OFFROAD MODELING CHANGE TECNINICAL MEMO

SUBJECT: DEVELOPMENT OF EMISSIONS INVENTORY FOR THE OUTBOARD MARINE TANKS AND COMPONENTS

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EXECUTIVE SUMMARY

Evaporative emissions inventory from outboard marine tank (OMT) in California was developed in support of the OMT certification, performance standards, and test procedures regulations adopted in 2008. A survey on OMT was conducted in 2006 to estimate population and usage information in California. The survey results were used to estimate the statewide OMT population, and gain a better understanding of typical usage and storage practices.

In addition, ARB in-house testing was performed to determine OMT emission rates for various emission modes (e.g., diurnals, permeations, liquid leaking) that occur during typical usage. Survey results of population and usage were analyzed and combined with the emission test results to produce the OMT emissions inventory. This inventory is used to estimate past and future OMT emissions to support air quality planning and modeling.

Table ES-1 shows the OMT emission inventory summary in tons-per-day (tpd) in California in recent years. This emission inventory reflects the most recent OMT regulation the board adopted in September 2008.

- The statewide OMT emissions population shows a decreasing trend (see Figure ES-1). This is due to the decreasing pleasure craft population based on DMV registration.

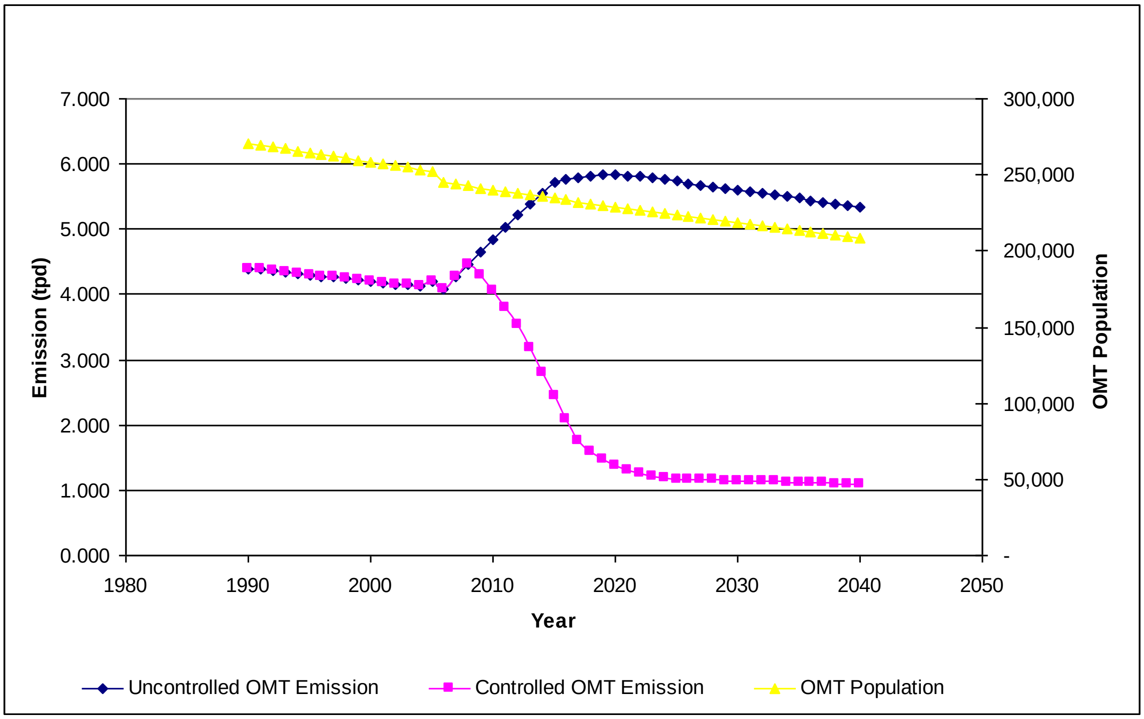
- The use of reformulated gasoline III (RGF III, with ethanol as oxygenate) results in more permeation and diurnal emissions from plastic OMT that than reformulated gasoline II (RFG II, with methyle-tertiary-butyl-ether, or MTBE). This causes an increase in OMT evaporative emissions in year 2005 when RFG II was being phased out.

- A detailed OMT emission inventory is listed in Appendix A.

Table ES-1. Summary of the California OMT Emission Inventory (ROG in tpd).

	Population				Emission
Year	Outboard	Sail Only	Auxiliary and Sail	Total	(tpd ROG)
2000	235,991	20,562	1,926	258,479	4.20
2001	235,000	20,355	1,907	257,262	4.18
2002	234,009	20,148	1,887	256,045	4.16
2003	233,018	19,941	1,868	254,828	4.14
2004	232,027	19,735	1,849	253,610	4.12
2005	231,036	19,528	1,829	252,393	4.21
2006	225,225	17,990	1,685	244,900	4.08
2007	224,309	17,752	1,663	243,724	4.26
2008	223,397	17,518	1,641	242,556	4.46
2009	222,488	17,287	1,619	241,395	4.66
2010	221,584	17,059	1,598	240,240	4.83
2011	220,683	16,833	1,577	239,093	5.02
2012	219,785	16,611	1,556	237,952	5.21
2013	218,891	16,392	1,536	236,819	5.38
2014	218,001	16,176	1,515	235,692	5.55
2015	217,115	15,962	1,495	234,572	5.72
2016	216,232	15,751	1,476	233,459	5.77
2017	215,352	15,544	1,456	232,352	5.80
2018	214,476	15,338	1,437	231,252	5.82
2019	213,604	15,136	1,418	230,158	5.83
2020	212,736	14,936	1,399	229,071	5.83
2021	211,871	14,739	1,381	227,990	5.82
2022	211,009	14,545	1,363	226,916	5.81
2023	210,151	14,353	1,345	225,848	5.79
2024	209,296	14,163	1,327	224,786	5.76
2025	208,445	13,976	1,309	223,731	5.73
2026	207,598	13,792	1,292	222,681	5.71
2027	206,753	13,610	1,275	221,638	5.68
2028	205,913	13,430	1,258	220,601	5.65
2029	205,075	13,253	1,242	219,570	5.63
2030	204,241	13,078	1,225	218,544	5.60
2031	203,411	12,905	1,209	217,525	5.57
2032	202,584	12,735	1,193	216,512	5.55
2033	201,760	12,567	1,177	215,504	5.52
2034	200,939	12,401	1,162	214,502	5.50
2035	200,122	12,237	1,146	213,506	5.47
2036	199,309	12,076	1,131	212,516	5.44
2037	198,498	11,916	1,116	211,531	5.42
2038	197,691	11,759	1,102	210,552	5.39
2039	196,887	11,604	1,087	209,578	5.37
2040	196,087	11,451	1,073	208,610	5.34

Figure ES-1. The Trend of OMT Emissions in California



BACKGROUND

OMT are gasoline tanks with capacity of 30 gallons or less and the accompanying fuel hoses, primer bulbs and tank caps used on various sized boats. For small and medium size boats the gasoline tanks and engines are portable to facilitate transportation, maintenance and storage. Portable outboard engines do not have a fuel pump so the primer bulb is used to prime (transfer gasoline from the tank to the engine through the fuel hose) the engine to ensure it will start. ROG emissions from OMTs come from evaporation and spillage. Even though the emissions from a single OMT are small, over 200,000 OMTs are used in California so the overall emissions are noticeable.

OMT emissions are classified by four emission processes.

- Diurnal emissions result when stored fuel vapors escape to the outside of a gas tank through any possible opening while the tank is subjected to daily changes of ambient temperature.

- Permeation emissions are produced after fuel has been stored enough in a plastic gas tank for a long period of time such that fuel molecules saturated and infiltrated hose assembly (primer bulb and fuel hose).

- Liquid fuel leakage occurs when fuel is leaked from container due to poor manufacturer practice and/or low quality materials used for OMT.

- From survey results, 3% of the OMT that stored with fuel do not have fill caps. Thus these group of containers has significantly higher diurnal emissions than the average OMT.

The OMT inventory is further sub-classified by the specific can materials (metal or plastic). OMT population also varies based on the application on different type of boats (sail only, sail and auxiliary, outboard boats). Due to safety issues, metal OMT is no longer produced since 2006. The phasing out of metal tanks has been taken into consideration of the emissions inventory. Fuel correction factor for RFG II and RFG III are also included. Seasonal corrections for annual, summer, winter and summer ozone are not included for temperature dependent emissions processes due to lack of information.

SURVEYS

In 2006, in collaboration with ARB staff, an OMT information phone survey was conducted by the Institute for Social Research of Cal State University of Sacramento (CSUS). Interviewees were selected from the 2005 DMV pleasure craft registration. The sample was a random digit sample for California and included household's listed in telephone directories and those with unlisted or non-published numbers. The majority of the telephone interviews were conducted between January 25, 2007 and February 7, 2007. In order to offset non-response bias in some of the more urban counties and to provide an adequate number of interviews, additional interviews were conducted with household in Los Angeles, Orange, Riverside, San Bernardino, San Diego, and San Francisco counties so that the response ratio is sync with DMV pleasure craft registration of each county.

For detailed survey results and input factors that used to develop OMT emission inventory, please refer to: *Analysis of the 2007 California Survey of Outboard and Sailboat Owners Regarding Use of Portable Outboard MarineTanks* (http://www.arb.ca.gov/regact/2008/omt2008/omtappe.pdf)

The analysis of the survey was based on 1,683 telephone interviews. The survey response rate was 64% phone interviews. Most interviews (97%) were conducted with the registered owner of the boat. Three percent of the interviews were conducted with another person who use the boat. Eighteen respondents who were not sure whether the boat uses an OMT were dropped from the analysis.

METHODOLOGY

OMT emissions are a function of the can material (I.e., plastic or metal) and the storage conditions. OMT are stored in either an "open" or "closed: condition. An open condition, or system, exists when a tank is stored with an open breathing (vent) hole and/or an uncapped main-filler opening or nozzle. A closed system exist when the vent hole is closed and the main-filler opening or spout is capped. In general, a metal can produce less permeation emissions than a plastic can. However, traditional metal tanks have been stopped be produced due to its potential risk in case of fire break out on a boat.

OMT population is divided to sail only, sail and auxiliary, outboard based on their application and activity. Tanks types are subdivided into metal tanks and plastics tanks.

Depending on population and emission process (i.e., diurnal, permeation, liquid leakage), total emissions can be calculated for each type of can.

The OMT emission inventory at any given year can be expressed as the following equation:

$$\textbf{OMT Emission} = \sum_{i,j} (\textbf{population of different type of cans}_i * \textbf{different types of emissions}_j) \quad \text{(Eq. 1)}$$

Where

i= metal tanks, plastic tanks
j= diurnal, permeation, liquid fuel leakage

INPUT FACTORS

The OMT emission inventory is constructed with six major input factors:

- Population and growth: the population of OMTs in any given year is calculated through the use of growth factors. The OMT inventory uses corresponding population growth rate for pleasure craft category in OFFROAD2007.

- Age distribution and survival rates (scrappage): age distribution and survival rates are static function of OMT age and usage.

- Emission factors and formulas, there are four types of emission types depending on the emission process.

- Allocation Factors: The OMT emission inventory model distributes the statewide OMT population and emissions to specific county/air basin/air district according to sets DMV registration information and survey data.

- Seasonal Temperature corrections factors: temperature correction factors are not applied to the inventory due to lack of information.

- Fuel correction factors: Fuel correction factors are applied to describe the evaporative emission difference between RFG II and RFG III.

Population and Growth

The OMT emission inventory uses calendar year 2006 as the baseline year for the calculation. As a result, growth rate calculation is normalized to 2006. In OMT inventory, population is subdivided into sail only, sail and auxiliary, outboard based on the difference in usage. Because their growth rates are different, three sets of growth rate are applied to them, respectively.

A. Population

OMT population is a function of boat population, percent of boats has OMT, and the average OMT per boat

Statewide OMT Population
= boat populations * % of boat have OMT * average OMT / boat
(Eq. 2)

Table 1 below shows the survey response statistics. Baseline year 2006's OMT population is therefore calculated.

Table 1. Baseline year OMT population

Year 2006 Survey				
Baseline Year 2006	**Boat Population**	**% of Boat have OMT**	**Average OMT/boat**	**OMT Population**
Outboard	267,786	64%	1.31	**225,225**
Sail Only	19,421	56%	1.67	**17,990**
Auxiliary and Sail	1,926	88%	1.00	**1,685**

B. Growth Factors

Growth factors for OMT used for outboard, sail only, auxiliary and sail are same as the corresponding growth factors used for pleasure crafts equipments in OFFROAD2007.

Survival Rate (Scrappage) and Age Distribution

The OMT emission inventory model estimates future year tank populations as the sum-scrappage for all years up the calendar year of interest. Future year sales are derived from growth rates applied to the base year's tank population, and scrappage is a static function of tank's age and use.

OFFROAD2007 applies a survival rate function to its base year equipment populations to determine the expected equipment population in future years. OMT emission inventory model applies a similar function to arrive at its population estimates.

The survey results from 2006 shows that the metal/plastic tanks ratio is 0.55/0.45. Major OMT manufactures also confirm that no new metal OMT tanks have been produced sine 2006. In addition, the outboard boat sales have been decreasing steadily over the years. Since metal tank's median useful life is 9 years, staff uses the exponential function to derive the metal cans scrappage rate.

In order to estimate the population percentage of regulated tanks that are introduced to the market every year, the survival rate and age distribution for each type of tanks need to be calculated. From the CSUS survey, the useful life for plastic OMT is 9 years, while for hose assembly the useful life is 7 years. Table 2 below lists the age distribution and survival rate values for equipment ages15 and 18. These are standard values used in OFFROAD 2007.

Table 2. Survival Rate and Age Distribution Information

Survival rate																				
	Life	**Age 0**	**Age 1**	**Age 2**	**Age 3**	**Age 4**	**Age 5**	**Age 6**	**Age 7**	**Age 8**	**Age 9**	**Age 10**	**Age 11**	**Age 12**	**Age 13**	**Age 14**	**Age 15**	**Age 16**	**A 17**	**Age 18**
Hose	**15**	0.99	0.97	0.96	0.96	0.96	0.93	0.90	0.40	0.72	0.72	0.74	0.65	0.53	0.31	0.00	0.00	0.00	0.00	0.00
OMT	**18**	0.99	0.98	0.97	0.98	0.97	0.96	0.95	0.95	0.90	0.42	0.74	0.83	0.77	0.77	0.71	0.64	0.60	0.33	0.00
Age Distribution																				
Hose	**15**	0.17	0.16	0.15	0.13	0.12	0.07	0.10	0.04	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OMT	**18**	0.14	0.12	0.11	0.11	0.11	0.08	0.10	0.09	0.07	0.03	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00

Baseline Model Year Distribution

The model year OMT distribution is calculated based on the data shown in Table 2, which is the numerical representation of the survival curve for OMT with expected median useful lives of 7 to 9 years. Since OMT last as long as twice the expected life, 15 and 18 model years have to be accounted for. First, the OMT faction remaining in use is summed over the period covering two times the expected OMT life. This sum is surrogated for the total number of pieces of OMT sold in the years leading up the current year, and is referred to as the sales population surrogate. Appendix B shows a sample baseline model year distribution calculation for OMTs.

Emission Processes: Factors and Formulas

As mentioned earlier, OMT emissions consist of the following four emission processes. The overall emission inventory sums all emissions from the four different emission processes. Appendix C shows emission factors for the various emission processes and its regulation timeline.

A. Diurnal

Diurnal emissions result when stored fuel vapors escape to the outside of a tank through any possible opening while the tank is subjected to the daily cycle of ambient temperature changes. Diurnal emissions are dependent on the closed- or open- storage condition of a tank. Accordingly, emission rates were determined for both conditions.

Diurnal emissions for both open-and closed system tanks are calculated as follows:

Diurnal emissions
= Population of the tank
*emission factor with respect type of tanks' condition and material (EFD)
*percent of tanks stored with fuel
*percentage of tanks with respect to storage condition and material (BR)
*weight average capacity of tanks (only for closed system)
*weight average amount fuel stored (only for closed system)

BR values

BR	Metal	Plastic
Closed	75.400%	75.400%
Open	24.600%	24.600%

EFD values

Weighted Percentage for Metal and Plastic					
			Gal		
Metal	1-5 gallon	28.00%	3	50.91%	1.53
	6 gallon	22.70%	6	41.27%	2.48
	7-10 gallon	2.70%	8.5	4.91%	0.42
	11-15 gallon	0.80%	13	1.45%	0.19
	More than 15 gallons	0.70%	22.5	1.27%	0.29
	Metal % of OMT	**55.00%**		**Metal Tank Average Capacity (gal)**	**4.90**
Plastic	1-5 gallon	21.40%	3	47.56%	1.43
	6 gallon	17.70%	6	39.33%	2.36
	7-10 gallon	3.00%	8.5	6.67%	0.57
	11-15 gallon	2.00%	13	4.44%	0.58
	More than 15 gallon	0.90%	22.5	2.00%	0.45
	Plastic % of OMT	**45.00%**		**Plastic Tank Average Capacity (gal)**	**5.38**

B. Liquid leak

Liquid fuel leakage was observed from tested OMTs. The leakage emissions are calculated as follows.

Liquid Fuel Leakage
= population that leaks fuel
* Percentage of tanks stored with fuel
* percentage of tanks leak with tank material
* liquid leak emission factor

C. Hose Assembly

Hose and primer bulb permeation emissions losses refers to the emission losses that result from fuel hoses and primer bulbs full of gasoline and subject to a temperature increase. The following example shows how the emission factor for a hose assembly was derived.

Hose:

Length = 7 ft, Diameter = 5/16 inch

Flux area = 7 ft *0.048m/ft * π * 5/16 in * 0.0254m / in = 0.0532 m^2

Tested hose average daily fuel loss = 6.4 g/day = 120.3g/m^2/day

If propose 15g/m^2/day for controlled hose 's emission factor

= 15/120.3*6.4 = 0.798 g/day

Primer Bulb

Flux area = 0.0087m^2

Tested bulb average daily fuel loss = 3.1g/day /0.0087m^2 = 356.32g/m^2 /day

If propose 15g/m^2/day for controlled bulb'‘s emission factor
= 15/356.32*3.1 = 0.1305 g/day

Allocation Factors

Statewide emssions are allocated to each county/air basin/air district in California. County specific allocation factors were developed based on CSUS's 2006 OMT survey report.

$$\textbf{HC}_{\textbf{county}} = \textbf{HC statewide} * \textbf{Allocation Factor}_{\textbf{county}}$$

Where: HC_{county} = PFC Emission Inventory for a County
HC statewide = Statewide PFC Emission Inventory
Allocation $Factor_{county}$ = Allocation Factor for the County

Values for allocation factors can be found in Appendix D and E.

Seasonal Temperature Correction Factors

The testing to determine the diurnal emission factors for PFC was done by summer ozone temperature profile (65-105-65 ^oF in 24 hour cycle). Temperature correction factors for hose assembly and liquid fuel leakage were not tested thus is not available at this time.

Fuel Correction Factors

Faced with evidence that MTBE found in ground and surface water posed a significant health threat to California citizens, the ARB at the instruction of the Governor began phasing-out its use in 2003 and with a full phase-out by 2005.

In the OMT emissions inventory, before year 2005, emission factors are referred for RFGII fuel, and there after are referred for RFGIII fuel.

FURTHER IMPROVEMENT

ARB does not have a scheduled update for the OMT inventory at this current time.

Appendix A-1 :   OMT California Population

Year	Outboard	Sail Only	Auxiliary and Sail	OMT population
1990	245,901	22,631	2,120	270,652
1991	244,910	22,424	2,101	269,435
1992	243,919	22,217	2,081	268,217
1993	242,928	22,010	2,062	267,000
1994	241,937	21,803	2,043	265,783
1995	240,946	21,597	2,023	264,566
1996	239,955	21,390	2,004	263,348
1997	238,964	21,183	1,984	262,131
1998	237,973	20,976	1,965	260,914
1999	236,982	20,769	1,946	259,697
2000	235,991	20,562	1,926	258,479
2001	235,000	20,355	1,907	257,262
2002	234,009	20,148	1,887	256,045
2003	233,018	19,941	1,868	254,828
2004	232,027	19,735	1,849	253,610
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2017	215,352	15,544	1,456	232,352
2018	214,476	15,338	1,437	231,252
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2028	205,913	13,430	1,258	220,601
2029	205,075	13,253	1,242	219,570
2030	204,241	13,078	1,225	218,544
2031	203,411	12,905	1,209	217,525
2032	202,584	12,735	1,193	216,512

2033	201,760	12,567	1,177	215,504
2034	200,939	12,401	1,162	214,502
2035	200,122	12,237	1,146	213,506
2036	199,309	12,076	1,131	212,516
2037	198,498	11,916	1,116	211,531
2038	197,691	11,759	1,102	210,552
2039	196,887	11,604	1,087	209,578
2040	196,087	11,451	1,073	208,610

Appendix A-2: OMT Emissions Breakdown.

Year	Diurnal from Tanks that Stored in		Liquid from Tanks that Stored in		Permeation from Hose that Stored in		Permeation from Bulbs that Stored in		Tanks Stored without Fill Cap		Total
	Open Condition	Closed Condition	Open Condition	Closed Condition	Open Condition	Closed Condition	Open Condition	Closed Condition	Open Condition	Closed Condition	
1990	0.439	0.510	0.322	0.987	0.266	0.816	0.129	0.395	0.132	0.406	**4.401**
1991	0.437	0.507	0.321	0.983	0.265	0.812	0.128	0.393	0.132	0.404	**4.381**
1992	0.435	0.505	0.319	0.978	0.264	0.808	0.128	0.391	0.131	0.402	**4.361**
1993	0.433	0.503	0.318	0.974	0.262	0.805	0.127	0.390	0.131	0.400	**4.342**
1994	0.431	0.500	0.316	0.969	0.261	0.801	0.127	0.388	0.130	0.398	**4.322**
1995	0.429	0.498	0.315	0.965	0.260	0.797	0.126	0.386	0.129	0.396	**4.302**
1996	0.427	0.496	0.313	0.960	0.259	0.794	0.125	0.384	0.129	0.395	**4.282**
1997	0.425	0.494	0.312	0.956	0.258	0.790	0.125	0.383	0.128	0.393	**4.262**
1998	0.423	0.491	0.310	0.952	0.257	0.786	0.124	0.381	0.128	0.391	**4.243**
1999	0.421	0.489	0.309	0.947	0.255	0.783	0.124	0.379	0.127	0.389	**4.223**
2000	0.419	0.487	0.308	0.943	0.254	0.779	0.123	0.377	0.126	0.387	**4.203**
2001	0.417	0.484	0.306	0.938	0.253	0.775	0.123	0.375	0.126	0.386	**4.183**
2002	0.415	0.482	0.305	0.934	0.252	0.772	0.122	0.374	0.125	0.384	**4.163**
2003	0.413	0.480	0.303	0.929	0.251	0.768	0.121	0.372	0.125	0.382	**4.144**
2004	0.411	0.477	0.302	0.925	0.249	0.764	0.121	0.370	0.124	0.380	**4.124**
2005	0.409	0.579	0.300	0.920	0.248	0.761	0.120	0.368	0.123	0.378	**4.208**
2006	0.397	0.562	0.291	0.893	0.241	0.738	0.117	0.357	0.120	0.367	**4.083**
2007	0.407	0.616	0.323	0.989	0.240	0.734	0.116	0.356	0.119	0.365	**4.265**
2008	0.418	0.674	0.357	1.094	0.238	0.731	0.116	0.354	0.119	0.364	**4.464**
2009	0.429	0.673	0.354	1.085	0.211	0.647	0.101	0.310	0.118	0.362	**4.290**
2010	0.438	0.651	0.338	1.037	0.187	0.573	0.088	0.271	0.117	0.360	**4.061**
2011	0.449	0.624	0.320	0.982	0.160	0.489	0.074	0.226	0.117	0.358	**3.799**
2012	0.460	0.593	0.299	0.918	0.133	0.406	0.060	0.183	0.116	0.357	**3.524**
2013	0.469	0.540	0.265	0.813	0.106	0.324	0.045	0.139	0.116	0.355	**3.173**
2014	0.479	0.480	0.227	0.695	0.080	0.246	0.032	0.098	0.115	0.353	**2.805**
2015	0.488	0.417	0.186	0.570	0.057	0.174	0.019	0.060	0.115	0.352	**2.435**
2016	0.490	0.334	0.135	0.413	0.048	0.146	0.015	0.045	0.114	0.350	**2.088**

2017	0.491	0.249	0.082	0.251	0.041	0.125	0.011	0.034	0.114	0.348	**1.746**
2018	0.491	0.215	0.061	0.187	0.036	0.110	0.009	0.027	0.113	0.347	**1.595**
2019	0.491	0.189	0.045	0.139	0.032	0.099	0.007	0.021	0.113	0.345	**1.480**
2020	0.491	0.167	0.032	0.098	0.030	0.091	0.005	0.017	0.112	0.343	**1.386**
2021	0.490	0.150	0.021	0.066	0.028	0.087	0.005	0.015	0.111	0.342	**1.315**
2022	0.488	0.136	0.013	0.040	0.028	0.085	0.005	0.014	0.111	0.340	**1.260**
2023	0.486	0.126	0.007	0.022	0.028	0.085	0.005	0.014	0.110	0.338	**1.221**
2024	0.484	0.119	0.003	0.010	0.028	0.084	0.005	0.014	0.110	0.337	**1.193**
2025	0.482	0.115	0.001	0.003	0.027	0.084	0.004	0.014	0.109	0.335	**1.174**
2026	0.479	0.114	0.000	-	0.027	0.084	0.004	0.014	0.109	0.334	**1.165**
2027	0.477	0.114	0.000	-	0.027	0.083	0.004	0.014	0.108	0.332	**1.160**
2028	0.475	0.113	0.000	-	0.027	0.083	0.004	0.014	0.108	0.331	**1.154**
2029	0.473	0.113	0.000	-	0.027	0.082	0.004	0.013	0.107	0.329	**1.149**
2030	0.471	0.112	0.000	-	0.027	0.082	0.004	0.013	0.107	0.328	**1.144**
2031	0.468	0.112	0.000	-	0.027	0.082	0.004	0.013	0.106	0.326	**1.138**
2032	0.466	0.111	0.000	-	0.027	0.081	0.004	0.013	0.106	0.324	**1.133**
2033	0.464	0.110	0.000	-	0.026	0.081	0.004	0.013	0.105	0.323	**1.128**
2034	0.462	0.110	0.000	-	0.026	0.081	0.004	0.013	0.105	0.321	**1.122**
2035	0.460	0.109	0.000	-	0.026	0.080	0.004	0.013	0.104	0.320	**1.117**
2036	0.458	0.109	0.000	-	0.026	0.080	0.004	0.013	0.104	0.318	**1.112**
2037	0.455	0.108	0.000	-	0.026	0.079	0.004	0.013	0.103	0.317	**1.107**
2038	0.453	0.108	0.000	-	0.026	0.079	0.004	0.013	0.103	0.316	**1.102**
2039	0.451	0.107	0.000	-	0.026	0.079	0.004	0.013	0.102	0.314	**1.097**
2040	0.449	0.107	0.000	-	0.026	0.078	0.004	0.013	0.102	0.313	**1.092**

Appendix B. Baseline model year distribution calculation for OMTs.

metal tank total life span = 18years, as of 2006 no longer produced, and it has 55% of overall population																						
					2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
MY	**age**	**age dist**	**survival rate**																			
2006	0	0.141	0.99		0.077	0.048	0.102	0.154	0.202	0.255	0.307	0.356	0.405	0.454	0.472	0.484	0.494	0.502	0.507	0.511	0.5123	0.5124
2005	1	0.119	0.98		0.065	0.076																
2004	2	0.108	0.974		0.059	0.064	0.074															
2003	3	0.112	0.976		0.062	0.058	0.062	0.072														
2002	4	0.114	0.965		0.063	0.06	0.056	0.06	0.07													
2001	5	0.076	0.964		0.042	0.06	0.057	0.054	0.058	0.067												
2000	6	0.096	0.951		0.053	0.04	0.058	0.055	0.051	0.055	0.064											
1999	7	0.093	0.953		0.051	0.05	0.038	0.055	0.052	0.049	0.053	0.061										
1998	8	0.068	0.905		0.037	0.046	0.045	0.034	0.05	0.047	0.044	0.048	0.055									
1997	9	0.029	0.423		0.016	0.016	0.02	0.019	0.014	0.021	0.02	0.019	0.02	0.023								
1996	10	0.012	0.745		0.007	0.012	0.012	0.015	0.014	0.011	0.016	0.015	0.014	0.015	0.017							
1995	11	0.01	0.829		0.005	0.005	0.01	0.01	0.012	0.012	0.009	0.013	0.012	0.012	0.012	0.014						
1994	12	0.008	0.772		0.004	0.004	0.004	0.008	0.008	0.009	0.009	0.007	0.01	0.009	0.009	0.01	0.011					
1993	13	0.006	0.775		0.003	0.003	0.003	0.003	0.006	0.006	0.007	0.007	0.005	0.008	0.007	0.007	0.007	0.009				
1992	14	0.004	0.709		0.002	0.002	0.002	0.002	0.002	0.004	0.004	0.005	0.005	0.004	0.005	0.005	0.005	0.005	0.006			
1991	15	0.003	0.641		0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.003	0.003	0.003	0.002	0.004	0.003	0.003	0.003	0.004		
1990	16	0.002	0.6		9E-04	9E-04	9E-04	9E-04	9E-04	9E-04	9E-04	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.0023	
1989	17	5E-04	0.333		3E-04	3E-04	3E-04	3E-04	3E-04	3E-04	3E-04	3E-04	5E-04	5E-04	7E-04	6E-04	5E-04	7E-04	7E-04	6E-04	0.0007	0.0008
				metal	**0.55**	0.499	0.444	0.389	0.34	0.284	0.229	0.178	0.127	0.077	0.057	0.042	0.029	0.02	0.012	0.007	0.003	0.0008
				tanks	1	0.908	0.807	0.707	0.617	0.516	0.417	0.324	0.231	0.139	0.103	0.076	0.053	0.036	0.022	0.012	0.0055	0.0014
					0.55	0.548	0.546	0.543	0.541	0.539	0.537	0.535	0.532	0.53	0.528	0.526	0.524	0.522	0.52	0.517	0.5153	0.5132
				GR	1	0.996	0.992	0.988	0.984	0.98	0.976	0.972	0.968	0.964	0.96	0.956	0.952	0.948	0.945	0.941	0.9369	0.9331

hose replacement: life = 14, 2009 reg starting

MY	age	age dist	survival rate	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
2009	0	0.171	0.988	0.171													
2008	1	0.156	0.973	0.156	0.166												
2007	2	0.146	0.965	0.146	0.15	0.16											
2006	3	0.132	0.959	0.132	0.14	0.144	0.154										
2005	4	0.124	0.957	0.124	0.127	0.134	0.138	0.147									
2004	5	0.073	0.932	0.073	0.115	0.118	0.125	0.129	0.137								
2003	6	0.096	0.895	0.096	0.065	0.103	0.106	0.112	0.115	0.123							
2002	7	0.04	0.402	0.04	0.039	0.026	0.042	0.042	0.045	0.046	0.049						
2001	8	0.024	0.72	0.024	0.028	0.028	0.019	0.03	0.031	0.032	0.033	0.036					
2000	9	0.021	0.718	0.021	0.017	0.02	0.02	0.014	0.021	0.022	0.023	0.024	0.026				
1999	10	0.008	0.743	0.008	0.016	0.013	0.015	0.015	0.01	0.016	0.016	0.017	0.018	0.019			
1998	11	0.005	0.655	0.005	0.005	0.01	0.008	0.01	0.01	0.007	0.01	0.011	0.011	0.012	0.012		
1997	12	0.003	0.528	0.003	0.003	0.003	0.005	0.004	0.005	0.005	0.003	0.006	0.006	0.006	0.006	0.0066	
1996	13	9E-04	0.307	9E-04	9E-04	9E-04	9E-04	0.002	0.001	0.002	0.002	0.001	0.002	0.002	0.002	0.0019	0.002
				1	**0.873**	**0.762**	**0.633**	**0.505**	**0.376**	**0.253**	**0.138**	**0.094**	**0.062**	**0.038**	**0.02**	**0.0085**	**0.002**

New OMT replacement: life = 18, 2009 regulation starting

MY	age	age dist	survival rate	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
2009	0	0.141	0.99	0.141																	
2008	1	0.119	0.98	0.119	0.138																
2007	2	0.108	0.974	0.108	0.116	0.134															
2006	3	0.112	0.976	0.112	0.105	0.113	0.131														
2005	4	0.114	0.965	0.114	0.108	0.101	0.109	0.126													
2004	5	0.076	0.964	0.076	0.11	0.104	0.098	0.105	0.122												
2003	6	0.096	0.951	0.096	0.072	0.105	0.099	0.093	0.1	0.116											
2002	7	0.093	0.953	0.093	0.091	0.069	0.1	0.095	0.089	0.095	0.11										
2001	8	0.068	0.905	0.068	0.084	0.083	0.062	0.09	0.086	0.08	0.086	0.1									
2000	9	0.029	0.423	0.029	0.029	0.036	0.035	0.026	0.038	0.036	0.034	0.037	0.042								
1999	10	0.012	0.745	0.012	0.022	0.021	0.027	0.026	0.02	0.028	0.027	0.025	0.027	0.032							
1998	11	0.01	0.829	0.01	0.01	0.018	0.018	0.022	0.022	0.016	0.024	0.022	0.021	0.023	0.026						
1997	12	0.008	0.772	0.008	0.008	0.008	0.014	0.014	0.017	0.017	0.013	0.018	0.017	0.016	0.017	0.0202					
1996	13	0.006	0.775	0.006	0.006	0.006	0.006	0.011	0.011	0.013	0.013	0.01	0.014	0.013	0.013	0.0135	0.0156				
1995	14	0.004	0.709	0.004	0.004	0.004	0.004	0.004	0.008	0.008	0.009	0.009	0.007	0.01	0.009	0.0089	0.0096	0.011076			
1994	15	0.003	0.641	0.003	0.003	0.003	0.003	0.003	0.003	0.005	0.005	0.006	0.006	0.004	0.006	0.0061	0.0057	0.006135	0.0071		
1993	16	0.002	0.6	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.004	0.004	0.003	0.0038	0.0036	0.003416	0.003681	0.00426	
1992	17	5E-04	0.333	5E-04	5E-04	5E-04	5E-04	5E-04	5E-04	5E-04	5E-04	1E-03	1E-03	0.001	0.001	0.0009	0.0013	0.001216	0.001139	0.001227	0.00142
				1	**0.908**	**0.807**	**0.707**	**0.617**	**0.516**	**0.417**	**0.324**	**0.231**	**0.139**	**0.103**	**0.076**	**0.0534**	**0.0358**	**0.021843**	**0.01192**	**0.005487**	**0.00142**

Appendix C. Regulation timeline

Emission Components	Emission Process	Uncontrolled Emission Factor	Regulation Starts	Controlled Emission Factor
Hose	Permeation	6.4 g/day	2009	0.798 g/day
Cap	Diurnal	106.1 g/day	2010	106.1 g/day
Bulb	Permeation	3.1 g/day	2011	0.1305 g/day
Metal Tank Open	Diurnal	7.714 g/day	2011	7.714 g/day
Metal Tank Close	Diurnal	0.083g/gal-day	2011	slowly phasing out
Plastic Tank Open	Diurnal	14.02 g/day	2011	14.02 g/day
Plastic Tank Close	Diurnal	1.899 g/gal-day	2011	0.202 g/gal-day
Tanks	Liquid Leak	117.05 g/day	2011	0 g/day

Appendix D

California Air Basin and Air District's Name and its Code

Air Basin Name	Code
Great Basin Valleys	GBV
Lake County	LC
Lake Tahoe	LT
Mojave Desert	MD
Mountain Counties	MC
North Central Coast	NCC
North Coast	NC
Northeast Plateau	NEP
Sacramento Valley	SV
Salton Sea	SS
San Diego	SD
San Francisco Bay Area	SF
San Joaquin Valley	SJV
South Central Coast	SCC
South Coast	SC

Air District Name	Code
Amador County APCD	AMA
Antelope Valley APCD	AV
Bay Area AQMD	BA
Butte County AQMD	BUT
Calaveras County AQMD	CAL
Colusa County APCD	COL
El Dorado County APCD	ED
Feather River AQMD	FR
Glenn County APCD	GLE
Great Basin Unified APCD	GBU
Imperial County APCD	IMP
Kern County APCD	KER
Lake County AQMD	LAK
Lassen County APCD	LAS
Mariposa County APCD	MPA
Mendocino County AQMD	MEN
Modoc County APCD	MOD
Mojave Desert AQMD	MOJ
Monterey Bay Unified APCD	MBU
North Coast Unified APCD	NCU
Northern Sierra AQMD	NSI
Northern Sonoma County APCD	NS
Placer County APCD	PLA
Sacramento Metropolitan AQMD	SAC
San Diego County APCD	SD
San Joaquin Valley Unified APCD	SJU
San Luis Obispo County APCD	SLO
Santa Barbara County APCD	SB
Shasta County AQMD	SHA
Siskiyou County APCD	SIS
South Coast AQMD	SC
Tehama County APCD	THE
Tuolumne County APCD	TUO
Ventura County APCD	VEN
Yolo/Solano AQMD	YS

APPENDIX E

California OMT Allocation Factors

			Outboard	Sail Only	Aux & sail
Air Basin	District	County	%	%	%
GBV	GBU	Alpine	0.00%	0.06%	0.00%
GBV	GBU	Inyo	0.20%	0.11%	0.10%
GBV	GBU	Mono	0.10%	0.14%	0.31%
LC	LAK	Lake	1.10%	1.27%	1.25%
LT	ED	El Dorado (partial)	0.39%	0.40%	0.40%
LT	PLA	Placer (partial)	0.13%	0.10%	0.10%
MC	AMA	Amador	0.50%	0.30%	0.26%
MC	CAL	Calaveras	0.90%	0.51%	0.52%
MC	ED	El Dorado (partial)	1.41%	1.44%	1.42%
MC	MPA	Mariposa	0.20%	0.15%	0.21%
MC	NSI	Nevada	1.40%	1.92%	1.56%
MC	PLA	Placer (partial)	0.24%	0.18%	0.18%
MC	NSI	Plumas	0.50%	0.37%	0.36%
MC	NSI	Sierra	0.10%	0.02%	0.05%
MC	TUO	Tuolumne	0.80%	0.79%	0.36%
MD	KER	Kern (partial)	0.31%	0.30%	0.20%
MD	AV	Los Angeles (partial)	0.31%	0.37%	0.43%
MD	MOJ	Riverside (partial)	0.04%	0.03%	0.03%
MD	SC	Riverside (partial)	0.02%	0.02%	0.02%
MD	MOJ	San Bernardino (partial)	0.76%	0.69%	0.80%
NC	NCU	Del Norte	0.20%	0.11%	0.36%
NC	NCU	Humboldt	1.40%	1.15%	1.30%
NC	MEN	Mendocino	0.80%	0.84%	0.78%
NC	NS	Sonoma (partial)	0.32%	0.38%	0.42%
NC	NCU	Trinity	0.30%	0.14%	0.26%
NCC	MBU	Monterey	1.00%	0.94%	0.67%
NCC	MBU	San Benito	0.20%	0.13%	0.26%
NCC	MBU	Santa Cruz	1.00%	1.84%	1.61%
NEP	LAS	Lassen	0.50%	0.26%	0.21%
NEP	MOD	Modoc	0.20%	0.04%	0.10%
NEP	SIS	Siskiyou	0.90%	0.42%	0.42%
SC	SC	Los Angeles (partial)	9.39%	11.26%	13.07%
SC	SC	Orange	5.60%	7.02%	8.98%
SC	SC	Riverside (partial)	2.86%	2.04%	2.28%
SC	SC	San Bernardino (partial)	2.64%	2.40%	2.79%

			Outboard	Sail Only	Aux & sail
Air Basin	**District**	**County**	**%**	**%**	**%**
SCC	**SLO**	**San Luis Obispo**	1.50%	2.30%	2.49%
SCC	**SB**	**Santa Barbara**	1.10%	1.84%	1.35%
SCC	**VEN**	**Ventura**	2.20%	3.03%	3.17%
SD	**SD**	**San Diego**	7.30%	11.02%	9.19%
SF	**BA**	**Alamed a**	2.90%	4.11%	3.84%
SF	**BA**	**Contra Costa**	3.70%	4.26%	3.69%
SF	**BA**	**Marin**	1.10%	2.17%	2.80%
SF	**BA**	**Napa**	0.90%	0.87%	0.67%
SF	**BA**	**San Francisco**	0.50%	0.80%	1.19%
SF	**BA**	**San Mateo**	1.40%	2.51%	2.13%
SF	**BA**	**Santa Clara**	3.20%	6.09%	5.04%
SF	**BA**	**Solano (partial)**	1.25%	0.65%	0.86%
SF	**BA**	**Sonoma (partial)**	2.18%	2.63%	2.85%
SJV	**SJU**	**Fresno**	3.20%	2.04%	1.71%
SJV	**SJU**	**Kern (partial)**	1.59%	1.52%	1.00%
SJV	**SJU**	**Kings**	0.40%	0.12%	0.10%
SJV	**SJU**	**Madera**	0.90%	0.42%	0.31%
SJV	**SJU**	**Merced**	1.00%	0.42%	0.47%
SJV	**SJU**	**San Joaquin**	3.30%	1.50%	1.71%
SJV	**SJU**	**Stanislaus**	2.80%	1.53%	1.14%
SJV	**SJU**	**Tulare**	1.20%	0.71%	0.52%
SS	**IMP**	**Imperia l**	0.30%	0.10%	0.05%
SS	**SC**	**Riverside (partial)**	0.78%	0.56%	0.63%
SV	**BUT**	**Butte**	2.70%	1.49%	1.30%
SV	**COL**	**Colusa**	0.30%	0.13%	0.21%
SV	**GLE**	**Glenn**	0.40%	0.15%	0.05%
SV	**PLA**	**Placer (partial)**	2.23%	1.69%	1.69%
SV	**SAC**	**Sacramento**	6.20%	4.23%	4.26%
SV	**SHA**	**Shasta**	2.90%	1.20%	1.51%
SV	**YS**	**Solano (partial)**	0.55%	0.29%	0.38%
SV	**FR**	**Sutter**	0.90%	0.33%	0.21%
SV	**TEH**	**Tehama**	0.80%	0.20%	0.47%
SV	**YS**	**Yolo**	0.90%	0.81%	0.73%
SV	**FR**	**Yuba**	0.70%	0.11%	0.21%
		Total:	100.00%	100.00%	100.00%