California Environmental Protection Agency

Air Resources Board

QUANTIFICATION OF DIURNAL EMISSIONS FROM PORTABLE OUTBOARD MARINE TANKS (February 2008)

Evaporative Controls and Certification Branch
Monitoring and Laboratory Division

QUANTIFICATION OF DIURNAL EMISSIONS FROM PORTABLE OUTBOARD MARINE TANKS

(February 2008)

Introduction

The term “diurnal emissions”, refers to the total evaporative emission losses that result from subjecting a container filled with gasoline to a standard daily temperature profile simulated under laboratory conditions. Diurnal emissions may be the result of evaporation through fittings or openings, or as permeation through plastic or rubber materials.

Prior to conducting this study, a number of previous studies had been conducted to quantify both permeation and evaporation characteristics. In 1999, the Air Resources Board passed its first portable fuel container (gas can) regulations that included both separate permeation and pressure integrity testing, but later learned there was a need for simplified testing that resembled in-use conditions. Following a significant amount of research and testing, the board adopted its first diurnal test procedure in September 2005.

In preparation for portable outboard marine tank regulatory activity, staff was in need of a test methodology to quantify emissions and develop a statewide emissions inventory.

Test Protocol

Test Procedure 510 (TP-510) was developed to measure diurnal emissions from portable outboard marine tanks. For simplicity, the test procedure has been summarized below.

1. Fill tank to 50% capacity with test fuel.
2. Precondition for minimum 45 days.
3. Acclimate at 65^{o}F for 16-36 hours.
4. Weigh.
5. Conduct 24-hour diurnal temperature profile (65^{o}F-105^{o}F-65^{o}F).
6. Re-weigh.
7. Calculate diurnal emission losses.

Test Results

Attachment A summarizes the results of testing. Aside from the metal tanks, no tanks had barrier controls to limit permeation. Due to the nature of the “as-is” testing, the results varied between tanks. At the request of the emissions inventory staff, testing was conducted with three different test fuels.

Attachement A

Diurnal Emissions Test Data

(THIS PAGE BLANK INTENTIONALLY)

E-10 Results (10.4% Ethanol)

1. All data collected using winter temperature profile and specified test fuel.
2. Fill level may vary as specified.
3. Hose, Fitting, and vent configuration may vary as specified.

Gal.	Fuel	Fill Lvl (%)	Vent Pos.	Fitting	1/25/2007	1/26/2007	Loss	1/27/2007	Loss	1/28/2007	Loss	1/29/2007	Loss	1/30/2007	Loss	1/31/2007	Loss	Avg	g/gal
6	E-10 (E-10.4%)	50	closed	n/a	10,590.4	10,584.1	6.3	10,578.2	5.9	10,572.9	5.3	10,568.2	4.7	10,562.8	5.4	10,557.9	4.9	5.4	0.9
6	E-10 (E-10.4%)	100	closed	n/a	18,950.9	18,944.3	6.6	18,938.2	6.1	18,932.6	5.6	18,927.5	5.1	18,921.4	6.1	18,916.0	5.4	5.8	1.0
3	E-10 (E-10.4%)	90	closed	Mercury	10,132.1	10,128.0	4.1	10,124.7	3.3	10,120.9	3.8	10,118.1	2.8	10,114.4	3.7	10,111.3	3.1	3.5	1.2
3	E-10 (E-10.4%)	50	closed	Mercury	6,472.3	6,469.3	3.0	6,466.4	2.9	6,463.4	3.0	6,461.0	2.4	6,458.0	3.0	6,455.5	2.5	2.8	0.9
3	E-10 (E-10.4%)	50	closed	Mercury	6,525.5	6,522.0	3.5	6,518.8	3.2	6,515.7	3.1	6,513.1	2.6	6,509.9	3.2	6,507.2	2.7	3.1	1.0
6	E-10 (E-10.4%)	50	closed	universal	10,904.8	10,898.9	5.9	10,893.7	5.2	10,888.3	5.4	10,883.4	4.9	10,878.8	4.6	10,874.2	4.6	5.1	0.8
3	E-10 (E-10.4%)	50	closed	Mercury	5,544.6	5,538.5	6.1	5,533.9	4.6	5,528.7	5.2	5,524.6	4.1	5,520.6	4.0	5,517.6	3.0	4.5	1.5
3	E-10 (E-10.4%)	100	closed	Mercury	9,686.3	9,682.4	3.9	9,678.7	3.7	9,675.0	3.7	9,671.6	3.4	9,668.0	3.6	9,664.5	3.5	3.6	1.2
3	E-10 (E-10.4%)	90	closed	Mercury	9,612.8	9,608.8	4.0	9,605.1	3.7	9,601.4	3.7	9,598.0	3.4	9,594.2	3.8	9,590.9	3.3	3.6	1.2
6	E-10 (E-10.4%)	50	closed	Johnson	12,404.9	12,403.8	1.1	12,403.4	0.4	12,402.7	0.7	12,402.3	0.4	12,401.8	0.5	12,401.5	0.3	0.6	0.1

Gal.	Fuel	Fill Lvl (%)	Vent Pos.	Fitting	39,107.0	39,108.0	Loss	39,109.0	Loss	1/28/2007	Loss	1/29/2007	Loss	1/30/2007	Loss	1/31/2007	Loss	Avg	g/gal
3	E-10 (E-10.4%)	50	auto close	plugged	5,840.7	5,829.4	11.3	5,821.9	7.5	5,815.7	6.2	5,810.3	5.4	5,803.7	6.6	5,796.8	6.9	7.6	2.5
3	E-10 (E-10.4%)	50	auto close	plugged	5,592.1	5,587.6	4.5	5,584.1	3.5	5,580.4	3.7	5,577.0	3.4	5,573.2	3.8	5,569.5	3.7	3.8	1.3
3	E-10 (E-10.4%)	50	auto close	plugged	5,077.6	5,027.5	50.1	4,978.3	49.2	4,931.4	46.9	4,883.1	48.3	4,839.4	43.7	4,793.8	45.6	48.6	16.2
3	E-10 (E-10.4%)	50	auto close	plugged	5,710.3	5,695.8	14.5	5,679.1	16.7	5,663.2	15.9	5,650.6	12.6	5,638.2	12.4	5,627.3	10.9	14.9	5.0

Gal.	Fuel	Fill Lvl (%)	Vent Pos.	Fitting	39,107.0	39,108.0	Loss	39,109.0	Loss	1/28/2007	Loss	1/29/2007	Loss	1/30/2007	Loss	1/31/2007	Loss	Avg	g/gal
3	E-10 (E-10.4%)	50	closed	universal	6,442.8	6,431.4	11.4	6,421.6	9.8	6,412.7	8.9	6,404.7	8.0	6,396.9	7.8	6,389.7	7.2	9.5	3.2
3	E-10 (E-10.4%)	50	closed	Mercury	6,404.4	6,399.9	4.5	6,395.9	4.0	6,391.7	4.2	6,387.7	4.0	6,383.6	4.1	6,379.4	4.2	4.2	1.4
3	E-10 (E-10.4%)	50	closed	Honda	6,378.2	6,367.3	10.9	6,357.6	9.7	6,347.0	10.6	6,337.0	10.0	6,327.2	9.8	6,317.2	10.0	10.3	3.4
3	E-10 (E-10.4%)	50	closed	Johnson	6,750.9	6,734.3	16.6	6,719.9	14.4	6,701.1	18.8	6,686.5	14.6	6,672.2	14.3	6,654.6	17.6	16.1	5.4
3	E-10 (E-10.4%)	50	closed	Suzuki	6,430.9	6,424.6	6.3	6,419.0	5.6	6,414.2	4.8	6,409.1	5.1	6,404.6	4.5	6,399.6	5.0	5.4	1.8

Winter Fuel Results (5.6% Ethanol)

1. All data collected using winter temperature profile and specified test fuel.
2. Fill level may vary as specified.
3. Hose, Fitting, and vent configuration may vary as specified.

Diurnal Tank Emissions With Manual Vents

Gal.	Fuel	Fill Lvl (%)	Vent Pos.	Hose	Fitting	1/18/2007	1/19/2007	Loss	1/20/2007	Loss	1/21/2007	Loss	1/22/2007	Loss	1/23/2007	Loss	1/24/2007	Loss	Avg	g/gal
6	Winter (E-5.6%)	50	closed	Tempo	universal	10538.2	10532.3	5.9	10527.6	4.7	10522.8	4.8	10517.8	5.0	10513.0	4.8	10508.8	4.2	4.9	0.8
6	Winter (E-5.6%)	100	closed	Tempo	universal	19190.8	19185.6	5.2	19181.3	4.3	19177.5	3.8	19172.4	5.1	19167.5	4.9	19164.1	3.4	4.5	0.7
6	Winter (E-5.6%)	100	closed	Tempo	universal	19201.2	19197.5	3.7	19193.6	3.9	19189.9	3.7	19186.1	3.8	19182.1	4.0	19178.8	3.3	3.7	0.6
6	Winter (E-5.6%)	50	closed	Tempo	universal	10946.9	10944.1	2.8	10941.9	2.2	10940.2	1.7	10938.2	2.0	10936.1	2.1	10933.8	2.3	2.2	0.4
12	Winter (E-5.6%)	50	closed	n/a	Johnson	20404.9	20401.9	3.0	20398.9	3.0	20396.6	2.3	20394.0	2.6	20391.6	2.4	20389.7	1.9	2.5	0.2
6	Winter (E-5.6%)	50	closed	n/a	Johnson	10692.9	10690.9	2.0	10688.3	2.6	10686.4	1.9	10684.4	2.0	10682.4	2.0	10680.4	2.0	2.1	0.3
6	Winter (E-5.6%)	100	closed	n/a	Johnson	19036.8	19034.7	2.1	19032.2	2.5	19030.6	1.6	19028.2	2.4	19025.9	2.3	19024.9	1.0	2.0	0.3
6	Winter (E-5.6%)	–	closed	n/a	n/a	2589.8	2589.6	0.2	2589.3	0.3	2589.5	-0.2	2589.5	0.0	2589.6	-0.1	2589.8	-0.2	0.0	0.0
3	Winter (E-5.6%)	–	closed	n/a	n/a	1339.1	1339.1	0.0	1338.9	0.2	1339.2	-0.3	1339.2	0.0	1339.1	0.1	1339.3	-0.2	0.0	0.0
6	Winter (E-5.6%)	100	closed	n/a	Johnson	19451.3	19449.4	1.9	19446.7	2.7	19445.1	1.6	19443.5	1.6	19441.6	1.9	19440.2	1.4	1.8	0.3
6	Winter (E-5.6%)	50	closed	n/a	Johnson	11345.2	11343.4	1.8	11341.6	1.8	11340.3	1.3	11339.4	0.9	11337.3	2.1	11336.5	0.8	1.5	0.2
6	Winter (E-5.6%)	50	closed	n/a	Johnson	11313.0	11311.4	1.6	11308.8	2.6	11307.2	1.6	11306.0	1.2	11304.0	2.0	11303.0	1.0	1.7	0.3

Gal.	Fuel	Fill Lvl (%)	Vent Pos.	Hose	Fitting	1/18/2007	1/19/2007	Loss	1/20/2007	Loss	1/21/2007	Loss	1/22/2007	Loss	1/23/2007	Loss	1/24/2007	Loss	Avg	g/gal
3	Winter (E-5.6%)	50	auto close	n/a	plugged	5884.3	5883.1	1.2	5881.6	1.5	5880.2	1.4	5879.7	0.5	5878.3	1.4	5877.4	0.9	1.2	0.4
3	Winter (E-5.6%)	50	auto close	n/a	plugged	5919.4	5917.9	1.5	5916.9	1.0	5915.8	1.1	5914.8	1.0	5914.0	0.8	5912.8	1.2	1.1	0.4
3	Winter (E-5.6%)	50	auto close	n/a	plugged	5389.6	5386.7	2.9	5384.1	2.6	5382.4	1.7	5380.4	2.0	5377.6	2.8	5375.8	1.8	2.3	0.8
3	Winter (E-5.6%)	50	auto close	n/a	plugged	5820.8	5819.0	1.8	5817.6	1.4	5816.3	1.3	5814.9	1.4	5813.4	1.5	5812.7	0.7	1.5	0.5
3	Winter (E-5.6%)	50	auto close	n/a	plugged	9794.6	9790.5	4.1	9787.7	2.8	9785.5	2.2	9783.0	2.5	9780.5	2.5	9778.3	2.2	2.9	1.0
6	Winter (E-5.6%)	50	auto close	n/a	plugged	12369.0	12367.3	1.7	12366.5	0.8	12365.4	1.1	12364.4	1.0	12363.1	1.3	12362.2	0.9	1.2	0.2

Various Fuel Blends

1. All data collected using summer (65-105-65) temperature profile and specified test fuel.
2. Fill level may vary as specified.
3. Hose, Fitting, and vent configuration may vary as specified.

Diurnal Tank Emissions With Manual Vents

Gal.	Fuel	Fill Lvl (%	Vent Pos.	Fitting	8/16/2006	8/18/2006	Loss	8/17/2006	Loss	8/18/2006	Loss	8/19/2006	Loss	8/20/2006	n/a	8/21/2006	Loss	8/22/2006	Loss	8/23/2006	Loss	8/24/2006	Loss	Avg	g/gal
6	Cert II	100	closed	n/a	17896.9	17891.2	5.7	17887.1	4.1	17882.3	4.8	17878.2	4.1	17873.0	5.2	17868.7	4.3	17864.2	4.5	17859.4	4.8	17855.1	4.3	4.6	0.8
6	Cert II	100	closed	n/a	15729.7	15724.8	4.9	15721.0	3.8	15716.2	4.8	15711.7	4.5	15707.8	3.9	15703.2	4.6	15698.9	4.3	15694.5	4.4	15689.9	4.6	4.4	0.7
3	Cert II	>50	closed	Yamaha	6053.7	5979.6	74.1																		
3	Cert II	50	closed	Johnson	5458.8	5453.3	5.5	5449.4	3.9	5445.0	4.4	5441.3	3.7	5436.7	4.6	5430.8	5.9	5425.7	4.1	5422.2	4.5	5416.9	5.3	4.7	1.6
3	Cert II	100	closed	Johnson	5306.5	5286.4	20.1	5269.2	17.2	5250.7	18.5	5235.5	15.2	5222.1	13.4	5203.4	18.7	5191.4	12.0	5180.9	10.5	5165.0	15.9	15.7	5.2
6	Cert II	100	closed	universal	11597.2	11590.2	7.0	11586.1	4.1	11580.1	6.0	11575.1	5.0	11570.3	4.8	11565.8	4.5	11561.1	4.7	11556.8	4.3	11552.2	4.6	5.0	0.8
6	Cert II	50	closed	universal	11375.4	11360.0	15.4	11346.7	13.3	11338.6	8.1	11331.4	7.2	11324.7	6.7	11318.9	5.8	11312.6	6.3	11306.9	5.7	11301.0	5.9	8.3	1.4
6	Cert II	>50	closed	Johnson	10379.4	10219.2	160.2																		
6	Cert II	50	closed	Johnson	10764.4	10757.7	6.7	10755.3	2.4	10751.8	3.5	10748.0	3.8	10744.8	3.2	10741.1	3.7	10737.5	3.6	10734.5	3.0	10730.5	4.0	3.8	0.6
6	Cert II	50	closed	Johnson	10472.1	10460.8	11.3	10455.1	5.7	10443.7	11.4	10436.0	7.7	10426.4	9.6	10420.1	6.3	10415.1	5.0	10406.5	8.6	10400.4	6.1	8.0	1.3
6	Cert II	50	closed	Johnson	12105.0	12104.6	0.4	12104.2	0.4	12103.6	0.6	12102.8	0.8	12102.7	0.1	12102.6	0.1	12102.2	0.4	12101.8	0.4	12101.7	0.1	0.4	0.1

Diurnal Tank Emissions With Automatic Vents

Gal.	Fuel	Fill Lvl (%	Vent Pos.	Fitting	8/16/2006	8/18/2006	Loss	8/17/2006	Loss	8/18/2006	Loss	8/19/2006	Loss	8/20/2006	n/a	8/21/2006	Loss	8/22/2006	Loss	8/23/2006	Loss	8/24/2006	Loss	Avg	g/gal
3	Cert II	50	auto close	plugged	5696.1	5689.3	6.8	5684.2	5.1	5678.3	5.9	5672.8	5.5	5667.3	5.5	5661.7	5.6	5655.6	6.1	5649.9	5.7	5643.9	6.0	5.8	1.9
3	Cert II	50	auto close	plugged	5903.3	5901.1	2.2	5899.3	1.8	5897.1	2.2	5895.2	1.9	5893.3	1.9	5891.4	1.9	5889.4	2.0	5887.5	1.9	5885.2	2.3	2.0	0.7
3	Cert II	50	auto close	plugged	5484.0	5480.4	3.6	5478.3	2.1	5475.7	2.6	5473.0	2.7	5470.3	2.7	5467.8	2.5	5465.3	2.5	5462.7	2.6	5460.4	2.3	2.6	0.9
3	Cert II	50	auto close	plugged	5542.2	5538.4	3.8	5536.2	2.2	5533.6	2.6	5530.7	2.9	5528.5	2.2	5526.3	2.2	5523.4	2.9	5521.2	2.2	5518.7	2.5	2.6	0.9
3	Cert II	50	auto close	plugged	5533.8	5529.7	4.1	5527.3	2.4	5523.5	3.8	5518.6	4.9	5515.3	3.3	5512.2	3.1	5509.6	2.6	5506.2	3.4	5503.1	3.1	3.4	1.1
3	Cert II	50	auto close	plugged	4378.9	4361.3	17.6	4344.5	16.8	4325.8	18.7	4306.6	19.2	4289.0	17.6	4272.6	16.4	4262.6	10.0	4248.9	13.7	4235.1	13.8	18.1	6.0
3	Cert II	50	auto close	plugged	5187.5	5182.8	4.7	5179.0	3.8	5171.9	7.1	5165.3	6.6	5159.6	5.7	5153.2	6.4	5147.4	5.8	5140.8	6.6	5133.7	7.1	5.5	1.8
3	Cert II	50	auto close	plugged	5192.4	5181.9	10.5	5175.5	6.4	5167.1	8.4	5158.4	8.7	5150.7	7.7	5142.3	8.4	5134.0	8.3	5125.3	8.7	5115.0	10.3	8.6	2.9
3	Cert II	50	auto close	plugged	5730.2	5724.6	5.6	5720.4	4.2	5715.2	5.2	5710.2	5.0	5706.2	4.0	5702.2	4.0	5697.6	4.6	5692.8	4.8	5687.8	5.0	5.0	1.7
6	Cert II	50	auto close	plugged	12410.2	12409.4	0.8	12408.7	0.7	12407.4	1.3	12406.5	0.9	12406.4	0.1	12405.7	0.7	12404.8	0.9	12404.4	0.4	12404.0	0.4	0.7	0.1

Evaporation Through Open Tank Vent

Gal.	Fuel	ill Lvl (%	Vent Pos.	Fitting	8/25/2006	8/26/2006	Loss	8/27/2006	Loss	8/28/2006	Loss	8/29/2006	Loss	Avg
3	Cert II	50	closed	plugged	5882.9	5880.8	2.1	5878.6	2.2					2.1
3	Cert II	50	closed	plugged	4201.2	4179.6	21.6	4159.8	19.8					20.7
6	Cert II	50	closed	plugged	14975.7	14975.0	0.7	14965.8	9.2					5.0
6	Cert II	50	closed	plugged	9816.0	9811.4	4.6							4.6
6	Cert II	50	closed	plugged	11331.9	11326.9	5.0							5.0
3	Cert II	50	open	plugged				5878.6		5871.1	7.5	5863.9	7.2	7.4
3	Cert II	50	open	plugged				4159.8		4149.7	10.1	4140.0	9.7	9.9
6	Cert II	50	open	plugged				14965.8		14956.5	9.3	14948.8	7.7	8.5
6	Cert II	50	open	plugged		9811.4		9797.4	14.0	9784.4	13.0	9772.9	11.5	12.8
6	Cert II	50	open	plugged		11326.9		11314.4	12.5	11301.2	13.2	11290.5	10.7	12.1

Hose & Squeeze Bulb Permeation

ID	Manuf	Fuel	Test Method	#######	8/26/2006	Loss	8/27/2006	Loss	8/28/2006	Loss	8/29/2006	Loss	Avg
Yam 1	Yamaha	RFG3 (E-7.47	Canister w/~600 ml test fuel	976.84	975.25	1.4	973.74	1.5	972.43	1.3	971.15	1.3	1.4
Yam 2	Yamaha	RFG3 (E-7.47	Canister w/~600 ml test fuel	778.95	777.67	1.3	776.37	1.3	775.13	1.2	773.98	1.1	1.2
Yam 3	Yamaha	RFG3 (E-7.47	Canister w/~600 ml test fuel	769.68	768.35	1.3	766.99	1.4	765.74	1.3	764.58	1.2	1.3
Tempo 1	Tempo	RFG3 (E-7.47	Canister w/~600 ml test fuel	566.69	559.03	7.7	551.77	7.3	544.25	7.5	537.35	6.9	7.3
Tempo 2	Tempo	RFG3 (E-7.47	Canister w/~600 ml test fuel	591.91	585.01	6.9	578.70	6.3	572.68	6.0	567.02	5.7	6.2
Tempo 3	Tempo	RFG3 (E-7.47	Canister w/~600 ml test fuel	721.78	712.47	9.3	703.45	9.0	694.79	8.7	686.52	8.3	8.8
SeaSns 1	Sea Sense	RFG3 (E-7.47	Canister w/~600 ml test fuel	810.61	807.80	2.8	804.96	2.8	802.24	2.7	799.64	2.6	2.7
SeaSns 2	Sea Sense	RFG3 (E-7.47	Canister w/~600 ml test fuel	787.80	785.07	2.7	782.25	2.8	779.40	2.9	776.75	2.6	2.8
Hose A	Tempo	RFG3 (E-7.47	Canister w/~600 ml test fuel	658.68	657.91	0.8	657.18	0.7	656.33	0.8	655.53	0.8	0.8

Hose Assemebly Permeation

ID	Manuf	Fuel	Test Method	8/27/2006	Loss	8/28/2006	Loss	8/29/2006	Loss	Avg
HA-1	Tempo	RFG3 (E-7.47	primed w/ test fuel	643.6		629.1	14.5	616.9	12.2	13.4
HA-2	Tempo	RFG3 (E-7.47	primed w/ test fuel	601.8		592.5	9.3	584.2	8.3	8.8
HA-3	Tempo	RFG3 (E-7.47	primed w/ test fuel	601.8		594.9	6.9	586.9	8.0	7.4
HA-4	Tempo	RFG3 (E-7.47	primed w/ test fuel	648.2		632.7	15.5	619.8	12.9	14.2
HA-5	Tempo	RFG3 (E-7.47	primed w/ test fuel	607.1		597.8	9.3	588.2	9.6	9.4
HA-6	Tempo	RFG3 (E-7.47	primed w/ test fuel	631.1		616.6	14.5	604.4	12.2	13.4