1E-03	0.0135	0.0106	0.0021	0.0007
Hydrogen Sulfide	7783-06-4	0.00015	2.8E-05	0.0001	0.0001	0.0000	0.0000
Isooctane	540-84-1	0.00020	3.7E-05	0.0002	0.0001	0.0000	0.0000
Isopentane	78-78-4	0.03458	6.5E-03	0.0284	0.0224	0.0045	0.0015
Isopropyl benzene	98-82-8	0.00020	3.7E-05	0.0002	0.0001	0.0000	0.0000
Pentane	109-66-0	0.03493	6.6E-03	0.0287	0.0226	0.0045	0.0015
Toluene	108-88-3	0.00448	8.4E-04	0.0037	0.0029	0.0006	0.0002
Xylene (-m)	108-38-3	0.00489	9.2E-04	0.0040	0.0032	0.0006	0.0002
Xylene (-o)	95-47-6	0.00117	2.2E-04	0.0010	0.0008	0.0002	0.0001
Xylene (-p)	106-42-3	0.00131	2.5E-04	0.0011	0.0008	0.0002	0.0001

Notes:

Non-Leaker Emissions = Petroleum Zero Emission Factor x (Total Number of Components - Number of Components Estimated to be Leakers) x Non-Leaking Hours

Screening Value Leaker Emissions = Petroleum Screening Value Emission Factor x [Number of Components Estimated to be Leakers - (Number of Components Estimated to be Pegged Leakers x Pegged Leaking Hours / 8,760)] x Screening V

Pegged Leaker Emissions = 10,000 ppmv Petroleum Pegged Emission Factor x Number of Components Estimated to be Pegged Leakers x Pegged Leaking Hours

CO2e Emissions	
0.582	Ratio of lowest molecular weight pollutant (cyclopentane) emissions from components to emissions from tanks
151.680	Tons CO2e per year from components (scaled from tanks emissions)

Emissions Estimation Basis

The key assumptions for this calculation are:

1) Each component in VOC service will be included in a leak detection and repair (LDAR) program requiring weekly visual inpsections and monthly inspections with portable instrument.

2) 1.5% of the total components in VOC service are assumed to be leakers.

3) The screening values are assumed to be one half the Phase II regulatory leak definition (2,000 ppm [pumps] and 500 ppm [valves, connectors, instrumentation, pressure valves], 40 CFR 63, Subpart H), which is considered BACT for this pr

4) The durations of pegged leakers for the remaining equipment types are assumed to be one month for all equipment.

5) Toxic emissions are based on the average composition of TAPs in crude oil.

6) Component counts for valves, pumps, connectors, flanges, and others were provided by Savage.

7) Zero emission rates, screening correlation equations, and pegged emission rates are from Tables 2-12, 2-10, and 2-14 (Petroleum Industries), Protocol for Equipment Leak Emission Estimates (EPA, November 1995).

Vapor Pressure and Liquid Density Values

Vapor Pressure Constants[1]

$$A = 12.82 - 0.962 \times \ln(RVP)$$

$$B = 7261 - 1216 \times \ln(RVP)$$

True Stock Vapor Pressure Equation (from AP42, Clausius-Clapeyron derivation)[1]

$$P = exp\ A - \frac{B}{(T + 459.7)}$$

True Stock Vapor Pressure (psi at 55.06°F) at Given RVP

RVP (psi)	0.98	3.25	3.27	3.59	3.96	6.1	8.05	8.41	9.8	13.9
Vapor Pressure (psi)	0.269	1.44	1.45	1.66	1.90	3.48	5.13	5.45	6.76	11.0

Liquid Density at Given RVP and Specific Gravity

RVP (psi)	**0.98**	**3.25**	**3.27**	**3.59**	**3.96**	**6.1**	**8.05**	**8.41**	**9.8**[2]
Specific Gravity (at 60°F)	0.937	0.929	0.844	0.816	0.928	0.811	0.819	0.811	0.814
Liquid Density (lb/gal at 60°F)	7.81	7.74	7.04	6.80	7.73	6.76	6.83	6.76	6.79

[1] Manual of Petroleum Measurement Standards Chapter 19.4 – Recommended Practice for Speciation of Evaporative Losses, second edition, September 2005

[2] Due to limited information, the specific gravity and liquid density associated with the 9.8 RVP was used for the 13.9 RVP tank run

TANKS 4.0.9d

Tank Parameters and Speciation Profiles

Tank Parameters[1]	
Diameter (ft)	240
Volume (gal)	15,120,000
Turnovers per year	60
Net Throughput (gal/yr)	868,700,000
Number of Columns	37
External Shell and Roof Color	White

Speciation Profiles for RVPs	
Chemical Name	**Percent of Total Liquid Weight**
Hexane (-n)	0.4
Benzene	0.6
Isooctane	0.1
Toluene	1
Ethylbenzene	0.4
Xylene (-m)	1.4
Isopropyl benzene	0.1
1,2,4-Trimethylbenzene	0.33
Cyclohexane	0.7

[1] Parameters for RVP 0.98, 3.25, 3.27, 3.59, 3.96, 8.41, Bakken 423, Bakken 430, Bakken 413, and Bakken 413 at 11 psi

Speciation Profiles for Bakken 423 and Bakken 430		
Chemical Name	**Bakken 423 - Percent of Total Liquid Weight**	**Bakken 430 - Percent of Total Liquid Weight**
Isopentane	0.81	1.512
Pentane (-n)	1.781	1.977
Cyclopentane	0.236	0.198

Speciation Profiles for Bakken 413 and Bakken 413 at 11 psi	
Chemical Name	**Percent of Total Liquid Weight**
Isopentane	0.96
Pentane (-n)	1.93
Cyclopentane	0.16
Benzene	0.209
Cyclohexane	0.477
Ethylbenzene	0.107
Xylene (-p)	0.219
Xylene (-m)	0.35
Xylene (-o)	0.198
Hexane (-n)	1.749
Toluene	0.378

TANKS 4.0.9d

Annual Emission Report: RVP 0.98 – Internal Floating Roof Tank

Individual Tank Emission Totals

	Losses (lbs)				
Components	**Rim Seal Loss**	**Withdrawl Loss**	**Deck Fitting Loss**	**Deck Seam Loss**	**Total Emissions**
Crude oil (RVP 0.98)	13.24	4,492.83	50.20	0.00	4,556.27
Hexane (-n)	1.37	17.97	5.20	0.00	24.54
Benzene	1.24	26.96	4.72	0.00	32.92
Isooctane	0.00	4.49	0.00	0.00	4.49
Toluene	0.58	44.93	2.18	0.00	47.69
Ethylbenzene	0.07	17.97	0.28	0.00	18.33
Xylene (-m)	0.22	62.90	0.82	0.00	63.94
Isopropyl benzene	0.01	4.49	0.03	0.00	4.53
1,2,4-Trimethylbenzene	0.01	14.83	0.04	0.00	14.88
Cyclohexane	1.51	31.45	5.73	0.00	38.69
Unidentified Components	8.23	4,266.84	31.20	0.00	4,306.27

TANKS 4.0.9d

Annual Emission Report: RVP 3.25 – Internal Floating Roof Tank

Individual Tank Emission Totals

	Losses (lbs)				
Components	**Rim Seal Loss**	**Withdrawl Loss**	**Deck Fitting Loss**	**Deck Seam Loss**	**Total Emissions**
Crude oil (RVP 3.25)	73.98	4,454.46	280.40	0.00	4,808.84
Hexane (-n)	1.43	17.82	5.42	0.00	24.66
Benzene	1.30	26.73	4.92	0.00	32.94
Isooctane	0.00	4.45	0.00	0.00	4.45
Toluene	0.60	44.54	2.28	0.00	47.42
Ethylbenzene	0.08	17.82	0.29	0.00	18.19
Xylene (-m)	0.23	62.36	0.86	0.00	63.44
Isopropyl benzene	0.01	4.45	0.03	0.00	4.50
1,2,4-Trimethylbenzene	0.01	14.70	0.04	0.00	14.76
Cyclohexane	1.58	31.18	5.97	0.00	38.73
Unidentified Components	68.76	4,230.40	260.59	0.00	4,559.75

TANKS 4.0.9d

Annual Emission Report: RVP 3.27 – Internal Floating Roof Tank

Individual Tank Emission Totals

	Losses (lbs)				
Components	**Rim Seal Loss**	**Withdrawl Loss**	**Deck Fitting Loss**	**Deck Seam Loss**	**Total Emissions**
Crude oil (RVP 3.27)	74.65	4,048.63	282.95	0.00	4,406.24
Hexane (-n)	1.43	16.19	5.42	0.00	23.04
Benzene	1.30	24.29	4.92	0.00	30.51
Isooctane	0.00	4.05	0.00	0.00	4.05
Toluene	0.60	40.49	2.28	0.00	43.37
Ethylbenzene	0.08	16.19	0.29	0.00	16.57
Xylene (-m)	0.23	56.68	0.86	0.00	57.76
Isopropyl benzene	0.01	4.05	0.03	0.00	4.09
1,2,4-Trimethylbenzene	0.01	13.36	0.04	0.00	13.42
Cyclohexane	1.58	28.34	5.97	0.00	35.89
Unidentified Components	69.43	3,844.99	263.13	0.00	4,177.55

TANKS 4.0.9d

Annual Emission Report: RVP 3.59 – Internal Floating Roof Tank

Individual Tank Emission Totals

	Losses (lbs)				
Components	**Rim Seal Loss**	**Withdrawl Loss**	**Deck Fitting Loss**	**Deck Seam Loss**	**Total Emissions**
Crude oil (RVP 3.59)	85.72	3,914.80	324.88	0.00	4,325.40
Hexane (-n)	1.44	15.66	5.46	0.00	22.56
Benzene	1.31	23.49	4.96	0.00	29.75
Isooctane	0.00	3.91	0.00	0.00	3.91
Toluene	0.61	39.15	2.30	0.00	42.05
Ethylbenzene	0.08	15.66	0.30	0.00	16.03
Xylene (-m)	0.23	54.81	0.86	0.00	55.90
Isopropyl benzene	0.01	3.91	0.03	0.00	3.96
1,2,4-Trimethylbenzene	0.01	12.92	0.04	0.00	12.98
Cyclohexane	1.59	27.40	6.02	0.00	35.01
Unidentified Components	80.45	3,717.88	304.92	0.00	4,103.26

TANKS 4.0.9d

Annual Emission Report: RVP 3.96 – Internal Floating Roof Tank

Individual Tank Emission Totals

	Losses (lbs)				
Components	**Rim Seal Loss**	**Withdrawl Loss**	**Deck Fitting Loss**	**Deck Seam Loss**	**Total Emissions**
Crude oil (RVP 3.96)	99.24	4,449.18	376.12	0.00	4,924.54
Hexane (-n)	1.45	17.80	5.51	0.00	24.76
Benzene	1.32	26.70	5.00	0.00	33.02
Isooctane	0.00	4.45	0.00	0.00	4.45
Toluene	0.61	44.49	2.32	0.00	47.42
Ethylbenzene	0.08	17.80	0.30	0.00	18.17
Xylene (-m)	0.23	62.29	0.87	0.00	63.39
Isopropyl benzene	0.01	4.45	0.03	0.00	4.49
1,2,4-Trimethylbenzene	0.01	14.68	0.05	0.00	14.74
Cyclohexane	1.60	31.14	6.07	0.00	38.82
Unidentified Components	93.92	4,225.39	355.98	0.00	4,675.29

TANKS 4.0.9d

Annual Emission Report: RVP 8.41 – Internal Floating Roof Tank

Individual Tank Emission Totals

	Losses (lbs)				
Components	**Rim Seal Loss**	**Withdrawl Loss**	**Deck Fitting Loss**	**Deck Seam Loss**	**Total Emissions**
Crude oil (RVP 8.41)	330.95	3,887.94	1,254.34	0.00	5,473.22
Hexane (-n)	1.69	15.55	6.40	0.00	23.64
Benzene	1.53	23.33	5.81	0.00	30.67
Isooctane	0.00	3.89	0.00	0.00	3.89
Toluene	0.71	38.88	2.69	0.00	42.28
Ethylbenzene	0.09	15.55	0.35	0.00	15.99
Xylene (-m)	0.27	54.43	1.01	0.00	55.71
Isopropyl benzene	0.01	3.89	0.04	0.00	3.94
1,2,4-Trimethylbenzene	0.01	12.83	0.05	0.00	12.90
Cyclohexane	1.86	27.22	7.05	0.00	36.13
Unidentified Components	324.77	3,692.37	1,230.94	0.00	5,248.08

TANKS 4.0.9d

Annual Emission Report: Bakken 423 – Internal Floating Roof Tank

Individual Tank Emission Totals

	Losses (lbs)				
Components	**Rim Seal Loss**	**Withdrawl Loss**	**Deck Fitting Loss**	**Deck Seam Loss**	**Total Emissions**
Crude oil (Bakken 423)	437.71	3,906.16	1,659.00	0.00	6,002.88
Isopentane	19.47	31.64	73.79	0.00	124.89
Pentane (-n)	29.24	69.57	110.81	0.00	209.61
Cyclopentane	2.37	9.22	8.97	0.00	20.55
Unidentified Components	386.65	3,795.74	1,465.44	0.00	5,647.82

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Annual Emission Report: Bakken 430 – Internal Floating Roof Tank

Individual Tank Emission Totals

	Losses (lbs)				
Components	**Rim Seal Loss**	**Withdrawl Loss**	**Deck Fitting Loss**	**Deck Seam Loss**	**Total Emissions**
Crude oil (Bakken 430)	193.39	3,889.85	732.99	0.00	4,816.23
Isopentane	31.19	58.81	118.20	0.00	208.20
Pentane (-n)	27.85	76.90	105.55	0.00	210.30
Cyclopentane	1.70	7.70	6.46	0.00	15.86
Unidentified Components	132.66	3,746.44	502.78	0.00	4,381.87

TANKS 4.0.9d

Annual Emission Report: Bakken 413 – Internal Floating Roof Tank

Individual Tank Emission Totals

	Losses (lbs)				
Components	**Rim Seal Loss**	**Withdrawl Loss**	**Deck Fitting Loss**	**Deck Seam Loss**	**Total Emissions**
Crude oil (Bakken 413)	306.57	3,927.38	1,161.96	0.00	5,395.92
Isopentane	21.29	37.70	80.67	0.00	139.66
Pentane (-n)	29.23	75.80	110.77	0.00	215.80
Cyclopentane	1.48	6.28	5.61	0.00	13.37
Benzene	0.53	8.21	1.99	0.00	10.73
Cyclohexane	1.25	18.73	4.73	0.00	24.72
Ethylbenzene	0.02	4.20	0.09	0.00	4.32
Xylene (-p)	0.04	8.60	0.17	0.00	8.81
Xylene (-m)	0.07	13.75	0.25	0.00	14.06
Xylene (-o)	0.03	7.78	0.11	0.00	7.92
Hexane (-n)	7.27	68.69	27.56	0.00	103.52
Toluene	0.26	14.85	1.00	0.00	16.11
Unidentified Components	245.11	3,662.80	929.00	0.00	4,836.90

TANKS 4.0.9d

Annual Emission Report: Bakken 413 at 11 psi – Internal Floating Roof Tank

Individual Tank Emission Totals

	Losses (lbs)				
Components	**Rim Seal Loss**	**Withdrawl Loss**	**Deck Fitting Loss**	**Deck Seam Loss**	**Total Emissions**
Crude oil (Bakken 413 at 11 psi)	949.68	3,906.16	3,599.40	0.00	8,455.24
Isopentane	30.74	37.50	116.52	0.00	184.76
Pentane (-n)	42.21	75.39	159.99	0.00	277.60
Cyclopentane	2.14	6.25	8.10	0.00	16.49
Benzene	0.76	8.16	2.88	0.00	11.80
Cyclohexane	1.80	18.63	6.84	0.00	27.27
Ethylbenzene	0.03	4.18	0.13	0.00	4.35
Xylene (-p)	0.06	8.55	0.24	0.00	8.86
Xylene (-m)	0.09	13.67	0.36	0.00	14.13
Xylene (-o)	0.04	7.73	0.16	0.00	7.94
Hexane (-n)	10.50	68.32	39.81	0.00	118.63
Toluene	0.38	14.77	1.45	0.00	16.59
Unidentified Components	860.90	3,643.01	3,262.92	0.00	7,766.82

TANKS 4.0.9d

Degassing Emissions - Tank Parameters

Internal Floating Roof Tank Parameters[1]	
Diameter (ft)	240
Volume (gal)	15,120,000
Turnovers per year	60
Net Throughput (gal/yr)	868,700,000
Number of Columns	37
External Shell and Roof Color	White

Vertical Fixed Roof Tank Parameters[2]	
Shell Height (ft)	48
Shell Diameter (ft)	240
Maximum Liquid Height (ft)	4
Average Liquid Height (ft)	1
Net Throughput (gal/yr)	1,353,647.4
Turnovers per Year	1
External Shell and Roof Color	White

[1] Speciation profile is the same as Bakken 413 and Bakken 413 at 11 psi
[2] Speciation profile is the same as RVP tank runs

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Degassing Emissions

Emission Type	Tank Type	VOC (lb/yr)
Withdrawal Losses	Internal Floating Roof	67.99
Working Losses	Fixed Roof	3,153.64
Total VOC Degassing Emissons		3,221.63
		1.61 tpy