Health Assessment Modeling

For

LOOP LLC Port Complex

Marine Terminal

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1.0 INTRODUCTION

LOOP LLC Port Complex (LOOP Complex) is located in Lafourche Parish, Louisiana and the Gulf of Mexico. The LOOP Complex consists of the Clovelly Dome Storage Terminal in Galliano, the Small Boat Harbor in Leeville, the Fourchon Booster Station in Leeville, and Marine Offloading Terminal in Grand Isle Block 59, Gulf of Mexico.

C-K Associates, LLC (CK Associates) was contracted to conduct an air screening model evaluation of the Marine Offloading Terminal to determine potential exposure to toxic constituents in crude oil on individuals located on the Marine Terminal as a result of loading Very Large Crude Carriers (VLCC). This report presents the modeling and calculations that support the evaluation. Additionally, a modeling run was also conducted to evaluate potential impacts to individuals located on the VLCC during loading operations.

2.0 AIR EMISSIONS EVALUATION

Total emissions from the loading of a VLCC were first estimated using the Loading Loss Emissions Calculation for vessels which is found in the EPA Compilation of Air Pollutant Emission Factors, AP-42, Section 5.2 – Transportation and Marketing of Petroleum Liquids. The loading rate of crude oil was 40,000 Bbls/hr and liquid properties were based on RVP8 Crude Oil.

Toxic constituents were speciated based on the known weight fractions in this crude and applied to the calculated emission rate of 1,848.8 lb/hr. The calculation and speciation is shown as Appendix A.

3.0 MODEL SELECTION

Air dispersion modeling is the mathematical simulation of how air pollutants disperse in the ambient atmosphere. The air dispersion model can effectively estimate the downwind ambient concentrations of constituents emitted from the loading operations.

Air dispersion modeling is performed with computer programs that solve the mathematical equations and algorithms which simulate the dispersion of emissions to air. EPA preferred models include AERSCREEN for screening analysis and AERMOD for refined model simulations. AERSCREEN is the recommended screening model that will produce conservative impact estimates without the need for actual hourly meteorological or detailed terrain data. The AERSCREEN model will produce estimates of "worst-case" 1-hour concentrations for a single source, based on a matrix of meteorological conditions, and includes conversion factors to estimate "worst-case" 3-hour, 8-hour, 24-hour, and annual concentrations. AERSCREEN is intended to produce concentration estimates that are equal to or greater than the estimates produced by AERMOD with a fully developed

set of actual meteorological and terrain data, but the degree of conservatism will vary depending on the application.

The AERSCREEN model was developed to provide an easy-to-use method of obtaining pollutant concentration estimates. To perform a modeling study using AERSCREEN, data for the following input requirements must be supplied:

- Source Type (Point, Flare, Area or Volume);
- Physical Source and Emissions Characteristics (emission rate, stack height, stack diameter, stack gas exit velocity and temperature, and receptor height above ground);
- Meteorology (surface characteristics, ambient temperatures, minimum wind speed, and anemometer height);
- Building downwash; and,
- Terrain data (flat, elevated and complex terrain).

4.0 MODEL INPUT

A "unity" method was used to conduct the modeling runs. This was accomplished by inputting a value of 1 lb/hr for the emission rate and applying a ratio of the actual emission rate per constituent to the model predicted concentration as follows:

Modeled Rate/Model Result = Actual Rate/Actual Result

Or

*Actual Rate/Modeled Rate * Model Result = Actual Result*

To accommodate for the varying VLCC stack height caused by loading, the model was run at the lowest height which occurs when the VLCC is full, and the highest height which occurs when the VLCC is empty. Additionally, to accommodate for the various levels of the Marine Terminal that can be occupied, model runs were conducted at 10-foot intervals beginning with a height of 70 feet above sea-level to 140 feet above sea-level. The VLCC was entered as a structure that could cause building downwash. The dimensions of the VLCC entered were 1050 feet X 200 feet (319 meters X 62 meters). The height used was dependent on the case whether the VLCC was full or empty.

To summarize, the model was run 16 times as follows:

Case	VLCC Stack Height (feet above Sea-level)	Marine Terminal Receptor Elevation (feet above Sea-level)	VLCC Structure Height (feet above Sea-level)
1a – Full VLCC	42.7	70	23
1b – Full VLCC	42.7	80	23
1c – Full VLCC	42.7	90	23
1d – Full VLCC	42.7	100	23
1e – Full VLCC	42.7	110	23
1f – Full VLCC	42.7	120	23
1g – Full VLCC	42.7	130	23
1h – Full VLCC	42.7	140	23
2a – Empty VLCC	95	70	75.4
2b – Empty VLCC	95	80	75.4
2c – Empty VLCC	95	90	75.4
2d – Empty VLCC	95	100	75.4
2e – Empty VLCC	95	110	75.4
2f – Empty VLCC	95	120	75.4
2g – Empty VLCC	95	130	75.4
2h – Empty VLCC	95	140	75.4

In addition to the stack, VLCC and Marine terminal receptor heights, the following stack parameters were used as input into the model -

- Stack gas exit velocity was determined using the vapor displacement from the loading operation at 40,000 Bbls/hr-Crude and the stack diameter of 20" (1.67') as follows:

  *Flow = (40,000 Bbls/hr) * (1 hr/3600 sec.) * (42 Gal/Bbls) * (1 ft^3/7.48 Gal) = 62.39 ft^3/sec*

  *Stack Area = [(1.67 ft/2)^2] * 3.1417 = 2.19 ft^2*

  Velocity = 62.39 ft^3/sec. / 2.19 ft^2 = 28.5 ft/sec

- Loading temperature was provided by Loop as 70 F.

5.0 MODEL RESULTS

Exposure levels were reviewed for each toxic constituent modeled. The Permissible Exposure Limits (PEL) are set by OSHA to protect workers against the adverse effects of exposure to chemical substances and generally are based on an 8-hour time-weighted average (TWA) exposure. For this evaluation, the OSHA PEL was chosen for comparison to the modeling results.

Table 1 shows the maximum concentrations at the Marine Terminal for each height modeled for each toxic constituent. The results shown are 1-hr averages, resulting in a more conservative comparison to the OSHA PEL which is an 8-hr TWA. As shown in the table, the modeling demonstrates that personal exposure due to the loading emissions will be well below the applicable OSHA exposure limit in every case representing various levels of the Marine Terminal which could be occupied by personnel.

Based on the air screening model evaluation, it was concluded that the emissions from the loading operations will not result in ambient air concentrations above OSHA regulatory standards, which are protective of human health.

6.0 ADDITIONAL ANALYSIS

An additional modeling run was conducted to evaluate potential impacts of personnel on the VLCC during actual loading operations. Receptors were placed on the level of the VLCC's deck which was assumed to be ground-level. The distances considered in the model began at one meter from the stack and continued at five-meter increments to 65 meters. All stack parameters were the same as that used in the Marine Terminal analysis except for stack height. Since the VLCC's deck was considered ground-level, the stack height above the deck was 19.7 feet. A "unity" method was also used for this modeling run.

Results of the analysis showed a maximum concentration at 55 meters. Table 1 gives the concentration of each of the individual constituents. As shown in the table, the modeling demonstrates that personal exposure on the VLCC due to the loading emissions will be below the applicable OSHA exposure limit.

Table 1

LOOP Marine Terminal
Air Modeling Results

Case 1 - Ship Loaded, Stack Ht = 42.7 ft	Results at 1 lb/hr (ug/m3)	Benzene Results at 1-Hr Averages	n-Hexane Results at 1-Hr Averages	Xylenes Results at 1-Hr Averages	1,2,4 - Trimethylbenzene Results at 1-Hr Averages	Ethylbenzene Results at 1-Hr Averages	Toluene Results at 1-Hr Averages	Isooctane Results at 1-Hr Averages	Hydrogen Sulfide Results at 1-Hr Averages
Case 1a - receptor ht 140'	5.6	60.03	65.24	11.37	1.01	4.14	29.01	5.15	0.112
Case 1b - receptor ht 130'	6.7	71.82	78.06	13.60	1.21	4.96	34.71	6.16	0.134
Case 1c - receptor ht 120'	10.8	115.78	125.82	21.92	1.94	7.99	55.94	9.94	0.216
Case 1d - receptor ht 110'	16.1	172.59	187.57	32.68	2.90	11.91	83.40	14.81	0.322
Case 1e - receptor ht 100'	19	203.68	221.35	38.57	3.42	14.06	98.42	17.48	0.380
Case 1f - receptor ht 90'	18	192.96	209.70	36.54	3.24	13.32	93.24	16.56	0.360
Case 1g - receptor ht 80'	14	150.08	163.10	28.42	2.52	10.36	72.52	12.88	0.280
Case 1h - receptor ht 70'	11.6	124.35	135.14	23.55	2.09	8.58	60.09	10.67	0.232
Case 2 - Ship Empty, Stack Ht = 95 ft									
Case 2a - receptor ht 140'	13.8	147.94	160.77	28.01	2.48	10.21	71.48	12.70	0.276
Case 2b - receptor ht 130'	14	150.08	163.10	28.42	2.52	10.36	72.52	12.88	0.280
Case 2c - receptor ht 120'	10.8	115.78	125.82	21.92	1.94	7.99	55.94	9.94	0.216
Case 2d - receptor ht 110'	12.6	135.07	146.79	25.58	2.27	9.32	65.27	11.59	0.252
Case 2e - receptor ht 100'	18.8	201.54	219.02	38.16	3.38	13.91	97.38	17.30	0.376
Case 2f - receptor ht 90'	18.8	201.54	219.02	38.16	3.38	13.91	97.38	17.30	0.376
Case 2g - receptor ht 80'	12.7	136.14	147.96	25.78	2.29	9.40	65.79	11.68	0.254
Case 2h - receptor ht 70'	7.6	81.47	88.54	15.43	1.37	5.62	39.37	6.99	0.152
	OSHA Limits	**1 ppm**	**500 ppm**	**100 ppm**	**25 ppm**	**100 ppm**	**200 ppm**	**500 ppm**	**10 ppm**
		3,195 ug/m^3	**1,762,372 ug/m^3**	**434,192 ug/m^3**	**122,894 ug/m^3**	**434,233 ug/m^3**	**753,701 ug/m^3**	**2,336,033 ug/m^3**	**13,939 ug/m^3**

Example calculation for each constituent - Case 1a @ 1 lb/hr = 5.6 ug/m^3

Benzene - 10.72 lb/hr/1 lb/hr *5.6 ug/m3 = 60.03 ug/m^3

Case 3 - On Ship, Stack Ht = 19.7 ft (above ship deck)	Results at 1 lb/hr[1]	Benzene Results at 1-Hr Averages	n-Hexane Results at 1-Hr Averages	Xylenes Results at 1-Hr Averages	1,2,4 - Trimethylbenzene Results at 1-Hr Averages	Ethylbenzene Results at 1-Hr Averages	Toluene Results at 1-Hr Averages	Isooctane Results at 1-Hr Averages	Hydrogen Sulfide Results at 1-Hr Averages
Case 3 - receptor ht ground level (on ship)	229	2,455	2,668	464.87	41.22	169.46	1,186	210.68	4.58
	OSHA Limits	**1 ppm**	**500 ppm**	**100 ppm**	**25 ppm**	**100 ppm**	**200 ppm**	**500 ppm**	**10 ppm**
		3,195 ug/m^3	**1,762,372 ug/m^3**	**434,192 ug/m^3**	**122,894 ug/m^3**	**434,233 ug/m^3**	**753,701 ug/m^3**	**2,336,033 ug/m^3**	**13,939 ug/m^3**

[1]Receptors placed at 1 meter to 65 meters from the stack in 5 meter increments. Maximum concentration occurred at the 55 meter receptor.

Appendix A

LOOP Marine Terminal
Loading Loss Emissions Calculation

Reference:
AP-42, Section 5.2 Transportation And Marketing Of Petroleum Liquids
Equation 2
Loading Loss: $C_L = C_A + C_G$

Calculated Laoding Loss (lb VOC/Mgal)

C_L = Loading Loss, lb/Mgal crude oil loaded	**C_L =**	**1.100**	**Uncleaned** <-- Selected
C_A = Arrival emission factor, contributed by vapors in the empty hold before loading, lb/Mgal		0.760	Ballasted
C_G = Generated emission factor, contributed by evaporation during loading, lb/Mgal loaded		0.650	Cleaned/Gas-free

CA Factor	Hold Condition
0.86	Uncleaned
0.46	Ballasted
0.33	Cleaned/Gas-free

VLCC Loaded/yr =	12	
VLCC Capacity =	2,000,000	Bbls
Barrels Loaded =	24,000,000	Bbls/yr
Maximum short-term loading rate =	40,000	Bbls/hr

Equation 3

$C_G = 1.84(0.44P-0.42)MG/T$

Use the AP-42 emission factor developed based on loading of a previously "uncleaned" ship/barge.
This approach was concurred with by Rob Ferry based on the operational description.

P = True vapor pressure of loaded crude oil, psia =	6.514
M = Molecular weight of vapors, lb/lb-mole =	50
G = Vapor growth factor = 1.02	1.02
T = Temp of vapors, R =	528.08
Assumed weight percentage that is VOC =	85%

Calculated Annual Emissions =	554.64	tons/yr
Calculated Maximum Hourly Emissions =	1,848.81	lb/hr

All values per TANKS4.09 for RVP8 Crude as used in the Clovelly Farm emissions basis
Factors and formulas from AP-42 are for TOC, assume 85% is VOC per AP-42 guidance.

	Wt Fraction	**lb/hr**	**TPY**
Benzene	0.0058	10.72	3.22
n-hexane	0.0063	11.65	3.49
xylenes	0.0011	2.03	0.61
1,2,4 TMB	0.0001	0.18	0.06
ethylbenzene	0.0004	0.74	0.22
toluene	0.0028	5.18	1.55
isooctane	0.0005	0.92	0.28

Hydrogen sulfide: <1 ppmv concentration
62.39 ft^3/sec flow rate or 3743 ft^3/min

(3743 ft^3/min)(1/1,000,000)(60 sec/min)(34 lb/lb-mol)/(379 ft^3/lb-mol) = 0.02 lb/hr