SECTION 4.9

MARINE PETROLEUM UNLOADING

(Revised May 1989; Reissued October 1997)

EMISSION INVENTORY SOURCE CATEGORY
 Petroleum Production and Marketing/Marine Petroleum Unloading

EMISSION INVENTORY CODES (CES CODES) AND DESCRIPTION
 330-370-1600-0000 (46714) Lightering - Crude Petroleum

 330-372-1100-0000 (46730) Ballasting - Gasoline

 330-372-1600-0000 (46722) Ballasting - Crude Petroleum

METHODS AND SOURCES

These categories are used to inventory the hydrocarbon emissions associated with lightering crude oil and ballasting marine vessels after unloading crude oil or gasoline.

The evaporative hydrocarbon emissions from unloading operations of marine vessels result from the displacement of organic vapors in the cargo tanks. Following cargo discharge, tankers must take on water ballast to obtain proper propeller, rudder, and hull submersion and to minimize hull stress. When the ballast water is taken into the cargo tanks that contain organic vapors, those vapors are displaced into the atmosphere. Emissions from ballasting are dependent solely on the vapor concentration within the tank or tanks that are ballasted. [1]

Lightering is the transfer of cargo from one marine vessel to another. Such an operation is usually carried out when a large incoming vessel has too great a draft to enter a port or to unload at a terminal. The large "parent" vessel transfers part of its cargo to a smaller "lighter" vessel until the parent vessel has been sufficiently lightened to dock at a port or moor at a terminal. Lightering operations conducted in and near ports in California are usually transfers of crude oil from large tankers to smaller tankers or barges. The physical parameters which affect the magnitude of lightering emissions are the same as those which affect loading emissions because lightering is a specialized form of loading in which the parent vessel acts as a terminal. [1]

The emission factor for crude oil lightering is the same as for loading and is obtained from a 1977 Western Oil and Gas Association (WOGA) study. [2] The emission factor for ballasting

4.9-1

crude oil and gasoline vessels is from a 1981 study by Scott Environmental Technology Inc. [3] Table I contains the emission factors for unloading of petroleum products from marine vessels.

Table I

Emission Factors for Unloading of Petroleum Products from Marine Vessels

Operation	Emission Factor lb/1000 gallons	Source of Emission Factor
Crude Oil Ballasting	0.9	Scott study
Gasoline Ballasting	1.8	Scott study
Crude Oil Lightering	1.0	WOGA study

The amounts of crude oil and gasoline unloaded at California ports are reported in a United States Army Corps of Engineers publication, "Waterborne Commerce of the United States," 1986, Part 4. [4] The 1986 edition of Waterborne Commerce was used since the 1987 edition was not yet published at the time this document was prepared. Crude oil lightering data were collected from the Bay Area AQMD for 1987. [5] San Luis Obispo data for crude oil and gasoline ballasting were obtained for 1987 from the Army Corps of Engineers by phone. [6]

The 1986 data were updated to 1987 data based on information from the Energy Commission. The 1986 values for the import of Alaskan and Foreign oil were compared to 1987 values. Based on these comparisons, crude oil ballasting was converted to 1987 values. The Energy Commission made a 1987 update to their table of "California Petroleum Product Shipments of Major Marketers by Transportation Method" and these data were used to convert 1986 gasoline ballasting data to 1987 data as shown in Table II and Table III. [7,8]

Table II

Convertion to 1987 from 1986 Crude Oil Unloading Data

	1986 millions of barrels	1987 millions of barrels	1986 to 1987 Ratio
Alaskan	237.508	257.934	-
Foreign	36.877	33.395	-
Total	274.385	291.329	106.2%

Table III

Conversion to 1987 from 1986 Gasoline Unloading Data [7,8]

	1986 thousands of barrels	1987 thousands of barrels	1986 to 1987 Ratio
Domestic Import	8,014	13,698	-
Foreign Import	1,232	1,810	-
Total	9,246	15,508	167.7%

The conversion of tons unloaded to 1000-gallon unloaded is based on densities found in Table IV.

Table IV

Densities of Fuels

Crude Oil	7.4 lb/gal
Gasoline	6.2 lb/gal

ASSUMPTIONS

1 . The 1986 Waterborne Commerce data are representative of the amounts of crude oil and gasoline unloaded form marine vessels in California ports in 1986.

2. The ratios of the 1987 Energy Commission data to the 1986 data are representative of the true growth of the amounts of crude oil and gasoline unloaded from marine vessels at California ports in 1987.

3. The 1987 data on crude oil lightering supplied by the Bay Area AQMD accurately represents the amount of lightering done in the Bay Area AQMD.

4. Following cargo discharge, tankers must take on water ballast (17% for crude oil and 21% for gasoline). [1]

5. The amounts of unleaded gasoline imported are characteristic of the amounts of all gasoline imported to California.

COMMENTS AND RECOMMENDATIONS

A more accurate emission estimate could have been made using the 1987 Waterborne Commerce data if the data were available.

CHANGES IN METHODOLOGY

Estimates of crude oil and gasoline ballasting were based upon 1986 Waterborne Commerce data in the 1987 inventory. The 1986 data was updated to 1987 based on the Energy Commission data. The only difference between the 1983 Waterborne Commerce and 1987 Waterborne Commerce emission estimates is that the 1983 Waterborne Commerce data was used in 1983 and the 1986 Waterborne Commerce data was used in 1987. The 1986 and 1987 Energy Commission data were used to convert 1986 data to 1987.

DIFFERENCES BETWEEN THE 1983 AND 1987 EMISSION ESTIMATES

The emissions from lightering went down statewide from 1983 to 1987. The emissions from crude petroleum ballasting went down statewide from 1983 to 1987. The emissions from gasoline ballasting went up 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 ballasting in San Diego in 1987:

Gallons of gasoline unloaded in San Diego:

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

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

$$= \text{(14,541 tons/yr)} \times 322.6 \text{ gallons/ton} \times 167.7\%$$

$$= 7,866.7 \times 10^3 \text{ gallons unloaded/year for 1987}$$

Gallons of water ballasted during unloading operations:

       = (gallons unloaded/yr for 1987) x 21% ballasted

       = $7,866.7 \times 10^3$ gallons unloaded/yr for 1987 x 21% ballasted

       = $1,652 \times 10^3$ gallons ballasted/yr for 1987

Emissions from ballasting during gasoline unloading operations:

       = $1,652 \times 10^3$ gallons ballasted/yr x 1.8 lb/10^3 gallon x 1 ton/2000 lb

       = 1.5 tons/yr

REFERENCES

1. Air Resources Board, State of California, <u>Report to the Legislature on Air Pollutant Emissions from Marine Vessels</u> (June 1984).

2. Western Oil and Gas Association, <u>Hydrocarbon Emissions During Marine Loading of Crude Oils</u> (August 1977).

3. Scott Environmental Technology, Inc., <u>Inventory of Emissions from Marine Operations within the California Coastal Waters</u> (June 1981).

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

5. Karas, J., Bay Area AQMD, San Francisco, CA (415) 771-6000.

6. Cook, P., U.S. Army Corp. of Engineers, New Orleans, Louisiana (504) 862-1440.

7. California Energy Commission, <u>Quarterly Oil Report - Second Quarter 1987</u> (September 1987).

8. California Energy Commission, <u>Quarterly Oil Report - Second Quarter 1988</u> (September 1988).

9. Stone & Webster, <u>Relative Energy Data</u>.

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Table V
1987 Area Source Emissions
Activity: Petroleum & Gas Marketing
Process: Marine Vessels
Entrainment: Crude Petro-Evap
Dimn: Lightering
CES: 46714
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	SAN FRANCISCO	1115000	557.50	0.00	0.00	0.00	0.00
TOTAL		1115000	557.50	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)

4.9-7

Table VI
1987 Area Source Emissions
Activity: Petroleum & Gas Marketing
Process: Marine Vessels
Entrainment: Crude Petro-Evap
Dimn: Ballasting
CES: 46722
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	1038410	467.30	0.00	0.00	0.00	0.00
SCC	SAN LUIS OBISPO	0	0.00	0.00	0.00	0.00	0.00
SD	SAN DIEGO	1887	0.80	0.00	0.00	0.00	0.00
SF	CONTRA COSTA	495339	223.01	0.00	0.00	0.00	0.00
	SOLANO	11956	5.47	0.00	0.00	0.00	0.00
TOTAL		1547592	696.58	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)

4.9-8

Table VII
Draft 1987 Area Source Emissions
Activity: Petroleum & Gas Marketing
Process: Marine Vessels
Entrainment: Gasoline-Evap
Dimn: Ballasting
CES: 46730
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	351004	315.90	0.00	0.00	0.00	0.00
SCC	SAN LUIS OBISPO	5742	5.20	0.00	0.00	0.00	0.00
SD	SAN DIEGO	1652	1.50	0.00	0.00	0.00	0.00
SF	ALAMEDA	3623	3.30	0.00	0.00	0.00	0.00
	CONTRA COSTA	163680	147.30	0.00	0.00	0.00	0.00
	SAN FRANCISCO	17583	15.80	0.00	0.00	0.00	0.00
	SOLANO	1663	1.50	0.00	0.00	0.00	0.00
TOTAL		544947	490.5	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)