SECTION 4.8

MARINE PETROLEUM LOADING TANKERS & BARGES

(Revised June 1989; Reissued October 1997)

EMISSION INVENTORY SOURCE CATEGORY

Petroleum Production and Marketing/Marine Petroleum Loading

EMISSION INVENTORY CODES (CES CODES) AND DESCRIPTION

330-366-1100-0000 (46581) Tanker Loading - Gasoline

330-366-1400-0000 (46599) Tanker Loading - Jet Fuel

330-366-1500-0000 (83048) Tanker Loading - Residual Oil

330-366-1600-0000 (46573) Tanker Loading - Crude Oil

330-368-1100-0000 (46631) Barge Loading - Gasoline

METHODS AND SOURCES

These categories are used to inventory the hydrocarbon emissions associated with loading crude oil, residual oil, gasoline, and jet fuel into marine tankers and gasoline into barges.

The evaporative hydrocarbon emissions from loading operations of marine vessels result from the displacement of organic vapors in the cargo tanks when they are loaded with gasoline, crude oil, residual oil, jet fuel, or other petroleum products. The organic vapors displaced from a cargo tank consist of the vapors in the tank before loading and the vapors generated in the tank as the new product is being loaded.

The emission factors for loading operations of marine vessels are listed in Table I. The emission factor for crude oil loading is obtained from a 1977 Western Oil and Gas Association (WOGA) study. [1] The emission factors for loading gasoline into tankers and barges and jet fuel into tankers are obtained from an ARB study. [2] The emission factor for loading residual oil is from a 1980 study by Scott Environmental Technology, Inc. [3]

Table I: Emission Factors for Loading of Petroleum Products to Marine Vessels

Operation	Emission lb/1000 gallons loaded	Source of Emission Factor
Crude Oil Loading (tankers)	1.0	WOGA study
Gasoline Loading (tankers)	1.8	ARB study
Jet Fuel Loading (tankers)	0.8	ARB study
Gasoline Loading (barges)	3.4	ARB study
Residual Fuel	0.3	Scott study

In "Waterborne Commerce of the United States," the U.S. Army Corps of Engineers provides the amounts of crude oil, gasoline, jet fuel, and residual oil shipped from California Ports in 1986. The ARB staff developed ratios based on the 1986 and 1987 California Energy Commission data, and then applied these ratios to the 1986 Army Corps of Engineers data.

Table II: Conversion to 1987 from 1986 data

Crude Oil Tanker	96.56%
Jet Fuel Tanker	45.70%
Motor Gasoline Barge	133.33%
Motor Gasoline Tanker	102.30%
Residual Oil Tanker	92.81%

The conversion of tons loaded to 1000-gal loaded are based on densities found in Table III.

Table III: Densities of Fuels

Crude Oil	7.4 lb/gal
Gasoline	6.2 lb/gal
Jet Fuel	6.4 lb/gal
Residual Fuel	8.0 lb/gal

ASSUMPTIONS

1. The 1986 Waterborne Commerce data are representative of the amounts of crude oil, gasoline, and jet fuel loaded into marine vessels in California ports in 1986.

2. The ratio of the 1987 Energy Commission data to the 1986 data are representative of the true growth of the amounts of crude oil, gasoline, residual oil, and jet fuel loaded into marine vessels in California ports in 1987.

3. Based on a survey of oil companies and marine operators conducted by ARB's Stationary Source Division, the following was assumed:

   a. In the Los Angeles/Long Beach harbors, all gasoline is loaded into tankers; and in the Bay Area, 64 percent of the gasoline is loaded into tankers; and 36 percent into barges.

   b. All crude oil, residual oil, and jet fuel is loaded into tankers.

COMMENTS AND RECOMMENDATIONS

If the local air pollution control districts have 1987district data, they should be evaluated for incorporation into the 1987 inventory.

CHANGES IN METHODOLOGY

Estimates of tanker loading and barge loading in the 1987 inventory are based upon 1986 Waterborne Commerce data. The 1986 data were updated to 1987 based on the Energy Commission of energy data. The only difference between 1983 and 1987 emission estimates is based on the different activity found in the 1986 Waterborne Commerce data and the 1987 Energy Commission data.

DIFFERENCES BETWEEN THE 1983 AND 1987 EMISSION ESTIMATES

The emissions from crude oil loading of tankers decrease statewide from 1983 to 1987. The emissions from gasoline loading of tankers increase statewide from 1983 to 1987. The emissions from jet fuel loading of tankers increase from 1983 to 1987. The emissions from gasoline loading of barges increase statewide from 1983 to 1987. The emissions from residual oil loading of tankers decrease statewide from 1983 to 1987.

TEMPORAL ACTIVITY

The annual, weekly, and daily activities were estimated by the ARB staff to be uniform.

SAMPLE CALCULATIONS

Gasoline loading emissions to ***tankers and barges*** in Contra Costa County in 1987:

Gallons of gasoline loaded in Contra Costa County: (tankers and barges)

$$= (\text{short tons of gasoline loaded in 1986}) \times \frac{2000 \text{ lb/ton}}{6.2 \text{ lb/gal}}$$

$$= (1{,}519{,}237 \frac{\text{tons}}{\text{year}}) \times (322.6 \frac{\text{gallons}}{\text{ton}})$$

$$= 490{,}105.9 \times 10^3 \text{ gallons} \frac{\text{loaded}}{\text{year}} \text{ for 1986}$$

Emissions from gasoline loaded to tankers:

$$= (490{,}105.9 \times 10^3 \frac{\text{gallons}}{\text{year}}) \times (64\% \text{ of gasoline is loaded on tankers}) \times (\text{Emission Factor})$$

$$\times (1986 \text{ to } 1987 \text{ conversion})$$

$$= (490{,}105.9 \times 10^3 \frac{\text{gallons}}{\text{year}}) \times (.64) \times (\frac{1.8 \text{ pounds}}{10^3 \text{ gallons}}) \times (\frac{1 \text{ ton}}{2000 \text{ lbs}}) \times (102.30\%)$$

$$= 288.8 \frac{\text{tons}}{\text{year}}$$

Emissions from gasoline loaded to barges:

$$= (490{,}105.9 \times 10^3 \frac{\text{gallons}}{\text{year}}) \times (36\% \text{ of the gasoline is loaded to barges}) \times (\text{Emission Factor})$$

$$\times (1986 \text{ to } 1987 \text{ conversion})$$

$$= (490{,}105.9 \times 10^3 \frac{\text{gallons}}{\text{year}}) \times (.36) \times (\frac{3.4 \text{ pounds}}{10^3 \text{ gallons}}) \times (\frac{1 \text{ ton}}{2000 \text{ lb}}) \times (133.33\%)$$

$$= 399.9 \frac{\text{tons}}{\text{year}}$$

REFERENCES

1. Western Oil and Gas Association, Hydrocarbon Emissions During Marine Loading of Crude Oils (August 1977).

2. Air Resources Board, State of California, Report to the Legislature on Air Pollutant Emissions from Marine Vessels (June 1984).

3. Scott Environmental Technology, Inc., Inventory of Emissions from Marine Operations Within the California Coastal Waters, Preliminary Draft (November 1980).

4. United States Army Corps of Engineers, Waterborne Commerce of the United States, Calendar Year 1986. Part 4 (1986).

5. California Energy Commission, Quarterly Oil Report - Second Quarter 1987 (September 1987).

6. California Energy Commission, Quarterly Oil Report - Second Quarter 1988 (September 1988).

7. Dale Rodman, California Energy Commission, "California Petroleum Product Shipments of Major Marketers by Transportation Method." (April, 1989).

8. Stone & Webster, Relative Energy Data.

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Table IV
1987 Area Source Emissions
Activity: Petroleum & Gas Marketing
Process: Marine Vessels
Entrainment: Crude Petro-Evap
Dimn: Loading Tankers
CES: 46573
Process Rate Unit: 1000 Gallons Capacity

AB	County	Process Rate	TOG Emis. (Tons / Year)	CO Emis. (Tons / Year)	NOX Emis. (Tons / Year)	SOX Emis. (Tons / Year)	PM Emis. (Tons / Year)
SC	LOS ANGELES	24437	12.20	0.00	0.00	0.00	0.00
SCC	SAN LUIS OBISPO	63751	31.90	0.00	0.00	0.00	0.00
SF	CONTRA COSTA	5449	2.70	0.00	0.00	0.00	0.00
	SOLANO	122478	61.20	0.00	0.00	0.00	0.00
TOTAL		216115	108.00	0.00	0.00	0.00	0.00

Fraction of Reactive Organic Gases (FROG): .9120
(Reactive Organic Gases (ROG) Emissions = TOG X FROG)
Fraction of PM10 (FRPM10): .9600
(PM10 Emissions = PM X FRPM10)

Table V
1987 Area Source Emissions
Activity: Petroleum & Gas Marketing
Process: Marine Vessels
Entrainment: Gasoline-Evap
Dimn: Loading Tankers
CES: 46581
Process Rate Unit: 1000 Gallons Capacity

AB	County	Process Rate	TOG Emis. (Tons / Year)	CO Emis. (Tons / Year)	NOX Emis. (Tons / Year)	SOX Emis. (Tons / Year)	PM Emis. (Tons / Year)
SC	LOS ANGELES	146424	131.80	0.00	0.00	0.00	0.00
SF	ALAMEDA	722	0.60	0.00	0.00	0.00	0.00
	CONTRA COSTA	320882	288.80	0.00	0.00	0.00	0.00
	SOLANO	131738	118.60	0.00	0.00	0.00	0.00
TOTAL		599766	539.80	0.00	0.00	0.00	0.00

Fraction of Reactive Organic Gases (FROG): .9720
(Reactive Organic Gases (ROG) Emissions = TOG X FROG)
Fraction of PM10 (FRPM10): .9600
(PM10 Emissions = PM X FRPM10)

Table VI
1987 Area Source Emissions
Activity: Petroleum & Gas Marketing
Process: Marine Vessels
Entrainment: Jet Fuel-Evap
Dimn: Loading Tankers
CES: 46599
Process Rate Unit: 1000 Gallons Capacity

AB	County	Process Rate	TOG Emis. (Tons / Year)	CO Emis. (Tons / Year)	NOX Emis. (Tons / Year)	SOX Emis. (Tons / Year)	PM Emis. (Tons / Year)
SC	LOS ANGELES	15288	6.10	0.00	0.00	0.00	0.00
SF	CONTRA COSTA	73350	29.30	0.00	0.00	0.00	0.00
	SOLANO	185	0.10	0.00	0.00	0.00	0.00
TOTAL		88823	35.50	0.00	0.00	0.00	0.00

Fraction of Reactive Organic Gases (FROG): 1.0000
(Reactive Organic Gases (ROG) Emissions = TOG X FROG)
Fraction of PM10 (FRPM10): .9600
(PM10 Emissions = PM X FRPM10)

Table VII
1987 Area Source Emissions
Activity: Petroleum & Gas Marketing
Process: Marine Vessels
Entrainment: Gasoline-Evap
Dimn: Loading Barges
CES: 46631
Process Rate Unit: 1000 Gallons Capacity

AB	County	Process Rate	TOG Emis. (Tons / Year)	CO Emis. (Tons / Year)	NOX Emis. (Tons / Year)	SOX Emis. (Tons / Year)	PM Emis. (Tons / Year)
SF	ALAMEDA	529	0.90	0.00	0.00	0.00	0.00
	CONTRA COSTA	235245	399.00	0.00	0.00	0.00	0.00
	SOLANO	96579	164.00	0.00	0.00	0.00	0.00
TOTAL		332353	563.90	0.00	0.00	0.00	0.00

Fraction of Reactive Organic Gases (FROG): .9720
(Reactive Organic Gases (ROG) Emissions = TOG X FROG)
Fraction of PM10 (FRPM10): .9600
(PM10 Emissions = PM X FRPM10)

Table VIII
1987 Area Source Emissions
Activity: Petroleum & Gas Marketing
Process: Marine Vessels
Entrainment: Residual Oil-Evap
Dimn: Loading Tankers
CES: 83048
Process Rate Unit: 1000 Gallons Capacity

AB	County	Process Rate	TOG Emis. (Tons / Year)	CO Emis. (Tons / Year)	NOX Emis. (Tons / Year)	SOX Emis. (Tons / Year)	PM Emis. (Tons / Year)
SC	LOS ANGELES	1850489	277.60	0.00	0.00	0.00	0.00
SD	SAN DIEGO	1537	0.20	0.00	0.00	0.00	0.00
SF	CONTRA COSTA	1360834	204.10	0.00	0.00	0.00	0.00
	SAN FRANCISCO	941	0.10	0.00	0.00	0.00	0.00
	SOLANO	53642	8.00	0.00	0.00	0.00	0.00
TOTAL		3267443	490.00	0.00	0.00	0.00	0.00

Fraction of Reactive Organic Gases (FROG): .9580
(Reactive Organic Gases (ROG) Emissions = TOG X FROG)
Fraction of PM10 (FRPM10): .9600
(PM10 Emissions = PM X FRPM10)